RAPID SOCIO-ECONOMIC AND HYDROLOGICAL ASSESSMENT OF PREY LANG FOREST

TASK ORDER NO. 04

JULY 2011

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CAMBODIA MSME 2/BEE PROJECT

RAPID SOCIO-ECONOMIC AND HYDROLOGICAL ASSESSMENT OF PREY LANG FOREST

TASK ORDER NO. 04

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ACRONYMS

The following list of acronyms is intended to be a guide to the Rapid Socio-economic and Hydrological Assessment of Prey Lang Assessment. It is not intended to be the complete list of the acronyms. During the preparation of the Assessment, and other documentation, this list will be extended. A complete list of acronyms will be included in the final report document.

AE	Advancing Engineering Consultants
AGB	Above ground biomass
ADB	Asian Development Bank
BAU	Business as usual
BCA	Benefit Cost Analysis
bcm	billions of cubic meters
BCR	Benefit Cost Ratio
BEF	Biomass expansion factor
BOD	Biological organic demand
CI	Conservation International
CBA	Community based assessment
CBNRS	Community Based Natural Resource Specialist
CDRI	Cambodia Development Resource Institute
COD	Chemical oxygen demand
cumecs	cubic meters per second (m^3/sec)
DAI	Development Alternatives Incorporated
DO	Dissolved oxygen
DUV	Direct use value
EA	Environmental Assessment
ELC	Economic land concession
ET/ETo	Evapo-transpiration
EV	Existence value
EWMI	East-West Management Institute
EWMI-PRAJ	East-West Management Institute Program on Rights and Justice
FA	Forestry Administration
FES	Forest ecosystem services
GIS	Geographic Information System
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
IUV	Indirect Use Values
IWRM	Integrated Water Resource Management
IWMI	International Water Management Institute
LMB	Lower Mekong Basin
MAFF	Ministry of Fisheries and Forestry
MCA	Multi-critieria Analysis
mcm	millions of cubic meters
MOE	Ministry of Environment
MOH	Ministry of Hydrology
MRB	Mekong River Basin
MRC	Mekong River Commission
MT/mt	MegaTonnes / Million tonnes
MS	Milestones
MSME	Micro Small and Medium Enterprise/Cambodia MSME
MWRAM	Ministry of Water Resource and Meteorology

NGO	Non-governmental organization
NPB	Net present benefit
NPC	Net present cost
NPV	Net present value
NRM	Natural Resource Management
NTFP	Non-timber forest products
NUV	Non-use values
OV	Options value
PES	Payment for Environmental Services
PDWRAM	Provincial Department of Water Resources and Meteorology
ppb	parts per billion
ppm	parts per million
QA/QC	Quality assurance / Quality control
REDD	Reducing Emissions from Deforestation and Forest Degradation
RGC	Royal Government of Cambodia
RIL	Reduced Impact Logging
SFMA	Strategic Forestry Management Analysis
SFMP	Strategic Forestry Management Plan
SLU	Sustainable Land Use
SOW	Scope of Work
SuDeX	Sustainable Development Extention
TDS	Total dissolved solids
TEV	Total economic valuation
TSS	Total suspended solids
UN	United Nations
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USAID	United States Agency for International Development
WB	World Bank
WCS	Wildlife Conservation Society
WQI	Water quality indice
WWF	World Wildlife Fund

Water Quality Abbreviations/Chemical Symbols (Typical units)

Alk	Alkalines
C	Carbon
Ca	Calcium
Cl	Chlorine
CO_2	Carbon dioxide
COD	Chemical oxygen demand,
Cond	Conductivity
K	Potassium
Mg	Magnesium
Na	Sodium
(NO3+2)-N	Nitrates
NH_4-N	Ammonia
PO_4-P	Phosphates
Si	Silicon
SO_4	Sulfates
TFE	Total Fe (iron)
Total P	Phosphorus
TSS	Total suspended solids
O_2	Oxygen

Executive Summary

An important component of USAID Cambodia MSME project is biodiversity conservation through sound management of areas of biological importance. One such area is the Prey Lang forest landscape, an evergreen dry forest located within Kampong Thom, PreahVihear, Stung Treng and Kratie Provinces in northern central Cambodia.

Entitled, *Rapid Socio-economic and Hydrological Assessment of Prey Lang Forest*, this study title identifies the three principle components of focus: socio-economics, hydrology and the Prey Lang forest. The overarching theme is to assess how these components are interrelated with respect to social, economic and environmental impacts within and downgradient of the study area.Focusing specifically on these main topics and themes, this assessment takes an initial step in building an optimum strategic planning and management model to maximize prudent sustainable forest utilization without devaluating the natural capital resulting from the services provided by the forest and interdependent ecosystems.

Working in close collaboration with Royal Government of Cambodia (RGC) and the MSME team, the report assesses at the socio-economic and environmental tradeoffs as a result of three different land use scenarios within the study area in a 10 year time frame relative to the hydrologic cycle and forest growth cycle (25 years).

A “sustainable development extension” or SuDeX Method was applied using well-established economic, social and environmental models used by the Asian Development Bank, the US Environmental Protection Agency, the World Bank the UN, as well as the Mekong River Commission. These models include TEV, BCA and MCA used to conduct environmental impact and resource development studies. Since the economic base analysis can only address those direct and indirect forest uses to which monetary values can be estimated, multi criteria analysis (MCA) was conducted to generate a SuDeX Matrix accounting for a myriad of socio-economic and environmental parameters that otherwise would not have been addressed. The matrix is a unique tool, which integrates economic, social and environmental themes into one score. Whereas TEV and BCA do not provide a ranking of options, the SuDeX Matrix does, and collectively, the integrated models indicate the optimum ranking of conservation, preservation, baseline, and uncontrolled exploitation.

Study Area

Determining the appropriate study area was the first step in the assessment. This required close consideration of the unique fixed characteristics of the area, e.g., watershed and political boundaries, and their relationship with the variable characteristics, e.g., economic land concessions and population density. The intent was to present a study area defined by the fixed characteristics inclusive of the indicator parameters to be used for the socio-economic and environmental benefit cost analysis. The watershed boundaries are the defining factor for the hydrological study area because of the dynamics of the hydrological cycle in relation to the forest, underlying aquifers, and surface water hydrology and river hydraulics. All of these were then considered with respect to internal and downgradient stakeholders, environmental impacts, and socio-economic conditions.

The Tonle Sap Lake and Mekong River form a unique complex dynamic water basin. The Prey Lang forest straddles three watersheds within this basin: Stung Chinit, Stung Sen, and Siem Bok.

Stung Chinit and Stung Sen are primary tributaries that drain into the Tonle Sap River, while Siem Bok runoff drains into both the Mekong River and the Tonle Sap River. The Study Area is defined by the perimeter boundary of the contiguous watersheds. In total, the spatial extent of the Study Area is approximately 33,500 square kilometers. This study area should not be confused with the Prey Lang forest itself, which was estimated to be 760,000 ha for this report.

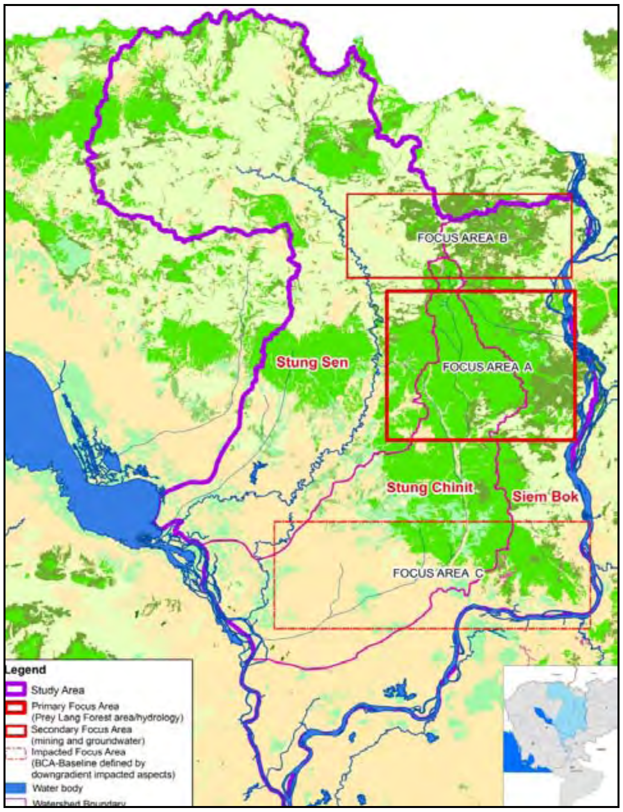
Monitoring stations located at Stung Treng and Kratie serve as important reference points to determine changes in baseline river hydraulics in the Mekong River due to the different forest use scenarios, while monitoring stations within the Stung Sen and Stung Chinit watershed provide general area hydrology data and to some extent Tonle Sap hydraulics.

This relatively large Study Area is then subdivided into three smaller focal areas which provide a representative model of the different perspectives considered as affected by the forest and hydrology. The three focus areas are:

- Focus Area A: Prey Lang Forest & hydrology
- Focus Area B: Upgradient surface and groundwater (aquifer) resources
- Focus Area C: Downgradient - Concentrated populations &peri-urban economic centers

Figure ES-1 shows Study Area used for this assessment.

Figure ES-1. Study Area



Baseline Information

In order to carry out the rapid socio-economic and hydrological assessment of the Prey Lang forest, a significant amount of data has been collected and analyzed. Given the rapid nature (limited time and resources) of this project, it is important to note that creating original primary data or the collection of investigative field samples was beyond the scope of the investigation. Instead, the analysis utilized existing data from previous reports, in combination with information obtained from key contacts in associated ministries, organizations, etc. The following categories of information were collected and analyzed during the research phase:

- Biophysical conditions: topography and meteorology
- Hydrological data: surface water and ground water
- Socio-economic statistics, and demographics

Incomplete and imperfect Information

Cambodia has good information through the Forest Administration, the Mekong River Commission, and a host of international organizations and institutions. However, there is not sufficient information needed to conduct scientific and engineering based quantifiable assessments. The method developed within this study provides a process which makes the most of the information currently available, dependent upon the active participation of the decision makers and stakeholders, producing a qualitative basis on which to make initial decisions and set interim policy until sufficient quantifiable credible reliable information is available to reach a definitive decision with a high level of confidence.

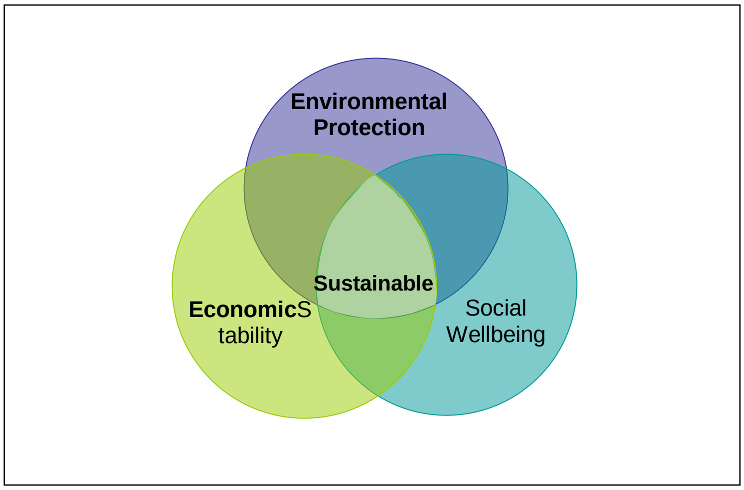
Scenarios

The baseline conditions determined by studying existing information established a benchmark for comparing the socio-economic tradeoffs of three different forest land use strategies relative to the hydrology cycle. Baseline is based on current conditions using the year 2010, assuming that the current ban on forestry was lifted, for continued operations through the study period. The three strategies (conversion, preservation and conservation) are summarized in the following scenarios:

- **Conversion** is the full exploitation and conversion of the existing forest to other land uses in order to reap the maximum economic value of the timber in the shortest possible time frame.
- **Preservation** is to provide sufficient funding, policy, regulation and enforcement to protect the forest from exploitation, environmental disruption and social-economic intrusion, to preserve the remaining forest as is or better in perpetuity.
- **Conservation** is the optimization of forest development and environmental conservation by developing, implementing and maintaining a balanced sustainable land use management approach involving local communities, advocacy groups, and economic enterprises in partnership with the national government to maximize optimum economic returns, while minimizing disruptive environmental and social impacts.

Each scenario seeks to maximize the objective of the specific goals. For conversion, the objective is to maximize revenues for economic benefits. For preservation, the objective is to maximize forest protection to mitigate environmental concerns relative to social welfare. And for conservation, the objective is to maximize the optimum balance between the two extremes. The scenarios were assessed in term of the three main pillars of sustainability: environmental protection, economic stability, and social wellbeing (Figure ES-2).

Figure ES-2 Primary themes of sustainability

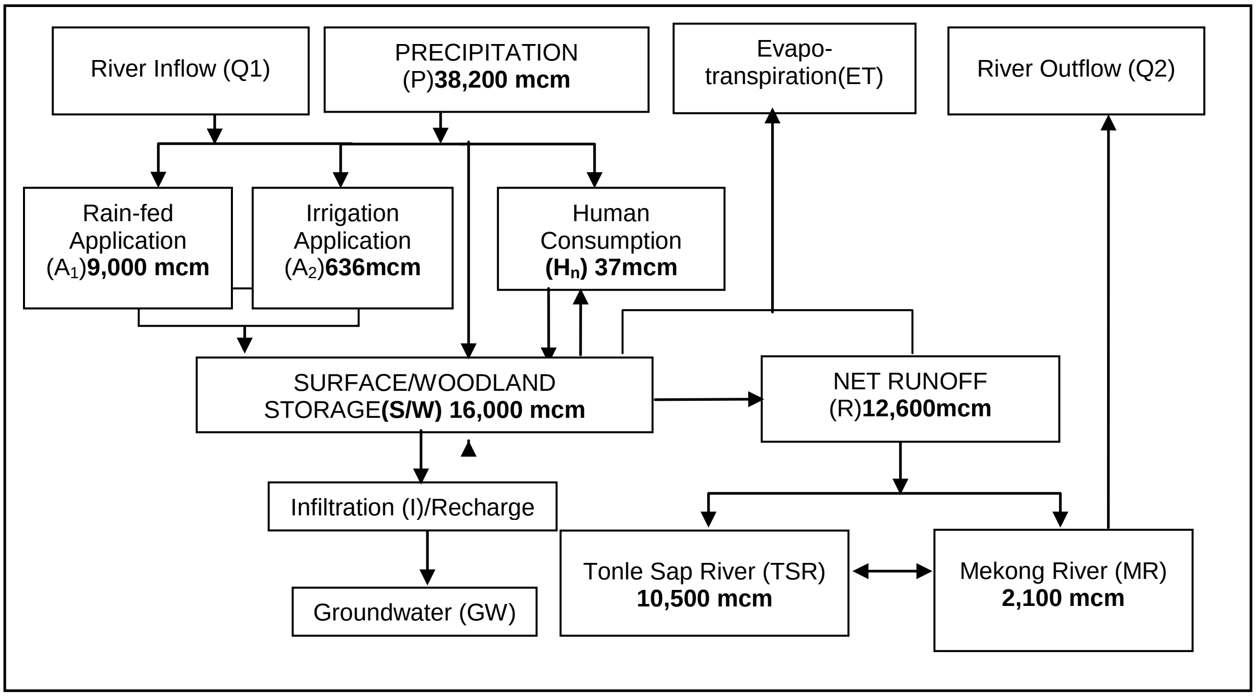


Hydrology and Forest Relationship

The forest serves as a hydrology buffer reducing runoff velocity, absorbing a portion of the precipitation, and anchoring soils in place. Clearing the forest removes these natural services and may increase the amount and rates of net runoff reaching their respective sinks (Tonle Sap or Mekong River), as well as the suspended solid concentration in the discharge altering sediment grain size, volumes and locations of sediment deposits, which affects fish migration paths and spawning grounds. Due to the size of the study area, and the complexity and importance of the relationship between the Tonle Sap and Mekong River, it would require a sophisticated quantitative model to determine how much the actual net runoff would be affected, which is beyond the scope of this study. However, adapting the Rational Method, and HEC-HMS as described in Section 2.3, the qualitative assessment conducted provides a relative objective indication of the potential outcomes.

In terms of water balance, the sum of flows into an area equals the sum of flows out of the system. The water balance is summarized in the Figure ES-3 below, for a detailed water balance description refer to section 4.2.8.

Figure ES-3 Study Area Water Inventory



{Note: Those cells without date indicate insufficient information available.}

Economic Analysis

To evaluate the three forest management scenarios in any meaningful manner is precarious at best, since the advantages and disadvantages of each are not necessarily compatible with the others. Based solely on economic factors in the present, Strategy 1 may seem like the only logical alternative. However, if the advantages and disadvantages can be normalized so that a common measure is used to compare both, not only intra-scenario, but inter-scenario as well, then a different assessment may be reached. Using a monetary value is one method, in which direct values are determined based on market economics and financial considerations, while indirect uses, for which there are not market forces to establish value, are monetized using economic rationales to establish a hypothetical value for the environmental services provided. This can be very difficult and contentious. A well meaning environmentally responsible logging company may value the natural services provided by the forest well below the value placed on it by a conservative environmentalist. However, working together they may well come to an acceptable compromise.

It is important to note that it is not the forest, per se, that is being valued, but the independent elements of ecosystem services provided by the system.

This study applies two economic or market based methods to determine the viability of the strategies. They are, Total Economic Value (TEV) and Benefit Cost Analysis (BCA), as described in Sections 2.0 and 6.0, and applied to the baseline and each scenario within this section. **The dollar values used for these analyses are based on baseline projections, extrapolations and interpolations and presented for illustrative purposes only and should not be used as the basis for financial projections and planning.**

The market based approached is followed by a more qualitative analysis of 112 social, and environmental parameters that cannot easily be normalized by monetary values.

Total Economic Value

The Total Economic Value (TEV) framework is an economic evaluation method widely used internationally, as well as in Cambodia. This framework integrates the various economic values of the forest, from direct benefits, like timber, to indirect intangible benefits such as forest ecosystem services to determine the baseline economic parameters. Due to the rapid nature of this study, TEV analysis was limited to Direct Use Values (DUV) and Indirect Use Values (IUV). Table ES-1 summarizes the Baseline TEV and NPV results.

Table ES-1 Summary of Baseline TEV and NPV

	STUDY AREA BASELINE			
	USE VALUES	**Economic Value (2010)** (USD Millions)	**Baseline TEV contribution to GDP %**	**NPV 10 YR Projection - Baseline** (USD Millions)
Direct Use Values	Timber	$68	0.6%	$487
	NTFP	$17	0.2%	$114
	Fisheries	$49	0.4%	$352
	Tourism	$6	0.1%	$49
	Agriculture	$49	0.4%	$348
	PES	$0.2	0.0%	$1
	Subtotal DUV	***$189***	*1.7%*	***$1,352***
Indirect Use Values	Carbon	$0	0.0%	$671
	Biodiversity	$23	0.2%	$156
	FES	$99	0.9%	$676
	Subtotal IUV	***$122***	*1.1%*	***$1,503***
	TOTAL TEV	**$311**	**2.8%**	**$2,855**

PES = Payment for environmental services; FES=Forest Ecosystem Services

{Note: Dollar figures are for illustrative purposes only and not to be used for formal planning or budgeting.}

Benefit Cost Analysis and Internal Rate of Return

Benefit Cost Analysis (BCA) builds upon the TEV using the monetary value of the benefits compared to the monetary values of the cost of achieving the benefits. Without stakeholder consensus on direct and indirect uses, this study relies on ranges of estimated assumed best case - worse case analysis.

The ratio of the benefits to costs (BCR) provides a less ambiguous determinant of relative benefit. If the ratio is greater than 1, the scenario is a viable economic option, as in the case of both Scenario 2, and 3 (1.72, 1.66 respectively). If it is less than one, as in the case of the baseline and Scenario 1, it is not a viable option. When several options have BCR greater than one, it is difficult to determine which one the better choice is. The amount of difference does not help since a small change in any of the parameters could sway the balance and using a different discount cash flow (DCF) could result in significant shifts. Consequently, economists generally do not use BCR for ranking, whereas internal rate of return (IRR) can be used (Martin, 1997).

IRR is a rate, or ratio, of return on investment and determines the discount rate at which benefit cost analysis is equal to zero. In general, the higher the IRR for a particular scenario, the more desirable it is. Table ES-2 summaries the BCA for the baseline and scenarios.

Table ES-2 Summary of BCA for Baseline & Scenarios (USD Millions)

USES	Baseline			Scenario 1: Conversion			Scenario 2: Preservation			Scenario 3: Conservation		
	Economic Value (2010)	Benefits NPV	Costs NPV	Economic Value (2010)	Benefits NPV	Costs NPV	Economic Value (2010)	Benefits NPV	Costs NPV	Economic Value (2010)	Benefits NPV	Costs NPV
Direct (DU)												
Timber	$68	$487	$4,380	$682	$4,867	$0	$0	$0	$4,867	$82	$1,076	$3,791
NTFP	$17	$114	$266	$17	$69	$112	$17	$181	$199	$17	$380	$0
Fisheries	$49	$352	$770	$50	$195	$927	$49	$1,122	$0	$49	$1,122	$0
Tourism	$6	$49	$81	$5.7	$22	$108	$5.7	$130	$0	$5.7	$130	$0
Agriculture	$49	$348	$1,714	$49	$357	$1,705	$49	$1,108	$954	$49	$2,062	$0
PES	$0.2	$1	$1	$0.2	$1	$2	$0.2	$2.8	$0	$0.2	$2.8	$0
Subtotal DUV	*$189*	*$1,352*	*$7,213*	*$803*	*$5,511*	$2,854	*$121*	*$2,544*	$6,020	*$203*	*$4,773*	$3,791
Indirect (IUV)												
Carbon	$0	$671	$48	$0	$219	$501	$0	$720	$0	$0	$673	$47
Biodiversity	$23	$156	$1,136	$23	$90	$1,202	$23	$1,292	$0	$23	$589	$703
FES	$99	$676	$5,124	$99	$390	$5,410	$99	$5,800	$0	$99	$4,180	$1,620
Subtotal IUV	*$122*	*$1,503*	*$6,309*	*$122*	*$699*	*$7,112*	*$122*	*$7,812*	*$0*	*$122*	*$5,442*	*$2,370*
TOTAL TEV	**$311**	**$2,855**	**$13,521**	**$924**	**$6,210**	**$9,966**	**$242**	**$10,356**	**$6,020**	**$324**	**$10,215**	**$6,161**
	BCR		**0.21**	**BCR**		**0.62**	**BCR**		**1.72**	**BCR**		**1.66**
	IRR		**n/a**	**IRR**		**n/a**	**IRR**		**4%**	**IRR**		**5%**

{Note: Dollar figures are for illustrative purposes only and not to be used for formal planning or budgeting.}

Sustainability Matrix

The Sustainability Matrix is adapted from the SuDeX Method, which is a sustainable development extension model used to assess non-monetized socio-economic and environmental aspects to evaluate optimum sustainability. Primary parameters determined to be indicative of the three pillars of sustainability (Figure ES-2) were selected from a comprehensive list of 112 indicator parameters (IP) and scored based on importance (I), value (V) and confidence levels (CL) with respect to each of the strategic scenarios. The scores represent the relative sustainability of the scenarios, which when taken in concert with TEV and BCA provides a basis for weighing the economic, social and environmental benefits and cost of the strategies. Tables ES-3 to 7 summarize the scores for the baseline, and scenarios. Table ES-3 establishes an ideal "Target" score, to be as performance objective for strategic planning.

Table ES-3 Sustainability Matrix - Target Score

Potential Forest Impacts	**TARGET**												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**SCORE**
Economics	3	5	0.9	499.5	3	5	0.9	499.5	3	5	0.9	499.5	**1499**
Social	3	5	0.9	445.5	3	5	0.9	445.5	3	5	0.9	445.5	**1336**
Environmental	3	5	0.9	526.5	3	5	0.9	526.5	3	5	0.9	526.5	**1580**
Ave CL/Sum			0.9	**1472**			0.9	**1472**			0.9	**1473**	**4415**

Table ES-4 Sustainability Matrix - Baseline Score

Potential Forest Impacts	**BASELINE**												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**SCORE**
Economics	3	3	0.8	264	3	3	0.8	270	3	2	0.9	204	**739**
Social	3	3	0.7	157	3	3	0.7	176	3	3	0.8	206	**540**
Environmental	3	3	0.7	246	3	3	0.7	246	3	3	0.9	275	**767**
Ave CL/Sum			0.7	**667**			0.7	**692**			0.8	**685**	**2045**

Table ES-5 Sustainability Matrix - Scenario 1 Score

Potential Forest Impacts	**SCENARIO 1: CONVERSION**												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**SCORE**
Economics	3	3	0.6	215	3	3	0.6	163	3	2	0.6	141	**519**
Social	3	3	0.6	199	3	3	0.6	176	3	2	0.7	159	**535**
Environmental	3	2	0.6	134	3	3	0.6	175	3	2	0.7	135	**443**
Ave CL/Sum			0.6	**548**			0.6	**514**			0.7	**435**	**1497**

Table ES-6 Sustainability Matrix - Scenario 2 Score

Potential Forest Impacts	**SCENARIO 2: PRESERVATION**												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**SCORE**
Economics	3	3	0.6	201	3	3	0.6	165	3	3	0.7	273	**639**
Social	3	3	0.6	225	3	3	0.6	165	3	4	0.7	305	**695**
Environmental	3	3	0.6	257	3	3	0.6	168	3	4	0.7	355	**780**

Ave CL/Sum			0.6	**684**			0.6	**497**			0.7	**932**	**2113**

Table ES-7 Sustainability Matrix - Scenario 3 Score

Potential Forest Impacts	**SCENARIO 3: CONSERVATION**												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**SCORE**
Economics	3	4	0.6	261	3	4	0.6	227	3	4	0.7	323	**811**
Social	3	4	0.6	264	3	4	0.6	234	3	4	0.7	318	**816**
Environmental	3	4	0.7	247	3	3	0.6	189	3	4	0.7	376	**812**
Ave CL/Sum			0.6	**772**			0.6	**650**			0.7	**1018**	**2439**

Conclusion

The objective of this study was to conduct a preliminary socio-economic hydrological analysis of the internal and external natural and social aspects of the Prey Lang forest, and to assess net negative and positive (economic and ecological) impacts on the forest and downstream ecosystems. The study focused specifically on the hydrological aspects of the forest as a whole on which to build an optimum strategic decision model to maximize prudent sustainable forest utilization without devaluating the natural capital and services provided by the forest.

Therefore, this assessment, subject to the limitations and qualifications discussed within the report, concludes that the optimum Prey Lang forest management strategy is Scenario 3: Conservation. This conclusion is based on the information discovered during this rapid assessment and is based on qualitative review of the information. Before any definitive conclusion can be reached additional study to fill data gaps, data confirmation, verification, and stakeholder participation is necessary.

Recommendations

The conclusion of this report is not intended as a terminal point, but rather as a beginning step in resource management assessment and decision process, especially when the available information is not sufficient to reach a definitive decision. Using the SuDeX Method, it is relatively easy to extend the model to serve as a screening tool providing a way and means to establish priorities, evaluate thematic interrelations, and identify the most helpful information needed be able be make the best decisions. Armed with reliable and credible information, a comprehensive interagency national integrated resource management program can be prepared to ensure Cambodia's social, economic and environment goals are attained prudently and sustainably.

Building upon the RGC National Forest Programme and this study, the following actions are recommended:

- Conduct workshops to train the Forest Administration personnel in the application of methodologies used in the report, so they can further develop and incorporate this analytical approach into economic decision making by the Council of Ministers.
- Conduct stakeholder participation workshops to establish parameters that best represent Cambodia's best interest.
- Identify information gap priorities and organize funding sources, academic and government institutions and NGOs to conduct the research and investigation necessary to

ensure the quality of the information is sufficient to reach sound decisions with the highest level of confidence.

- Using the data base from above, establish values for Cambodia's ecosystems as uniquely applicable to Cambodia to be sure that they are adequately accounted for in the decision analysis process.
- Prepare a holistic integrated resource management plan starting with the Prey Lang forest as a model including but not limited to:
    - Community Forests
    - Surface and ground water hydrology
    - Enhanced agricultural practices and food security
    - Land use practices
    - River dynamics hydraulics
    - Tonle Sap/Mekong River protection
    - Fish habitat and migration path protection
    - Biodiversity protection
    - Concession management (e.g. mining and plantation)
    - Rigorous meaningful performance measurements, monitoring and evaluation are critical to early detection of problems;
    - Proactive follow-up with conscientious follow-through is essential to mitigating the problems before they become a crisis; without which problems do not get solved.

1.0 INTRODUCTION

The title of this study is: *Rapid Socio-economic and Hydrological Assessment of Prey Lang Forest*. The title aptly identifies the three principle components of the study: socio-economics, hydrology and the Prey Lang forest. The overarching theme of the study is to assess how these components are interrelated, including environmental aspects. The "rapid" indicates the qualitative nature of the study, "socio-economic" identifies two of the themes of the study as affected by changes in hydrology as a result of logging the Prey Lang forest. While hydrology is indeed affected and addressed, the primary driving determinant is the unit area of forest removed over time. The term of the study is 10 years, although as discussed below, more long-term affects are considered. Three scenarios were evaluated for this study: conversion, preservation, and conservation, and discussed in the following section. All three can be considered subsets of the larger social, economic and environmental systems and each has its own unique flow cycle.

1.1 Project Objectives

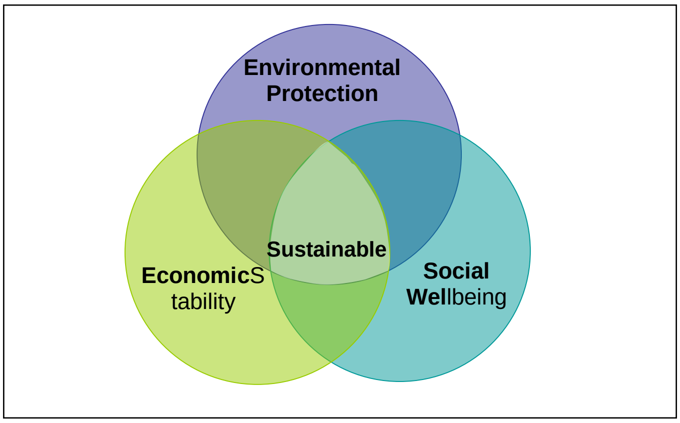
The objective of this study is to conduct a preliminary socio-economic hydrological analysis of the internal and external natural and social aspects of the Prey Lang forest and to assess net negative and positive impacts on the forest and downstream ecosystems (economic as well as ecological). The study focuses specifically on the hydrological aspects of the forest as a whole on which to build an optimum strategic decision model to maximize prudent sustainable forest utilization without devaluating the natural capital and services provided by the forest. This study was carried out in close collaboration with the Royal Government of Cambodia (RGC) and the Cambodia Micro, Small and Medium Enterprises (MSME) team. It looks at the socio-economic and environmental tradeoffs of different land use models for the forest and assesses the downstream regional economic, health and social impacts of the different land uses, relative to the hydrology cycle based on the following scenarios:

- **Conversion** is the full conversion of the existing forest to other land uses in order to reap the maximum economic value of the timber in the shortest possible time frame.
- **Preservation** is to provide sufficient funding, policy, regulation and enforcement to protect the forest from exploitation, environmental disruption and social-economic intrusion, to preserve the remaining forest as is or better in perpetuity.
- **Conservation** is the optimization of forest development and environmental conservation by developing, implementing and maintaining a balanced sustainable land use management approach involving local communities, advocacy groups, and economic enterprises in partnership with the national government to maximize optimum economic returns, while minimizing disruptive environmental and social impacts.

In assessing the different strategies, referred to as Scenarios 1, 2 and 3 respectively, the baseline is the strategy of doing nothing. That is not to imply to take no action at all, but rather to continue doing business as usual (BAU) under current policies and institutions - to maintain status quo. For the purposes of this study BAU is somewhat modified to assume that bans on logging and concessions development will be lifted to allow development at current development and production rates.

The study seeks to create a tool for decision makers which can be used to assess the different scenarios based on a list of parameters related to economic, environmental and social issues and weighted by the decision makers, see Figure 1.1. This report will outline the methodologies and approaches utilized, summarize data synthesized, and provide a set of decision criteria, including total economic value (TEV), benefit cost analysis, and sustainability matrix, on which to base a preliminary strategy and to address the development of the forest.

Figure 1.1 Primary Aspects of Sustainable Development



Adapted from Conference Board, NYC 6/04

1.2 Project Background

The USAID Cambodia MSME Project facilitates technical and business assistance to thousands of micro, small and medium-sized enterprises in rural Cambodia. Through this assistance, businesses learn new technical and business skills making them become more productive and competitive. New skills provide them the incentive to overcome technical constraints, make productive investments, and serve markets well. For the first time, many enterprises receiving assistance begin to make profits and understand their contribution to the value chain in which they are engaged.

An important component of this project is the integration of economic, social and environment conservation through sound management of areas of biological importance. One such area is the Prey Lang forest landscape, an evergreen dry forest located within Kampong Thom, Preah Vihear, Stung Treng and Kratie Provinces in central Cambodia.

CARBON CREDIT PROGRAM

Deforestation is the loss of forested as result of planned forestry and land use conversion; while degradation is forest loss due to unplanned forestry, land use and fire. In 2007 the Intergovernmental Panel on Climate Change (IPCC) recognized that prevention of both deforestation and degradation of tropical forest was the most practical immediate short term measure to curbthe release of CO_2 into the atmosphere. Maintaining the carbon storage capacity of the forest's biomass increases carbon sequestering which in turns serves to capture CO_2 (Sasaki, 2010). As a result of the IPCC's finding the Kyoto Protocol, which expires in 2012, and subsequent accords have attempted to address the reduction of emissions from deforestation and degradation (REDD) by encouraging sustainable forest management (SFM) practices to increase carbon stocks by maintaining sinks. Collectively REDD and SFM are referred to as REDD+, which is a form of geo-engineering incorporating the natural designs of nature, and includes reforestation. The UN Copenhagen Accord of 2009 recognized REDD+ and pledged "fast-start" funds between 2010-2012 to develop SFM in tropics to include production and ecosystem services. (The SFM implies conservation as opposed to preservation as defined in this report).

One initiative of the accord is to develop an incentive to increase carbon stock by regulating timber production, where by the amount of carbon storage capacity based on tones per year becomes a marketable resource, referred to here-in as “carbon credit”. The Copenhagen initiative is to provide a short term funding source to pay the carbon credit with the idea that over time a self sustaining carbon market will develop, such as the arguably successful air pollution credits market in many developed countries. At this point, whether or not such a market does develop is uncertain, but a great many of the developing tropical countries are preparing SFM plans in order to be eligible for the available funds.

Cambodia has been proactive in seeking to conserve its forest, not only to take advantage of the credit, but more importantly to prudently manage its forest. A successful reliable carbon credit market would be a powerful mechanism to ensure the success of the optimum forest management program in Cambodia and the global community at large.

This report assumes that a successful carbon credit market does develop, which introduces a bias into the assessment in favor of conserving if not preserving forests. However, while time and resources are not available to address the casein which the carbon market does not develop, the study does consider plausible alternatives, not equal but equivalent perhaps to a carbon credit market. These alternatives include maximizing forest production efficiencies and reforestation, and enhanced agriculture yield of viable cash crops within Scenario 3 and a robust ecotourism program within Scenarios 2 and 3. The intent is not to introduce a counter-bias to ensure an outcome, but to provide alternatives whose benefits are well established, which could offset the loss of carbon credit market, or serve to augment a market should it develop. In the former case (Scenario 3), the carbon storage capacity retains its value as Indirect Use (IUV as discussed in Section 2), and in the later cases (1 and 2) as a direct use value (DUV); therefore, in either case the BCA results are the same.

The value placed on the carbon as used in this report is based on interpolation of existing studies as discussed below. The range in the available studies is expansive from $1.04 to $38.15 per ton of CO_2 (Sasaki, 2010). If the market does in fact develop, the price will most assuredly increase in accord with the basic laws of supply and demand to stabilize once the market is mature. At the lowest, its value as DUV must be at least comparable to other land use opportunities, while as an IUV its value may be much more subjective. As discussed in (Section 2.0) the value for carbon in this study was set at $3.50/ton. It is not within the scope of this report to determine the “real” best case, nor the worse case, but rather to provide a conservative level of most likely case within the limitations of the confidence level as discussed previously.

Deforested lands may be replaced by agriculture, and/or forest plantations and as discussed in Section 4.0; however, this study used rice as the benchmark, since it is such a significant part of the agricultural economy and Cambodia’s GDP, and a main food source, as well as cultural icon. Nevertheless, much of the soils within the study area are not conducive to rice; therefore, its value in considering Scenario 3 (the only scenario in which agriculture makes potentially significant contribution) depends on applying improved agriculture practices to increase soil quality and improve yield, as well as, improved water management.

REDD+ management is assumed to incorporate reduced impact logging (RIL) practices, as well as liberation treatment to prevent alien species migration (RIL+) (Sasaki, 2010). In addition, there are is a large cadre of best resource management practices for surface water (e.g. IWRM), ground water, soil, wild life, habitat, agriculture, and community participation and management that can be applied to the Prey Lang forest. While this report does not go into the specifics of these best practices, their benefits are well documented and are assumed to apply to Scenario 2 and particularly to Scenario 3 as reflected in the assumed best cases. They are not considered in Scenario 1, since the strategy is generally counter to best practices and is essentially the worst case scenario for all but timber production.

Generally, REDD+ addresses only the direct forest uses for timber and firewood and does not take into account other benefits associated with NTFP and indirect uses, such as the ecosystem services provided by the forest. In addition, the forests of Cambodia are not addressed holistically, particularly those which play an integral role in the dynamics of the unique and immensely important Tonle Sap Great Lake, its fisheries and wetlands, and its relationship to Mekong River basin as a whole, including the Mekong Delta. The entire holistic system and individual components have significant ecological importance to and beyond human concerns. Its value far exceeds any monetary price from any perspective, be it short term, long term, intergenerational, or purely ecological, with potential unintended consequences that could be as tragic as the Aral Sea or Easter Island. It is beyond the capabilities of this report to address these issues in any meaningful manner, but it does, at the very least, attempt to take them into consideration as intrinsic or passive values through multi-criteria analysis (MCA), although no attempt to place a “real” value is undertaken. For some it would be astronomically high, while for others it would be of little worry.

In all cases of social and environmental benefit cost of analysis, where so many important factors cannot be valued based on direct economic markets, an alternative must be established to normalize the values for comparison. Economic analysis uses monetary value, but even then many of the estimated values, especially the indirect and intrinsic values, are subjective, subject to a great deal of debate. In all cases there is significant uncertainty and most references make a great many subjective assumptions about what to include and what not to include and which information is valid and reliable and which is not. Every assumption made that is not based on rigorous quantitative scientific methods lessens the reliability and credibility of the study and compounds the errors introduced. However, to wait for sufficient quantitative scientifically based analysis can introduce as much, if not greater, risk than making decisions prematurely (Forbes, 2009).

This study relies on available information and makes a fair number of assumptions; however, does try to introduce a level of replicable quantification by interpolating and extrapolating between established low and high, best and worst case ranges. For the most part, this report takes the easy route by using either the mean or median of the ranges. This makes it relatively easy to conduct sensitive analysis using different factors within the ranges, which is beyond the scope of this study, but could be a very helpful follow up.

1.3 Rapid Assessment Limitations

This study is a rapid assessment based on existing data and information compiled during the project. The existing data provides a very good foundation on which to build the model, but much of it is qualitative rather than quantitative information (i.e., relies on secondary data, and limited primary quantitative research based on statistically supported data). The existing information is integrated to reinforce and broaden the foundation and provides policy makers with a decision matrix model, so that informed and prudent decisions can be made regarding the development and management of the forest landscape, within the limitations and quality of the information available.

Due to time constraints, the qualitative nature of the available data, and the focus on only one primary aspect (hydrology), the findings of this report serves as an initial guide on which to base preliminary decisions on how best to proceed. This assessment relies on secondary information accepted as presented, and does not include generation of new primary data. Forecasts and projections may be offered for informational purposes and guidance, providing an indication of additional information needed and data gaps to be filled, but will not be sufficient alone to be used for ultimate policy making without more quantitative investigation.

The ten year term of the study limits the ability to account for long term affects of the various strategies after that period and therefore does not consider sustainability. For example, assuming a reasonable maximum logging production rate of 1% a year as suggested by the FA, 10% of the forest would be removed within the term of the study. If no management or reforestation takes place, the long term social and environmental costs would not be fully realized until well after ten years. This is also true for the other strategies, except it would be the long term social and environmental benefits that would not be fully accounted for within the ten year period. Therefore, while the ten year period was applied for the economic analysis, each of the aspects of sustainability as shown in Figure 1.1 were considered for each scenario assessed for this study, not only from an opportunistic perspective (option value), but also so that the future generations will be able to reap the natural advantages of the resource (bequeath value) and enjoy the pure beauty, and appreciate the spiritual aspect of the very existence of the forest (existence value). This is relatively easy when addressing a forest, not so easy when considering a mine or plantations. The multi-criteria analysis (MCA) is not directly time constrained and consequently time is implicit in each of the aspects of sustainability as discussed in Section 6.0.

There was rarely a literature search that did not discover one more treasure of information. For example a paper in the Journal of Environmental Science and Policy entitled, *Benefits of tropical forest and management under the new climate agreement—a case study in Cambodia* (Sasaki, Yoshimoto, 2010). The point being that there is always more information that ideally fits if time allowed, but it never does.

These limitations illustrate the enormity of what this study is trying to cover, even in its basic and qualitative perspective. But taking into account these limitations, this study does provide a starting point and preliminary guidance until more quantitative studies are available. As it is now, given the available information, it is not possible to conduct a comprehensible quantitative study. It would take an immense amount of time, money and human resources to fill the data gaps. These studies are highly recommended, but in the meantime development is happening and while this study needs much more refinement, use of the Sustainability Matrix tool, in combination with TEV and BCA calculations provides, not an answer perhaps, but at least a basis for determining which scenario most likely presents an optimum strategy.

The study is akin to making environmental policy and regulations based on perceived but unquantifiable risk that cannot be proven or disproven since a consensus cannot be reached within the scientific community. Should decision makers wait and see If a consensus can be reached before deciding, or take the precautionary approach and prepare for the worst, at extreme costs, for fear that it will occur. And if not, only the costs are lost and ecosystems are preserved (i.e. the TEV option values). The precautionary approach is followed by most of the environmental policies in developed countries, while the opposite is generally true in developing ones (China was a good example of the latter, although changing as transitions into a major developed nation). The method developed within this study provides a process which makes the most of the information currently available, depending upon the active participation of the decision makers and stakeholders, and produces a qualitative result on which to base initial decisions and set interim policy until sufficient quantifiable credible reliable information is available to reach a definitive decision with a high level of confidence.

It should be noted that the monetary values provided in this report are for illustration purposes only and should not be used for formal planning or design.

2.0 METHODOLOGY

Several methodologies were used in this Assessment. In general, the overarching method has been to rely on available secondary, tertiary, and to the extent available, primary information using standard methods and procedures to assess watershed hydrology and river hydraulics, forestry management, soil classification and environmental assessments (EA), total economic value (TEV), benefit cost analysis (BCA), geographic information system (GIS), watershed analysis, etc. Community participation approaches have been utilized to the extent that these approaches have been incorporated into existing exercises/data after applicable translation, compilation, organization, and tabulation. The following section provides a brief description of the methodologies utilized in this study.

2.1 Study Area Delineation

Assessing the interrelationship between forest, hydrology and socio-economics of Prey Lang Forest first required delineating a study area. The method used to determine a reasonable representative area that would best characterize these conditions was an application of Ian McHarg's, *Design with Nature* concept, which is the basis for layering critical study parameters as used by GIS programs (1995). Due to the rapid time frame, size of the area and limited hydrology and hydraulic data available, the assessment is qualitative by nature, and important characteristics within the study area have been identified to represent the area as a whole.

In general, the process to define the study area was to first identify the parameters within their known spatial boundaries using available maps. Political and watershed boundaries were used as the base maps for the initial assessment. Since the Prey Lang Forest is the focus area of interest in terms of cause and effect, the location of the forest became the focal point. The location of active mines and population centers are also relatively fixed. These were overlain over the base maps to determine where they fell in relation to the focal point.

Determining the appropriate study area required close consideration of the unique or fixed characteristics of the area, i.e. watershed and political boundaries; and their relationship between the variable characteristics, i.e. economic land concessions and population density. The goal was to present a study area defined by the fixed characteristics inclusive of the indicator parameters to be used for the socio-economic benefit cost analysis. The watershed boundaries were the defining factor for the hydrological study area because of the dynamics of the hydrological cycle in relation to the forest, underlying aquifers, and surface water hydrology and river hydraulics. All of these were then considered with respect to internal and down-gradient stakeholders, environmental impacts, and socio-economic conditions. Section 3.0 of this report discusses each of the study parameters as they relate to the delineation of the study area.

2.2 Data Collection

A literature review was conducted that covered the study area (as agreed by the MSME team and the Royal Government of Cambodia). The following categories of information were researched, collected, and analyzed during the assessment process.

BIO-PHYSICAL CONDITIONS: TOPOGRAPHY AND METEOROLOGY

This included historical and present land use and cover, surface vegetation cover, forest canopy cover, slopes, soil types and characteristics, historical rainfall (intensity, frequency, and duration) and surface water drainage and infiltration.

SURFACE WATER FLOW CHARACTERIZATION

This included drainage patterns, streams and flow rates, gradients and water quality based on existing data. Details of the hydrology indicators that were collected are detailed in Appendix A. It was not practical, given the limited time frame of this study, to collect sufficient samples or stream flow measurements in the field to adequately characterize or confirm surface water conditions on a quantitative scientific basis.

OTHER DATA COLLECTED

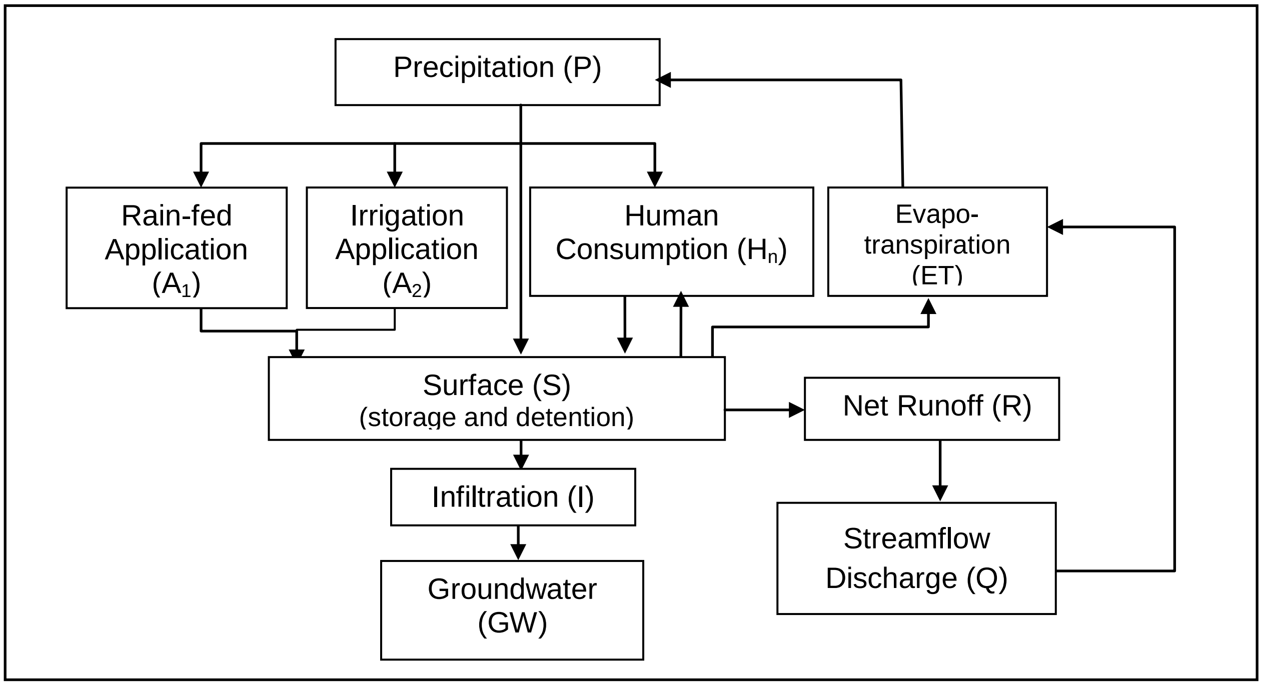
- Current population estimates and increase projections
- Public works infrastructure update
- Estimates of land use changes
- Current economic activities
- Government Policies

2.3 Hydrology Analysis

WATER BALANCE

The water balance study was adapted from standard watershed hydrology concepts using the Rational Method for small areas, and HEC-HMS computer model (or its older version HEC-1) for medium to large areas. Figure 2.1 shows the inputs and outputs that are contained in the Rational Method. There is insufficient hard data to be able to run a meaningful simulation, so the model is used as the reference framework on which to base qualitative interpolation and extrapolations, as discussed in Section 4.2.8, Water Balance Baseline.

Figure 2.1 Common Simplified Water Balance Model



Mathematically, the rational method relates the peak discharge (Q) to the drainage area (A), the rainfall intensity (I), and topography and infiltration (C).

$$Q = 0.0028CIA \qquad \text{[SI Units]}$$

Where:

Q= design peak runoff rate [m^3/s]
C= the runoff coefficient, dimensionless
I = rainfall intensity [mm/h]
A= drainage area [m^2]

Based on the following assumptions:

1) Rainfall intensity and duration is uniform over the area of study
2) Storm duration must be equal to or greater than the time of concentration of the watershed

In terms of water balance the equation is: $\sum$ **inflow-$\sum$Outflow= 0** or

$$Q = R = P-([S-\sum(A_n + H_n)]+ET+ I)$$

Where:

Q = the net runoff (R), after all inputs accounted for
P = precipitation intensity and duration
S = surface storage and detention until filled to capacity (e.g. surface water collection sinks, such lakes, rivers, streams, depressions, etc.)
A_n = sum of all surface applications *n* (such as irrigation; industrial discharges)
H_n = human consumptive uses *n*, such as domestic and industrial uses
ET = combined natural evaporation and transpiration exchange
I = infiltration from P, A, and H into soils until fully saturated, i.e. soil storage capacity reached (may include groundwater recharge)

For large areas with sufficient gauging station data, discharge values should be generated using models such as HEC-HMS.

HYDROLOGIC AND HYDRAULIC CHARACTERISTICS

The hydrological history of the study area was analyzed using as much data as could be uncovered within the timeframe of this project from the available sources. The historical data was used to determine the Baseline Conditions. Subsequently, a range of hydrological changes associated with each scenario was estimated.

The following criteria were compiled from as many monitoring locations within the study area as possible (not all the data was available for all stations), and for as many years available:

- Average, Maximum, and Minimum Daily Discharge Flow
- Average, Maximum, and Minimum Gage Height
- Average, Maximum and Minimum Monthly Rainfall
- Average Monthly Evapo-transpiration (ET)
- Average Monthly Total Suspended Solids (TSS)
- Average pH

While the data gaps and inconsistencies were many, the quantity of data over an extended period of time did allow for an overall general qualitative representative characterization of the study area, and this study relied on the MRC Water Quality Index (WQI), which fits in well the structure of this report. See Section 4.2.6.

2.4 Economic Analysis

Total Economic Value (TEV) (Section 4.4), in conjunction with Benefit Cost Analysis (BCA), determined the Net Present Value (NPV) of the Study Area in an attempt to look at the broader aspects of the direct and indirect negative and positive impacts of developing the forest. Using the method described in the following section, TEV addresses direct use values, such as timber, NTFP and potentially affected uses, such as tourism, fishing, and agriculture, and indirect uses primarily as function of undisturbed forest service's which could be valued in monetary terms, which for the purposes of this study are: carbon sequestering, biodiversity and watershed stabilization. The method of valuing is shown in TEV section, and the basis for valuing ecosystem is discussed in Section 2.4.3.

BCA as discussed in Section 2.4.2 weighs the net result of measuring the value of the benefits less the costs of taking a specific action, policy, or in this case strategy. However, like TEV indirect uses, the actual price paid for implementing a strategy cannot always be measured in monetary units alone, there may be consequences unaccounted for, such as environmental impacts that are not included in the price, but such impact cannot be overlooked if a rigorous assessment of the net value of the strategy is to be evaluated. However, placing values on indirect uses, and external costs typically cannot be determined directly from economic market dynamics of supply and demand.

Section 2.4.3 describes the basis used to attempt to place monetary values on measurable ecosystems services to be used for TEV and BCA.   However, there are many subtleties and second and third tier interrelations that defy even indirect cost accounting, but if ignored the sustainability of the strategy cannot be assessed.

Sustainability is assured only by the optimum integration of economic, social and environmental policy as represented by Figure 1.0. While, TEV and BCA both use monetary units, the integrated system as a whole cannot be measured in purely financial terms. Economics and social considerations may be seen only as human conditions, offsetting the balance in favor of human wellbeing over the environment, but humans are an integral part of the ecosystem as well and as reliant on it as all other species, if not more so; therefore by ensuring the sustainability of the environment ensures the sustainability of the species, within whatever limits and capabilities it has to do so. Consequently, a matrix adapted from Forbes (2009) was created to normalize the measurement units of the different parameters in order that they could be considered on a common basis. It is not a "decision matrix" per se, but rather a means to assess sustainability as a function of its three primary aspects, a "Sustainability Matrix", if you will, as described below in Section 2.5.

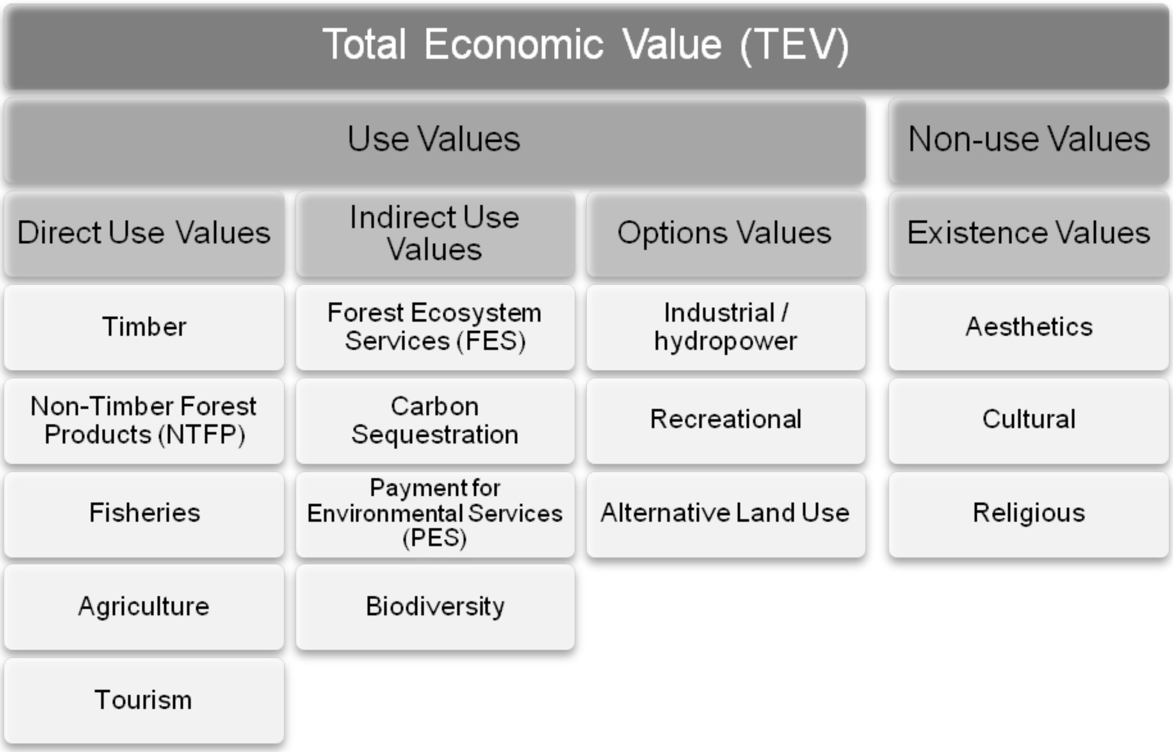
Together TEV, BCA and the Sustainability Matrix can be used by policy makers as a tool to determine an optimum strategy to achieve a sustainable economic, social, and environmental policy that will maximize the benefits, and minimize the losses for the greatest good of all aspects. It is no more than a tool that to be most effective, must be evaluated by all stakeholders affected by the outcome of the strategy. To do less, devalues the effectiveness of the tool. This assessment is not the determining factor, but only provides the preliminary print to be refined and improved by feedback and input by all parties concerned.

2.4.1 Total Economic Value (TEV)

The Total Economic Value (TEV) framework is an economic evaluation method widely used internationally, as well as in Cambodia. This framework integrates the various economic values of the forest, from direct benefits, like timber, to indirect intangible benefits such as forest ecosystem services. The indirect ecosystem valuation takes into account the various complex dynamics between the forest, the environment and socio-economic concerns and establishes a monetary value for its intrinsic services (see Figure 2.2). Assessing the TEV is a useful tool for policymakers combining the social values of the direct economic uses of the forest with interpolated indirect values for the environmental services rendered and then comparing the net value for specific projects or policies to determine optimum management practices.

The TEV is defined as the sum of all use and non-use values for a given resource or service being measured. This assessment utilizes the TEV framework adapted from the Cambodia Development Resource Institute (CDRI), "Natural Forest Benefits and Economic Analysis of Natural Forests Conversion in Cambodia, Working Paper 33," (Hansen and Neth, 2006).

Figure 2.2 Total Economic Value (TEV) Framework



Total Economic Value (TEV)			
Use Values			Non-use Values
Direct Use Values	Indirect Use Values	Options Values	Existence Values
Timber	Forest Ecosystem Services (FES)	Industrial / hydropower	Aesthetics
Non-Timber Forest Products (NTFP)	Carbon Sequestration	Recreational	Cultural
Fisheries	Payment for Environmental Services (PES)	Alternative Land Use	Religious
Agriculture	Biodiversity		
Tourism			

(Adapted from Hansen & Neth 2006; OECD, 2000)

TEV measures the value of uses and non-uses of an environment or natural resource. Use Values (UV) are comprised of various physical uses, environmental services and future options for economic gain. Whereas Non-Use Values (NUV) encompasses the intrinsic value of the environment, such as religious and cultural value, these can be difficult to place a monetary value on as discussed below under Ecosystem Values (Section 2.4.3).

The formula for Total Economic Valuation (TEV) is:

$$\mathbf{TEV = UV+NUV = (DUV+IUV+OV) + EV}$$

Forest ecosystems provide a wide range of benefits on a local, national and international scale. The most common of which are directly measurable, and thus categorized, Direct Use Values (DUV). These include products for consumption or sale, like timber, resin, fish and tourism. Indirect Use Values (IUV) are services that are derived from forests, such as watershed protection, erosion control, carbon sequestration, and habitat. Additionally, Options Values (OV), represent economic gains of potential future use of a resource, i.e. hydropower. Finally, Existences Values (EV) covers issues such as aesthetics and spiritual/cultural importance.

For the purposes of this assessment, TEV will focus on DUV, IUV, and OV, although ten-year study time frame is relatively short in assessing future options of the study area. The TEV does not include EV, because it is difficult to assign value to the inputs included in this parameter. However, these and a host of other important considerations, many subjective, are considered in the BCA matrix, as discussed below.

This study will utilize the following equation adapted from above:

$$\mathbf{TEV = DUV + IUV}$$

The economic value calculated for the baseline year and the NPV value is projected over the ten-year study period.

MEASURING CARBON SEQUESTRATION VALUES

Carbon values are determined in Section 4.4.5. They are calculated by estimating carbon stores in the forest using a Biomass Expansion Factor (BEF). Above-ground biomass (AGB) is calculated, and then converted to tons of carbon. The value of carbon sequestration depends on the alternative land use.

Above-Ground Biomass = Standing Volume * Wood Density * Biomass Expansion Factor

$$\mathbf{AGB = SV * WD * BEF}$$

Carbon assumptions:

- Standing Volumes (SV) were calculated for the forested areas
- Average Wood Density (WD) for natural forests in Asia is 0.57 ton/m^3 (Hansen & Neth, 2006)
- Biomass Expansion Factor (BEF) = 1.74 (Brown, 1997, IN Hansen & Neth, 2006)
- Price of carbon per ton is $3.50. Price is based on voluntary market and fluctuates
- AGB is converted to tons of carbon assuming tree biomass has a carbon content of 50% (Hansen & Neth, 2006; Chheng, 2007)
- The estimated cost of setting up management scheme for a carbon program in Prey Lang Forest is currently unknown and not evaluated in this assessment.

BIODIVERSITY

As discussed in Section 4.4.6 there are very few studies regarding biodiversity in the Prey Lang Forest or models to estimate values, such as those for carbon. Therefore, values determined by secondary resources were used to interpolate and extrapolate values to apply to this study

FOREST ECOSYSTEM SERVICE (FES)

In addition to carbon sequestering and biodiversity habitat, forest ecosystem services include watershed protection, which directly affects hydrology a focus of this study. However, like biodiversity direct values for the forest services were not discovered and secondary resources were relied upon as discussed in the Section 4.4.7.

2.4.2 Benefit Cost Analysis (BCA)

Benefit Cost Analysis (BCA) is a common method of economic analysis. It is a decision tool, which evaluates projects according to benefits (advantages) and compares them to their costs (disadvantages). The Benefit Cost Analysis (BCA) method assesses the direct (internal) and indirect (external) benefits and costs of the different scenarios. Direct refers to conditions for which a monetary value can be assigned and measured in national currency or US Dollars (USD). This generally means that there is price paid to meet market demand. Indirect benefits or costs are those conditions for which there are no market to define a monetary value. This includes most of the intangible services provided by environmental systems. There are methods being developed to provide a quantifiable framework using Total Economic Value (TEV) to place values on the inherent services provided by ecosystem such as the UNEP's TEEB (*The Economics of Ecosystems and Biodiversity,* 2010). The values established to date are relatively few, and the variances are very large, such as $91- $23,222 USD ha/yr for the services provided for tropical forests in Indonesia (TEEB, 2010). However, BCA provides a means to determine the net relationship between benefits to costs that provides a measure to support a decision.

While the direct costs and benefits are an important consideration, decisions based solely on monetary value may not take into account the perceived social value of say, increased education levels that could outweigh the perceived importance of protecting remote wetlands, or the cost of biodiversity loss may be seen as too important to allow construction of a large industrial complex.

To overcome these difficulties the benefit cost decision analysis (BCA) is applied, which takes into account both direct benefits and costs by calculating Total Economic Value (TEV), and indirect benefits and costs by BCA empirical calculations for ecosystem for which values have been determined in references (i.e. forest watershed services and biodiversity). A weighted matrix allows for scoring of unvalued services. Each on their own provides guidance on the merits of a decision; collectively, they provide the foundation a decision can be reinforced with a reasonable level of confidence.

This assessment attempts to determine direct and indirect forest values to assess which of the three different forest strategies are economically favorable. If the project shows a net benefit, it means the project is advantageous; it can be compared to other scenarios and be ranked according to the size of their net benefits. Refer to Section 5.0 and 6.0.

NET PRESENT VALUE (NPV)

The first step to BCA analysis requires determining the present value of a particular forest service and then converting the net value of benefits and costs to Net Present Value over 10 years. Discount rates of 3%, 8%, 10% and 12% were analyzed in this assessment.

The NPV is calculated as follows (Chheng, 2007):

Net Present Value (NPV):

$$NPV = \sum_{t=0}^{n} B_n /(1+r)^n - \sum_{t=0}^{n} C_n /(1+r)^n = \sum_{t=0}^{n} \frac{B_n - C_n}{(1+r)^n}$$

Where:

B_n = value of benefit in year n
C_n = value of cost (loss) in year n
n = year of B and C (0,1,2………..n when is final year of study)
t = starting year of study, 0= current year
r = discounted rate

The higher the NPV, the more economically viable a project is considered, although generally any positive NPV can be considered beneficial. A discount rate converts all costs and benefits to a present day value, incorporating time into account. A dollar today compared to a dollar in one year is equal to a dollar plus or minus the change in value (‘r’ above) earned in one year; it is more valuable to have the money up-front. Discounting takes this into account, as interest earned could be invested elsewhere. Discount rates are sometimes selectively changed to include issues such as risk. It is common practice to use discount values of 8%, 10%, and 12%. For this study, a discount rate of 8% was used due to the shorter time frame of 10 years; prices are not as subject to longer-term fluctuations, and it is believed to be a conservative representation of stable economic development in developing countries (Sasaki, 2010) and reflective of Cambodia’s potential.

Benefits include total direct, indirect and option use (including economic, environmental, and social aspects). Direct use value (DUV) is calculated using market price and produce quantities (Chheng, 2007):

$$DUV = \sum_i (P_i Q_i - C_i)$$

Where,

P = price per unit of product i,
Q_i = quantities/ amounts of products i being collected,
C_i= cost involved in the collection of product

BENEFIT COST RATIO (BCR)

The BCR represents the ratio between total benefits and total costs. It is also used to compare the financial return when net present value = net present benefits – net present cost, as discussed above.

The benefit cost ratio (BCR) is:

$$BCR = \frac{\sum_{t=0}^{n} B_n /(1+r)^n}{\sum_{t=0}^{n} C_n /(1+r)^n}$$

By looking at BCR and financial return of each scenario, the most profitable scenario can be determined from the perspective of business and/or pure economic gain. However, this assumes all benefits and costs can be evaluated on the basis of market values, and such is not the case. There are intangible benefits and costs that cannot be easily priced in terms of monetary values; the aesthetics of a forest, the educational value of maintaining biodiversity, the cost of sedimentation of fish habitat. Even if a value could be placed on such indirect financial gains or losses, the range would be from priceless to nothing.

INTERNAL RATE OF RETURN (IRR)

The difference between the benefits and the costs is the net benefit (or cost). If the benefits are greater than costs then the scenario is a viable economic option; otherwise it is not. However, since the value of the NPV benefits is based on estimated effects, the net difference is not the actual “real” value. Therefore, the ratio of the benefits to costs (BCR) provides a less ambiguous determinant. If the ratio is greater than 1, the scenario is a viable economic option. If it is less than one, it is not.

When several options have BCR greater than one, it is difficult to determine which is the better choice. The amount of difference does not help since a small change in any of the parameters could sway the balance and using a different DCF could result in significant shifts. Consequently, economists generally do not use BCR for ranking, whereas internal rate of return (IRR) can be used (Martin, 1997).

The DCF includes NPV and IRR methods of analyzing cash flows. The NPV is the time-phased costs over the economic life of a scenario and is the best single-number measure of its life-cycle cost, when quantifiable numbers can be obtained**.** To solve for NPV, the "opportunity cost of capital" or "discount rate" (or DCF) is calculated, and the discounted cash flow is used to normalize benefit and cost streams. NPV is highly sensitive to the discount rate and selection of the rate is nearly always arguable (Martin, 1997, TEEB 2010, Turner, 2008).

IRR determines the discount rate at which benefit cost analysis is equal to zero. Consequently, it is a rate or ratio, and of its advantages is that it is not necessary to decide which DCF to use (Martin, 1997, TEEB 2010, Turner, 2008).

NPV is the best absolute measure of value of an outflow-inflow stream. IRR is the best relative measure. IRR is strongest where NPV is weakest. However, IRR is incalculable for complex cash flows when all cash streams are positive or negative, or when net zero. When IRR is incalculable, NPV is suspect. They are best used together. Together they give an indication of risk as well as return. IRR is good for screening projects (Martin, 1997, TEEB 2010, Turner, 2008)

A decision involving ecosystems and the environment should not rely on BCR alone. Ecosystem valuing as discussed in the following section attempts to address these difficulties.

2.4.3 Placing a Value on Ecosystems

The TEV and BCA analysis discussed above examines various layers of usage, both those important to people directly reliant on the forest (local inhabitants, companies), and to the greater population (for example climate impacts). Traditional economic valuation may only focus on one sector of the economic model (e.g. the direct financial implications of timber exploitation) without taking into account the associated indirect and intangible benefits and costs of the forests to dependent populations. It is qualitative in that in placing a value on ecosystems services within the TEV requires determining values without an economic system (e.g. market place based on supply and demand) to base it on. While all of the services may be considered needed by one faction, another may disagree and determining which take priority is arguable, since there is no system to determine demand by market determinants.

An ecosystem is a complex set of interacting living organisms and non-living matter, within some natural boundary such as forest perimeter or watershed. Ecosystem services are the mechanisms and functions it derives from biophysical processes and diversity within the system that maintains homeostasis. These services have value to the system regardless of human values, although human intervention can affect both the ecosystem and economic values. Common to all, are the sun and water; the sun the heart and water the lifeblood of the ecosystem of earth.

To place a value on the services within the ecosystem from a human perspective typically means a monetary value, such as TEV as discussed above. The ecosystem monetary value then is the accumulated worth of the multi-services provided within the system. For example, the value of the watershed services is the aggregate value of all the ecosystem services within the watershed. This includes forest, water and soil, biodiversity, carbon sequestering (a segregated forest service), which covers the basic services of the watershed as is currently exists. One group of ecological economists estimated the often quoted total value all services the world's ecosystems to be approximately $33 trillion (Costanza, *et. al.*, 1997). But can we determine the inestimable value of the water and sun, as well as of the other natural cycles?

Since there is no direct way, such as the economic market place, to determine the monetary value of most ecosystems, there are many non-empirical methods being used to interpolate and extrapolate ecosystem value. The methods commonly attempt to base service values on estimates of the replacement costs that humans would have to pay if the service was no longer available. The economic market value of a forest could be the financial worth of logging the trees for lumber, harvesting non-timber products such as honey and resin, and in some cases ecotourism based to the attraction of the forest. Its ecosystem value would be the environmental services it provides in stabilizing soils, providing nutrients and pollination, temperature control, provide habitat for biodiversity, photosynthesis, and sequestering carbon to name but a few. To place monetary values on these services can never be high enough, since the services are not finite, or unidirectional, but are disseminated throughout all the system, although not necessarily equally and do not recognize boundaries.

There are three methods commonly used to assign a monetary value to ecosystems that cannot be priced based on market supply and demand. They are:

- *Mitigation costs* - placing a price based on the cost of offsetting damages as a result some activity impacting the ecosystem (e.g. pollution, or clearing land).
- *Willingness to pay (WTP)* - a preferential approach where value is established based on surveys of different groups to determine the amount of money they are willing to pay to preserve or conserve the various services of an ecosystem. An alternative to WTP is willingness to accept (WTA) in compensation to give up a good, or put up with a bad (e.g. pollution).
- *Maintenance and protection costs* - the ecosystem value is the estimated amount of money it would take to maintain and protect the system. Carbon sequestering might come under this method.

All these methods are susceptible to the biases of the evaluator, and the situation of the interviewee. The price a person says they are willing to pay is affected by their ability to pay. A poor person living off the forest may be willing to pay any price imaginable beyond their means; while the affluent may be willing and able to pay, as long as does not compete with other preferences. Bill Gates may be willing to give up half his fortune to alleviate the ravages of poverty, without any direct significant effect on his quality of life, but would he be willing pay two-thirds of his fortune, even though qualify of life may still not be affected?

Currently, there is no universally accepted standard for creating a monetary value for ecosystem services in terms of dollars, although the UN TEEB method referred to in Section 5.0 is an attempt at standardizing this valuation. However, in most cases, including TEEB, no two estimates agree, hence the immense disparity found in the references. Therefore, the use of any must be done cautiously and skeptically.

The watershed ecosystems contain a slew of ecosystems each providing a list of unique and complementary (and some not so complementary) services. The value of the watershed services is the aggregate value of all the ecosystem services provided within it. The basic ecosystems addressed in this report are the forest, biodiversity, each including a list of services with some overlap.

The forest services include erosion control, buffering water velocity, rain fall distribution and impact, water quality, temperature control, soil quality (organics, nutrients, etc.) as well as carbon sequestering, photosynthesis, etc., plus the economic value the wood used as lumber, paper, and NTFP, as well heat from the wood used as fuel. It also provides habitat for flora and fauna, and protects biodiversity (which is not covered by value of biodiversity), as well as a host of sub and micro ecosystems, which provide their own unique contribution. There are also the values of the very presence (existence) of the forest, such aesthetic, cultural, and social context.

Biodiversity contributes to ecological balance through species interactions (e.g. mutualism, parasitism, predation, competition, etc.), which reinforce sustainability of the ecosystem. In addition, there are cultural, educational, and traditional values. Biodiversity of the study area assessed in this report is quite high, of which the variety of fish makes a significant contribution. In the context of this report, biodiversity is best presented by the fish species.

2.4.4 Dealing with Uncertainty, Incomplete and Imperfect Information

For every choice there is worst and best case outcome that defines some upper and lower bounds based on the availability and reliability of information. For example, in the case of forest preservation, it is known that by eliminating deforestation there will be positive (e.g. protection of ecosystems) and negative results (e.g. loss of direct revenues). With complete and perfect information, a discrete quantitative effect can be determined and the “real” net benefits and cost can be established with a high level of economic and scientific certainty. Consequently, the decision analysis is straight forward with little room for controversy. However, complete and perfect information is hard to come by, and the higher the effort expended to attain near perfect information, the more exorbitant the cost and time required. This may be the preferred level of certainty on which to base a decision, but if decision makers wait for certainty and complete and perfect information, no action may ever be taken.

The answer to the question, “when is there enough information to be able to make a good enough decision with an acceptable level of confidence,” is invariably, “it depends.” It depends upon the complexity of the situation, risks, degree of consensus, funding and time required, perceived urgency, confidence level desired and how to define “what is good enough”.

The higher the level of confidence in the information desired; the higher costs to obtain it. Furthermore, for any given set of conditions there is a point beyond which the cost of collecting one more piece of information is not worth the increase in confidence gained. The marginal improvement in the value of information is not worth the time or money. The cost in time and money to fill the remaining 9.999% is likely to exceed that required to attain the first 90% confidence level.

In the case of forests, the reserves are observable and estimating their size is quantifiable with a higher confidence level at a relatively low cost. However, the size of the reserves play a complex and integral role in natural ecosystem cycles at the local and macro levels, not the least of which is the important role forests play in climate control. In the context of this study, there is a lot of information, but it is not perfect and far from complete, resulting in a low confidence level. Consequently the decision alternatives are:

- Wait and see which is to do nothing until physical evidence occurs to confirm there is a concern.
- Conduct proactive scientific studies to confirm whether or not there is a valid concern, and in the interim—
    - Assume the worst case concerns are valid taking aggressive corrective action to mitigate what might be an non-problem, or
    - Assume less than the worst case most likely taking precautionary preemptive measures to mitigate concerns, adjusting actions as more relevant information becomes available.

The alternatives need not and should not be mutually exclusive; that is, the alternative to use what is available should include identifying information gaps and plans to fill them, so that initial preemptive action to mitigate a concern can be improved.

ASSSUMED BEST CASE AND WORST CASE

The results of this study have shown that the information necessary to reach a decision is incomplete and imperfect making it difficult to reach a final decision

Reasonable worse case - best case scenarios are common methods used in risk and financial analysis to reach a decision when there is sufficient information to establish a quantifiable level of confidence. For example, exploration is conducted to generate sufficient data to achieve at least an 80% (0.8) confidence level that there are sufficient reserves of a resource before exploitation will be undertaken. The exploration lead time is typically very long and the costs are very high. And yet in many cases reserves are not borne out upon development.

The range of confidence levels (CL) used in this report is discussed in the following section (2.5). In general, the guiding rules are that confidence levels above 0.7 have sufficient information to estimate reasonable worse and best cases, although the aversion to risk will dictate whether a decision can be reached based on the information. The cost of reaching 0.7 is quite high and increase significantly to reach 0.8 and exponentially to go beyond.

If the confidence level in the available information is equal to or below 0.5, the information is insufficient, since however one decides there is a 50-50 chance or greater that the information relied upon is wrong. For this study, a CL range of greater than 0.5 to 0.7 indicates the information significantly incomplete and imperfect. *Note: These CL ranges are project specific and in this study consensus driven. Since this assessment is a singular study, the CL used is purely for illustrative purposes and requires multi stakeholder analysis to establish a reliable CL*.

This study determined a CL of 0.6 for economic and social information, and 0.7 for environmental. Therefore, the information is considered incomplete and imperfect and insufficient to define “reasonable” best and worst cases. As a result, an alternative yet equivalent method was applied; using assumed best and worst cases. It is important to note that this is not a new concept, but was adapted from game theory to estimate range of impact as a result of specific actions (Stevens, S.P, 2008).

“Assumed” best and worst case (ABC and AWC respectively) are established for each economic category. ABC and AWC are equivalent to reasonable best and worst case, except the CL in the information is insufficient to establish definitive limits; therefore, ABC and AWC are assigned in terms of an assumed change in the baseline TEV for each category as result of taking the specific strategy. The assumed change is estimated as a percentage of impact on the TEV. An ABC might estimate an increase in the TEV; while the AWC could be a lower increase or a negative decrease. The assumed estimate is not arbitrary, but based on professional judgment and experience, and must be the result of stakeholder group consensus. The greater the number in the group and the more diversely affected by the final decision, the higher the level of confidence in those issues in which consensus is achieved.

For this assessment the accumulated benefit was used to determine multiple effects as outlined in Table 6.1 and applied in the BCA worksheets in Appendix B. The AWC/ABC percentages are assigned to each baseline NPV for the respective benefit within each scenario. As can be seen in Appendix B worksheets, small percentage differences can have a large change in the baseline values over the ten year study period. Relatively low percentages were used for this study to be ultra conservative.

The NPV was determined for each AWC and ABC based on the assumptions tabulated in Table 6.1. The average of the two assumed cases is the assumed expected NPV representative of the economic category under consideration, and is referred to as “assumed likely case” (ALC) which is analogous to “reasonable likely case” in comparable financial and risk assessments.

Costs were determined by taking the highest ALC NPV for each respective category, and subtracting the respective ALC cost for the scenario under consideration. This is equivalent to the opportunity cost. If the difference is zero or negative, there is no respective categorical loss for selecting that particular scenario. Otherwise, it is the cost for selecting that scenario over the scenario with the highest value. Management, marketing, and O&M costs etc. are assumed to be accounted for in baseline TEV.

The BCA total expected value for the scenario is the sum of all the ALC less the total cost. See box below for example. The objective of this analysis is to evaluate the perceived benefits and costs of the different scenarios; therefore, as long as the basis for the bounds are reasonable and represent a composite of stakeholders perceptions to balance biases, a relative benefit cost ratio (BCR) can be obtained at the very least to indicate potential acceptable decisions.

Furthermore the CL identifies and prioritizes the data gaps which would need to be filled first, while concurrently strategic planning and policies can be established implementing the scenario which has the highest potential for improving the social, economic and environmental aspects, without having to wait until all the information is complete and adequate, much less perfect.

BCA EXAMPLE: AGRICULTURE

(Data from Section 6 and Appendix B)

For Scenario 1 it was assumed that in the best case the agriculture production would increase annually as new land became available, but the increase would be limited due to poor soil, water management, and farming practices. Therefore, an increase in agriculture NPV of 1% per year was assumed to be the ABC. On the other hand, in the worse case the losses of forest ecosystem services would limit the ability to startup new farms and even existing farm production would be negatively impacted and a decrease in NPV of 1% was assumed for the AWC.

Using the Baseline annual revenues for agriculture ($49 million from Table 4.25) as the base NPV the agricultural, the change in NPV was calculated using the assumed percent change for the respective ABC and AWC. The average of the best and worst case NPVs for agriculture determined the relative assumed expected value of agriculture likely (ALC) for each scenario.

For Scenario 1 is $357 million from Table 6.2. This is the ALC NPV, which is the average of the ABC and AWC NPV using the assumption from Table 6.1. *Note: this is not the average of the respective percent changes, i.e. +1% and -1% respectively, but the average NPV of ABC AND AWC.*

For Scenario 2 it was assumed that, since logging would be banned, no new land would become available for farming, but existing farm production would increase by 2% each for improved farming practices, enhanced natural forest ecosystem services and improved water management, resulting in a ABC of 6% increase in NPV. And in the AWC there would be a 1% increase in each of the attributes resulting in AWC of +3%. The ALC value for agriculture using Scenario 2 is $2,544 million from Table 6.2, i.e. the average of ABC and AWC NPV.

Under Scenario 3, the ALC value for agriculture is $2,062 million since in addition to the benefits under Scenario 2, more land would become available due to controlled logging and consequently ABC is assumed to be 8%, while AWC assumed to be 4%.

Costs are determined as opportunity costs. The agricultural NPV expected values for ALC benefits for different scenarios (from Appendix B worksheets rounded off to USD millions) are: $357; $1,108; and $2,062 respectively. If Scenario 1 is selected the agricultural opportunity cost for not selecting Scenario 3 (the highest cost benefit) is:

Scenario 3 ALC NPV minus Scenario 1 ALC NPV for agriculture, that is: $2,062-$357=$ 1,705 which is the loss of revenues from agriculture for choosing Scenario 1 over 3.

If Scenario 2 is selected, the costs would be: $2,062 -$1,108= $954.

And if Scenario 3 is selected there is a net gain over the other scenarios, so the there is no loss of revenues from agriculture.

Similar rationales are followed for each of the economic categories considered for each scenario. The assumed rates of growth are not arbitrary but based on the knowledge and experience of the evaluator taking into account the information available. Therefore, the rates could change as different stakeholders completed the process. While each would have a different perspective and the ABC and AWC might vary a great deal, collectively the values should provide a good basis for consensus for assessing the scenarios. {Note: It is not the dollar values that are important (which are for illustrative purposes only, but rather the relative difference in comparing one scenario to the other.}

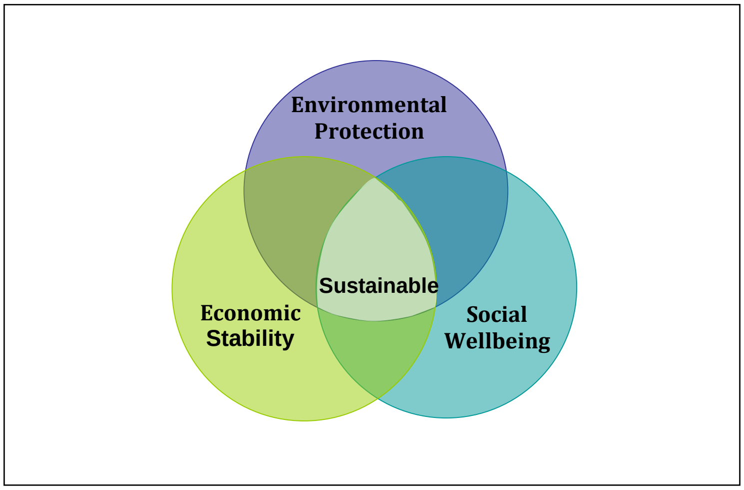
2.5 Sustainability Matrix

The Sustainability Matrix is fundamentally a chart that allows a team or an individual to systematically identify, evaluate, analyze, and score sets of information. In this assessment, the matrix is used to weigh and compare the baseline and 3 scenarios as presented in Section 6.0. However, as emphasized throughout this report, the Matrix, as presented within this report, is but one party's evaluation, and to be of real value must be evaluated by all the individual stakeholders independently and then compiled by process of elimination into a consensus to be used to establish a plan of action to implement the optimum strategy, a Sudex plan, to set goals and indentify performance measures to ensure continuous improvement is made toward reaching the goals. **Input from the RGC Forestry Administration on the identification of key parameters and assignment of weights is critical to the successful application of the Sustainability Matrix.** The following sections describe the steps of creating this matrix.

2.5.1 Matrix Methodology

The Sustainability Matrix is unique in that it integrates economic, social and environmental themes into one score, which can also be considered individually either as theme or indicator parameter as discussed below. It is essentially three-dimensional in that it considers the three pillars of Sustainability (see Figure 2.3) as one system.

Figure 2.3 Primary themes of sustainability



"Sustainability is assured only by the optimum integration of economic, social and environmental policy."

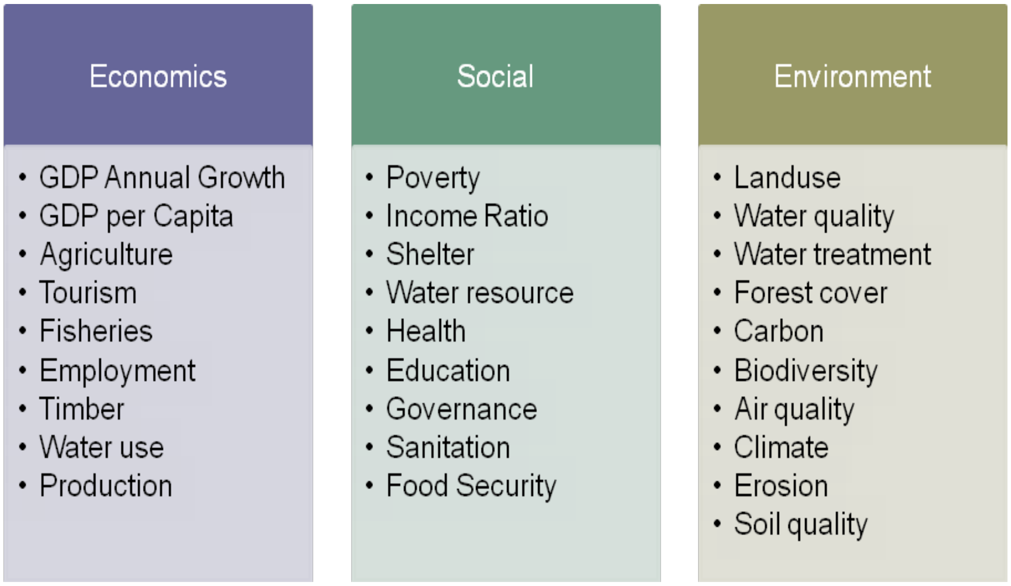
INDICATOR PARAMETERS (IP)

Rapid assessments (RA) by their very nature are qualitative, assessing secondary information to develop a representative portrait of the study area. The quality of the portrait is a function of the quantity, reliability, accuracy and credibility of the information in regard to indicator parameters (IP) used to create the portrait. In general, the more IP used, like pixels of a photograph, the greater the clarity of the portrait, but the more unwieldy the data.

The composite list of IP used for this assessment was derived from *Sudex* (Forbes, 2009), *Indicators of Sustainable Development* (UN), and *The Wellbeing of Nations* (Prescott-Allen, 2001). The composite list is comprised of nearly 300 parameters, divided into three aspects of sustainability. The UN includes a fourth pillar "institutions" which are included within governance under the social theme in the matrix. *The Wellbeing of Nation's* HWI (Human Wellbeing Index) used People and Ecosystems for its two main themes, which are subdivided into the three themes for the Sustainability the matrix. The composite list is shown in Appendix B.

The composite list was reduced to items, which were directly or indirectly affected by the forest logging, and surface water affects. The revised list includes 112 parameters. Figure 2.4 provides a condensed list of indicator parameters used for the matrix. This is a preliminary list for the purposes for this study. It can be extended or shortened subject to objectives of subsequent studies. A completed Matrix is shown Section 6.0.

Figure 2.4 Condensed lists of indicator parameters for the matrix



Economics	Social	Environment
GDP Annual Growth	Poverty	Landuse
GDP per Capita	Income Ratio	Water quality
Agriculture	Shelter	Water treatment
Tourism	Water resource	Forest cover
Fisheries	Health	Carbon
Employment	Education	Biodiversity
Timber	Governance	Air quality
Water use	Sanitation	Climate
Production	Food Security	Erosion
		Soil quality

A parameter referred to as “Econ” and “Environ-Sustainability” respectively was added to the economic and environmental themes, but not the Social. This is because, regardless of individual preferences, social sustainability cannot be sustained without willingness and ability to pay (e.g. carbon credit and payment for environmental services (PES)), which are dependent on economic sustainability. On the other hand, a scenario may not be economically sustainable as result of social pressures, but environmentally sustainable without social intervention (e.g. preservation).

Originally, the matrix was intended just to include 5 to 10 parameters for each theme which would best address the important considerations of each, but due to the low confidence level in the available data, as discussed in the next section, more parameters are needed to offset variances due to subjectivity.

In addition, it was felt that Cambodians were best qualified to determine the parameters. It should be noted that while the IP parameters are also divided into the same themes, they are not being duplicated. Each theme parameter is to be considered with respect to cost or benefits for each theme under each scenario.

CONFIDENCE LEVEL (CL)

Ideally, at least three confirming references would be available for each datum, without which the confidence level (CL) in the information would be lowered. With each data compromise (e.g. sporadic, infrequent datum points, unexplained outliers, conflicting data, data bias, incomplete measurement stations) the CL decreases. The following is the CL scale:

0	No confidence in information and data available
>0.0 to <0.5	Low confidence in data, generally unacceptable
0.5	Median confidence level, qualitative 50-50 probability that data is reliable.
>0.5 to 0.7	Medium confidence, qualitative probability that data is reliable.
>0.7 to 0.9	High level of confidence, quantitative probability that data is reliable.
>0.9	Very high confidence level. Rigorous quantifiable and reliable data.
1.0	100% confidence (generally not attainable).

The lower the confidence level, the higher the number of indicator parameters necessary to create a satisfactory image (Forbes, 2009). If 0 represents no confidence in the data, and 1 represents full confidence, the best that a RA can attain is a CL of between 0.5-0.7, because it relies on secondary information.

Below 0.5 the uncertainty is too great and cannot be used. Between 0.5-0.6 the CL is very subjective but based on sufficient research and information to reach an acceptable level of intuitive knowledge. A CL of greater than 0.5 should provide an indication that consensus can be reached and there is confidence that there is a reasonable possibility that the same decision would be reached, even though the relative scores conducted by different individuals of the same cohort are different.

Above 0.6 to 0.7 there is sufficient quantifiable data to make a reasonable semi-quantitative evaluation. This can be increased to 0.8 for individual IP, if there is reliable primary and secondary information based on rigorous confirmed quantitative data, or there is a strong consensus in support of the assessment. A preliminary RA cannot achieve a CL greater than 0.7 without more focus group consensus, as discussed below.

Above 0.7 it can anticipated that further investigation would most likely affirm the ranking of the results, but there is a significant exponential increase in cost to achieve an incremental increase in CL, and the value added may exceed the margin of returns after 0.9, which can be cost prohibitive. However, an assumed CL of 0.9 can be used to establish an attainable Target score. A CL of 1, which is 100% surety, is not attainable, but can be used to define the ideal score, as the ultimate objective in strategic planning, discussed in Section 2.5.2.

A great deal of research was conducted to define and understand the study area and establish a baseline of current conditions as discussed in Sections 3.0-5.0. Cambodia has been diligently and proactively generating essential information over an extended period of years, but there remain many data gaps making it difficult to attain a sufficient CL to conduct the assessment (i.e≥ 0.5). Consequently, a lot of additional research and time was necessary to define the appropriate indicator parameters to reach a CL within 0.5-0.7 in each of the three sustainability aspects evaluated for each scenario assessed as shown in Figure 2.3.

Whether to include CL in the score is dependent upon the objectives of the specific study and the available data. In this case it was included to take account of the data gaps, and inconsistencies in the data. Discretely the CL and importance ('I' as discussed below) can be used to determine which IP have the most important data gaps that need to be filled.

IMPORTANCE (I)

The list of indicator parameters for potential forest impacts were subdivided into the three sustainability themes and an attempt was made to prioritize their importance. Since all the parameters are considered important, a scale of relative importance from 1-3 for each parameter was established where:

- 3 = Very important
- 2 = Important
- 1 = Least important

It should be noted that "least" important does not mean "unimportant", and once again, it is felt that stakeholders and decision makers are best qualified to establish relative importance.

'I' is an important criterion to include providing measurable relationship between the individual parameters and the themes, and helps in strategic planning to rank the different objectives, and as discussed above along with CL can help to identify where the dollars are best spent for additional investigation.

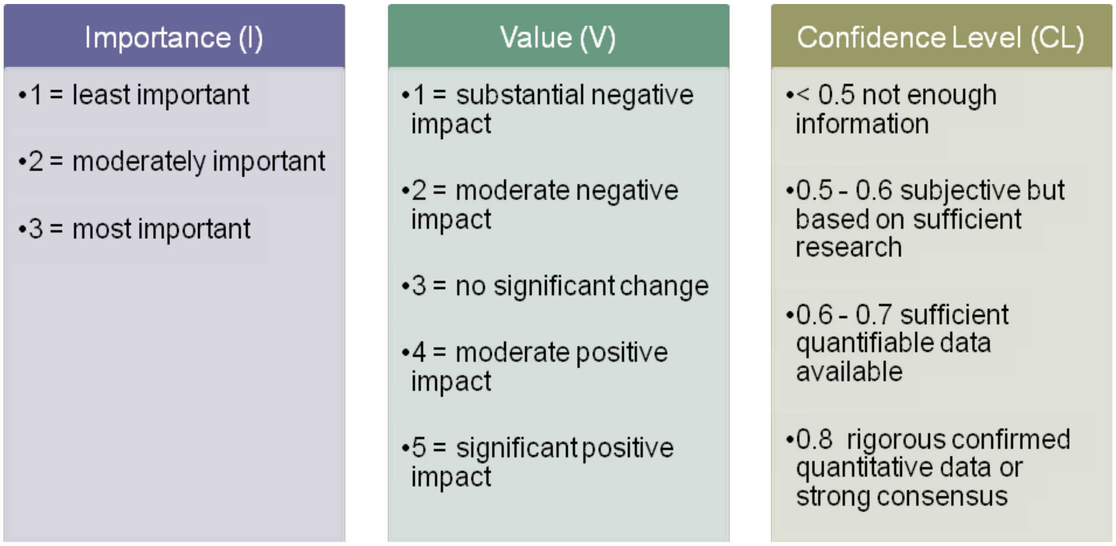
VALUE (V)

A value (V) was assigned for each parameter relative to its potential impact as a result of each of the scenario strategies relative to each of the sustainability themes. The values range from 1-5 based on degree of negative or positive impact:

- 1 = Substantial negative impact, e.g. loss of habitat, increase in number of endangered species, or loss of employment)
- 2 = Moderate negative impact (there is a potential negative impact between 1 and 3)
- 3 = No significant change (there may a slight negative or positive change but not sufficient to change scale level)
- 4 = Moderate positive impact (there is a potential positive impact between 3 and 5)
- 5 = Significant positive impact (e.g. significant increase in GDP, or decrease in pollution)

The value is determined for each parameter for each scenario by asking the question: ***Given the objective of the scenario, how will the parameter impact each of the themes based on the scale of 1-5?*** Figure 2.5 provides a summary of scoring inputs and ranges.

Figure 2.5 Matrix scoring ranges (Score = I x V x CL)



Importance (I)	Value (V)	Confidence Level (CL)
•1 = least important •2 = moderately important •3 = most important	•1 = substantial negative impact •2 = moderate negative impact •3 = no significant change •4 = moderate positive impact •5 = significant positive impact	•< 0.5 not enough information •0.5 - 0.6 subjective but based on sufficient research •0.6 - 0.7 sufficient quantifiable data available •0.8 rigorous confirmed quantitative data or strong consensus

SCORING

The subtotal score (S) is determined by multiplying I x V x CL for each indicator parameter relative to the respective sustainability theme under each scenario. The total score (S) for the respective scenario is then determined summing each S. The subtotals are added for each parameter theme and the Grand Total Score is the totaled for each scenario and the CL is averaged to determine the overall CL of the evaluation. Figure 2.6 is a simplified matrix used for this assessment. See Section 6.0 for the Assessment Sustainability Matrix.

Figure 2.6 Simplified Sustainability Matrix

Indicator Parameters	**Scenario X**												
	Economics				**Social**				**Environmental**				**Total Score**
	I_x	V_x	CL_x	S_{eco}	I_x	V_x	CL_x	S_{soc}	I_x	V_x	CL_x	S_{env}	$S=\sum S$
GDP													
NTFP													
Forest													
Carbon credit													
Fisheries													
Water Quality													
Irrigation													
Average CL													
Total Score for Scenario X				(S = I x V x CL)									**∑S**

Adapted from Forbes 2009

I = Importance, V = Value, CL = Confidence Level, S = Score

MATRIX LIMITATIONS

Theoretically, the comparative total scores provide a qualitative determination for which scenario presents the best outcome. However, one matrix completed by one evaluator is not sufficient to rely on and the matrix included in the report is included for illustrative purposes only.

This type of a matrix approach has its limits. The qualitative scores that result from a user's subjective scoring, are nothing more than that - a subjective assessment of the importance and value of different parameters with regard to a specified scenario and when CL is included, the user's confidence in their own ability to make this assessment. Unless the reasoning and rational to why a user chose to assign each score is explicit, then the seemingly "hard numbers" (scores) provide no more insight past a specific user's preference. However, taken collectively accounting for all the stakeholders, the matrix approach does have significant cost effective utility, which can be expanded and improved as funding allows.

While there are several approaches that can be taken each with its own merits and faults, regardless of which is followed, collectively all stakeholders should decide upon a list of indicator parameters they feel best addresses their perspective. They need not agree on the importance or value of parameter, but it is important that the set of parameters represent the significant issues as defined by each group. A group representative of each special interest then fills out the matrix from their own perspective. Teams within each group can either fill out the matrix individually or in brainstorming sessions to reach a consensus. Then the individual stakeholder matrices are compared with the others, and the same process is conducted in a plenary session until there is one master consensus. Not all parameters will be seen as important to each group and many will be valued at the opposing extremes, but those that are common to all can provide a starting place on which to focus.

STRATEGIC PLANNING

The primary purpose of the Sustainability Matrix within the context of this assessment is to provide a holistic qualitative measurement for each of the individual themes and then a comparative score for each of the scenarios. However, the matrix is not intended as a terminal point, but rather as a beginning step in the assessment, decision and planning process, especially useful when the available information is inadequate to reach a quantitative decision, but can still define a common objective from which to start.

The matrix is relatively easily expandable and serves as a screening tool providing a way and means to establish priorities, evaluate thematic interrelations, and identify the most helpful information gaps, which need to be filled for more quantitative assessment. In addition, with the appropriate data gaps filed, it provides a good foundation for systems analysis to assess quantitative alternatives and reach optimum decisions.

While beyond the scope of this assessment, the matrix provides a strategic planning tool similar to that of Sudex (Forbes, 2009). Using the matrix a baseline score can be established for conditions as they are now, and a target score can be established for where the participating parties would like to be. Both baseline and target scores are included for comparative purposes in Section 5. Their respective V scales were retained but the definitions were changed from relative impact to relative quality (good to bad). Importance (I) was held constant at 3 for baseline and I, V and CI were all held constant at 3, 5, and 0.9 respectively for the ideal target score.

These scores can be compared as a ratio to identify current conditions relative to ideal target. For example, the ideal target score for this assessment is 4415, and the Baseline is 2045, or 46%. A reasonable goal might be 70%-90% (the ideal is not attainable). This indicates that an improvement of nearly 2 times the current state is desirable. The same comparison is made in Section 6 for the different scenarios.

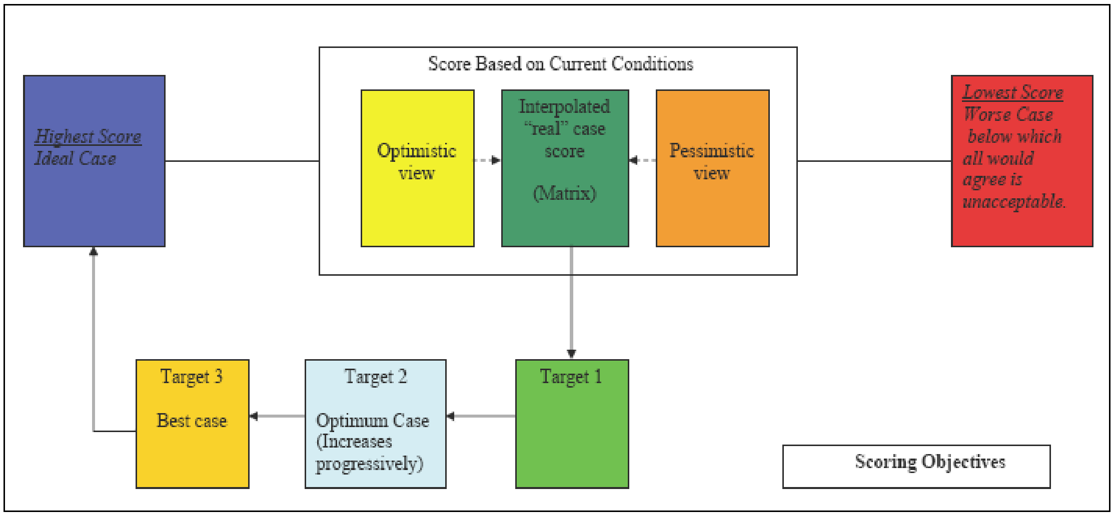
It is important to recall that the scores presented in this report, while representative of the findings of this assessment, are for illustrative purposes only, since it represents only the perspective of the investigators, which is of value for it objectivity, but is lacking in cultural perspectives of the direct stakeholders that are essential for the score to have any meaning.

Each of the measurement criteria I, V and CI provide critical decision analysis tools. ‘I’ indicates which parameters are considered the most important. V assigns a relative impact. These are not the same. The economic value of logging the forest may be extremely important in regard to employment and short term financial gains. On the other hand, while the impact from the loss of the environmental services and the inability to sustain long term logging does not diminish the economic importance of logging, it could affect its consideration as viable alternative. Further analyzing CI indentifies which of the more perceived important and valuable parameters lack sufficient credible and reliable information to reach a reasonable decision.

Taking all these factors into consideration a potential course of action to reach a modified target will become apparent. Using this course of action as a guide, a strategic plan can be prepared using a phased approach as shown in Figure 2.7 incorporating additional measurements (e.g.

funding, political will, best available appropriate technology, probabilities and feasibility) to establish reasonable attainable targets as data gaps are filled.

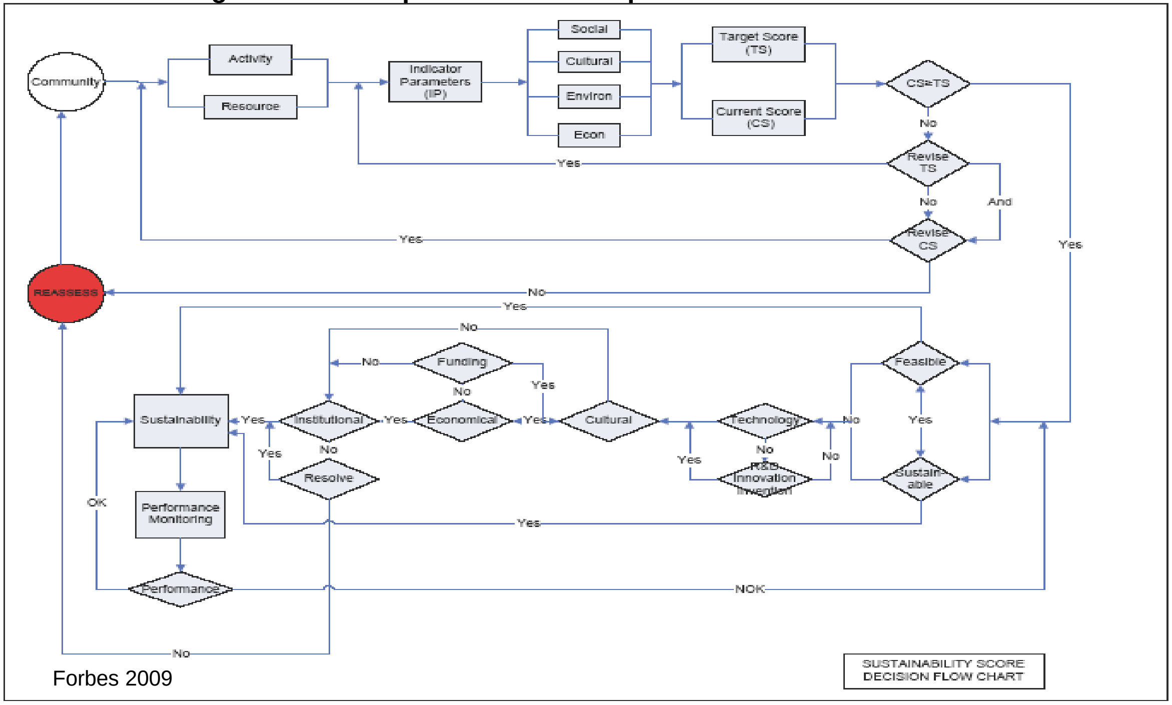
Figure 2.7 Conceptual scoring



Forbes 2009

The strategic plan serves as a "road map" as shown in Figure 2.8. As progress is made toward target score (TS), the current score (CS) is measured at critical milestones along the way, using both the baseline and target as measures of performance over time. The ratio of the baseline to the CS defining the degree of improvement and the ratio of the CS to the TS (as well as the ideal) a measure were how much more needs to be accomplished, both providing early warning signs when progress is not meeting expectations, so the map can be revised to progressively assure the desired optimum level of sustainable economic stability, social wellbeing, and environmental protection is reached.

Figure 2.8 Conceptual sustainable performance measurements



Forbes 2009

3.0 STUDY AREA

The delineation of the study area takes into account all the various economic, social and environmental parameters that would reasonably be representative of the area, while considering the complexities of the hydrology of Prey Lang Forest and hydraulics of the Mekong River Basin. The process started by looking at the big picture including the Mekong River Basin, Cambodia Watersheds, and accounting for various critical parameters such as political boundaries, socioeconomic centers, groundwater and aquifers, and economic land concessions. This identified the Study Area at large based on the watershed boundaries, which was then subdivided into three smaller focal areas to represent the area as a whole. The focal areas do not and cannot be a finite boundary, because what happens upstream along the Mekong, and within its primary and secondary watersheds to the east and west outside the study area, influence any assessment within or downstream of the focal areas. This section provides the general basis for determining the study area.

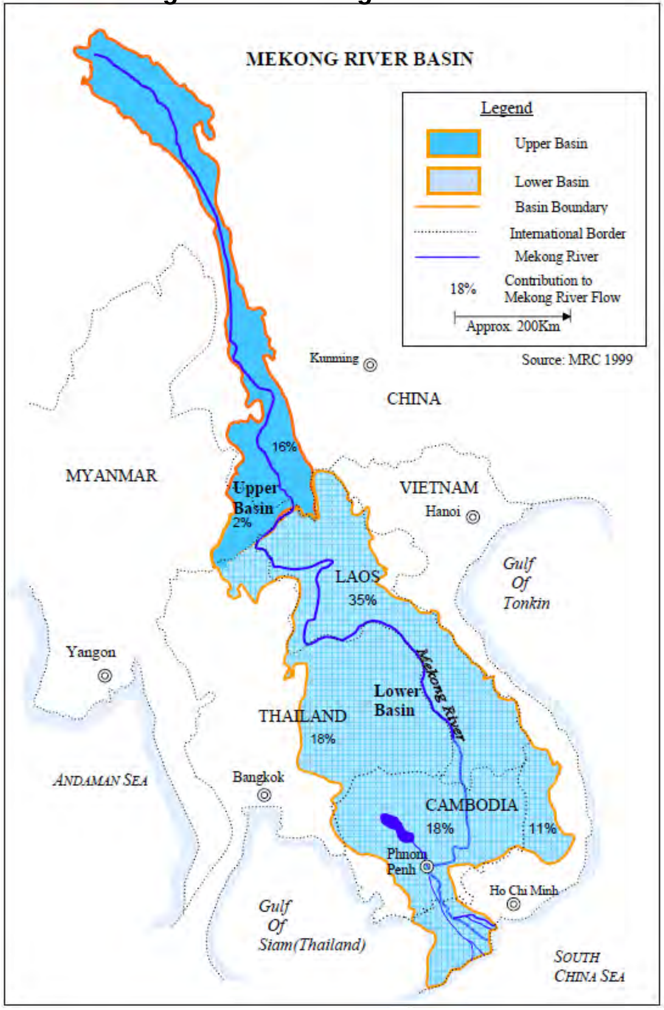
3.1 Mekong River Basin – The Big Picture

The Mekong River Basin (MRB) extends from the hinterlands of China to the Viet Nam Delta where the river flows into the South China Sea, as shown in Figure 3.1.

The course of the MRB covers the distance of 4,800 km from its source in the Tibetan plateau to its delta south west of Ho Chi Minh City. The MRB is divided into the Upper and Lower Mekong River Basins, with the upper located predominately within China, and the lower encompassing nearly all of Laos and Cambodia, with a significant portion within Thailand, and the Viet Nam Delta.

The Mekong River is the twelfth largest river in the world. The entire Mekong Basin drains an area of approximately 795,000 km^2, of which about 606,000 km^2 is the Lower Mekong Basin; 155,000 km^2 is in Cambodia (MRC, 2005). Common national boundaries were an important consideration in determining the limits of the study area, but transboundary issues are beyond the scope of the study.

Figure 3.1 Mekong River Basin



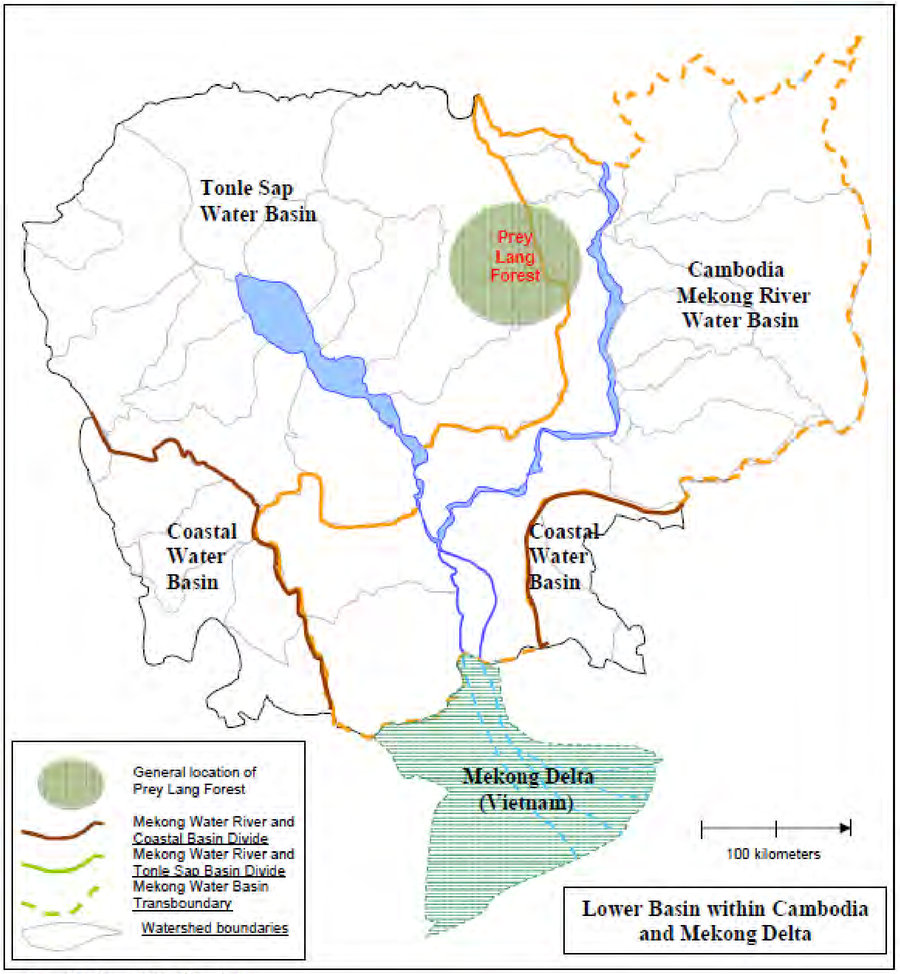
Source: MRC 1999

3.2 Lower Mekong Basin – Cambodia

Focusing on Cambodia within the Lower Basin, the country can be divided into two primary sub basins, one draining into the Tonle Sap and the other into the Mekong River. For the purposes of this study each is referred to as the Tonle Sap and Mekong Basins respectively, with both ultimately flowing into the ecologically sensitive Mekong Delta. There are two smaller coastal watersheds outside the Cambodia Mekong Lower Basin, which are not included in the study. See Figure 3.2. The generalized area of the Prey Lang Forest within the basins is highlighted.

While together both of the basins comprise the lower portion of the Lower Mekong River Basin, the interrelation between the two is quite unique and complex with significant importance to the Delta.

Figure 3.2 Cambodia Water Basins



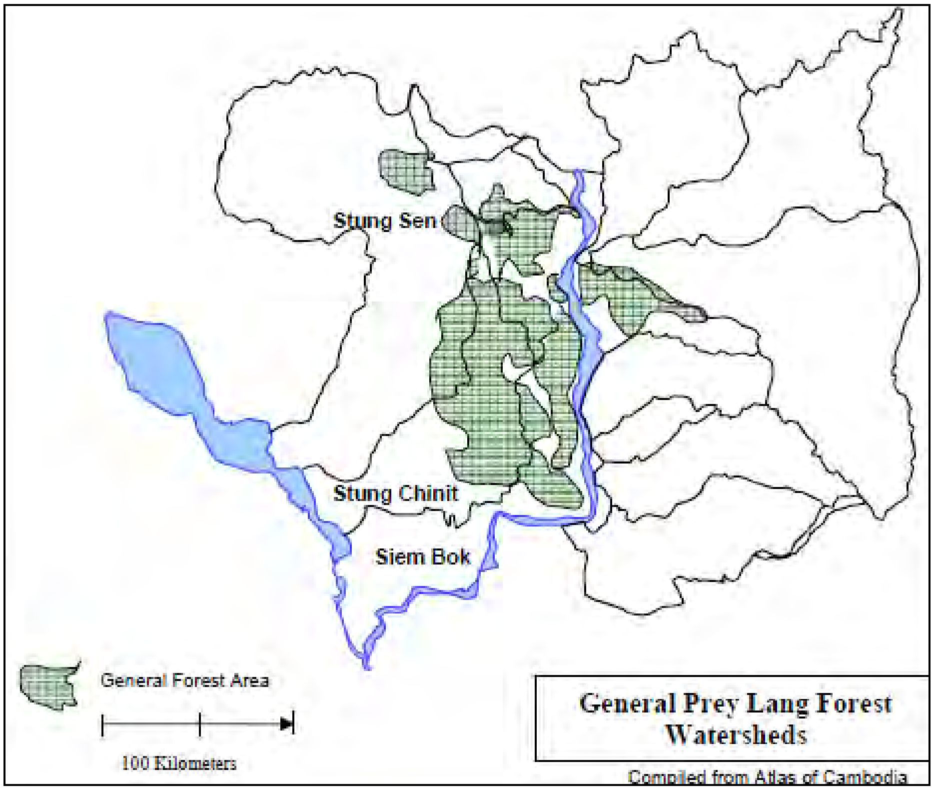
Compiled from Atlas of Cambodia

3.3 Study Area Watersheds

The location of the Prey Lang forest lies within three watersheds, the Stung Sen, Stung Chinit and Siem Bok, and traverses the hydrological divide between the Tonle Sap and Mekong Basins, as shown in the preceding figure and Figure 3.3 (a) below. Figure 3.3 (b) shows how the location falls with the regional provinces.

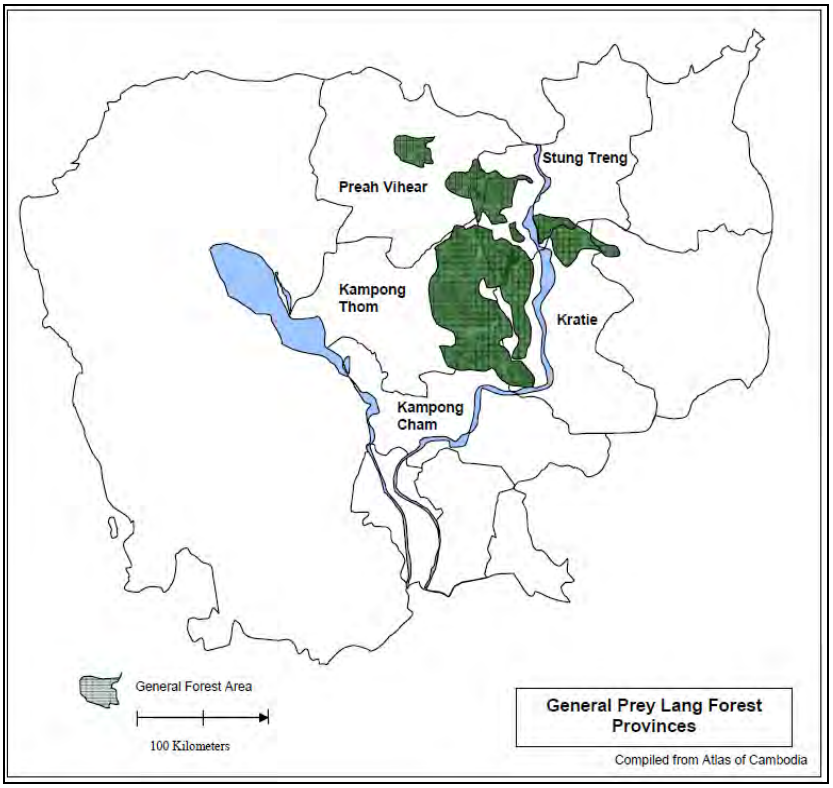
A general review of Cambodia's watersheds was conducted. The primary rivers and streams, with secondary tributaries were plotted and apparent watershed trends were assessed. From these maps a conceptual drainage map, illustrated in Figure 3.4, was prepared for the Prey Lang Forest area. Collectively these maps showed that Stung Sen, Stung Chinit, and the far west portion of Siem Bok discharge into the Tonle Sap River, while the largest area of Siem Bok discharges into the Mekong. This increases the forest's hydrological significance and the importance of the watershed boundaries.

Figure 3.3 (a) Prey Lang Forest Watersheds



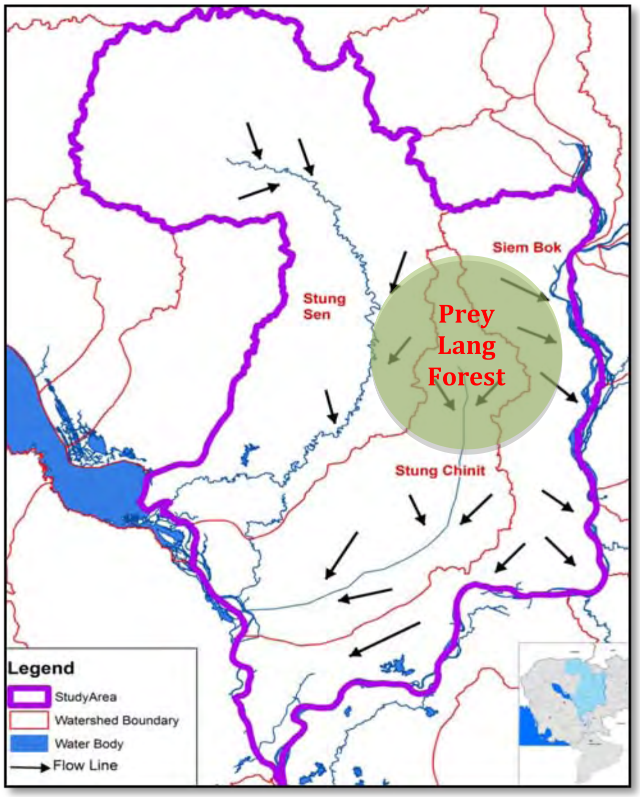
Compiled from Atlas of Cambodia

Figure 3.3 (b) Prey Lang Forest Provinces



Compiled from Atlas of Cambodia

Figure 3.4 Conceptual Drainage Map

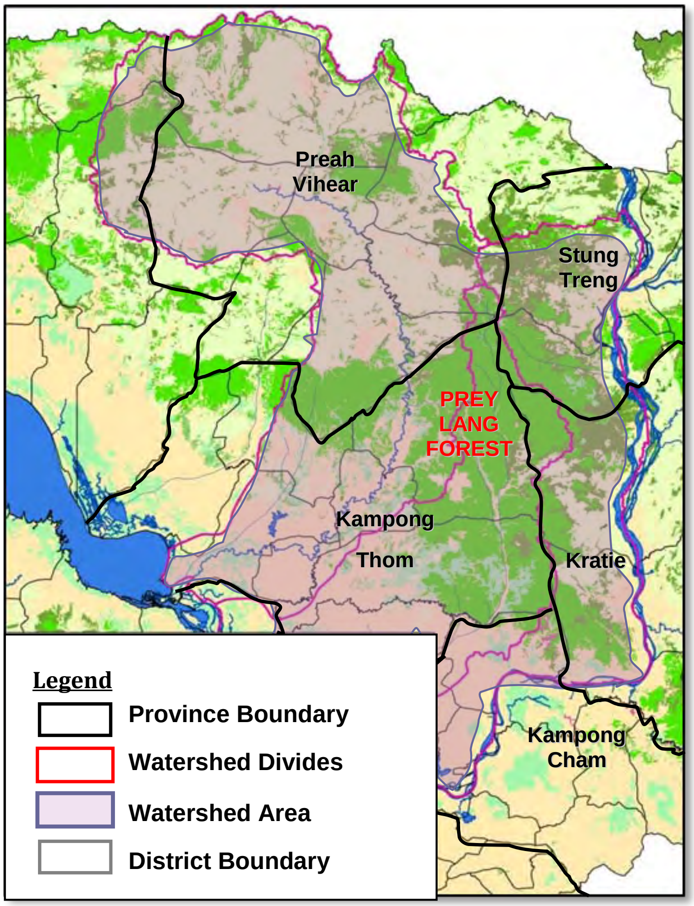


Since water flows according to natural characteristics within stream, river catchment areas and are not constrained by provincial boundaries, a surface hydrological study should be defined by the watersheds. The number of sheds should be based on those most representative of the basin as a whole, and could potentially have the greatest impact on stakeholders affected by the objectives of the study.

3.4 Political Boundaries

The maps showing political provinces and the watersheds in the area of the Prey Lang (Figures 3.3 (a) and (b) above were overlain as shown in Figure 3.5. The provinces within the overall watershed area are: Preah Vihear, Kampong Thom and the northern portion of Kampong Cham on the side of the basin divide and the western portion of Stung Treng and Kratie east of the basin divide. The larger portions of Kampong Cham, Stung Treng, and Kratie Provinces all lay on east side of the Mekong River. Consequently, the political boundaries would not serve well as study area boundaries, and socio-economic information for the portions within the watersheds would have to be extrapolated from the Provinces at large. Therefore, the three Prey Lang Forest watersheds, Stung Sen, Stung Chinit and Siem Bok were identified as the Study Area.

Figure 3.5 Province, Watershed, and Prey Lang Forest Map



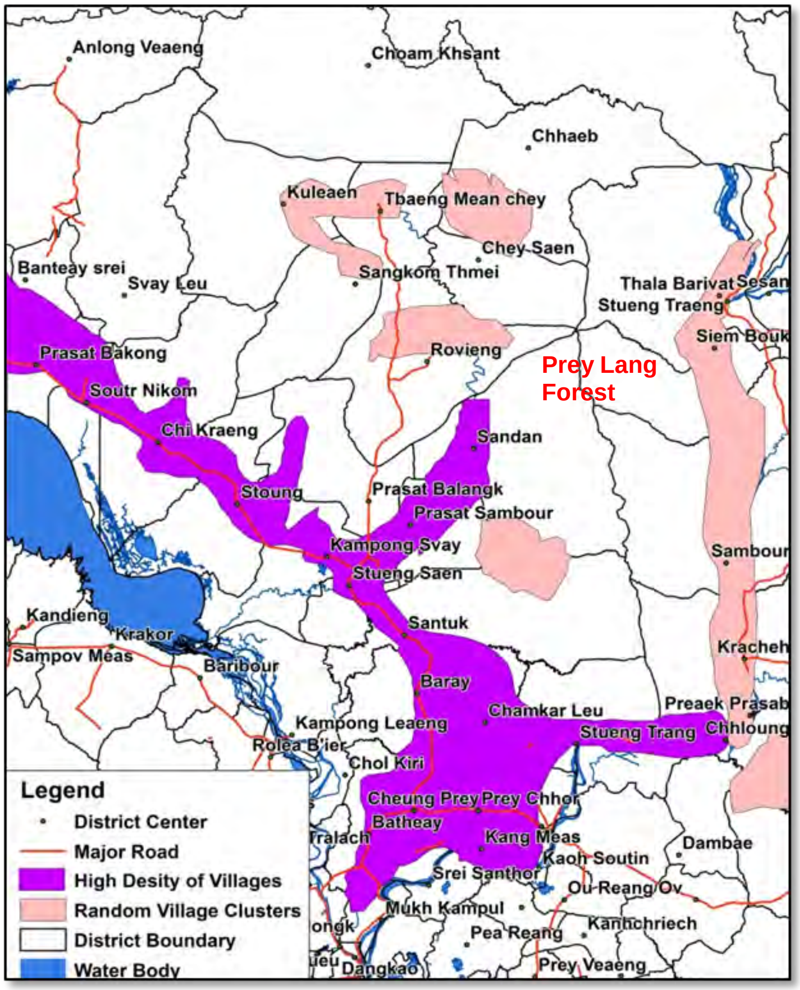
3.5 Socio Economic Centers

Using the watershed map as the base map for more detailed study, basic study area indicator parameter maps were drawn. These included population density and economic centers (based on population density), village location density, vulnerable aquifers, and identified mining operations, as shown in Figure 3.7.

The highest concentration of population is at the confluence of the Tonle Sap with the Mekong and to the south and southeast of Phnom Penh. There are some areas of high population around Tonle Sap in Siem Reap; however, for the most part, it appears that a significant portion of Cambodia's population is in the south from Kep and Svay Rieng to above the lake and river confluence (west portion of Kampong Cham), with obviously the highest population in Phnom Penh.

As expected, the concentration of villages correlates with population, but there is a wider distribution throughout Cambodia, in particular along the reaches of the Mekong and lower reach of the Stung Sen. Therefore, the Stung Sen watershed, which makes up a large segment of the overall study area, has an added significance.

Figure 3.7 Population Density Map

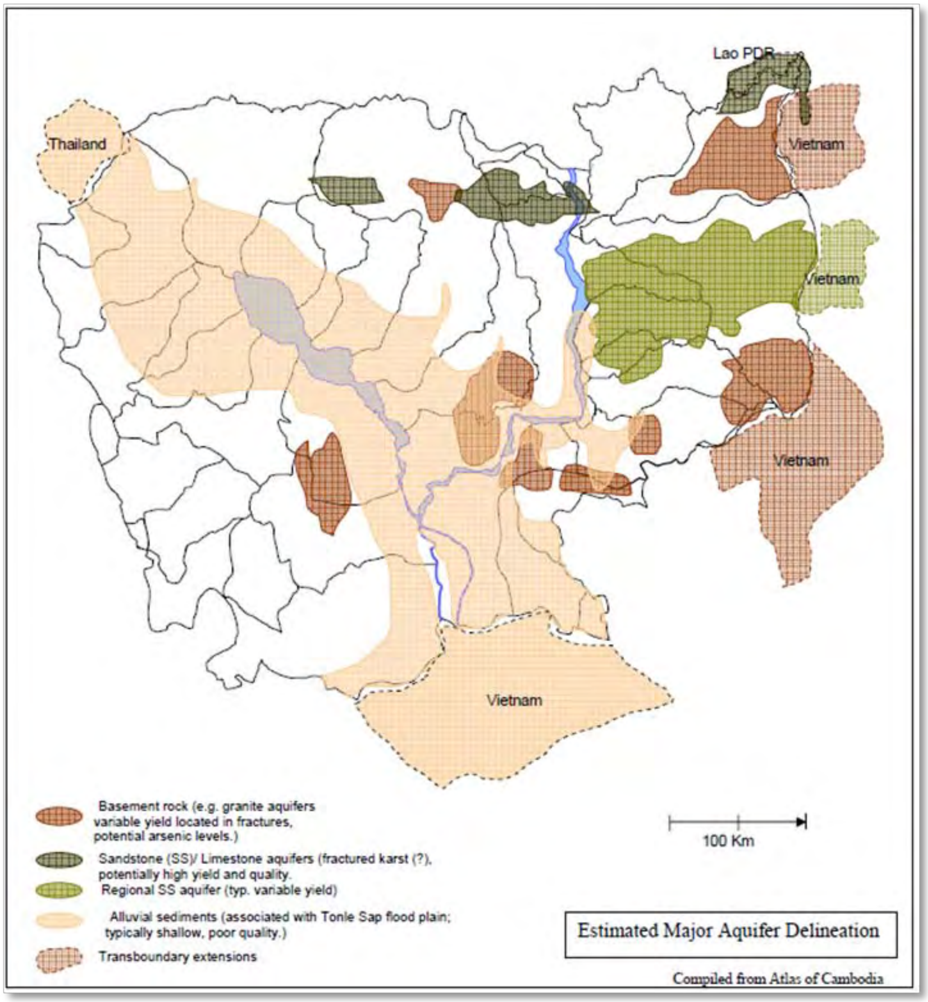


3.6 Groundwater and Aquifers

Cambodia has limited aquifer information and groundwater resource information, particularly to the west of the Mekong. The more extensive regional and transboundary aquifers lie to the east. However, there are local aquifers in the granite and limestone geologic formations to the north of the Stung Chinit watershed and underlying the Stung Sen. Additionally, there is an aquifer in the limestone formation in the southern portion of Stung Chinit and Siem Bok watersheds. These aquifers have the potential to be very productive water resources, but there is not enough information to determine geologic structure or the aquifer characteristics. Fluoride and arsenic are potential concerns in water drawn from granite formations.

There is a large aquifer in the alluvial sediments of the Tonle Sap flood plain. This is most likely a shallow water table aquifer and the groundwater source most often used for shallow water wells for local domestic use. However, the locations may require hauling the water long distances to homes, and water quality in shallow water table aquifers is generally poor. Figure 3.8 indicates Cambodia's known aquifers.

Figure 3.8 Cambodia Aquifers

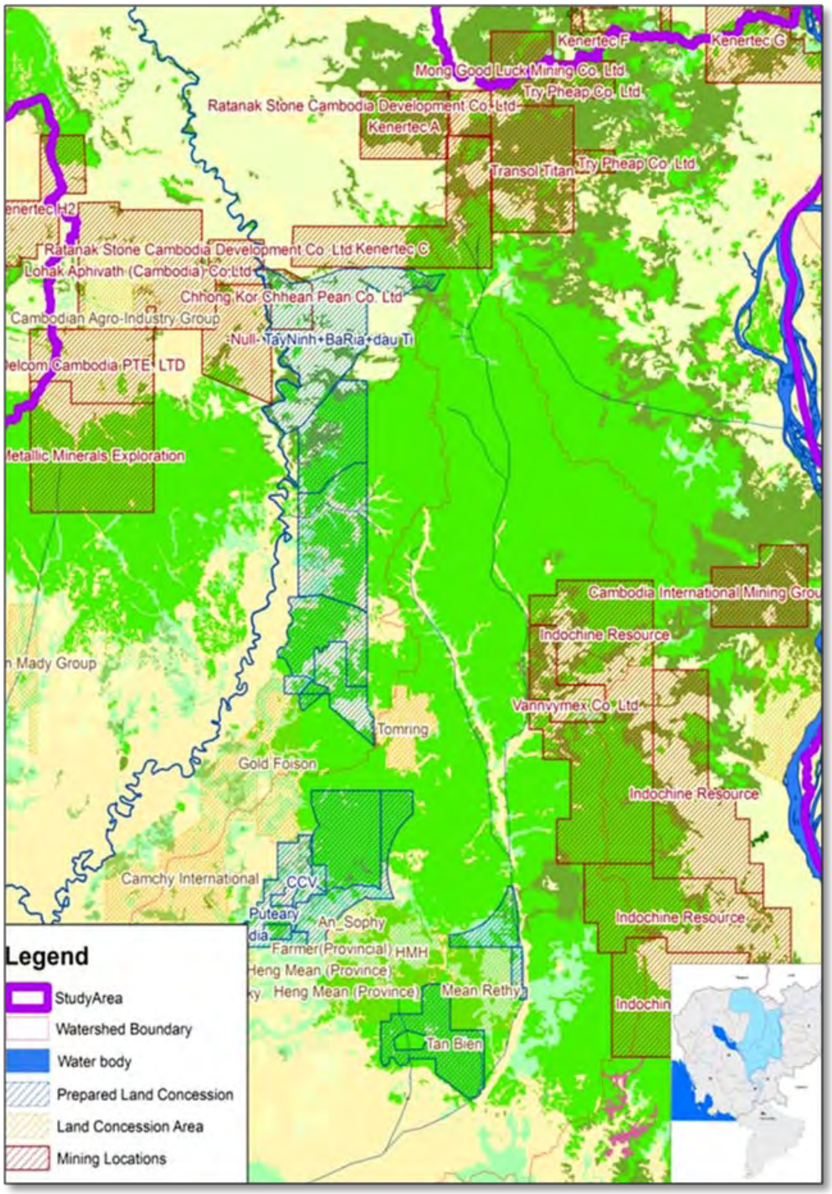


Compiled from Atlas of Cambodia

3.7 Mining and Economic Land Concessions

Finally, mining activity was identified in the initial broadly defined study area and was mapped and overlain over the watershed map. Interestingly, the location of the mining activities closely correlate with the location of the aquifers discussed above. Although the degree of impact is beyond the scope of this report, the mines could present a potential impact on both the forest and the aquifers; their location supports the inclusion of the Stung Sen watershed in the Study Area. Figure 3.9 illustrates Cambodia's mining and economic land concessions. However, as discussed in Section 4.0 regarding Baseline Conditions, both the plantation and mining concessions deserves a similar in depth assessment of their own in order to attain a holistic view.

Figure 3.9 Concessions Map



3.8 Study Area and Focus Area

Water runoff flows downgradient into streams feeding rivers that discharge into surface water bodies as determined by the slope, vegetation, and soils within watersheds and catchment areas delineated by topographic divides. Natural catchment areas are not determined by administrative boundaries. A surface water study can best be assessed by the hydrology of its watershed(s). The number of catchment areas should be based on those most representative of the basin as a whole, and include those that could potentially have the greatest impact on stakeholders affected by the objectives of the study.

The biome, or major ecological community type, and the ecotone, or the transition area between two adjacent ecological communities, best delineates the forest. However, representative sections can be defined within watersheds that address the various interrelationships between the two ecosystems and how they impact the socio-economic status of the communities within and downgradient of the study area.

Therefore, the study area to serve as a model for this assessment was determined as the area that best represents the area as a whole and takes into account as many of these multifaceted factors as possible, while ensuring that the most critical and potentially contentious issues are not overlooked. As discussed earlier, the proposed study area is defined by the three watersheds: Stung Sen, Stung Chinit, and Siem Bok.

The Study Area is approximately 33,448 square kilometers in total as shown in Table 3.1. This area is too large to assess within the time frame available. Therefore, smaller focus areas within the Study Area were assessed to establish a baseline set of conditions representative for the areas as whole.

Table 3.1 Spatial Extent of the Study Area

Watershed	Area (Sq. Km)
Stung Sen	16,360
Stung Chinit	8,237
Siem Bok	8,851
Study Area Total	**33,448**

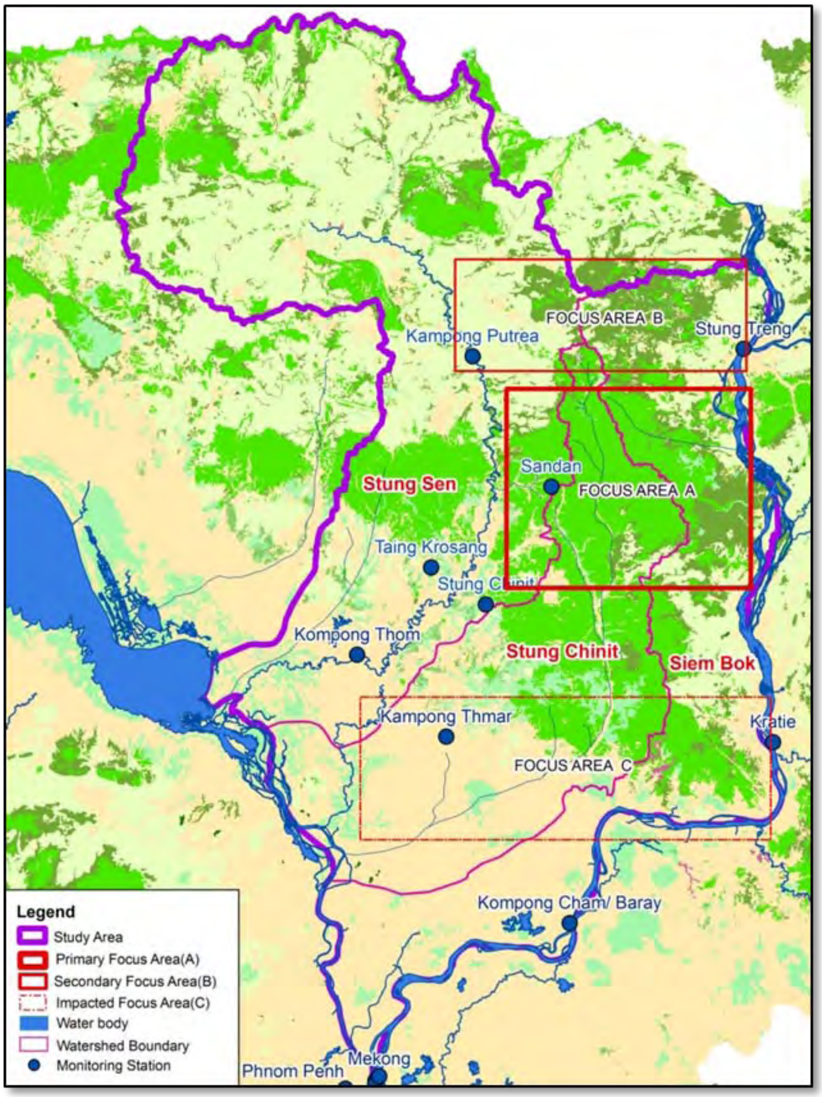
Since the focus of the Study Area hydrology is the Prey Lang Forest and the related downgradient impacts, three focus areas (A, B, C) were selected and are listed below:

- **Focus Area A**: Prey Lang Forest & hydrology
- **Focus Area B**: Upgradient aquifer resources
- **Focus Area C**: Downgradient - Concentrated populations & urban economic centers

Each area provides a representative model of the different perspectives considered in the study, as affected by the forest and hydrology. Focus Area A is the Prey Lang Forest itself. Area B is the upgradient area and potentially important aquifer resources that could affect and be affected by forestry development. The current conditions within Focus Area C serves as the basis for socio economic conditions used to assess downgradient changes as a result of the hydrological affects of forestry development over the ten year study time period.

Figure 3.10 shows the study focus areas addressed in this report. This is not say that only these areas were investigated, and in fact baseline conditions were based on data taken from many sources throughout the area, and Cambodia in general. The obvious prime area is A, the Prey Lang Forest, the subject of this work. Areas B and C were the areas focused on to obtain area specific data and information as available that could be applied to the investigation, as well as, outside sources, which possessed relevant information to make the study complete to meet its objectives.

Figure 3.10 Study & Focus Areas



The primary forest activity considered as part of this study are the harvesting of the trees for logging value, since this would have the most significant economic, social, and environmental impact on the surface water. The primary social economic impacts focus on the positive and negative effects of resource development on local populations living in and around the forest and the urban economic centers downgradient of the forest with in Focus Area C. Since the impacts have been assessed as a function of hydrology, the study area is defined by the watershed boundaries that encompass those indicator parameters that could be most affected by the impacts.

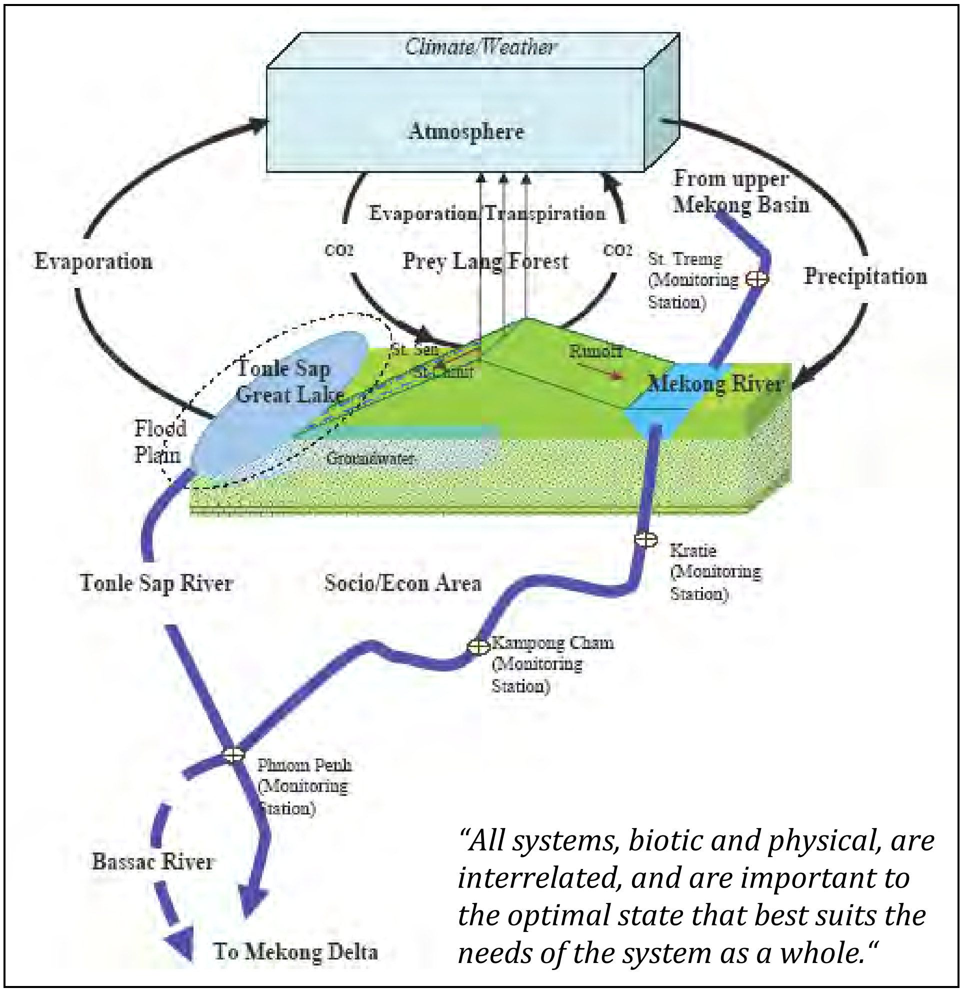
The following section describes the baseline socio-economic, environmental and hydrological conditions of the assessment study area.

4.0 BASELINE CONDITIONS

Baseline conditions are the existing conditions of the Study Area as determined in Section 3.0 that are relevant to the assessment. The baseline provides a benchmark with which to measure results of changing conditions, in this case changes in the forest and hydrology. The following section attempts to provide a general overview of the study area describing, as best able, based on the data and time available, in terms of environmental, social and, economic attributes. While there is a lot of good data available, there are also a lot of data gaps, and the baseline is only as good as the gaps can be bridged, but this section does provide a reasonable portrait within the qualification of the study.

The following figure presents a conceptual model of the Prey Lang Forest Study Area.

Figure 4.1 Conceptual Model of Prey Lang Forest Area



“All systems, biotic and physical, are interrelated, and are important to the optimal state that best suits the needs of the system as a whole.“

The baseline will be defined by those components of the forest and hydrology within the Study Area that can be sufficiently characterized, with respect to the socio-economic and environmental aspects of sustainability, using available existing information. The components are discussed at depth within this section, and include the forest itself, the hydrology of the watershed and how changes to these might impact the river and lake hydraulics. Those aspects, which can be assessed based on monetary value, either directly or indirectly, are addressed in the Total Economic Value model, which along with the conceptual model described in the text, provide the foundation of the Baseline model. TEV includes the value of the revenues generated or potentially generated or otherwise affected by the various scenario tactics. These include forests production (logging and NTFP), fishing (commercial and subsistence), tourism, and agriculture. Indirect values are determined for the carbon storage, water and soil protection, and biodiversity services provided by the forest. A benefit cost analysis is conducted to establish a benchmark for current conditions. In addition, a myriad of unquantifiable parameters are evaluated to establish a qualitative baseline for sustainability with which to assess the potential sustainability of each of the scenarios, which is extended beyond the ten year time frame of the study.

MINING

Mining activity, within the study area, is an important industrial enterprise, which could have an equivalent, if not greater positive and negative, impact than the forest on social, environmental and economic conditions. However, to adequately consider it would require an equivalent, if not more, quantitative study than this one to do so. Although the immediate effected land footprint might be relatively small compared to full conversion of the forest, its potential environmental impact per hectare could be far greater, and as a non-renewable resource, sustainability takes on a different meaning and requires a different set of tactics to achieve it. While its effects on surface hydrology can be high, due to its relatively small footprint it can be managed by applying best engineering practices. However, its effect on quality of both surface and groundwater can be quite significant as well and much more difficult to remediate once impacted.

Deforestation should not prevent mining, although timing could make a difference; and conversely, with good scheduling and planning mining should not prevent at least a first logging harvest, but it obviously removes regrowth potential in the short term and without reclamation, indefinitely. Therefore, as duly noted in Section 3.0, it is not addressed as part of the baseline for this assessment. However, a separate study would be very helpful, not only of mining, but all potential activities that could affect socio-economic and environmental conditions. Collectively, these studies could be integrated and a comprehensive long-term sustainable development extension plan could be produced.

4.1 Prey Lang Forest Baseline

Prey Lang is the last remaining forest area in Cambodia where differing forest types, including deciduous and evergreen, are found intact in a continuous landscape. Prey Lang falls under the jurisdiction of the Forest Administration (FA), and has the largest lowland evergreen forest in Cambodia, which is one of the largest tracts in the Indo-Burma hotspot and one of 25 biodiversity hotspots worldwide (Schmidt & Theilade, 2010). In addition to grades of forest from dry evergreen to semi-evergreen to deciduous, there are additional tree type communities including mixed deciduous forests dominated by Crape Myrtle, short riparian and Myrtle forests, short semi-evergreen forests, deciduous, swamp forests and evergreen swamp forests (McNaughton, 2009).

In 1993, Cambodia established 23 protected areas by Royal Decree; these areas encompass over 18 percent of the Kingdom's land area. Three forest conservation areas were later established to explicitly promote biodiversity conservation (www.biodiversityhotspots.org). A 1997 survey by the British NGO Fauna and Flora International, found Prey Lang to be one of the richest biodiversity hotspots in Asia, containing endangered species including elephant, tiger and the Siamese crocodile, thought to have been extinct in the wild.

Biological surveys have been underway since 2007 by the Forestry Administration, Conservation International (CI), University of Copenhagen and others to determine if the area should be considered a priority for conservation. Furthermore, Prey Lang Forest area has been nominated for World Heritage status. The central area, which is of most biological importance and the most intact, covers roughly 135,000 ha (18% of entire forest).

The Prey Lang Forest is generally referred to as the lowland evergreen forest (Ashwell, 2008; McNaughton, 2009). Seven distinct types of forests have been identified by Schmidt and Theilade in Prey Lang and are described in Table 4.1 (2010).

Table 4.1 Forest Types of Prey Lang

Deciduous forest	Forest similar to the dry seasonal forest found in dryer climates Indochina. Trees are relatively short (3-12 m). Mainly drought tolerant species with small leaves and thick barks. Dry deciduous forests form a transition to natural grassland, which are found on the very dry sandy sites.
Evergreen short forest	Transition type forest to tall evergreen forest, and often with similar species composition, yet trees are significantly smaller.
“Sralao” (Lagerstroemia) forest	Lagerstroemia stands are distinct by their white bark and high, erect, fluted stems. They often dominate patches of forests.
Short riparian forest	Forest type occurs near rivers and streams, periodic inundated and remaining moist during the dry season.
Deciduous swamp forest	A quite unique forest type occurring around Pes Lake in northern part of Prey Lang. Several unique species and growth forms, normally associated with mangrove forest are found in this swamp forest.
Tall evergreen dipterocarp forest	Forest type found on the moist but not waterlogged areas. The forest consists of a large diversity of species with canopy closure at 30-50 m.
Evergreen swamp forest	Forest type occurs on wet sites with permanent or long term flood inundation. The forest type is rare and endemic to Cambodia.

(Source: Schmidt & Theilade, 2010)

Lowland evergreen forests contain not only higher diversity of tree species than semi-evergreen and deciduous forests, but higher numbers of rare trees (Ashwell, 2008). This area stores more carbon than other forest types, as timber volume and biomass in their undisturbed state is higher than other forest types in Cambodia (Ashwell, 2008). There are 53 rare species of lowland evergreen trees, 21 of semi-evergreen species, and 12 of deciduous species considered rare or relatively rare (over 30m in height). An additional 38 species can be added if all trees over 10m are taken into consideration (Dy Phon and Rollet, 1999 IN Ashwell, 2008).

The endemic evergreen swamp forest is unique to Cambodia (Schmidt & Theilade, 2010), and the Prey Lang Forest has the only deciduous swamp forest in Cambodia. The few remaining areas of swamp are about 35 ha in size. These areas are thought to have significant carbon potential.

Swamp and riverine forests are botanically unique and serve as water sources for wildlife, and are particularly sensitive to disturbance, such as conversion to rice paddies. Generally, swamps are in fact wetlands, as defined by standard environmental references. Wetlands are increasingly becoming protected areas as a matter of environmental importance.

There are isolated pockets of endangered tree species, such as *Afzelia*, *Diospyros,* and *Dalbergia* in the tall dipteropcarp forest, which are already extinct in many localized areas within the Prey Lang Forest (Danida, 2004). The surviving species are threatened by illegal logging due to their high economic value and accessibility. According to Schmidt and Theilade, “the continued fragmentation of the dwindling populations may affect regeneration and long-term survival of these highly valuable species in Prey Lang (2010).” As these tree populations dwindle, their environmental rarity increases their critical importance and raises their ecologic value; arguably to priceless.

In addition to its unique flora biodiversity, there is a unique fauna biodiversity within the Prey Lang area sensitive to the forest and hydrology balance, including the 55 km reach of the Mekong River referred to as the “Central Section” between Kratie and Stung Treng into which the Siem Bok watershed discharges. Within this section, a rare richly diverse aquaculture of national and global significance has recently been discovered, including the Cantor’s Giant Soft Shell Turtle thought to be extinct, as well as the endangered Irrawaddy Dolphins (MRC SEA Report, 2010).

4.1.1 Forest and Hydrology

This study assesses the potential socioeconomic affects of changes in hydrology as a result of clearing the forest. It is assumed that the most significant change to the hydrology associated with the forest is loss of cover area. This results in exposed and vulnerable surface soils, which effects stream flow and discharge, local weather conditions and global climate changes.

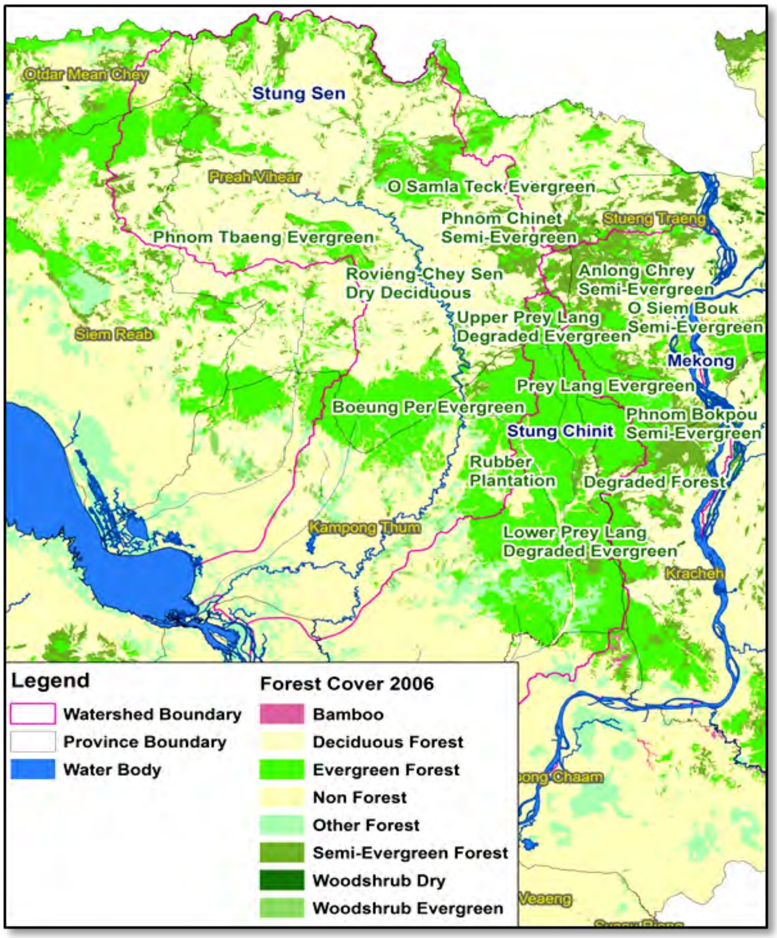
A variety of factors contribute to forest loss including: logging (both commercial and illegal), agriculture, fuel wood, new settlements, roads (logging and development), as well as forest fires and infrastructure development (MRC, 2003). Logging roads have eased the way for new settlers to reach the interior of the forest and the increasing population has caused agricultural clearing, primarily by shifting forest to subsistence farming. As is common in most developing economies, lack of an enforced land title and legal process to ensure ownership security leads to poor land management, compounded by poor farming practices which cause further forest degradation. Forest and hydrology relationship is described in detail in Section 4.2.8.

The first step of the assessment was to estimate the current area of the forest, and then to project the rate of area forest decay as a result of forest development. Generally, forests are delineated by a common density and stand of trees defined by the contiguous tree line separating it from the adjacent transitional ecotone. There are no known official demarcations of the Prey Lang Forest, but it is generally referred to as the predominant evergreen forest located along the west bank of the Mekong River just south of the Cambodia/Laos border to southern border of the Kratie Province (Schmidt & Theilade, 2010; Aruna, 2009; Ashwell, D, 2008; Olsen, A & D. Emmet, 2007). Well over 80% of the forest lies on the west side of the river, but some smaller stands lie to the east, which are not included as part of this study. Section 3.0 describes the process used to estimate the area of Prey Lang Forest in detail.

4.1.2 Spatial Extents of Prey Lang Forest

Aruna (2009) determined the forest size to be 840,000 ha, while Schmidt & Theilade (2010) used 520,000 ha and there are numerous estimates in between. Variances in forestry cover estimates could be due to a variety of reasons, such as comparing different data sets to estimate the same parameter, using different classification of forest types which changed over time, as well as difficulty in distinguishing regrowth cover from mature forest cover, so that regrowth in cleared areas is misinterpreted as mature cover. Figure 4.2 shows the cover area used for this study.

Figure 4.2 Prey Lang Forest Cover Map



Using the definition of the forest cited above in Table 4.1, and the common forest area shown in Figure 4.2, the area of the forest is approximately 890,000 ha and by removing the stands across the river would be 834,000 ha. This study classifies three types of forest, as suggested by the FA: evergreen, semi-evergreen, and dry deciduous, totaling 760,000 ha. Figure 4.2 illustrates the various forest classifications in Prey Lang and Table 4.2 below reflects various forest area estimates.

Table 4.2 Classification of Prey Lang Forest Type

Forest Type	Hectares	%
Evergreen	406,884	39%
Semi-Evergreen	160,724	15%
Dry Deciduous	192,398	18%
Total Forest	**760,006**	**72%**
Total Non-Forest	289,649	28%
Total Prey Lang Land Area	**1,049,655**	**100%**
Adapted from Aruna, 2009		

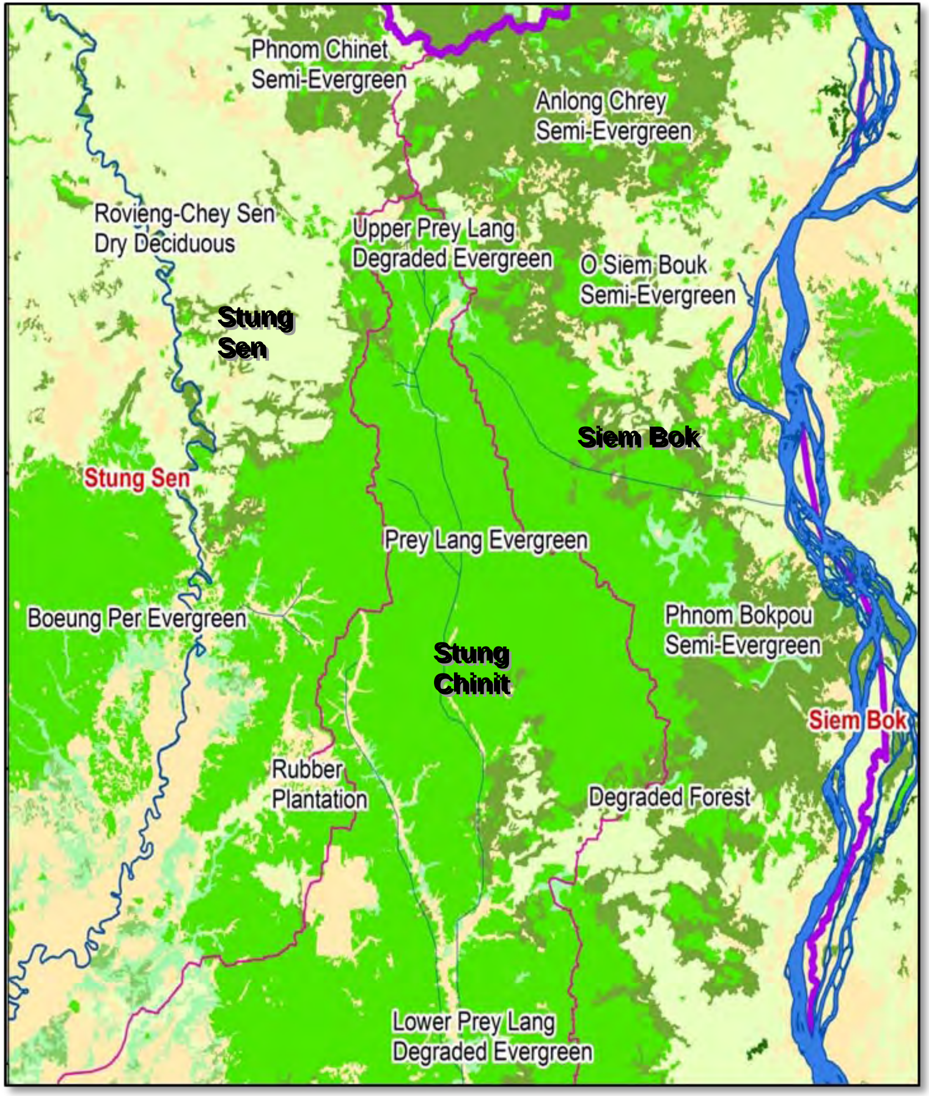
4.1.3 Prey Lang Forest Physical Characteristics

FOREST TYPE DISTRIBUTION

The evergreen, semi evergreen and dry deciduous forests cover an area of 760,000 ha. The rest of the area is designated as non-forest and includes: degraded/other forest, grass, agriculture, plantations and shrub lands. It accounts for 289,649 ha out to the total Prey Lang area of 1,049,654 ha (Aruna, 2009).

The forest lies within three watersheds: Siem Bok, Stung Chinit, and Stung Sen, as shown in Figure 4.3. See Section 4.2.1 for further description of the watersheds.

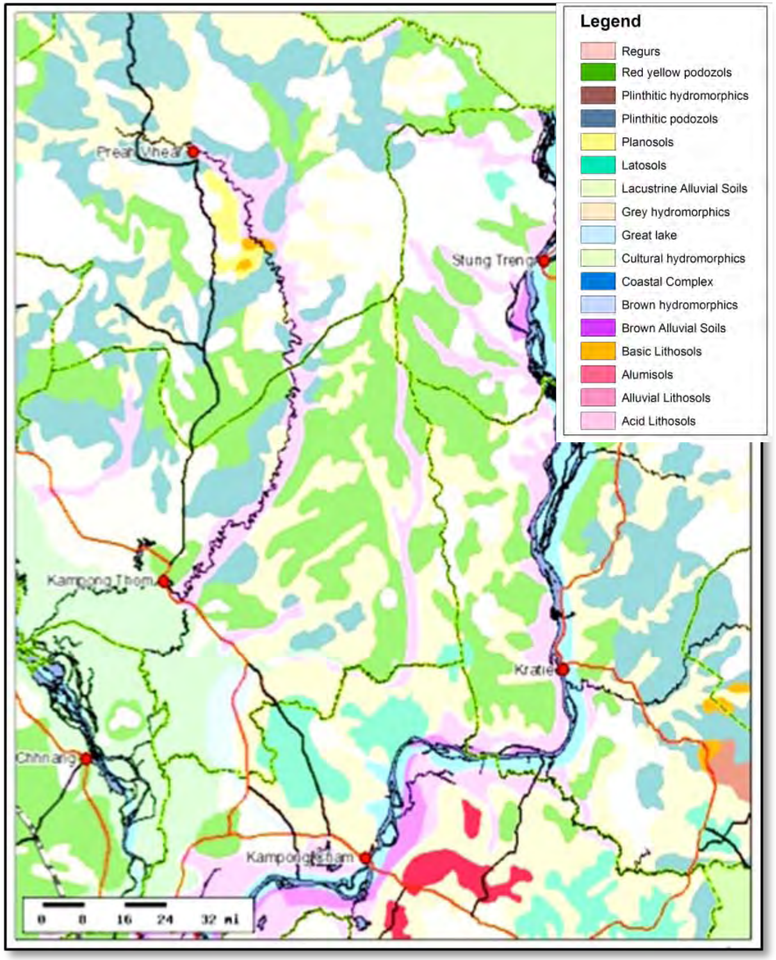
Figure 4.3 Prey Lang Forest Types & Watershed Areas



SOILS

Soils in the Prey Lang forest area are derived from ancient alluvia. The predominant soils of the forest are shallow hydromorphic soils and deep podzols. The hydromorphic soils develop under wetland conditions with poor drainage such as marshes, swamps, seepage areas, or flats. The podzols typically have low water storage capacity, but leach rapidly and contain low nutrient concentrations. These soils tend to have poor fertility, and consequently low potential for agricultural use (MAFF, 2006; Ashwell, 2008). However, there are small areas of alluvial organic sediments within dry evergreen forests (Ashwell, 2008), which provide rich soil more favorable to farming. See Figure 4.4 for a depiction of the soils.

Figure 4.4 Study Area Soils



Source: Atlas of Cambodia, Danida

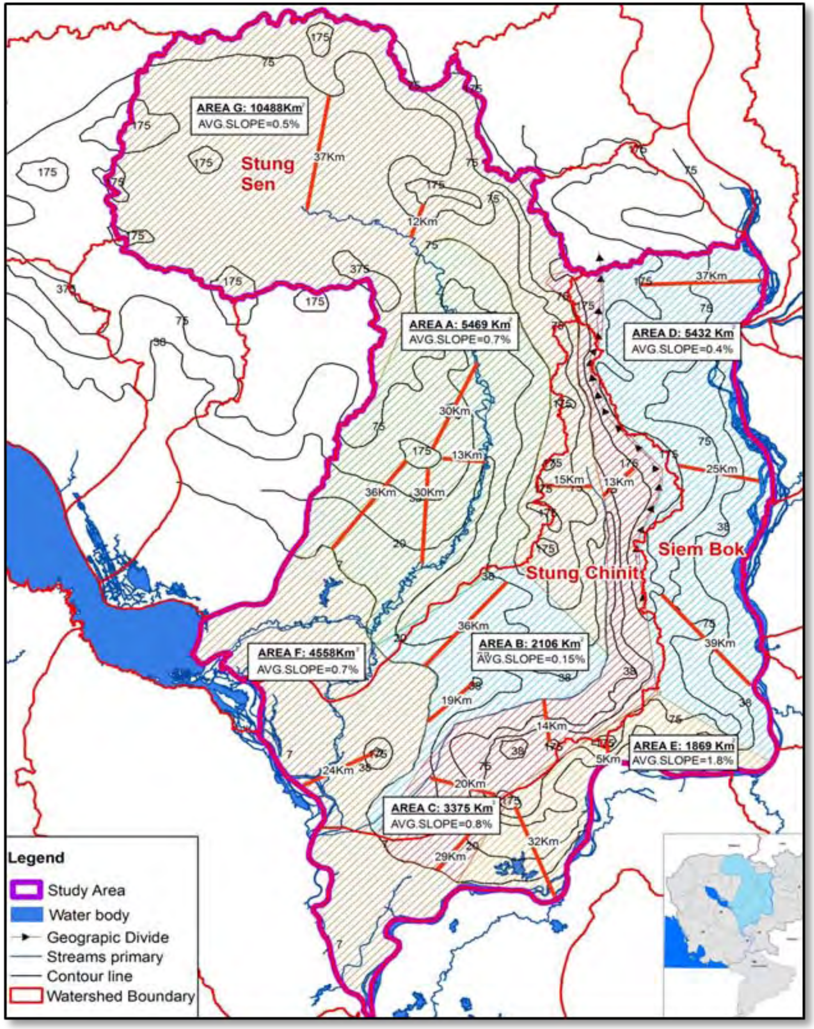
INFILTRATION PROPERTIES OF SOIL

The poor drainage soils are in the low land areas with little infiltration and low velocities. The storage capacity characteristics of the podzols would indicate a low infiltration with higher drainage potential, but with slow velocities due to the generally low gradients of the topography, as discussed below.

TOPOGRAPHY

Slopes within the Assessment study area are generally flat, with slopes ranging from 0.15% to 1.8%. Comparing the three watersheds, Siem Bok has steeper slopes ranging from 0.4%-1.8% as shown in Figure 4.5.

Figure 4.5 Study Area Slopes

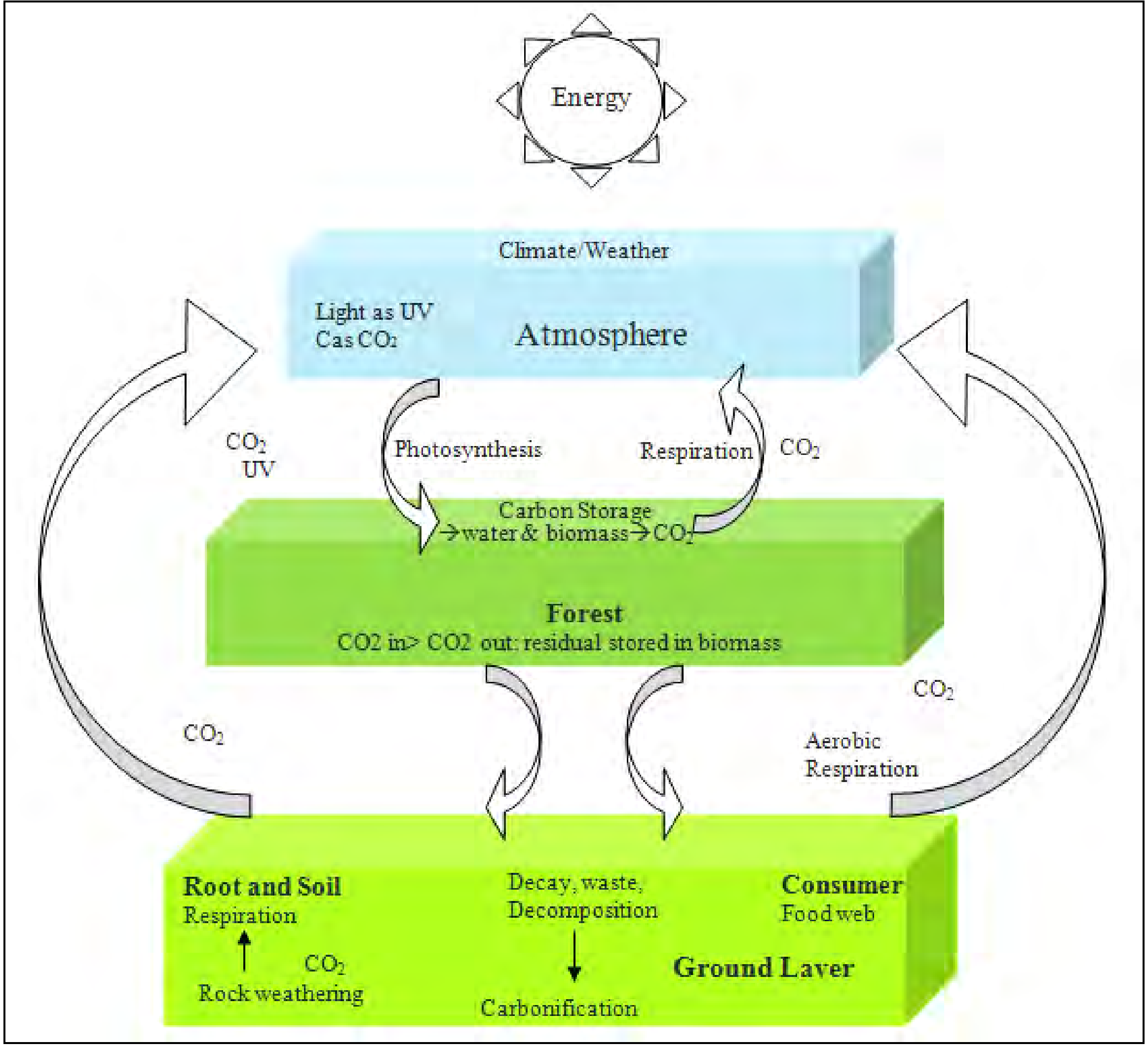


4.1.4 Carbon Cycle

Of all the services provided by the forest, photosynthesis and carbon sequestering may have a more urgent value today because of the growing awareness of the effects of excess concentrations of carbon dioxide (CO_2) building up in the atmosphere. This buildup is considered a likely cause of climate change. Figure 4.6 shows the process for the conversion of CO_2 from the atmosphere to oxygen, water and biomass within the tree.

Some of the carbon is stored in the biomass (sequestered) and the remainder is converted back into CO_2 and respired back into the atmosphere. All plants go through this process, but the large mass of a tree's biomass makes them especially effective in removing large volumes of CO_2 from the atmosphere. The effectiveness is increased with size of the tree. Tropical and swamp trees (wetlands or ramsar) are considered among the most effective.

Figure 4.6 Forest CO_2 Cycle



4.1.5 Prey Lang Forest Clearing Rates

The estimates of forest clearing rates are based on comparing forest cover over the years as interpreted by the various sources. Focusing on Prey Lang specifically and comparing a forest cover map from 1976 and a Terrestrial Vegetation map of 2005 from the Atlas, it is estimated that the Prey Lang cover has decreased by approximately 6% with most of it occurring in the northern most reaches of the forest. This study estimates that 6% of the forest cover has been cleared since 1973 (see Table 4.3). From 1973-1997 the total clearance was 9,000 ha with an average of 380 ha per year, and from 1997-2009 the total removed was 37,893 ha with an average of 3,158 ha per year. This 8-fold increase indicates that significant Prey Lang Forest exploitation started in 1998, with a slight decrease after 2004 presumably due to holds on concessions within the forest.

Table 4.3 Prey Lang Forest Clearing Rates (1973-2009)

Years	Interval Years	Forest Cleared	Annual Clearance	Net Annual Cleared
		ha	ha	%
73-84	11	2,814	256	0.03
84-90	6	2,295	383	0.05
90-97	7	3,997	571	0.07
97-00	3	9,200	3,067	0.40
00-04	4	17,802	4,451	0.57
04-09	5	10,891	2,178	0.28
73-09	36	46,999	1,306	0.16
Current forest cover*		760,000		
Original forest cover		806,999		
Overall clearance of 36 years:				5.8%
Average clearance per year:				0.22%
Maximum clearance per year:				0.57%
Minimum clearance per year:				0.03%
* From Table 4.2				

Table 4.4 summarizes the results that provide a more conservative estimate of clearance rates over three years.

Table 4.4 Prey Lang Forest Clearing Rates (2006-2009)

	% Coverage			
Prey Lang Forest type	**2006**	**2009**	**Δ %**	**Annual Ave Δ %**
Evergreen	41.1	38.8	2.3	0.8
Semi-Evergreen	17.7	15.3	2.4	0.8
Deciduous	27	18.3	8.7	2.9

(Source: FA 2006 IN Aruna, 2009)

It was assumed that the high deciduous clearing rate is due more to settlement clearing, subsidence farming and firewood.

Wood density for evergreen forest is 128 m^3/ha with a cover ranging between 70-90% depending on density. For deciduous forest the density is 95 m^3/ha with cover significantly lower and seasonal. Mixed forests would fall somewhere in between. The cover loss to date is primarily through illegal logging and encroachment for agriculture, since current legal concessions have been under a moratorium since about 2004, which is reflected in the clearance table (Table 4.3). Luxury woods *Afzelia* and *Dalbergia* are steadily logged on a small scale, and are becoming locally extinct in many areas. Regeneration and long term survival is threatened by fragmentation and declining species populations.

FA has set limits of harvest volumes to 10 m^3/ha with harvests limited to no more than 30 percent of market volume stand (based on 25-30 year rotation plans) (McKenny, 2002). Most active concessions have been logged at a pace far higher than these limits, and questions remain about the commercial viability for companies logging within FA limits. Operators have financial incentive to harvest as much as possible, as quickly as possible (McKenny, 2002).

The following default rates and areas (Table 4.5) are used for this assessment as interpolated from the references.

Table 4.5 Forest Baseline Parameters

Current Forest Cover	760,000 ha
Estimated cleared land for all uses Cleared rates (since 1998)	46,999 ha
Mean	0.3%
Max	0.5%
Min	0.2%
Annual clearance by forest type (2006-2009)	
Evergreen	0.8%
Semi-evergreen	0.8%
Dry Deciduous	2.9%

4.1.6 Economic Land Concessions

Approximately 288,525 ha have been let as Economic Land Concessions (ELCs) within the provinces of the study areas, for teak, rubber, Fang lean, accadia and other (agro industry), listed in Table 4.6. Prey Lang is governed by the Forest Law, and classified as state private land. ELC is a broad term that refers to land concessions in general. Forest concessions refer to concessions within a forest area. Figure 3.9 shows the locations of current ELC within the study area. ELCs can apply to a forest or any tract of land; however, there is a moratorium on logging forest, and limited the economic viability of forestry in many concessions.

Table 4.6 Economic Land Concessions in Study Provinces

Province	Concession	Area (ha)	Type of Crop
Stung Treng	Cassava Powder Production Co. LTD.	7,400	Teak
	GG World Group (Cambodia) development Co. LTD	5,000	Teak and smallwood, fruit trees
	Sopheak Nika Investment Agro-industry Plant	10,000	Rubber, acacia and teak
	Sal Sophea Peanich Co. LTD	9,917	Rubber acacia and teak
	Grand Land Agricultural Development Co. LTD	9,854	Teak and other crops

Table 4.6 Economic Land Concessions in Study Provinces (continuation)

Province	Concession	Area (ha)	Type of Crop
	Siv Guek Investment	10,000	Teak and other trees
	Pou Mady Investment Group	9,854	Teak and other trees
	Sok Heng Company Limited	7,172	Teak, accacia and others
	Sekong Development	9,850	Agro-industry and animal husbandry
	Green Sea Industry Co. LTD	100,852	Teak
Kratie	Global Agricultural Development (Cambodia) Co. LTD	9,800	Teak
	Asia World Agriculture Development	10,000	Teak
	Green Island Agriculture Development (Cambodia)	9,583	Teak
	Plantation Agriculture Development (Cambodia)	9,214	Teak
	Great Asset Agriculture Development (Cambodia)	8,985	Fang lean tree
	Great Wonder Agricultural Development (Cambodia)	9,231	Fang lean tree
	Tai Nam Ltd.	7,560	Rubber, cassava and cashew
Kompong Thom	Cambodia Eversky Agriculture Development	10,000	Cotton
	An Mady Group	9,863	Accacia
	HMH Co. LtD	5,914	Accacia
	Mean Rithy Co. LtD	9,784	Rubber
Preah Vihear	Cambodian Agro Industry Group	8,692	N/A
TOTAL		**288,525**	

(Source: MAFF 2007)

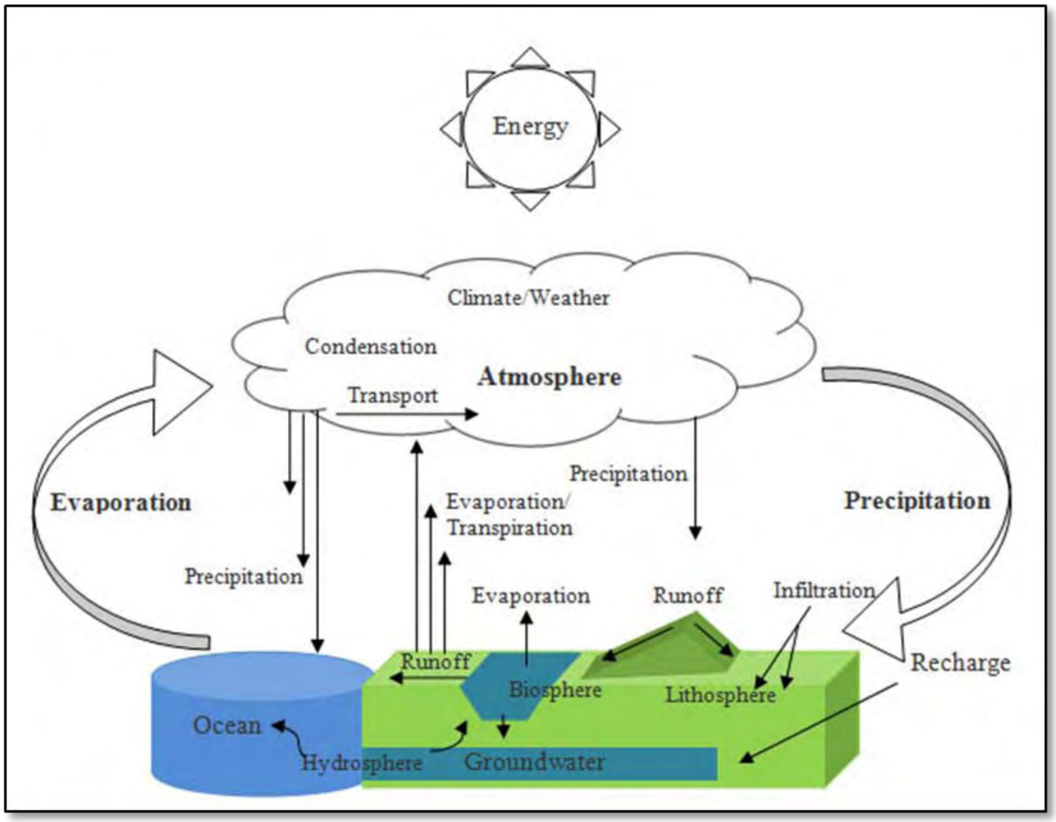
4.2 Hydrology Baseline

This section introduces general concepts of hydrology and presents historical hydrological data to show the baseline hydrologic conditions at key stations contained within the three watersheds that make up the Study Area: Siem Bok, Stung Chinit, and Stung Sen.

Figure 4.7 presents a basic conceptual model of the hydrological cycle, which is one of the major natural cycles on earth, which interacts with each of the earth's primary systems: lithosphere, biosphere, atmosphere and hydrosphere.

The driving forces of the hydrologic cycle are the climatic systems and local weather patterns, which are also the deterministic factors for ecosystems and biomes around the world; the Prey Lang Forest serves as an excellent example of these ecosystems and biomes.

Figure 4.7 Simplified Hydrological Cycle



Tropical rain forests require low elevation, relatively constant temperature, high humidity and heavy rainfall. Any major natural disruption in one part of the world, for example, a volcano erupting in Indonesia, will upset the normal weather patterns locally and can have major impacts globally. Typically, the various cyclic systems rebound on their own; recovering slowly in response, to the most stable micro-biosystems at the lowest level seeking to reach homeostasis. The exception to this is recovering from anthropogenic disruptions, which tend to be self-sustaining because the cause is driven by satisfying increasing needs, perpetuating the cycle of the disruption. Whereas natural disruptions can have immense immediate and disastrous results to living systems, they are generally relatively short lived, allowing recovery to start right away. On the other hand, human disruptions start out slow and small, but their effects can be very long lasting, making recovery very difficult. Frequently, this is because the supply of the resource has been exhausted, making full recovery to the natural state before exploitation nearly impossible.

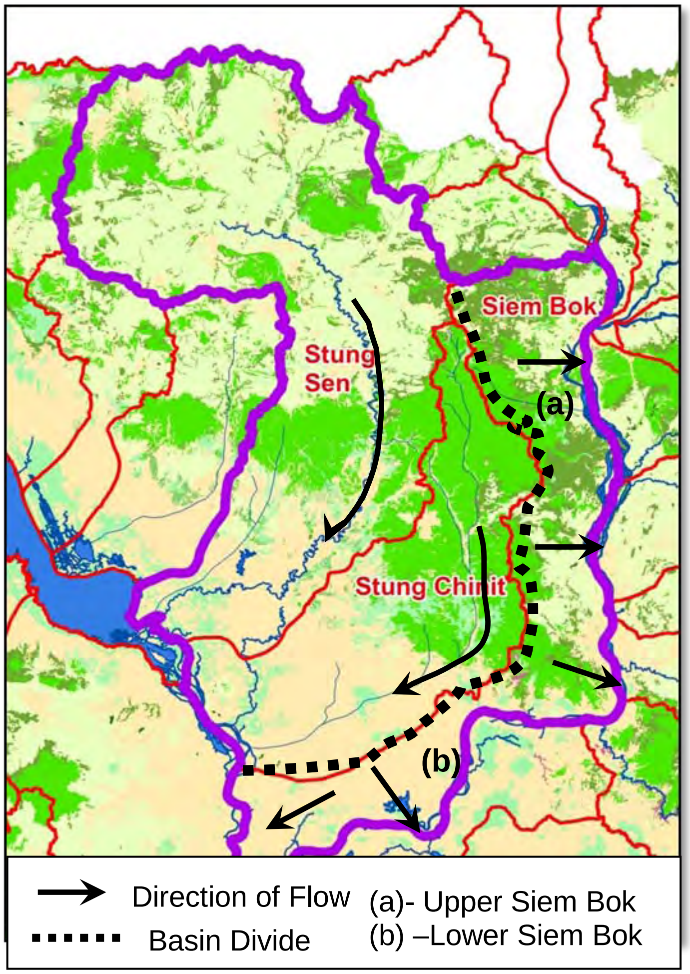
All systems, biotic and physical, are interrelated, and are important to the optimal state that best suits the needs of the system as a whole. This includes humans, who are an integral part of the system, not above it. Each entity provides services through its natural behavior and instincts that contribute to the survival of those entities on which it depends; hence all are interconnected either directly or indirectly. The multiple conditions of the optimal state at any one time (as measure in geologic time) are not static but dynamic, reinforced as it adapts to changing conditions while trying to maintain some instinctive level of homeostasis. Extinction of species or depletion of resources disrupts the optimal state, creating a new homeostasis to maintain, but whether the optimal state can ever or should be regained is arguable.

4.2.1 Watersheds

The entire Mekong River Basin catchment area is approximately 795,000 km^2 and reaches about 4,500 km from the highlands of Tibet to the South China Sea. The annual mean discharge is 475 billion m^3 (bcm). Lao PDR is the largest contributor at 35% of the total, and Myanmar is smallest at 2%. Cambodia and Thailand are essentially the same at 18% and Viet Nam contributes 11% (MRC, 2003). The Mekong River Basin catchment area within Cambodia is 155,000 km^2, which is 20% of the total basin and 86% of the entire country area (WEPA, 2010).

The primary water sources to the Tonle Sap Lake are the Mekong River (57%), watershed tributary discharge (30%) and precipitation (13%) (ARD Fish Report). Due in part to the complexity of the Tonle Sap / Mekong Water Basin dynamics, as discussed previously, the study area is defined by the three watersheds: Siem Bok, Stung Sen and Stung Chinit, in which a significant portion of the Prey Lang Forest is located (Figure 4.8). These three watersheds make up about 22% of the entire Cambodian Mekong River Basin catchment area.

Figure 4.8 Watershed Boundaries



A topographical divide separates the Stung Sen and Chinit watersheds from the Siem Bok watershed as shown in Figure 4.9. This dictates the direction of water flow from each watershed; water from the Stung Sen and Chinit flows towards the Tonle Sap, and most of the water from the Siem Bok flows towards the Mekong. Tables 4.7 and 4.8 show the areas of watersheds and the percentage of forest and non-forest within each watershed.

Table 4.7 Forest & Watershed Areas

Watershed	**Watershed Area**	**FOREST TYPE**								**Total Forest Area**	
		Evergreen		**Semi-Evergreen**		**Deciduous**		**Degraded Evergreen**			
	Sq. Km	**Sq. Km**	%	**Sq. Km**	**%**	**Sq. Km**	**%**	**Sq. Km**	**%**	**Sq. Km**	**%**
Siem Bok	8,851	512	6%	1150	13%	22	0.2%	493	6%	**2,177**	**25%**
Stung Sen	16,360	1,320	8%	190	1.2%	1,735	11%	374	2%	**3,619**	**22%**
Stung Chinit	8,237	1,084	13%	5	0.1%	28	0.3%	1,410	17%	**2,527**	**31%**
Total	**33,448**	**2,916**	**9%**	**1,345**	**4%**	**1,785**	**5%**	**2,277**	**7%**	**8,323**	**25%**

Table 4.8 Non-Forest & Watershed Areas

Watershed	**Watershed Area**	**NON-FOREST TYPE**								**Total Non-forest Area**	
		Woody Shrub		**Plantation**		**Degraded**		**Other***			
	Sq. Km	**Sq. Km**	%	**Sq. Km**	**%**	**Sq. Km**	**%**	**Sq. Km**	**%**	**Sq. Km**	**%**
Siem Bok	8,851	29	0.3%	23	0.3%	9	0.1%	6,613	75%	**6,674**	**75%**
Stung Sen	16,360	134	0.8%	3	0.02%	145	0.9%	12,741	78%	**13,023**	**80%**
Stung Chinit	8,237	56	0.7%	0.2	0.002%	38	0.5%	5,710	69%	**5,804**	**70%**
Total	**33,448**	**219**	0.6%	**26.2**	0.08%	**192**	0.6%	**25,125**	75%	**25,501**	**76%**

** Other refers to lowland areas of Tonle Sap, including agriculture, barren lands, and, wetlands.*

STUNG SEN WATERSHED

The Stung Sen River flows into the Tonle Sap Great Lake, which is connected to the Mekong River via the Tonle Sap River. Hydrological and meteorological data was collected from four monitoring stations in this watershed. The stations, from north to south, are Kampong Putrea, Taing Krosang, Sandan, and Kampong Thom.

The Stung Sen watershed includes most of the Preah Vihear Province to the north and most of the northern half of the Kampong Thom Province to the south. This watershed is sparsely populated, although the river is a major tributary to Tonle Sap.

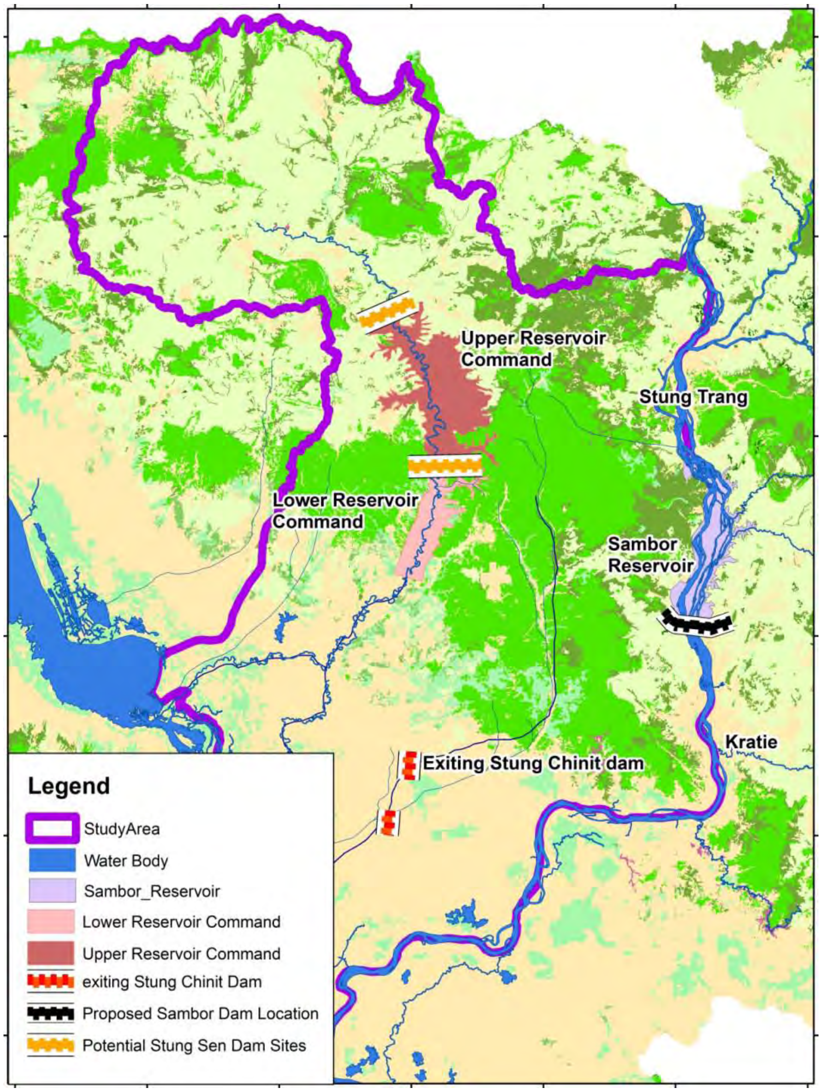
Hydrological and Meteorological data was collected from Mekong River Commission (MRC) Hydrologic Yearbooks, as well as from the Provincial Department of Water Resources and Meteorology (PDOWRAM) offices in Kampong Thom during the initial Prey Lang field trip in September 2010. Additional data was obtained from the International Water Management Institute (IWMI) World Water and Climate Atlas. Between the years 1960-1990, the aforementioned stations reported an average precipitation of 1460 mm per year and evaporation rates of 1550 mm per year. The average runoff is estimated at 11,685 m^3/s (WEPA, 2010).

Changes in Stung Sen River flow have been reported since 2000. These changes are reportedly due to forest concessions in the Prey Lang Forest, resulting in an apparent corresponding increase in flooding (Mak, 2005). However, the relative scale would indicate that there is insufficient information to draw any definitive correlation one way or the other.

STUNG SEN IRRIGATION

There are currently no irrigation systems in this watershed and the river floodwaters provide water for farmland. Feasibility and environmental studies are being conducted to assess building a large irrigation/hydropower system on the Stung Sen River to increase irrigated land as much as 130,000 ha; potentially tripling current paddy rice production. In addition, the system would provide estimates of 40MW of hydropower (Sithi.org, 2009). The proposed location is shown in Figure 4.9.

Figure 4.9 Proposed and Existing Dam Locations



STUNG SEN RIVER FISHERIES

The Stung Sen River is a tributary of the Tonle Sap providing an important migratory path for fish. Currently, the Stung Sen watershed provinces are generally undeveloped, and the portion of the Prey Lang forest in the area is relatively small. However if the proposed irrigation/hydropower plant is constructed and the forest developed, it seems likely that this area will experience significant growth.

Changes along the river hydraulics as a result of forestry and dam construction, would have a noticeable effect on local fishing, as well as Tonle Sap fisheries, this includes the irrigation dams and reservoirs, with the outflow through spills replenishing oxygen concentrations, reduced within the reservoir due to decay of organic material. The oxygen increase in outflow can be as much as 20% of the inflow into the reservoir (Baran, 2007).

STUNG CHINIT WATERSHED

The Stung Chinit flows into the Tonle Sap Great Lake River. Hydrologic and meteorological data has been collected from the Stung Chinit and Kampong Thmar monitoring stations located on the river and its major tributary, obtained from the same sources as cited above.

The Stung Chinit watershed includes the southern portion of the Kampong Thom Province and the northern portion of the Kampong Cham Province, which lie north of the Mekong River.

The area receives an average of 1400mm of rain per year and evaporates 1,530mm per year based on data covering the period from 1960-1990. The average discharge (total cumulative runoff) from the Stung Chinit watershed is estimated to be 6,711 m^3/s (WEPA, 2010).

STUNG CHINIT IRRIGATION

The Stung Chinit Irrigation System and Rural Infrastructure Project is currently the largest in Cambodia (Baran, 2007). This project has been in operation since 2006, as part of the Second Socio-Economic Plan of Cambodia, to reduce poverty by improving agricultural production by increasing irrigation coverage. Therefore, it is anticipated that irrigation capacity will increase substantially over time, within the study area and throughout the country (Baran, 2007).

The Stung Chinit reservoir is approximately 12 km long with a total storage area of 25 km^2. Up to 60 million m^3 (mcm) of water can be stored. The spillway is built across the Stung Chinit River to irrigate surrounding agricultural land in Santuk and Baray districts of Kampong Thom.

There are two Tonle Sap tributaries in the area: Stung Chinit and Tang Krasang. The project is intended to benefit 2,400 households within 3 communes and 25 villages, mainly in Kampong Thmor commune. The irrigated area is projected to be 3,000 ha in the wet season (supplemental irrigation) and 1,800 ha in the dry season (full irrigation). The project was designed to deliver economic benefits primarily through increased agricultural income and productivity. The overall cost of project maintenance has been estimated to be US$80/ha/year, and water use fees are planned to offset these costs (Baran, 2007).

It is too early to assess direct impacts of the irrigation system on socio-economic status of communities and downstream beneficiaries. Reportedly, there are conflicts with upstream forestry development, and mining activity. There are engineering controls which could mitigate the issues, but much more detail would be necessary.

STUNG CHINIT RIVER FISHERIES

The Stung Chinit River system has one of the richest natural fish populations migrating upstream and downstream (Try, 2008). Seventy-nine species were found in 2003-2004 (Puy, 2004 IN Try, 2009). Prior to the construction of Stung Chinit reservoir, fish catch was 7,000 tons/year from five commercial fishing lots downstream in Tonle Sap Lake, and 1406 tons/year from families and professional catches (Try, 2008). It is not known at this time what impact the reservoir may have had on the production.

Prey Lang is heavily forested the northern portion of the Chinit Watershed. Heavy logging of this area could affect the richness of the fish populations, and biodiversity along the Chinit River, as well as reduce fish catch yield without engineering controls to reduce sedimentation and manage flow.

SIEM BOK WATERSHED

The Siem Bok is a long narrow watershed along the west bank of the Mekong, discharging into the vulnerable biodiverse “Central Section” as discussed previously in the report. Below Kratie, the watershed lies along the north bank of the southwest trending river, terminating at the Tonle Sap River and Phnom Penh. The watershed has two directional axes, one running north-south, referred to in this report as Siem Bok (a); the other running to the south west and referred to as Siem Bok (b). The upper third of Siem Bok (a) lies in the west portion of the Stung Treng Province, and lower two thirds lies in the west portion of the Kratie Province. All of Siem Bok (b) lies in northern portion of Kampong Cham Province. See Figure 4.8.

Essentially all of the Prey Lang Forest focus area within this watershed lies within the Siem Bok (a) along the Central Section of the Mekong, which is the river reach between Stung Treng and Kratie monitoring stations. The area is rural with a low population density.

Siem Bok (b) is medium to highly populated and could be considered peri-urban area devoid of forest. Its area lies within the socio-economic focus area, with a projected population growth increase of nearly 100% by 2020 (Atlas of Cambodia, 2006).

There is no hydrological and meteorological data collected directly from the Siem Bok Watershed. Therefore, the data was interpolated from six monitoring stations in the general vicinity, as recorded in the MRC Hydrologic Yearbooks, and the IWMI World Water and Climate Atlas. The stations are: Stung Treng, Kratie, Kampong Cham, and three Phnom Penh stations (Mekong, Tonle Sap and Bassac). Between the years 1960-2004, the average annual rainfall for the area was 1420mm annually, with average evaporation rates of 1700mm per year.

Since the Siem Bok (a) areas is not very populated, there is not a great amount of farming activity, hence, little controlled irrigation. The most vulnerable area to forestry logging operations, would be the Mekong River between the Stung Treng and Kratie monitoring stations and more specifically the biodiversity rich Central Section. However, large hydroelectric projects are being considered atboth Stung Treng and Sambor, Kratie (ICEM, 2010). If these projects move forward, the impact of forest logging in Siem Bok, would be overwhelmed by those associated with the impact of these projects. Because of the low topography and nature of the river channel, the area of inundation would be quite large and could encroach on the forest.

4.2.2 Floodplain

The natural flood cycle as a result of the wet season during the months of July and October as discussed above is the basis for the high ecosystem productivity in the Lower Mekong floodplains. Changes in the frequency and amplitude of seasonal flooding due to increased runoff discharge into the Mekong River and the Great Lake as result of deforestation could significantly affect the flood cycle system, which would impact the ecosystem yield. In addition, flood delays can have dire effects of sensitive fish juveniles bred in the floodplains, due to slow arrival of oxygen rich waters.

The flood plain gauge heights for the study monitoring stations are listed below (Table 4.9) along with the equivalent rainfall (MRC Flood Report, 2010). The gauge heights are referenced on Ha Tien Datum.

Table 4.9 Flood Gauge Heights & Rainfall

Location	Flood Level Gauge Height (m)	Rainfall (mm)*
Stung Treng	12	460
Kratie	23	450
Kampong Cham	16.2	450
Phnom Penh Tonle Sap	11	ND
Phnom Penh Bassac	11	334

**Typical rainfall to reach flood gauge height.*

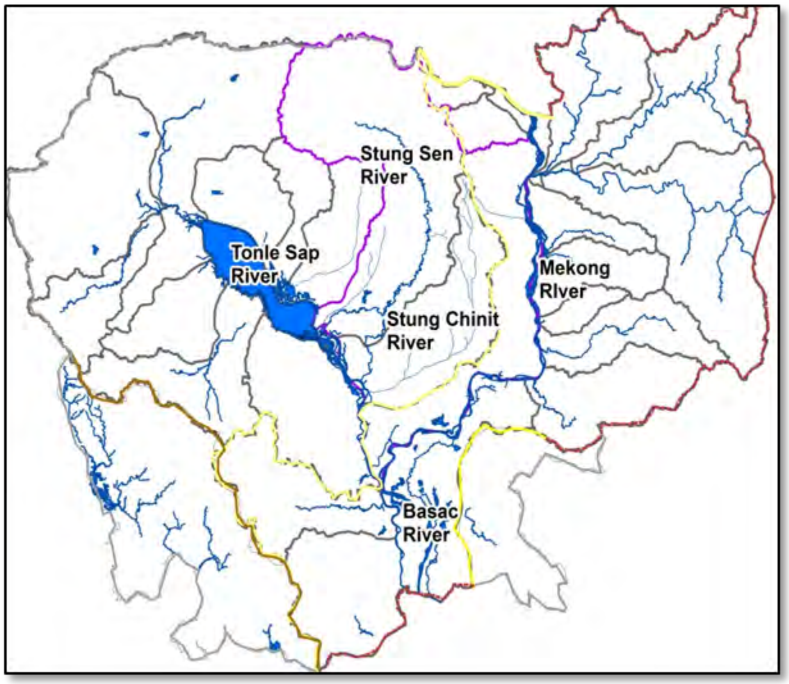
4.2.3 River Systems

As discussed in previous sections of this report, the predominant hydrologic system of Cambodia is the phenomenal water basin created by the drainage system into the Tonle Sap Great Lake and the Mekong River which hosts all of the major rivers of Cambodia. See Figure 4.10.

MEKONG RIVER

The length of the Mekong River within Cambodia is about 480 km reaching from the Lao PDR border to the north to Vietnam border to the south. The flow rate along this reach is 2,860m^3/s (MRC, 2003; WEPA, 2010). In an interesting 1999 study, the FAO estimated the total annual total discharge of the Mekong River into Cambodia to be approximately 300 billion m³, and the annual discharge as it flowed into the South China Sea was estimated to be 500 billion m³. A significant portion of this increase would be due to the contribution of the Tonle Sap Basin and the Mekong River within Cambodia.

Figure 4.10 River Systems



The Mekong River conditions are affected by projects already in existence upstream, creating a highly complex array of variables that must be considered when considering the impacts from any Mekong River development in Cambodia. The relationship between rainfall, runoff, and pollutant concentration/load is complex as well, and depends on the size of the river system – the larger the river, the more difficult it is to assess. And the Mekong is one the world's largest river systems (MRC, 2008).

The Mekong River reach between Stung Treng and Kratie, with a length of 55km, is referred to as the "Central Section" as mentioned above. It is relatively shallow and flows at high velocity, making the river difficult to navigate from north of Kratie to the upper basin. A significant portion of the discharge from the Upper Siem Bok (a) watershed flows into this section, which is a highly biodiverse section of the Mekong River.

South of Kratie the flow rates decrease as the river depth increases, making it navigable to the Bassac River, which branches off at Chactomukh as discussed below (See Figure 4.1). The Bassac is suitable for ocean class cargo ships up to 3,000 tons all the way to the South China Sea (Russell R. Ross, 1987).

The gradient of the Mekong River from the Cambodia/Laos border to the Kratie monitoring station is relatively steep with the average measured water level at the Stung Treng monitoring station of +41.07m above MSL Ha Tien, compared to the down gradient station at Kratie, with an average water level of +9.49m above MSL Ha Tien. (Note: Ha Tien is the reference datum point or bench mark, located in Viet Nam used to caliber water levels within the Lower Mekong Basin).

Below Kratie, the Mekong River gradient is relatively low as measured from Kampong Cham monitoring station, which has an average water level of +5.62m above MSL Ha Tien to Phnom Penh's Mekong station, which has an average water level of +3.95m above MSL Ha Tien.

MEKONG AND TONLE SAP RIVERS

The Mekong and Tonle Sap Rivers converge at a point called the Chattomukh (Four Faces), where they diverge into the Mekong and Bassac Rivers. From this point, the two rivers become independent headwaters of the Mekong Delta, which extends from Cambodia into Vietnam and discharges into the South China Sea (Russell R. Ross, 1987).

TONLE SAP RIVER

The directional flow in the Tonle Sap River is determined by the wet and dry seasonal flow of the Mekong River. During the monsoon rains of September to October the volume and height of the Mekong increases to a level where the flow into the Mekong Delta backs up into the Tonle Sap River which then reverses flow into the Great Lake raising the water elevations from a couple of meters to as much as 15 meters in elevation, an estimated 8-fold increase in elevation. This increases the size of the lake from approximately 2,500 square kilometers to about 25,000 square kilometers at the peak flow, approximately a 10-fold increase in area.

As the monsoon rains decrease, the flow in the Mekong recedes until it can return to the Delta and the Tonle Sap River reverses flow as the Lake recedes and returns to pre-monsoon levels, the lake volume bleeds into the Delta loaded with an immense bounty of fish.

BASSAC RIVER

The Bassac River serves a vital and often overlooked role in the hydraulic system dynamics. Deltas are extremely sensitive and vulnerable to seemingly minor disturbances. In a sense, the Bassac River serves as a spillway during the wet season, ensuring that a relatively constant flow reaches the Delta, and sustains it during the large seasonal water availability fluctuations.

During this unique dynamic stage, the Tonle Sap serves as a huge settling pond for sediments and each cycle and fresh layer of sediments is deposited in the lake and due to poor drainage along exposed lowlands returns to marshland, unsuitable for agriculture. Overtime, there is a natural net gain in the sediments retained in the lake versus those, which are transported out, due to the physical properties and dynamics of the lake. This is a natural lake succession, which over geologic time would normally lead to the ultimate transition of the lake to a terrestrial biome. However, in the case of the Tonle Sap / Mekong River system the succession is muted, and if left undisturbed may well continue indefinitely. Any change within the system, be it due to natural or anthropogenic occurrences, could affect the balance.

While the change could be in either direction as a result of a natural event, human related events would most likely increase the rate of succession as a result of altering the hydrology, hydraulics and loading of the Tonle Sap / Mekong Water Basin. Deforestation of any of the forests within the basin will have an effect. Neither the magnitude of the effect, nor the time in which they will occur is known. This study has attempted to provide some preliminary tools to decide how to manage perceived effects.

4.2.4 Groundwater

Cambodia has very limited groundwater information. Estimations by the Ministry of Water Resources and Meteorology (MOWRAM) report the potential groundwater resources to be 17.6 billion m^3. While it is not a primary water source at this time, groundwater is being used at an increasing rate as domestic water supply and for irrigation. There are at least 25,000 community water supply tube wells and large diameter motorized tube wells for irrigation in place, and about 2,000 manually operated shallow wells installed annually (Atlas, 2006).

There are reports of industrial use of groundwater, but information on quantities is not available. In general the available information regarding ground water reserves, yield and quality is very limited.

What is known is that one of the main sources of recharging the groundwater is surface water through infiltration and direct recharge pathways. As the use of groundwater increases, its sensitivity to surface water quantity and quality becomes increasingly important, and changes in surface water dynamics, such as runoff velocity and retention times, due to increased open surface area as a result of deforestation can have significant groundwater consequences.

Due to apparent lack of faulting or karst-like geologic features, direct surface recharge is suspected to be limited within the Study Area of the three watersheds. In addition, the highly responsive increases and withdrawal of the Tonle Sap flood zone to seasonal rainfalls would indicate that there is not a significant recharge system. However, the alluvial deposits of the Tonle Sap floodplain do present a likely host for extensive shallow water table aquifers, as supported by the large regional wetlands characteristic of the lake. Such aquifers are relatively easy and inexpensive to tap as a water supply, but also very vulnerable to natural, agricultural, industrial and domestic waste pollutants.

4.2.5 Prey Lang Hydraulics & Meteorology

HYDRAULICS

River Hydraulics data are measured by MRC and others at monitoring stations along the river reaches. For the purposes of this Study the two main monitoring stations on the Mekong River are located at Stung Treng and Kratie, and the downstream stations located around Phnom Penh, and Tonle Sap as well was the stations located within the study watersheds (shown in parentheses) important to assessing Tonle Sap. The monitoring stations included in the study are:

- Stung Treng
- Kratie
- Kampong Cham
- Phnom Penh Mekong
- Phnom Penh Tonle Sap
- Phnom Penh Bassac
- Kampong Thom (Stung Sen)
- Sandan (Stung Sen)
- Kampong Putrea (Stung Sen)
- Taing Krosang (Stung Sen)
- Kampong Thmar (Stung Chinit)
- Stung Chinit (Stung Chinit)

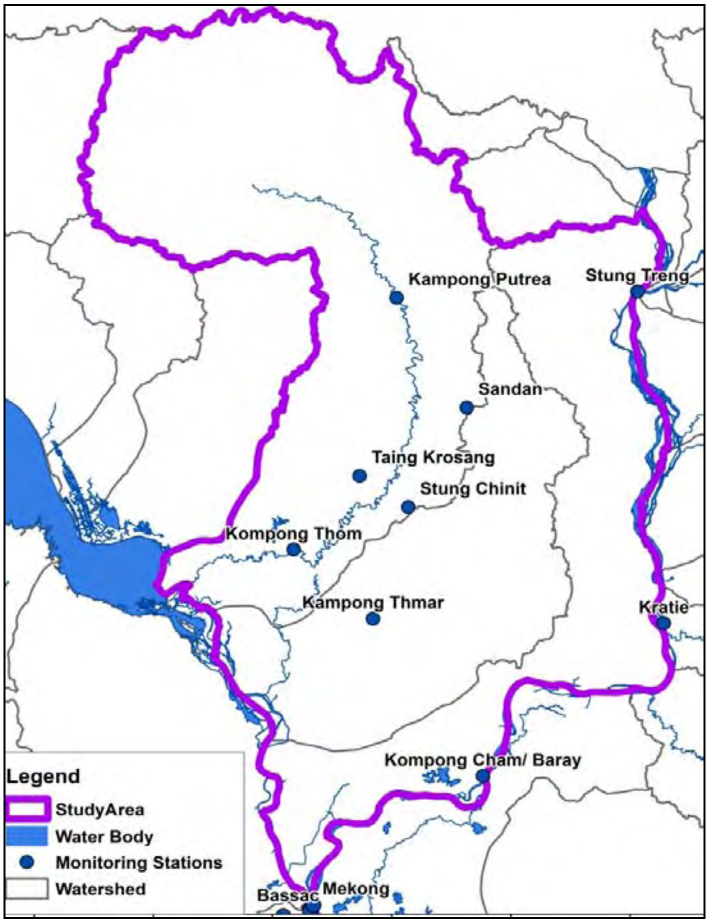
Monitoring station locations are shown in Figure 4.13. The key data being considered from these stations are:

- Annual rainfall
- Evaporation
- Weather parameters
- Discharge rates
- Gauge Height and flood levels
- Water Quality

Data has been reported for the last 50 years, from 1961-2010, using MRC Hydrological Yearbooks, PDOWRAM records, and the IWMI (International Water Management Institute) World Water & Climate Atlas. The IWMI World Water and Climate Atlas includes hydrological modeling software that provides meteorological data for locations based on their latitudinal and longitudinal coordinates, for the years 1961-1990.

Collectively, this data has provided the baseline for the hydrology and hydraulics of the study area, and have been used to qualitatively estimate the runoff volumes as a result to clearing caused by forestry operations. These have been used as a baseline to compare the potential magnitude of relative affects based on the three scenarios. See Appendix A for summary of data collected for this study.

Figure 4.11 Monitoring Stations Included in Study



CLIMATE & METEOROLOGY

Cambodia's climate is classified as a tropical monsoon climate with two distinct seasons associated with tropical monsoons:

- Dry Season from November to April, Northeast Monsoon
- Rainy Season from May to October, Southwest Monsoon

The country is defined by three climatic zones: coastal and mountainous area of the southwest, central plains which include the Mekong River and Tonle Sap Lake, and North and Northeastern Region.

Annual rainfall estimates vary by region. The lowland area around the Tonle Sap Lake receives about 1,200mm to 1,900mm of rain annually. The coastal zones receive the heaviest rainfall, about 3,000mm per year.

The graphs below (Figures 4.12-4.14) show monthly rainfall averages for each of the watersheds discussed in this study. In addition, wet season averages for rainfall and evaporation have been calculated and displayed on the graphs.

During the rainy season (May – October), the station at Stung Treng records an average rainfall of about 240-250 mm/month, Kratie records 245mm/month, Kampong Cham records 195mm/month and Phnom Penh records an average of around 180mm/month (MRC Hydrological Yearbooks, IWMI Climate Atlas). The graphs show the annual variations very well, and can be used as trends to highlight significant changes when and should they occur.

Figure 4.12 Mekong River Rainfall

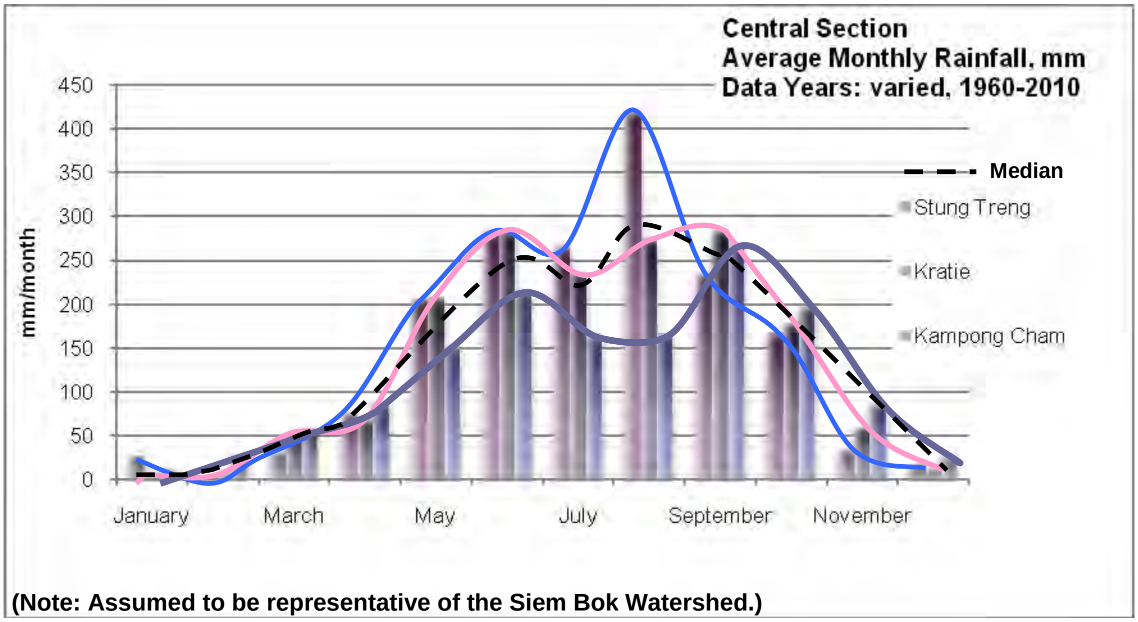


Figure 4.13 Stung Chinit Watershed Rainfall

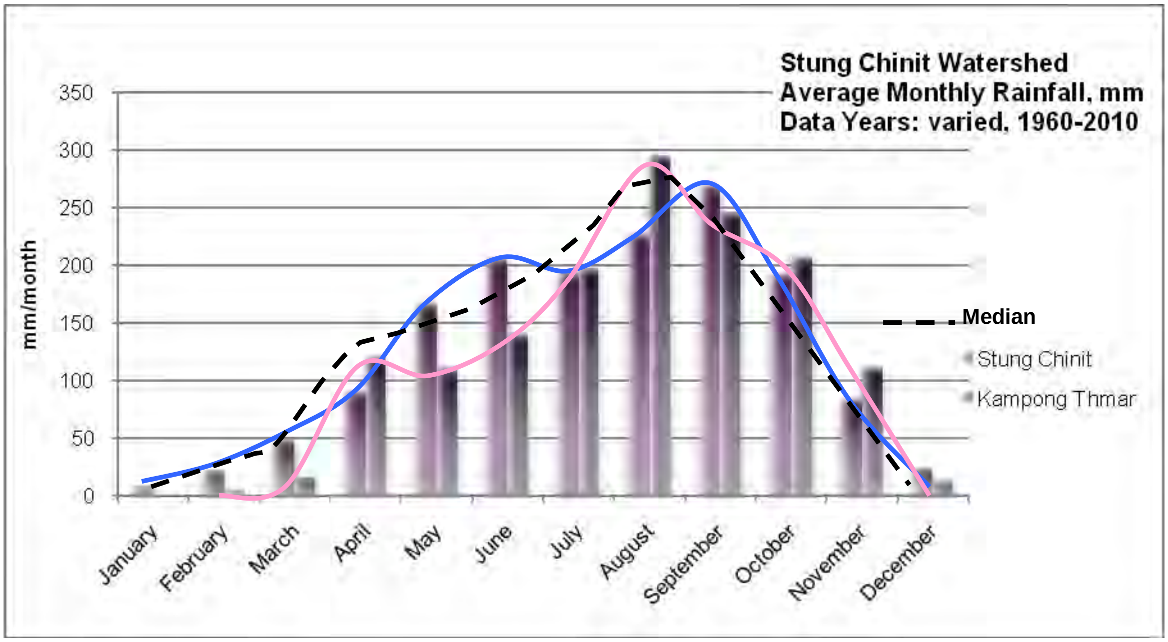
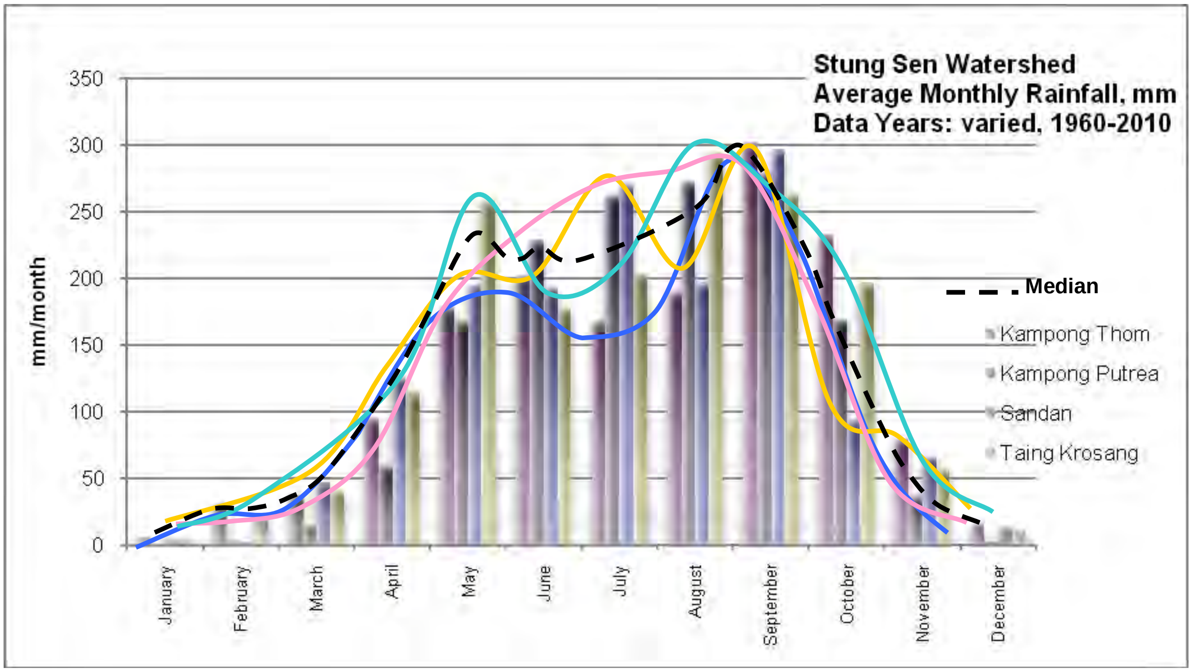


Figure 4.14 Stung Sen Watershed Net Rainfall, Monthly Averages



4.2.6 Water Quality

The basis for the baseline water quality is the *MRC Lower Mekong Water Quality Assessment, 2008.* The MRC has established a method of determining the relative quality of the water using a Water Quality Index (WQI) at the different monitoring stations along the Mekong River from China to Viet Nam. The generalized MRC method is to assign a relative score (e.g. 2, 1, 0) if a specific water parameter meets or exceeds guidelines. The scores are weighted to reflect relative risk and probabilities. The relative importance is based on three general classifications: aquatic life (al), human impact (hi), and agriculture (ag). Agriculture is included because it is such a prevalent activity in the Mekong Basin, and is subdivided into three broad categories: 1) general, 2) paddy rice and 3) livestock. Each classification is scored differently based on unique conditions and considerations. All the parameters are evaluated and the weighted scores are determined. Table 4.10 provides the general performance measurement indices, which the MRC used to rate water quality scores.

Table 4.10 MRC Water Quality Index (WQI)

WQI (al)		**WQI (hi)**		**WQI (ag)**	
High quality	10-9.5	Not impacted	10-9.5	No restrictions	10-8
Good quality	<9.5-9	Slightly impacted	<9.5-8.5	Some restrictions	<8-7
Moderate quality	<9-7	Impacted	<8.5-7	Severe restrictions	<7
Poor quality	<7	Severely impacted	<7		

The MRC established median WQI values over the period of 2000-2005 for three monitoring stations on the Mekong, which receives runoff from the Study Area, primarily Siem Bok. While not sufficient to serve as representative for the area as a whole, it does provide general baseline indication of water quality. The MRC WQI for the study area monitoring station is indicated in Table 4.11.

Table 4.11 MRC Baseline Water Quality Index (WQI) For Prey Lang Study Area

	WQI(al)	WQI(hi)	WQI(ag1)	WQI(ag2)	WQI(ag3)
Stung Treng	9.8	7.6	10	10	10
Kratie	10	9.5	10	10	10
Kampong Cham	9.8	8.2	10	10	10

The MRC indicator parameters and respective water quality base guidelines are shown in Table 4.12. The table has been expanded by additional parameters for which there is some data, which could be included if more data is acquired.

For the purposes of this study, the guidelines should not be considered binding standards. They are benchmarks of the baseline water quality characteristics of river water at the present time. With enough data collected over time it can be used to compare changes in the river hydraulics caused by deforestation. Ideally, water quality parameters should be measured on regular intervals over a sufficiently long period to include seasonal changes to establish baseline conditions. Heavy metals, in particular arsenic, need to be considered to establish potential significant health risks.

Table 4.12 MRC Water Quality Indicator Parameters

Water Quality Indicator Parameters	MRC Guidelines	Monitoring Stations		
		St. Treng	Kratie	Kpg. Cham
Dissolved Oxygen (D0)	>5.0 mg/L	ND	7.4	7
pH	6.5-8.5 SU	ND	7.26	7.33
Conductivity	< 70 mS/m	ND	TBD	TBD
Total Phosphorous (P)	0.13 mg/L	ND	0.03	0.03
Ammonia-Nitrate (NH_3-N)	< 0.10 mg/L	ND	ND	ND
Nitrite (NO_2-N)	< 0.7 mg/L	ND	0.15	0.15
Nitrate (NO_3-N)	< 0.7 mg/L	ND	0.15	0.15
Ammonia (NH_4-N)	< 0.05 mg/L	ND	ND	ND
Chemical Oxygen Demand (COD_{Mn})	< 4 mg/L	ND	ND	ND
Additional Parameters to be considered				
Total suspended solids (TSS)	NE mg/L	ND	120	120
Turbidity	NE NU	ND	ND	ND
Heavy Metals	NE mg/L	ND	ND	ND
Biological Oxygen Demand (BOD)	NE mg/L	ND	ND	ND
The transported loads in ton are determined by flow rate (Q) x concentration. ND = no data, NE= Not established by MRC				

Stung Treng and Kratie are the primary data points, since they are relatively undisturbed compared to the stations in the vicinity of Phnom Penh, which has too many point sources to be able to differentiate the upgradient sources. This logic is also true for Kampong Cham, but it is included as a “key station” to provide an outer limit comparison point.

In Stung Treng, 25% of the population has access to safe water, which may explain the relatively low WQI (hi). In Kratie province, the WWI is much higher and reportedly 40% of the population has access to safe water. The overall number of households that have access to safe water declines in both urban and rural areas during the dry season (JICA, 1997).

How these indices might change as a result of deforestation can be assessed qualitatively, based on the probabilities of reasonable worse case and best-case ranges, integrated into the holistic qualitative benefit cost analysis (See Section 5.0).

SEDIMENTATION

Sediments play a key role in providing nutrients to the Tonle Sap system and thus sustain its high productivity. About 70% of the sediment influx to the Tonle Sap originates from the Mekong. Thus the changes in the amount and composition of sediment caused by upstream development or land use changes can have a major impact on the sediment flow and Tonle Sap productivity. Analyses detailed in Plinston and He Daming (2000) showed that about half the sediment reaching the Mekong Delta originates in the Upper Mekong in China (Carling, 2009).

The soils suspended storm water runoff, have both positive and negative effects depending upon concentration (load), gradation (size distribution), and where and when deposited. Silts deposited in low lying areas can be the foundation for fertile soils, such as those found in the Tonle Sap flood plain. The sand-silt-clay ratio can determine the habitat for different fish species at different locations along the Mekong and Tonle Sap tributaries (e.g. Stung Sen and Chenit). Sediment deposition in channels and depressions establish spawning migration paths and hatching locations. Upsetting the natural balance can disrupt aquatic habitat, alter the soil profile and increase stream sediment concentrations and turbidity lowering water quality further impeding migration. High sediment deposition in ship channels, water treatment facilities and estuaries require significant costs for preventive and control measures, and maintenance and repairs. The mechanics of soil suspension removes top soils and creates rivulets that initiate erosion.

For these reasons, sediments are considered the most widespread pollutant transported by rivers, streams and runoff. As land is cleared for development, soil transport increases and its impacts are proportional to the area exposed, and the types of preventive and control measures implemented.

Measuring the effects of soil transport as Prey Lang is logged, requires an understanding of the sedimentation loads and deposition in the Mekong. The Cambodia floodplains and Mekong Delta become the final areas of deposition before the river flows into the South China Sea making this area a critical natural integrated ecological control point.

The affects of increased sedimentation into this system as result of the Prey Lang forest are bi-directional. One direction is runoff flowing to the east from the Siem Bok watershed into the Mekong River; the other to the west flowing from the Stung Sen and Chinit watersheds into the Tonle Sap Basin. (There is a minor third vector from the lower portion of Siem Bok into the Mekong and Tonle Sap Rivers, but it is not directly affected by the Prey Lang Forest.)

The magnitude of the affect of the deforestation on sedimentation in the river and lake environs is relative to incoming sediment concentration above the Stung Treng monitoring stations, current development within the watersheds on both sides of the Mekong River, and the increases to the sediment concentrations due to construction and development along the Mekong River, Tonle Sap, and their tributaries.

The existing sediment data exhibits the same variances and quality issues as most of data available and used in this report. Sediment concentrations are generally determined using two different measuring methods, suspended-sediment concentration (SSC), and total suspended solids (TSS), which produce widely divergent estimates (ICEM 2010). In references used for this assessment, the little soil concentration data available were reported as TSS. However, the following information is based on SSC. It is difficult to correlate the two, and according to ICEM the margin of error can be as high as 30%.

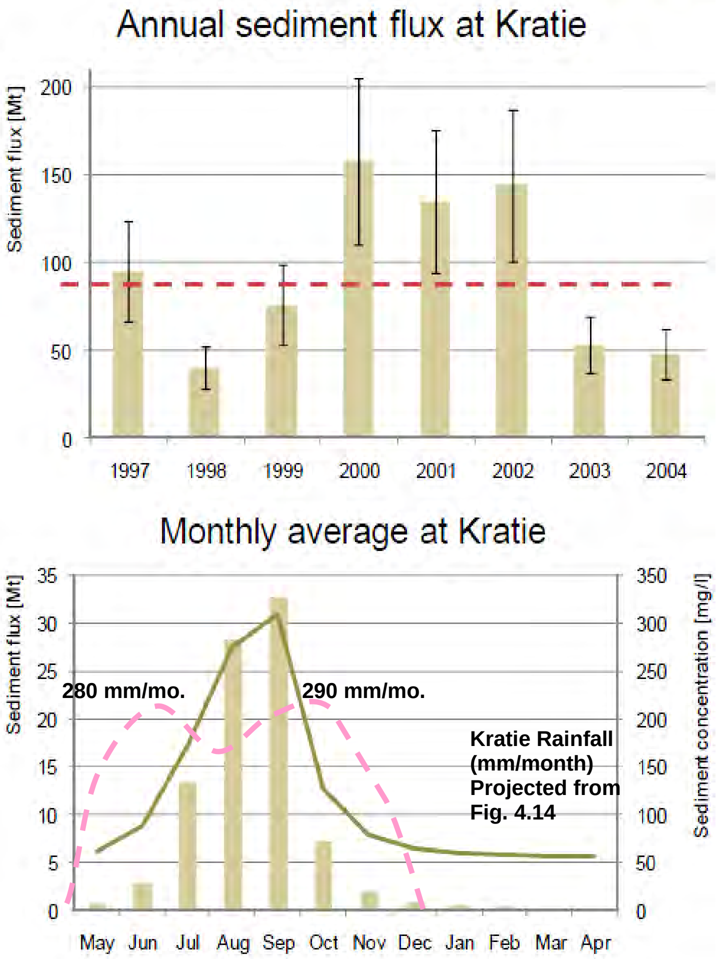
One of the weaknesses of TSS, is that it is a poor indicator of sediment load when there are more than 25% of sand size materials (ICEM, 2010), which surprisingly is reported to be the case for this study. However, there is little information available on the grain size distribution of the water flow in the Mekong River, much less the watershed discharges. Estimates based on one distribution curve for Pakse (presented in Carling, 2009) shows that 99% of the sediment has a grain size smaller than 4.75mm (fine gravel) and 41% of the distribution is finer than 0.45mm (coarse sand).

The fine silts and clay sediments are likely to remain in suspension until the Mekong River enters the Cambodian floodplain and the Mekong Delta. The Cambodian floodplains, of which Tonle Sap is the most significant, are likely to store 15-25% of the sediment load measured at Kratie. Based on 8 years of data, ICEM estimates of the average annual sediment load at Kratie to range from 66-160 Megatonnes (Mt). The peak sediment load at Kratie correlates with the respective flood peak. Approximately 4-7% of the sedimentation load measured at Kratie is deposited in the Tonle Sap Lake, while 8-20% of the load settles in the Cambodian floodplain and the rest enters the Mekong Delta. See Figure 4.17 below. ICEM demonstrated that sediment deposition in the vicinity of Tonle Sap Lake is concentrated around Lake Chma, the Tonle Sap river channel north of Kampong Chnhang and the broad floodplains on the western extent of the lake’s floodplain. During the flood season these are the shallowest areas of the lake and therefore encourage sediment deposition (ICEM 2010).

The following graphs (Figure 4.15) from ICEM provide the sediment loads over the eight years studied by Kummu and monthly average at the Kratie monitoring station.

Figure 4.15 Annual average sediment load (1997 – 2004) at Kratie

Source: Kummu et al, 2009b, ICEM 2010



The information is insufficient to assess the effect of the increase in sedimentation as a result of deforestation on the river and flood plain, especially in light of the proposed large scale irrigation and hydroelectric plants in the area.

4.2.7 Water Uses

According to MRC State of the Basin Report (2010), approximately 25 million people within the lower Mekong basin live along the 15km corridor along both sides of the Mekong mainstream. Approximately 70% of Cambodia's total population (13,395,682) or 9,376,977 people reside within this corridor (MRC, 2010).

In general populations living closer to water resources are more dependent on it than people that live further away. However, as the river course is altered its influence can be far ranging, such as irrigation, hydropower, transportation, changing flood plain, and its national economic significance. In addition, there are seasonal factors due to tourism, and seasonal trades, such Cambodian fishermen who travel great distances from the interior during the harvest season (MRC, 2010).

Within the Phnom Penh urban area the primary water uses are: drinking, domestic, and commercial, with relatively minor industrial use. In the rural provinces outside of Phnom Penh the primary water uses are: drinking, domestic, agriculture and livestock feeding.

According to a study by Water Utilization Program (WUP-JICA), the estimated urban water usage is approximately 68 mcm per year. At the Phnom Penh Port, water extraction is about 100,000 m^3 per day, which is higher than most provincial towns (JICA, 1997).

In Cambodia an estimated 500 mcm is used for industrial purposes, which is about 1% of all uses. Very little industrial activity takes place within the Study Area. Commercial use is primarily in the urban areas and not included in the Study area.

DOMESTIC

The MRC has determined Cambodia Domestic Water Use as shown in Table 4.13

Table 4.13 Cambodia Domestic Water Use

Average per Capita Use (liters / day)				
	2000	**2007 (2008)**	**2030**	**2060**
Rural	32	90	100	100
Urban	No Data	130	150	170

Source: MRC, 2010

Based on this data, it is assumed that the total daily domestic consumption has not significantly changed from 2007 to 2008. The estimated increase in domestic water consumption over the ten-year period of this study is calculated from projected population growth rates and consumption rates.

The population of the study area is estimated to be 630,000, of which approximately 2/3 live in rural communities and 1/3 may be considered peri-urbanites located south west of Kratie. Applying the 2007 domestic uses from Table 4.13 respectively, the total annual domestic water use for the study area is approximately 37 mcm. This is considered to be conservative since many living in peri-urban areas do not have any better access to water than those living in rural settings.

IRRIGATION

In most agricultural societies, irrigation is typically the largest water user. In the Lower Mekong Basin irrigation uses an estimated 41.8 bcm of freshwater resources (MRC, 2005). In Cambodia 2.7 bcm collected and stored during wet season is used to fully irrigate multi-crops. This implies significant storage areas which would affect water balance and watershed discharge.

The total irrigable area available in Cambodia is 504,245 ha. Rice is the primary crop irrigated accounting for 98% of the irrigated land. The remaining 2% is used for other crops such as maize (MRC, 2003e).

Reportedly, 2% of the precipitation within the Stung Sen and Chinit watershed is used for irrigation, most if not all of which is believed to be within the Stung Chinit watershed, which would be equivalent to 460 mcm.

INDUSTRY

At the present time there is relatively little heavy industrial activity in Cambodia. Of those that do exist, mining is the one with the most immediate importance to the study area. In terms of water usage mining is generally a high consumer, but the entire annual industrial water use for Cambodia is reported to be 500 mcm, which is about 1% of all use. It is presumed that a relatively large portion of this use is for mining, but the percent is not known, although obviously less than 1%. There are approximately 120 mining operations in 2006 (Atlas of Cambodia) with a relatively high concentration of mining activity (18%) located in the upper regent of Stung Sen watershed in the Preah Vihear Province. However, nearly all of this activity is outside of the primary Prey Lang Forest area. If mining made up for all the industrial use of water, the mines in the study area would use an estimated 90 mcm, which is about 13% of all human water use (excluding direct rainfall irrigation). Since, in fact mining does not make all industrial use the actual percentage would be a lot less. Therefore, without more focused study and information about mining, it was not included directly in the water inventory.

4.2.8 Water Inventory Baseline

There is insufficient data to conduct a complete water balance for the study area, but using the meteorological, hydrological and hydraulic databases available, key parameters were interpolated to estimate a preliminary inventory of the study area water inflow and outflow. See Section 2.3.

In general, the Mekong River Basin high season flow is 15-30 times the low season flow. The minimum monthly river discharges are 6% to 0.01% of the maximum as measured at Kratie and Stung Sen respectively.

Of the net runoff from the Mekong River Basin 37% of total is attributed to precipitation. Forest and woodland cover 43% of the entire basin and consume about 33% of the precipitation. Grassland cover (22% mostly in upper basin) consumes 10% of the precipitation, and irrigated agriculture covers 6% of the basin and uses 4% of precipitation.

Table 4.14 General Mekong River Basin Vegetation Cover

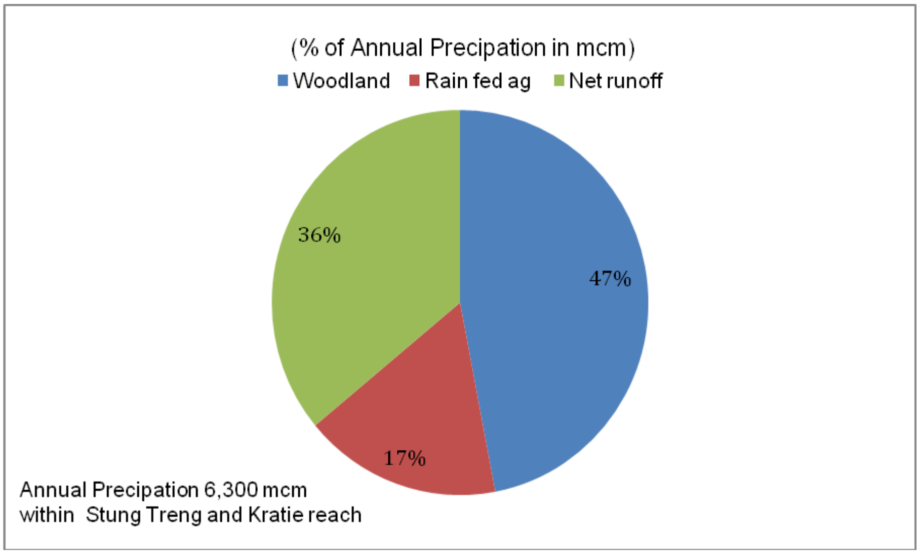
Land Type	% Basin area covered	% Precipitation consumed
Forest/Woods	43%	33%
Grassland	22%	10%
Irrigated Agriculture	6%	4%
Total	**78%**	**47%**

In terms of water inventory within the study area, inputs are: rainfall and upgradient river flow as measured at the Stung Treng monitoring station. Water balance study area outputs are primarily natural forest and vegetation uptake and direct rain fed agricultural irrigation, and secondarily mechanical irrigation and human consumptions as discussed above.

Using percentage estimates, in lieu of more sophisticated hydrologic models, has allowed for overcoming the data gaps, inconsistencies and uncertainties in historic data. While insufficient for engineering design or quantifiable economic analysis, this model does provide a reasonable qualitative rapid assessment within the objectives of this study.

The following charts (Figures 4.16 and 4.17) show the relative water use percentages within the Study Areas.

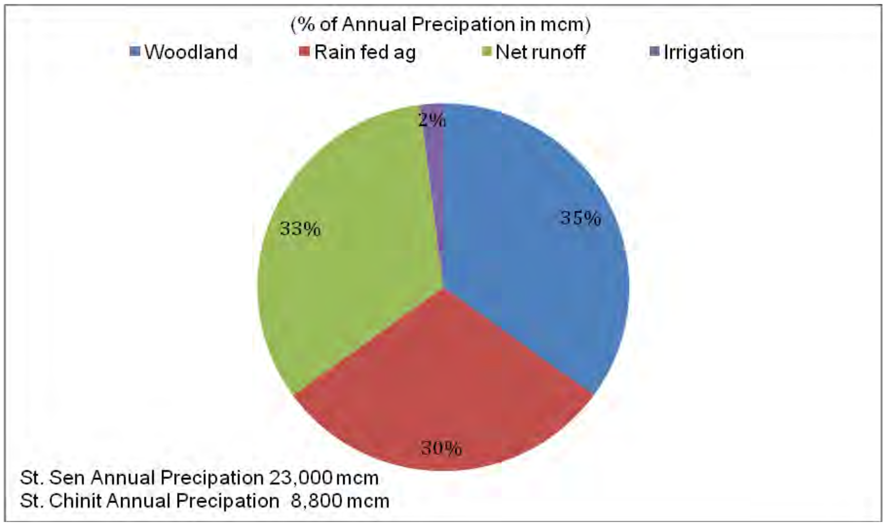
Figure 4.16 Siem Bok(a) Watershed Water Use



Annual Precipation 6,300 mcm
within Stung Treng and Kratie reach

Note: woodland assumed to include surface

Figure 4.17 Stung Sen & Chinit Watershed Water Use



St. Sen Annual Precipation 23,000 mcm
St. Chinit Annual Precipation 8,800 mcm

The existing Prey Lang study area hydrology data is summarized below (Tables 4.15 – 4.20).

Table 4.15 Study Area Watershed Hydrology

Watershed	Area (ha)	Population within watersheds	Max Discharge (m^3/sec)	Mean Rainfall (mm/yr)	Mean ET (mm/yr)
Stung Sen*	1,624,541	249,230	971	1404	1604
Stung Chinit*	677,297	256,260	210	1328	1542
Siem Bok(a)	427,647	127,132	128**	1520	1498
TOTAL	2,729,485	632,622	-	-	-

* *As reported at lowest monitoring station (Kampong Thom and Kampong Thmar respectively)*

** *There are no monitoring stations within this watershed; maximum discharge extrapolated using the ratio of maximum discharge to Ha from Stung Chinit, with similar forest density, excluding peri-urban area (Siem Bok(b).*

Table 4.16 Study Area Precipitation & Runoff

Watershed	Annual Precipitation (m)	Area (km^2)	Annual Volume ($m^3 \times 10^6$, mcm)	Net Runoff* (mcm)
Stung Sen	1.4	16,245	23,000	7,600
Stung Chinit	1.3	6,773	8,800	2,900
Siem Bok(a)	1.5	4,276	6,400	2,100

* *Extrapolated from data using HEC-1 Rational Method coefficients based on land use and conditions*.

Using these estimates the following preliminary water inventory was prepared for the study areas as a whole, averaging the inputs of the three watersheds, but separating out the discharges of Stung Sen and Chinit from Siem Bok(a), since both discharge into the Tonle Sap, while Siem Bok(a) discharges into the Mekong River. Siem Bok (b) was not included since it is essentially a peri-urban area outside the forest hydrology influence, and there is not enough specific information regarding surface area characteristics to even make a quasi realistic rough estimate. ET was not included since the data was collected at the river monitoring stations, where it s assumed the evaporation rates might be the highest, and not representative of the forest cover area.

There is insufficient data to establish a similar generalized inventory of the water inputs and outputs for the forest areas itself, but the following summarizes the data collected.

Table 4.17 Study Area Forest

Pre Lang Forest	Area (ha)	Populations in Forest Area	Areas as a Percentage of Watershed
Stung Sen	32,508	49,846	2%
Stung Chinit	507,973	192,195	75%
Siem Bok(a)	427,647	57,209	80%**
TOTAL	968,128*	299,250*	

* *From various varying estimates in and around Prey Lang, and allows for a conservative distribution of population within the forest relative to study area watersheds.*

** *Estimated from Atlas of Cambodia.*

Table 4.18 Study Area Woodland Area Annual Precipitation & Runoff

Woodland	Annual Precipitation (m)	Area (m^2 x 10^6)	Annual Volume (mcm)	Net Runoff* (mcm)
Stung Sen	1.4	320	450	148
Stung Chinit	1.3	5,100	6,600	2,178
Siem Bok(a)	1.5	4,200	5,040	1,800

* *Extrapolated from data using HEC-1 Rational Method coefficients based on land use and conditions.*

TONLE SAP GREAT LAKE

Along with the Mekong River, the Tonle Sap Great Lake is the primary receptor of the Mekong Basin with in Cambodia. As discussed throughout the report it serves as a critical component of the unique pulsating dynamics of the river hydraulics and provides extremely important ecological services for the region from both an environmental and economic perspective, and the basis for an entire Khmer culture.

Table 4.19 Tonle Sap General Information

	Area (km^2)	Volume (km^3)	Water Elevation (amsl)
Base Line (dry season)	2,200	1.6	7
Flood Area (max range)	9,600 – 15,000	33 – 76	9.17 – 9.76

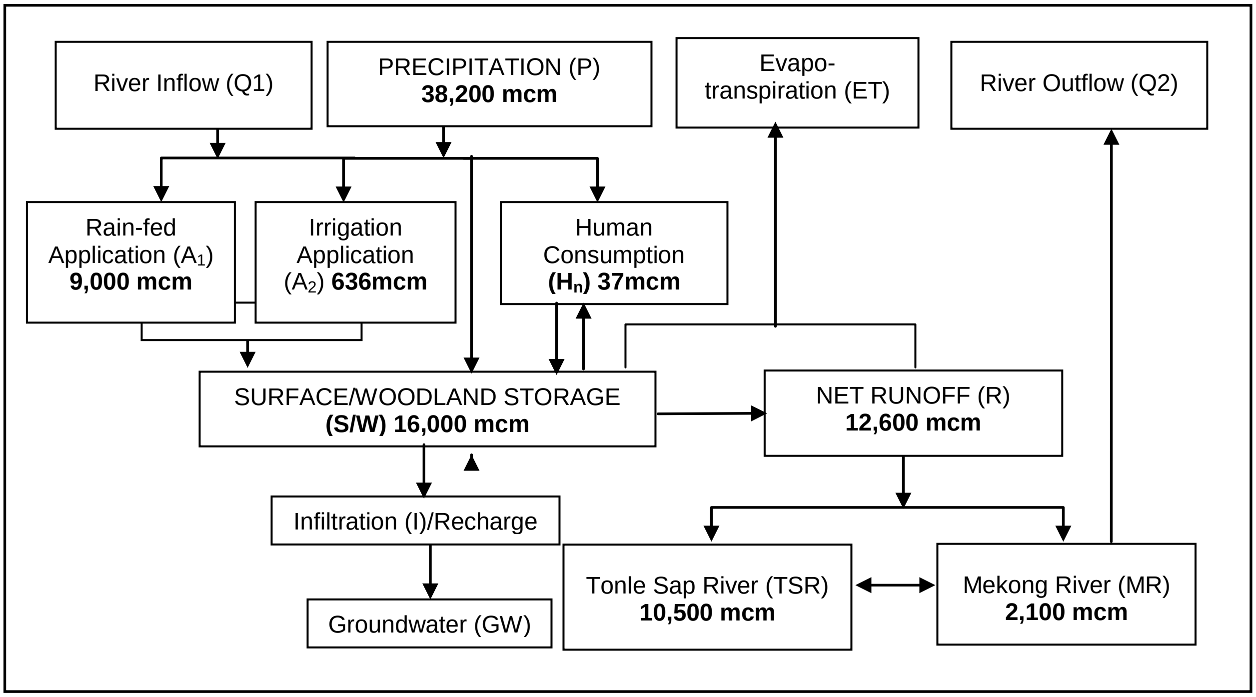
Table 4.20 Tonle Sap Inflow

Inflow	km^3/yr	Percent of Total
Tonle Sap River/Runoff	43	52%
Tributaries (11 of which Stung Sen is the largest)	29	36%
Direct Precipitation	10.4	12%
Outflow		
Tonle Sap/Mekong River	70	88%
Surface Area Evaporation	9	12%

STUDY AREA WATER INVENTORY

Since there was insufficient data to compete a full water balance to account for water inflow and outflow, Figure 4.20 provides a summary of the available water volumes. The boxes without data indicate respective volumes were not discovered.

Figure 4.18 Study Area Water Inventory



HYDROLOGICAL EFFECTS OF FOREST CLEARING

The forest serves as a hydrology buffer reducing runoff velocity and absorbing a portion of the precipitation. Clearing the forest removes these natural services (among others) and increases the amount of net runoff reaching their respective sinks (Tonle Sap or Mekong River) and rates of and locations of sediment deposits. Due to the size of the area involved and the complexity and importance of the relationship between the Tonle Sap and Mekong River it would take a sophisticated quantitative model to determine how much the actual net runoff would be affected, which is beyond the scope of this study. However, adapting the Rational Method (introduced in Section 2.0) to the qualitative assessment conducted provides a relative objective indication of the potential outcomes.

The affect of forest removal on the hydrology of the region is a function of the area of forest removed. Since the study area slopes are relatively flat, the coefficient (C) would change as a function of soil drainage characteristics and change in land use (See Section 2.3). Therefore, the runoff coefficient becomes the primary factor in determining hydrology changes. As used in the rational model, C ranges from 0.30-0.40 for flat woodland areas over semi-permeable to impermeable soils. C increases to 0.50-0.60 for a change in land use to cultivation with the same soil types, which is an increase by a factor of 1.5-1.67. Therefore, using the higher multiple of 1.67, if the entire forests in all three watersheds were removed, the total net runoff contributed by the change in the forest to cultivated land in mathematical terms, would be 7,725 mcm resulting in an increase in runoff into the Tonle Sap/Mekong system of 3,100 mcm. Refer to Section 2.3 for a description of these terms.

As discussed earlier in Section 4.2.3, MRC determined that 300 bcm flowed into Cambodia and 500 bcm discharged into the China Sea. A significant portion of the 200 bcm increase is assumed to be from the Tonle Sap/Mekong River complex. Therefore, in the extreme worse case, totally removing the Prey Lang forest would result in 1.5% increase to discharge from Cambodia assuming relatively small inflow into the Mekong Delta from other sources.

4.3 Ecosystem Services

The natural services provided by any ecosystem, such as hydrology and forest, both of which are important to this study, are referred to as "*ecosystem services*" as defined by the Millennium Ecosystem Assessment (MA) undertaken by the United Nations in 2001. The MA assessed, "the consequences of ecosystem change for human wellbeing."

Ecosystem services are defined as: "Natural services or capital that support life on the earth and are essential to the quality of human life and the functioning of the world's economies."

The MA divided the services into four broad categories:

- Supporting
- Provisional
- Regulating
- Cultural

One of the difficulties of this definition is that it is one directional. It determines services as those activities that affect human well being, without consideration of other species, so that it may be viable to exploit a resource and account for ecosystem services, but not account for those disruptions that do not affect (directly) humans. And yet such disruptions may decimate the habitat of some undervalued species, which may trigger unintended catastrophic consequences (e.g. disturbing beaver habitat caused major changes in river dynamics in the US). However, while human ecosystem services may be hard to identify relative to other species, in taking the services of other species into account, albeit for its own self interest, may well be one of humankinds own most important ecosystem services.

The focus of this assessment concentrates on how the "*natural services*" of the fresh water cycle are affected by the replacement of forest's services by clearing the land. The *natural services* are any service that benefits an ecosystem, regardless of the human considerations. And then with this in mind, the affects of human socio-econ conditions are considered.

FRESH WATER ECOSYSTEM SERVICES

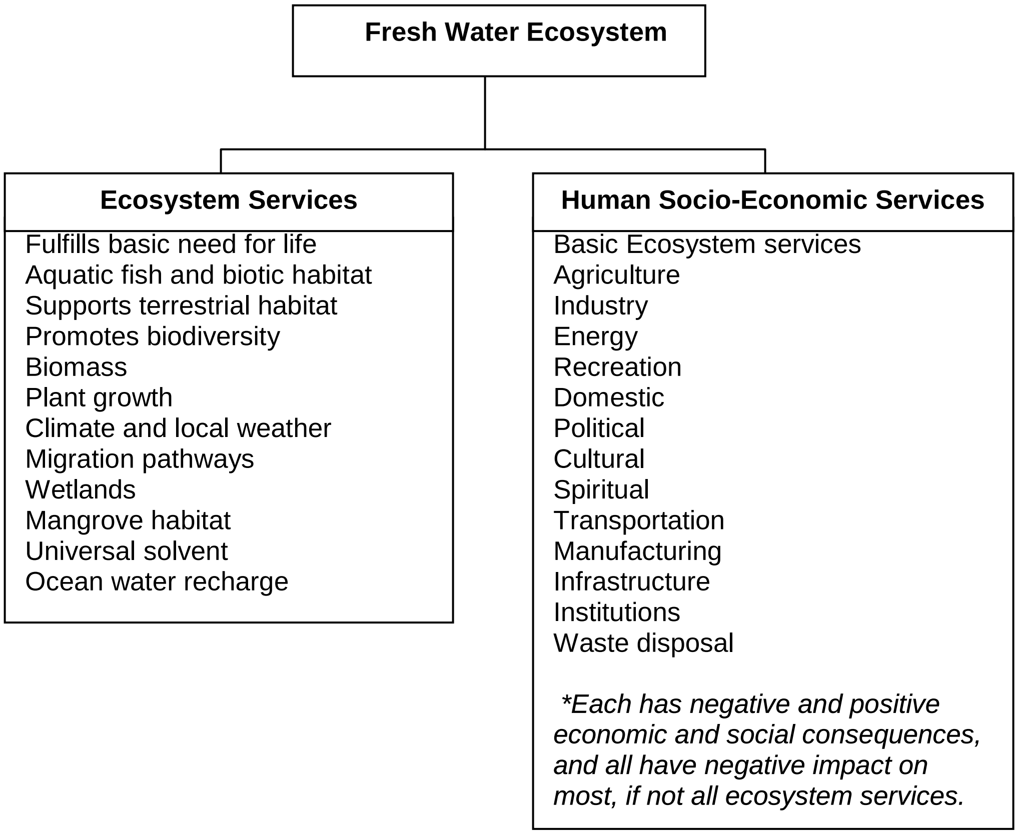
The list of water ecosystem services can include just about every aspect of life on earth, and is affected by every aspect of life on earth. While a list of services for a discrete ecosystem, such as a forest, would apply to the forest itself (even if humans were not directly involved), those same services do arguably have significant direct and indirect effects on human well being. Water however, is ubiquitous and any and all changes in the hydrologic cycle, regardless of where these changes take place, have certain direct and indirect effects on humanity's well being, as well as other species.

Water does not generally restore itself as many other systems attempt to do, while all the services of other systems are dependent on water; without it all other systems will fail (including, the deep rock zones holding ancient water). On the other hand, while water quality, usable quantity, and location will all be affected by the characteristics of the host biome, its global mass balance remains relatively constant and its impact is much more profound. Ecosystems adapt to the existing quality, quantity and location of water, as determined by physical and climatic conditions, and it is therefore one of the principle ecosystem determinants. As the biological aspects of the system affect the water quality and characteristics, the system re-adjusts accordingly and the integrated environmental cycles are perpetuated.

By clearing a forest, all the natural services provided by the forest are lost until (and if) renewed. By depleting a naturally occurring water source (e.g. over pumping groundwater), the local water balance is altered, and ecosystem services adjust accordingly, but the water cycle and its essential service is maintained. Humans can and do effect water quality, quantity and location, all of which have significant affects on ecosystems, but perhaps its most damaging impact is on water quality, since by rendering it unfit for consumption, humans in effect reduce their own usable water supply, potentially threatening its own existence.

Figure 4.19 provides a partial general list of fresh water services ecosystem and socio-econ services.

Figure 4.19 Fresh Water Services



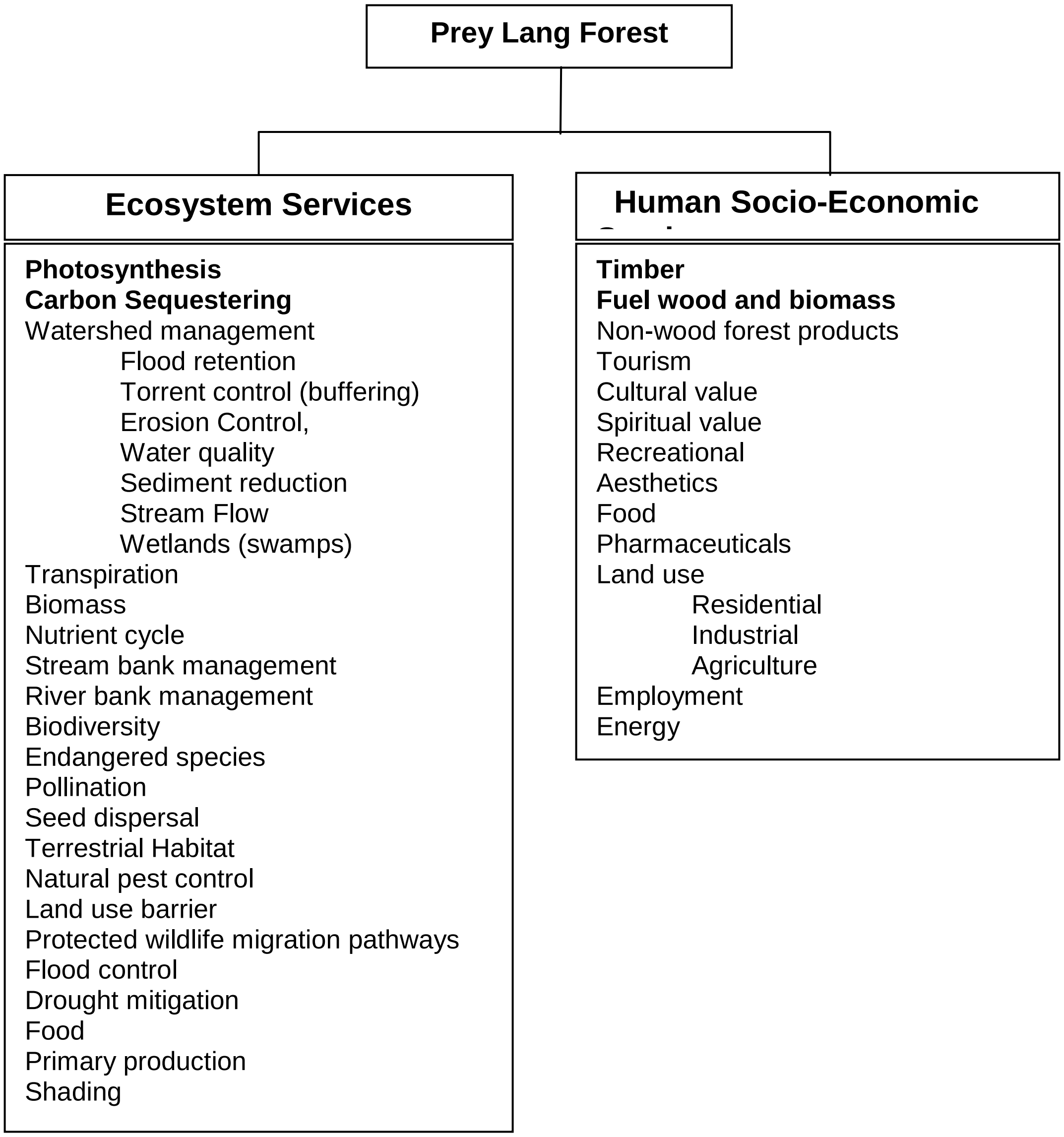
PREY LANG WATER ECOSYSTEM SERVICES

Figure 4.1 in Section 4.0 presents a schematic of the Prey Lang forest ecosystem illustrating the interrelationships of the forest, the water cycle and the carbon cycle. As an ecosystem in its own right, the Prey Lang forest provides services and is dependent upon the services provided by the water present within its system as defined by the surface hydrology. The obvious, and arguably most important service, is that the Prey Lang ecosystem provides water to the trees, and other species that depend on the trees in a mutualistic relationship. Transpiration is an important way in which water is returned to the atmosphere as water vapor, and in tropical areas forests make up in part for the loss of evaporation through high humidity. Additional services are the flushing of the surface and removal of sediment buildup. Removal of the forest will affect the ability of the water to provide these services without engineering controls (e.g. retention ponds, artificial recharge, buffer zones) to restore them.

The Prey Lang Forest potentially stores more carbon than other forests since its undisturbed timber volume and biomass are relatively high. In addition, the swamp areas are reported to have significant carbon storage potential.

Figure 4.20 lists the potential Prey Lang Forest Ecosystem Services. It contains most of the services provided by any forest. Figure 4.21 shows how those services might be affected by clearing the forest.

Figure 4.20 Potential Prey Lang Forest Ecosystem Services



Prey Lang Forest

Ecosystem Services

Photosynthesis
Carbon Sequestering
Watershed management
    Flood retention
    Torrent control (buffering)
    Erosion Control,
    Water quality
    Sediment reduction
    Stream Flow
    Wetlands (swamps)
Transpiration
Biomass
Nutrient cycle
Stream bank management
River bank management
Biodiversity
Endangered species
Pollination
Seed dispersal
Terrestrial Habitat
Natural pest control
Land use barrier
Protected wildlife migration pathways
Flood control
Drought mitigation
Food
Primary production
Shading

Human Socio-Economic

Timber
Fuel wood and biomass
Non-wood forest products
Tourism
Cultural value
Spiritual value
Recreational
Aesthetics
Food
Pharmaceuticals
Land use
    Residential
    Industrial
    Agriculture
Employment
Energy

Figure 4.21 Potential Effects of Deforestation on Ecosystem Services

Potential Prey Lang Effects of Deforestation

Ecosystem Services

Decreased
- Photosynthesis
- Recreational
- Food
- Tourism
- Carbon Sequestering
- Watershed management
  - Torrent control
  - Erosion Control
  - Water quality
  - Sediment reduction
- Biomass
- Nutrient cycle
- Stream bank management
- River bank management
- Biodiversity
- Pollination
- Seed dispersal
- Terrestrial Habitat
- Transpiration
- Land use barrier
- Drought mitigation
- Food
- Primary production
- Shading

Increased
- Stream Flow
- Flood potential
- Sediment load
- Wetlands vulnerability

Altered
- Endangered species
- Natural pest control
- Wildlife migration pathways

Socio-Economic Services

Increase
- Timber
- Non-wood forest products
- Pharmaceuticals
- Land use
  - Residential
  - Industrial
  - Agriculture
  - Transportation
- Employment
- Economics
- Energy

Decrease
- Aesthetics
- Fuel wood and biomass
- Fisheries

Unknown
- Cultural value
- Spiritual value

Downstream
Socio-Economic Services

Increase
- Recreational
- Migration to Forest Area
- River flow
- River height
- Flood intensity
- Sedimentation
- Economics

Decrease
- Aesthetics
- Fisheries

Altered
- Cultural value
- Spiritual value
- Social value

Placing a dollar value on ecosystem services is complex and difficult, if not impossible, to accomplish quantitatively. Identifying interrelations between service and value can be subjective and contentions. Extrapolations and interpolations between incomplete or inconsistent data sets can be compromising and presumptive. Assumptions can be very broad to cover a host of inadequacies. All are necessary if any semblance of a common measurement base is to be established, but each relies on qualitative evaluation, and precludes quantitative conclusions. Willingness to pay becomes the measure of value, rather than market supply and demand. While methods like carbon credit payments (e.g. REDD) and payments for environmental services (PES) do place a value on specific aspects of ecosystems, the reliability of payment is dependent on willingness to pay and not market driven forces. Therefore, the valuing of the ecosystem is only sustainable as long as funding provider is willing to pay, which is dependent on social and political will, and economic conditions. Consequently, those services, which can be qualitatively valued in terms of money, are included within the economic model (TEV, See Section 4.4); otherwise, they are considered as part of the sustainability matrix scorecard (See Section 2.5).

4.3.1 Non-Timber Forest Products (NTFP)

NTFPs are of particular importance to the Prey Lang area. Typical NTFPs used in and around the Prey Lang area include slabrick (leaf), bark, frogs, toads (hing are common), eels, orchids, ginseng, resin, rattan, honey, fuel or local firewood fencing, vegetable, mushrooms, and fish. Local villagers are highly dependent on NTFP as source of food.

Resin is one of the most important NTFPs Cambodia-wide, and shows significant potential for market development (Prom, 2009). Resin trees species belong to Dipterocarp trees found in both mixed deciduous, semi-evergreen, and evergreen forests (Sloth et al 2005; Evans et al 2003). *D. alatus* is commonly tapped in Cambodia (Evans et al 2003; Prom 2009). The estimated total value of resin for Prey Lang is about $10 million (See TEV Section 4.4).

A field survey was conducted by AE in Kbal Ou Thnong CF (Community Forestry) in the Dang Kambet commune, of the Sandan District, in Kampong Thom Province. The CF has 9 villages dependent on collection of NTFP. The estimated annual income per household of NTFPs is 1,000,000 – 2,500,000 Riel ($238-$595 USD), which is 50% of their annual income. NTFPs are collected from 28,611 ha of Community Forest. Resin and honey are the most important. Resin is collected twice a month. Collection costs average about 10,000 Riel per trip for food and gasoline based on the AE survey results.

The Sampor Thom Village CF, in the same commune as above, has 6 villages dependent on collection. The estimated annual income per household of NTFPs is 1,800,000 – 2,400,000 Riel, which is 50% of their annual income. NTFPs are collected from 2,733 ha of Community Forest. Resin is the most important. Travel is up to 10km to collect, for 4-7 days of collection twice a month. Collection costs were similar to those for reported above (AE field survey).

4.3.2 Fisheries Important to Prey Lang Forest

Inland fisheries in Cambodia are part of the two interrelated systems made up of the Tonle Sap and Mekong River. Fish migrations of economically important species are triggered by seasonal hydrological changes. Fifty percent of water flowing into the Tonle Sap comes from the Mekong via the Tonle Sap River, which reverses direction twice a year and flows back into the Mekong and into the Tonle Sap Lake as discussed earlier.

Many fish spawn in the dry season around Stung Treng and migrate to the Tonle Sap. As waters recede at the end of rainy season, they migrate back to the upper Mekong. Fish migrate from the Tonle Sap, and spawn in the Mekong River north of Stung Treng, where there are up to 25 deep pools that serve as habitat for 21 species of fish that are economically important (IUCN, 2008). This is also the typical migration route of the *Henicorhunchus*, one of the most important species in the lower Mekong in terms of commercial output, and for the endangered Giant Catfish. This migration path is particularly sensitive to forestry in the Prey Lang Forest.

Projections from the lower Mekong have been as high as 3 million tons of fishery production (Middleton, 2005). Baran (2005) cites 2.5 million tons based on MRC data from 2004 Consumption is estimated to be 54.2 kg per capita (Mak, 2010), with 50%-60% of the fish coming from the Tonle Sap (Clausen, 2005). Production can range dramatically during different years, with a low of 230,000 tons to 442,000 tons. This is related to Mekong flows and levels.

The total annual income per year of fisheries in the Prey Lang watershed Provinces is roughly $7 million for small-scale fishermen. Commercially the annual total fish catch is about $36 million (Mak, 2010; MRC Fisheries, 2010).

Roughly 4,032 households depend on fishing as a primary source of income, and 16,080 households as a secondary source. Households earn roughly $2,200,000 USD and $4,500,000 USD annually, respectively (Mak, 2010; MRC Fisheries, 2010).

MEKONG RIVER FISHERIES

The total 2007 commercial and industrial fish catch for Cambodia was 125,000 tons. In Stung Treng Province, the catch was 2,000 tons (1.6% of national catch), and in Kratie Province 2,000 tons (1.6% of national catch). In 2009, these increased to 6,373 tons in Stung Treng, while decreased to 1,885 tons in Kratie (Mak, 2010; MRC Fisheries, 2010). While portions of the provinces lie within the study area, they also extend across the Mekong and outside the assessment boundaries, so it is assumed that most of the commercial fishing takes place on either side of the river and is essentially equally distributed.

COMMUNITY FISHERIES

The community fisheries were established in 2001 with the objective to promote sustainable fishing practices to help improve community socio-economic conditions and alleviate poverty. In 2006, 388 community fisheries existed. As would be expected nearly all lie along the Mekong and within the Tonle Sap flood plain along its tributaries. Within the study area, 17 existed in Kampong Thom mostly along Stung Sen. Oddly, very few existed in the Stung Chinit watershed. Fifty-one were present in Stung Treng and Kratie Provinces each and again roughly estimated to lie equally along the Mekong. Therefore, approximately 51 are located within Siem Bok (a) watershed. Sixteen were located in Kampong Cham province, most of which within Siem Bok (b) (Atlas of Cambodia, 2006).

4.4 Socioeconomic Baseline

Determining Prey Lang forest’s socioeconomic baseline profile is very complex. While many socioeconomic studies have been conducted in Cambodia, very limited information is available on the socioeconomics of the study area forests and hydrology. The economic value of the study area is based on direct use values, for timber, fisheries, NTFP and tourism as described in the following sections. Agriculture is the largest sector of the GDP and it is primarily subsistence farming within our study area. The following subsections describe the socioeconomic parameters used for this study. Tables 4.21 through 4.30 summarize the TEV and NPV for each parameter over the 10 year period of the study. ***It is important to note and keep in mind that the data provided in these tables are for illustrative purposes only, and should not to be used for planning or budgeting purposes without further study and confirmation.***

Several valuation techniques were used for the main direct use and indirect use values (DUV and IUV) as described previously (Section 2.4.1 Total Economic Value (TEV)). The baseline analysis is dependent on a number of parameters, such as average forest density, NTFP collection per hectare values, and market costs for fish and tourism statistics. The values for these DUV are based on previous studies and/or statistical reports within Cambodia, if not within the study area provinces. Information regarding indirect values of forest resources in Cambodia was not found during the timeframe of data collection. Values for IUV were based on research done outside of Cambodia. A summary of data collected for economic analysis is provided in Appendix B.

4.4.1 Timber Baseline

This study focuses on potential values from evergreen, semi-evergreen, and deciduous based on current loss rates of 1% as advised by the RGC Forestry Administration (FA). The loss rates for the different forest types range from 0.8% to 2.8% (See Table 4.4), with deciduous forests having the highest. Since deciduous forests are not valued as highly as the other types, the FA 1% clearing rate was assumed to be appropriate for the study area.

The analysis of timber TEV is based on the following assumptions:

- Forest area is based total forest cover, which is estimated to be 760,000 ha for the Prey Lang forest.
- Timber volume varies within the three types of forest and an average of 115 m^3/ha density value was used based on studies within the study area provinces (Hansen & Neth, 2006).
- Logged wood prices and production/manufacturing costs were based on market rates from various 2008 studies within Cambodia, using average commercial wood value of \$130/m^3 (Ashwell, 2008, Pearson, et. al., 2008).
- Studies done on forest growth rates vary widely and forest annual growths make up a relatively small amount of forest volume lost.

Based on these assumptions, the Total Economic Value (TEV) for timber logged at 1% annually is currently worth approximately \$68 million and contributes about 0.6% to the GDP of Cambodia. See Table 4.21.

Selecting an appropriate discount factor (DCF) to determine the Net Present Value (NPV) to today's TEV requires quantitative econometrics considering such factors as economic growth, GDP, GNI, national debt etc. As discussed in section 2.0, three discounted rates (DCR) were considered, 3%, 8%, and 12% in determining NPV. However, the use of any DCR is arguable as discussed below and depending upon the reference, can be quite contradictory. The calculations are very sensitive to the varying any of the variables (DCR, ABC, AWC) as well as the PLC. For the purposes of the BCA and TEV used it this report the 8% DCR was applied since it is believed to be a conservative representation of stable economic development in developing countries (Sasaki, 2010) and reflective of Cambodia's potential.

Table 4.21 Logged Timber TEV and NPV over 10 Years

Timber	
Timber volume (m^3)	**87,400,000**
Production rate (1% of available baseline forest per FA) remains constant (assumes no improved harvesting efficiency)	1%
Available for market after 40% wastage (assume no improvement)	60%
Stumpage Value ($\$/m^3$)	$130
Baseline TEV (2010) (million USD)	**$68**
Baseline NPV 10 yrs @ 8% (million USD)	**$487**

4.4.2 Non-Timber Forest Products (NTFP) Baseline

Forest communities are heavily dependent on NTFPs for subsistence and income. NTFP are considered a Direct Use Value (DUV) of forest, and have considerable economic value to Cambodia. For valuation purposes, the cash and subsistence values are determined by examining collection, trading, and consumption to determine consumption/use per ha per year (Heov et. al., 2006).

Direct values for NTFP are based on studies reported by Hansen and Neth (2006) in Mondulkiri, Kratie, Kampong Thom and Prusat districts. Average reported values of NTFPs for different types of Prey Lang tree types are: $32/ha for deciduous, $23/ha for semi-evergreen and $13/ha for evergreen. An average of $22/ha for all forest is applied for NTFP TEV valuation.

The NTFP baseline TEV is based on standing volume of forest multiplied by the average per hectare value of NTFP collection. Because NTFP collection is the main source of income and subsistence for forest dependant households, harvesting costs (i.e. labor) are very low, and were not included for this NTFP valuation.

The total economic value of NTFP collection for Prey Lang forest is estimated at $17 million. Net present values (NPV) were calculated at the various discount rates as shown in Table 4.22. An annual 1% deforestation rate was applied over the study 10 year projection. The NPV NTFP, at the 8% discount rate is $114 million.

Table 4.22 NTFP TEV and NPV over 10 years

NTFP	
Forest area (ha)	**760,000**
Available forest for NTFP based on constant 1% annual loss of forest due of logging production rate	1%
FV assumed to be constant over study period	$22
Baseline TEV (2010) (million USD)	**$17**
Baseline NPV 10 yrs @ 8% (million USD)	**$114**

4.4.3 Fisheries Baseline

Fisheries are included as direct forest use because the forest is a contributing factor to both commercial and subsistence production.

The fish catch estimate of 21,000 tons is based on NCDD and MAFF data from 2008 for the four provinces. Fish market values are taken from IUCN data for the same year and valued at $2350 per ton. Similarly to NTFP, costs are assumed very low for subsistence and household fishing and are not considered for this study. Various studies show a decreasing fish catch over the years, while also reporting significant fish cash underestimates (MAFF, and ICEM). For these reasons, estimating fish catch and projections are difficult.

The total economic value of fisheries is estimated at $49 million. Net present values were calculated at the study discount rates as shown in Table 4.23. Assuming fish catch and market price stays constant for the NPV 10 year projection at 8% discount rate, the NPV value for fisheries is $352 million.

Table 4.23 Fisheries TEV and NPV over 10 years

Fisheries	
Fish catch for study area (tons per year)	21000
FV of fish catch based on $ per ton assumed to remain constant over study period.	$2,350
Baseline TEV (2010) (million USD)	**$49**
Baseline NPV 10 yrs @ 8% (million USD)	**$352**

4.4.4 Tourism Baseline

The Mekong River and Tonle Sap areas are assumed to have significant potential tourist attraction that will be directly affected by the different forest development strategies considered in this assessment and are considered as direct use value (DUV) for economic valuation (MOT Statistics, 2008).

Statistics were based on official Ministry of Tourism (MOT) and NCDD data for Northeast Cambodia. It is assumed that the majority of tourists visiting Northeast Cambodia visit the Mekong River and dolphin pools. While Stung Treng province has an estimated budget for ecotourism of $414,575 for 2010 (MRC, 2010), at the time of this report, very limited information on ecotourism statistics outside of dolphins was available. However, the need for alternative costs to replace logging activity for Scenario 2 and the potential decrease in tourism as a result of Scenario 1 cannot be ignored.

The number of foreign tourist for this area is about 13,350 and 117,180 for locals (NCDD, 2010). According to MOT statistics, foreign tourists spend about 7 days in Cambodia. Based on MOT (2008) studies**,** the average tourist spends about $118/day for foreigners and about $22/day for locals. According to the government statistics, tourism is increasing at 5% annually (MOT, 2010). Information regarding local tourist projections is limited and within the ten year time frame is not considered a significant contributor.

The total annual economic value of tourism is approximated at $6 million and a NPV is about $49 million at 8% discount rate. See table 4.24. This is based on tourism on a national level. The different scenarios will present a range of RWC-RBC to determine respective impacts for each.

Table 4.24 Tourism TEV and NPV over 10 years

Tourism	
International visitors/year	13,356
Average expenses per international visitor/year (2 days at $118/day including transportation)	$236
FV at 5% growth rate	5%
National visitors per year	117,187
Average expenses per national visitor/year (1 days at $22/day including transportation)	$22
FV at 3% growth rate	3%
Baseline TEV (2010) (millions USD)	**$6**
Baseline NPV 10 yrs @ 8% (millions USD)	**$49**

4.4.5 Agriculture Baseline – Rice

Traditionally rice production remains to be the most important irrigated crop in Cambodia. It is the main staple and one of the most important sources for employment and income.

This study evaluates the Agriculture, and or forest plantations may replace deforested lands. Based on the Sasaki study, it is not generally cost effective to replace evergreen forest by teak, acacia, eucalyptus, or rubber plantations (palm oil had a negative NPV). The study used rice as the benchmark, since it is such a significant part of the agricultural economy and Cambodia's GDP, as well as its cultural and main food source. However, much of the soils within the study area are not conducive to rice and therefore, its value in considering Scenario 3 (the only scenario in which agriculture makes potentially significant contribution) depends on applying improved agriculture practices to increase soil quality and improve yield, as well as, improved water management.

The TEV is based on map imagery metadata and current market values for rice. An estimated $49 million of rice is produced during 2010 and the NPV is approximated at $384 million. Refer to table 4.25 for more details.

Table 4.25 Agriculture Baseline - Rice TEV and NPV over 10 years

Agriculture Note: Rice is used since Cambodia's most critical crop, accounts for conversion to other landuse e.g. plantations, etc. which would have lower economic and social (health) values.	
Study areas under cultivation (ha) assumed to remain constant over study period	39,000
Yield tons based on ton/ha (assumed to be constant).	2
FV of crop value based on $/ton)	$625
Sliding scale assumed to be constant over study period.	0%
Baseline TEV (2010) (millions USD)	**$49**
Baseline NPV 10 yrs @ 8% (millions USD)	**$384**

4.4.6 Carbon Sequestration Baseline

Like tourism, carbon credit can significantly alter the benefic cost analysis. While tourism is market driven, there is no system currently in place to pay for the carbon storage service, and very little data is available for setup, monitoring, and management. However, the apparent willingness to pay appears to be sincere and the potential offsetting benefits and costs for the different scenarios is too great not to be included as a separate TEV line item. This is supported by the recent (November 2010) $3 million grant Cambodia received from the United Nation's REDD Policy Board to be applied toward developing Cambodia's Carbon Credit Program (www.un-redd.org, 2010).

This study limits carbon valuation to above ground biomass estimates for evergreen, semi-evergreen and deciduous forests only. Evergreen and semi evergreen forest regrowth rate is 0.33 m^3/ha/year (Ashwell, 2008). It would take considerably longer than 10 years for forest regrowth to contribute to carbon sequestering (FAO FRA Report, 2005). This would be a significant BCA consideration for Scenario 1 and relatively less of one for Scenario 3 within the 10 year time frame but very important if the long term. Regrowth would not be a significant factor for Scenario 2, but still a contributing factor restoring existing uncovered land. Therefore, evergreen and semi-evergreen regrowth will be considered in scenarios BCA.

As discussed in Section 2.0, above ground biomass (AGB) is based on standing volume of forest, then converted to tons of carbon by using the general assumption that tree biomass is 50% carbon (Hansen and Neth, 2006; Pearson, et. al, 2008; Chheng, 2007).

Depending on the market (regulatory or voluntary) the price of carbon can range between $3.50/ton to over $20/ton. This study uses $3.50/ton as a reasonable conservative estimate. Based on the 760,000 ha estimate and conservative carbon value of $3.50/ton, the TEV of standing forest is about $150 million. Considering the annual loss rate of 1%, the NPV at 8% is projected just over $1 billion (refer to Table 4.26).

Table 4.26 Carbon TEV and NPV over 10 years

Carbon Storage (sequestering)	
Forest study area (ha)	760,000
Density (tree volume in m^3/ha)	115
Forest study volume(m^3)	87,400,000
Standing Stem Volume (SV) is the remaining forest volume after assumed baseline production rate of 1%.{Note: volume loss assumed to an annual rate to account for natural decay and forest degradation due to roads, etc.)	-1%
Wood density (WD) is the average wood density for natural forest in SE Asia	0.57
Biomass expansion factor (BEF) converts SV to AGB	1.74
Carbon factor (Cf) is the carbon stored in mt based on 0.5 C ton/SVm^3 (based on dry volume and weight)	0.5
Above Ground Biomass (AGB= SV*WD*BEF)*Cf in (mt) = .5*SV {Note:1.74*0.57=0.99}	0.5
FV at Carbon value in $/ton	$3.50
Baseline TEV (2010) (millions USD)	**-**
Baseline NPV 10 yrs @ 8% (millions USD)	**$671**

Using a range between RWC and RWB would make a significant difference for all scenarios (See Section 5.0). Again, limited information is available for set-up, monitoring and management costs, but a recent REDD+ roadmap has been prepared and estimates that a program to begin mid 2014. Therefore, the current valuation for 2010 is $0, and assuming a program will take place mid 2014, the estimated NPV is around $671 million.

4.4.7 Payment for Environmental Services & Biodiversity

Very limited studies were available covering biodiversity and Payment for Environmental Services values in Cambodia. Bann conducted a biodiversity study in the Kampot Province (1997), which placed a total "captural" value $30/ha on forest biodiversity based on Ruitenbeek's *"Rainforest Supply Price*" (1990).

PES values are based on planned community forest (CF) management schemes. In Prey Lang, there are currently 100,000 ha of CFs with a management value of $2/ha. See Table 4.27

Table 4.27 PES TEV and NPV

Payment for environmental services (PES)	
Community forests (CF=26) area within study area (ha) (assume remains constant)	100,000
Rate of change (assume remain constant)	0%
FV of CF at ($/ha)	$2.00
Baseline TEV (2010) (millions USD)	**$0.2**
Baseline NPV 10 yrs @ 8% (millions USD)	**$1.4**

Using a value of $30/ha for biodiversity, the total estimated TEV for Prey Lang forest based on standing volume and a 1% deforestation rate is $23 million (Table 4.28). The NPV over 10 years at 8% is $156 million.

Table 4.28 Biodiversity TEV and NPV

Biodiversity	
Forest Study Area (ha)	760,000
Forest loss based on annual production rate	-1%
FV biodiversity value based on $/ha.	$30
Baseline TEV (2010) (millions USD)	**$23**
Baseline NPV 10 yrs @ 8% (millions USD)	**$156**

4.4.8 Forest Ecosystem Services

Studies on forest hydrological services in Cambodia were not found during the literature review phase of this project. However, CDRI valuation studies provided several case studies within the South East Asia region, which this study assumes are relevant and applicable to this assessment.

Watershed protection and soil erosion mitigation values are typical measuring tools for estimating watershed services provided by a forest (Hansen & Neth, 2006). In a case study by Emerton, *et.al.*, in Lao PDR, the value of water conservation and soil conservation is estimated at $70/ha/year and $60/ha/year respectively (2001). This study indicated that deciduous forests can only provide benefits when a constant crown covers is established; however, forest ecosystem services are provided by the entire forest and, therefore, applied to the entire study forest area. Deforestation rate was applied annually at 1%.

The total economic value of watershed protection and soil erosion for the forest area (760,000 ha), is approximated at $99 million for 2010, and net present value at 8% discount rate is estimated at $676 million. See Table 4.29.

Table 4.29 Forest Ecosystem Services TEV and NPV

Forest Ecosystem Service (FES)	
Forest Area (ha)	760,000
Forest loss based on annual production rate	-1%
FV of FES at $/ha (assumed watershed protection-$70; soil erosion $60)	$130
Baseline TEV (2010) (millions USD)	**$99**
Baseline NPV 10 yrs @ 8% (millions USD)	**$676**

4.4.9 Summary of Economic Valuation

The separate TEV for direct and indirect use values are $189 million and $122 million respectively.

When considering only Direct Use Values of the forest, timber is the largest contributor with approximately $68 million. Fisheries and rice each account for $49 million followed by NTFP at $17 million and tourism at $6 million. In total, these contribute about 1.7% to Cambodia’s GDP of $11 billion (EIC, 2010; WB 2010). Alternately, when Indirect Use Values are taken into account, the TEV of the 2010 baseline is drastically altered, and the total contribution to GDP is 2.8%. Table 4.30 summarizes the TEV and NPV values generated in this Section.

However, the indirect use values are based on limited and very subjective resources at this time. Further valuing of ecosystems is necessary before their values can reliability be incorporated into TEV. On the other hand, even the direct use values are subject to uncertainty based on the limited resources, although not quite as subjective. One potential way to overcome part of the difficulties is to define ranges between reasonable worse case (RWC) and reasonable best case (RBC) and interpolate a reasonable most likely case within the range limits. Like BCA and the sustainability matrix as discussed in the Section 6.0, RWC, and RBC are best defined by consensus.

In summary the total 2010 economic value of the study area is $311 million, contributing 2.8% to the overall GDP of Cambodia. The NPV projection over the 10 year assessment at 8% discounted rate for the Baseline “continuing to do business as usual (BAU) is estimated at $2.9 billon. A detailed summary is included in Appendix B.

Table 4.30 Baseline TEV, NPV and GDP Contribution

	STUDY AREA BASELINE			
	USE VALUES	**Economic Value (2010)** (USD Millions)	**Baseline TEV contribution to GDP**[1] **%**	**NPV 10 YR Projection - Baseline** (USD Millions)
Direct Use Values	Timber	$68	0.6%	$487
	NTFP	$17	0.2%	$114
	Fisheries	$49	0.4%	$352
	Tourism	$6	0.1%	$49
	Agriculture	$49	0.4%	$348
	PES	$0.2	0.0%	$1
	Subtotal DUV	***$189***	*1.7%*	***$1,352***
Indirect Use Values	Carbon	$0	0.0%	$671
	Biodiversity	$23	0.2%	$156
	FES	$99	0.9%	$676
	Subtotal IUV	***$122***	*1.1%*	***$1,503***
	TOTAL TEV	**$311**	**2.8%**	**$2,855**

4.4.10. Baseline Sustainability Matrix

The Sustainability Matrix as discussed in Section 2 provides a means to consider the external indirect considerations which are not captured in the economic and financial models, but have an equal and often far more significant effect on the decision making process. If not taken into account, decisions made today may be much regretted in the future; there are enumerable examples. The Baseline Sustainability Matrix was completed in it entirety as described in Section 2. Its total scores are summarized in Table 4.31. The full Matrix can be found in Appendix B.

Table 4.31 Baseline Sustainability Scores

Potential Forest Impacts	**Economics**				**Social**				**Environmental**				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**
Economics	3	3	0.8	264	3	3	0.8	270	3	2	0.9	204	**739**
Social	3	3	0.7	157	3	3	0.7	176	3	3	0.8	206	**540**
Environmental	3	3	0.7	246	3	3	0.7	246	3	3	0.9	275	**767**
Average CL/Sum of S			0.7	**667**			0.7	**692**			0.8	**685**	**2045**

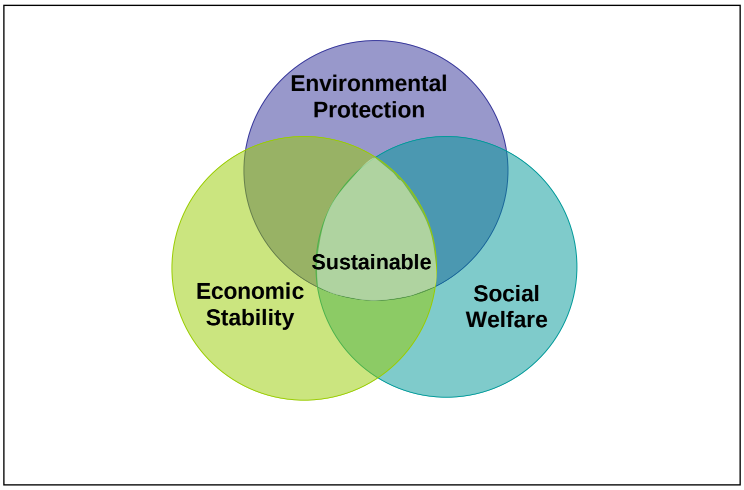
The importance (I) was held constant for each of the individual parameters, since all were considered to be of high importance (3), but value (V) varied from 3 to 1 as rated from good to bad. The confidence level (CL) is higher than in the scenario matrices, since the relevant data is more readily available.

The Baseline Sustainability Scores present an indication of how current conditions are perceived, and become the benchmark by which progress is measured, or in comparing the scenarios indicates how each strategy is measured relative if things remain the same, as discussed in Section 6. And finally the baseline score as compared to target score provides the spread from where “we are now, relative to where we would like to be. This is covered in Section 6.

5.0 ASSESSMENT SCENARIOS

This section presents a comparative assessment of three forest development strategies on hydrology and its effect on the social, economic, and environmental aspects of sustainable development as shown in Figure 5.1.

Figure 5.1 Primary themes of sustainability



The strategies are addressed in three scenarios: conversion, preservation and conservation as discussed in Section 1.1, and defined below.

- **Conversion** is the full conversion of the existing forest to other land uses in order to reap the maximum economic value of the timber in the shortest possible time frame.
- **Preservation** is to provide sufficient funding, policy, regulation and enforcement to protect the forest from exploitation, environmental disruption and social-economic intrusion, to preserve the remaining forest as is or better in perpetuity.
- **Conservation** is the optimization of forest development and environmental conservation by developing, implementing and maintaining a balanced sustainable land use management approach involving local communities, advocacy groups, and economic enterprises in partnership with the national government to maximize optimum economic returns, while minimizing disruptive environmental and social impacts.

Each scenario seeks to maximize the objective of the specific goals. For conversion, the objective is to maximize revenues for social and economic benefits. For preservation, the objective is to maximize forest protection to mitigate environmental concerns relative to social welfare. And for conservation, the objective is to maximize the optimum balance between the two extremes. The scenarios were assessed in terms of the three main themes of sustainability: environmental protection, economic stability, and social welfare.

As discussed in Sections 2.0 and 4.0, BCA/TEV and Sustainability Matrix compares (Section 6.0) the three scenarios over a period of 10 years taking into account the social, economic and environmental implications. Data used for this assessment was extracted from localized and general research studies, and extrapolated to fit with the Study Area.

5.1 Forest Scenarios

The Prey Lang Forest is currently used for multiple purposes, including farming, residential, mining, logging, fuel, and tapping natural resources provided directly by the trees (e.g. resin, and honey) and indirectly (e.g. pharmaceutical plant). Some areas have been heavily exploited, and yet there still remains a large undisturbed forest with high ecological and environmental importance which is susceptible to a wide range of long term negative impacts. At the same time the forest provides the opportunity for economic growth which could reduce degrees of poverty and increase economic stability. However, in and by itself, the economic contribution of the Prey Lang Forest to sustainable economic growth and security may be relatively limited on a national scale, and short term; while in the long term, irreparable environmental costs could be incurred.

Logging activities in forest concessions have been on hold since January 2002, subject to concessionaires, mostly international companies, developing adequate strategic forest management plans (SFMP) (Atlas of Cambodia, 2006). The restrictions remain in place to date, presumably due to FA dissatisfaction with the SFMP submitted. It is assumed likely that at some point in the near future, at least some logging will be allowed to proceed adding to the economic and mining concessions that have already been issued, and the existing Community Forest areas. This study assumes the restrictions are in place for baseline and lifted for the different scenarios.

Since the economic value of the trees is selective and applicable to discrete tree types, it is possible that not all areas of the forests may be harvested solely for its timber, and within the relatively short time frame defined for this study (10 years), the forest may not be totally converted by the end of the study period. However, in the long term, beyond the ten year period, uncontrolled clearing for all purposes including agriculture, rural development and mining and other land uses, could potentially result in full conversion of the forest as is common in very many areas of the world, developed and otherwise.

The economic gains on a local and national level are calculated for large-scale timber exploitation and conversion using the baseline default factors, as discussed in Section 4.0. These are then qualitatively considered with respect to how the affected hydrology affects the socio-economic and environmental benefits and costs, within the study area, as well as the impacts on downstream infrastructure, water supplies, agriculture and fisheries, including water quality such as arsenic concentrations and the potential of significant changes in flooding in the high density population area.

Figure 5.2 lists the potential ecosystem services affected by the development of the Prey Lang Forest. In general, ecosystem services are considered benefits, and the loss of services are considered costs. However, it should be noted that an increase or decrease in affects is not necessarily indicative of positive or negative impacts, and each has a counter effect, or tradeoff, to some degree.

Figure 5.2 Potential Effects of Forest Development

Potential Effects of Forest Development

Ecosystem Services

Decreased
- Photosynthesis
- Carbon Sequestering
- Watershed management
  - Torrent control
  - Erosion Control
  - Water quality
  - Sediment reduction
  - Wetland protection
- Biomass
- Nutrient cycle
- Stream bank management
- River bank management
- Biodiversity
- Pollination
- Seed dispersal
- Terrestrial Habitat
- Transpiration
- Land use barrier
- Drought mitigation
- Shading
- Natural pest control

Increased
- Stream Flow
- Flood potential
- Sediment load

Altered
- Food chain supply
- Natural primary production
- Endangered species
- Wildlife migration pathways

Socio-Economic Services

Increase
- Timber
- Non-wood forest products
- Recreational
- Food production
- Pharmaceuticals
- Land use development
  - Residential
  - Industrial
  - Agriculture
  - Transportation
- Employment
- Economics
- Energy

Decrease
- Aesthetics
- Fuel wood
- Fisheries
- Tourism

Altered
- Cultural value
- Spiritual value

Downstream Socio-Economic Services

Increase
- Recreational
- Migration to Forest
- River flow
- River height
- Flood control
- Sedimentation
- Economics

Decrease
- Aesthetics
- Fisheries

Unknown
- Cultural value
- Spiritual
- Social

5.1.1 Baseline Conditions

The Baseline conditions, as established in Section 4.0, are equivalent to the “do-nothing” scenario, typically considered a benchmark in economic studies and risk analysis. There are studies which concluded that taking no action was the most cost effective solution with the least risk. The Baseline for this study focuses on the financial sectors of agriculture, fishing, tourism, and logging, since they are the main revenues sources for the study area, as well as NTFP which provides an estimated 36% of the income for medium to low income families in the area (Atlas of Cambodia, 2006). Agriculture in and around the forest area itself is largely subsistence farming, which does not typically generate income directly; however, it does have a significant value to those dependant on it, and the cost incurred, if lost, can be quite traumatic, causing social and cultural problems.

Each sector addressed in the baseline, is considered with respect to its relative economic, social and environmental benefits and cost on a qualitative basis. In addition, carbon credit is considered as a potential significant source of revenues, even though there is currently no system for payment, and it is uncertain when, how and if the credit will actually be given. However, regardless of payment, carbon sequestering is a service provided by the forest, and the carbon credit is a good basis for valuing those services. Therefore, carbon credit is included in the TEV as a separate item.

The baseline annual production rate of 1% of existing forest in hectares is based on the RGC Forestry Administration feedback, and assumes that at least a portion, of the current moratorium on forestry concessions will be lifted to support this rate. Since the baseline standing area is 760,000 ha, the baseline production rate is 7,600 ha/year, which is held constant throughout the 10 year study period. This is based only on that portion of the forest that potentially has the greatest impact on local and national GDP.

For the Baseline scenario, it is assumed there is no significant decrease in NTFP revenues, since substantial areas of forest remain intact. On the other hand, the decreasing forest coverage would reduce its capacity to provide CO_2 sequestering services. Baseline agriculture and fishing yields are assumed to remain constant, although there might be relatively small increases in the former and decreases in the latter, as forest areas cleared.

The costs of ecosystems for which a value has been placed are (biodiversity and forest service) are based on the magnitude of the land cleared. For baseline production rates, the overall loss of cover over the 10 study period would be equivalent to one year for Scenario 1. Thus, the relative baseline ecosystems losses would be small. The following Tables 5.1 summarizes the Baseline TEV as discussed in Section 4, and Tables 5.2.1 and 5.2.2 summarize the baseline and target sustainability scores for respectively as discussed in Section 6.

Table 5.1 Baseline TEV Summary (million USD)

USE VALUES	Base*	% GDP	NPV**
Direct	$189	1.7%	$1,352
Indirect	$122	1.1%	$1,503
Total	**$311**	**2.8%**	**$2,885**

* Revenues for base year 2010

** 10 years at 8% DCF

Table 5.2 Baseline Sustainability Score

Potential Forest Impacts	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**
Economics	3	3	0.8	264	3	3	0.8	270	3	2	0.9	204	**739**
Social	3	3	0.7	157	3	3	0.7	176	3	3	0.8	206	**540**
Environmental	3	3	0.7	246	3	3	0.7	246	3	3	0.9	275	**767**
Average CL/Total S			0.7	**667**			0.7	**692**			0.8	**685**	**2045**

Table 5.3 Target Sustainability Score

Potential Forest Impacts	TARGET												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**
Economics	3	5	0.9	499.5	3	5	0.9	499.5	3	5	0.9	499.5	**1498.5**
Social	3	5	0.9	445.5	3	5	0.9	445.5	3	5	0.9	445.5	**1336.5**
Environmental	3	5	0.9	526.5	3	5	0.9	526.5	3	5	0.9	526.5	**1579.5**
Average CL/Total S			0.9	**1472**			0.9	**1472**			0.9	**1473**	**4415**

The baseline sustainability score (2045) provides an indication of the current conditions, and the ideal target score (4415) indicates preferred conditions as a goal for improvement. Consequently, it would take a factor of 2.15 to increase the baseline score to the ideal state. As discussed in Section 6, regarding strategic planning, the ideal score may not be realistic and a more reasonable goal may be a score of 4010 (90% of ideal), reducing the improvement factor to 1.9, and if we start with a more moderate staged approach, the initial goal might be achieved by a factor of 1.08 (i.e. target score of 2228).

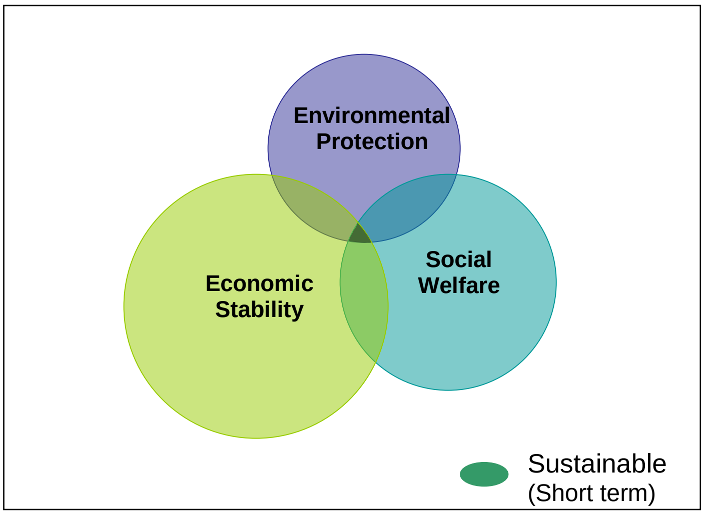
It is important to recall at this time that while these scores are representative to this assessment, which are of value in that they represent an independent objective engineering perspective, they are limited in that they are based on only one evaluation, they do not reflect the Khmer perspective, and they do not include all the interested parties and stakeholder.

The following sections describe the general dynamics and assumptions for the different scenarios relative to baseline.

5.1.2 Scenario 1: Conversion

Scenario 1 assumes that the primary motivation for the conversion is to realize maximum economic gain from harvesting the trees. Conversion focuses on logging of Prey Lang Forest to obtain maximum revenues relative to GDP within the study period (10 years). While there may be other reasons for removing trees (e.g. rural development, agriculture, reservoirs, hydropower, roads, and mining—to name a few) they are not the focal point of this study, although how they may be affected by forestry operations are considered. The sizes of the circles in Figure 5.3 show the relative focus of conversion with respect to the three core themes (environmental, social and economics).

Figure 5.3 Conversion Sustainability Interactions



ECONOMICS

Since the financial returns in terms of direct monetary value is the primary driving force of this strategy, there is no motivation to consider the environmental tradeoffs. From a business standpoint the objective is maximum economic gain or profit on an annual basis, as determined by the maximum harvest yield or production rate through logging efficiency and economies of scale, without concern for external environmental costs. Therefore, maximum logging production rate as measured relative to decreasing forest cover is the basic determining factor for Scenario 1.

The actual maximum achievable production rate for Scenario 1 is not known, but it is reasonable to assume that it will be greater than Baseline. In the worse case, the entire forest would be depleted over the study area period of 10 years, which would be 10% a year of the entire baseline forest, or 76,000 ha/yr. It is uncertain, that this rate is attainable but is supported by one reference (FAO in mongabay.com), and is used as the worse case projection for TEV. A reasonable best case of 2% ha/yr is assumed based on the high estimate using the cover changes over 10 years without restrictions as discussed in Section 4.4.1. It is equivalent to a production rate of 15,200 ha/yr. The median of the two extremes is (6%) is considered a reasonable likely case for Scenario 1. The worse case is used to be conservative, but using the RWC/RBC range provides more robust assessment (See Section 6.0).

The Baseline contribution to TEV by NTFP, tourism, agriculture and fisheries are considered constant, because the area cleared by forestry annually is relatively small as compared to Scenario 1 (nearly tenfold under worse case prediction). Under the Scenario 1 strategy, the cleared land would be significant, and NTFP and carbon credit revenues would decrease annually, inversely proportional to the timber production rate as a function of area, while agriculture land use would increase with a corresponding increase in revenues, assuming farming practices stay constant. Scenario 1, in and by itself and within the Prey Lang forest, would probably not attract tourism, and it may well repulse it. The highest tourism attractions are not within the forest area, but several attractions, could be negatively affected by the conversion strategy, such as the Irrawaddy dolphins in Mekong River and the Great Lake itself. Therefore, it is assumed tourism would decrease.

The direct affect on fishing is not easily determined, but the evidence (See Section 4.3.2) supports the hypothesis that the negative effects could be substantial, not only to commercial and subsistence fishing, but also to biodiversity as a whole, to which fish species make up a significant portion as discussed below. However, these effects may not be immediately noticeable.

Therefore, on a strictly economic basis, TEV would increase as compared to Baseline due to increased forest and agricultural revenues, and decrease due to reduction in NTFP, tourism and fishing revenues.

However, there are unaccounted costs, such as the loss of opportunity cost, (e.g. ecotourism as discussed under preservation), and cost of engineering controls and remedies to address the loss of environmental services (such as forest watershed services) as discussed below. In the long term, these costs could far exceed the short-term revenue benefits of this scenario.

SOCIAL

The results of the increased TEV is not expected to be significant on national level based on Prey Lang forest yield by itself, although will have some immediate economic benefits to the local economy through increased employment. The employment opportunities would not only be in forestry but also in building the infrastructure and roads to support it, as well as the increased farming activities, all of which are assumed to make up for the loss in subsistence from fishing and NTFP. Along with the increase in employment, is an increase in personal income, and the ability to pay for previously foregone necessities, such as education, and health care, as well as amenities. However, there are concerns that the employment might not go the local inhabitants and then if indeed the forest was depleted in ten years, the economic advantaged would be short lived, since the exploitation rate would exceed the restoration rate which reportedly could be 50 years.

In addition to the key economic consideration and potential physical impacts associated with the logging of the forest, there is the major change in life for the estimated 250,000 indigenous people who live around forest and rely on it. How to compensate for these losses is relatively easy if it is just a matter of cost of relocation and assimilation, but as countless historic studies show, the psychological adjustment can be devastating to the culture and the cost to society can be extremely high, both financially and politically.

ENVIRONMENTAL

Since neither environmental preservation nor conservation is a matter of concern in this worst case strategy, the environmental costs will be high and the difficulty of putting a price on the losses is quite complex. The loss of environmental services alone could far exceed any financial gain, especially in the long term. Because of the assumed total exploitation of the forest, it is reasonable to assume the equivalent degradation of the environments, which would include to some extent all those listed in ecosystem services column in Figure 5.2 above. It is difficult to segregate out aspect to focus on since the net effect is the accumulated interaction of all. Therefore, the Sustainability Matrix (see Section 2.5 and 6.0) is a relatively simplistic way to arrive at a reasonable indication of the net effect. But as discussed in Section 6.0 the matrix cannot be based on single party evaluation, but should be the culmination of all the parties who have a stake in the score. However, since the focus of this assessment is hydrology, the following attempts to address some of the potential key considerations that could be affected by the watershed services provided by forest, which is a function of its hydrology. These services include holding soils in place, reducing erosion, reducing rainfall impact, buffering runoff velocity and providing organic nutrients to soils.

Based on the existing baseline data, the current surface water quality is relatively good and, unless industrial activity increased significantly, there is no reason to suspect a major change, although mining could be the exception, and depending on the sources of reported elevated concentrations of arsenic, arsenic levels could raise. It is assumed that the most extensive use of the cleared forest land will be for agriculture. However, the soils for the area are reportedly poor (See Section 4.1.3), so it is anticipated that farming practices will remain the same as baseline conditions, but if the use of fertilizers and soil enhancement additives are increased, the quality of the watershed runoff could go down.

Due to the generally low sloped topography and poor soil quality, there is not anticipated to be a major change in mechanical forces of hydrology (e.g. erosion) within the forest area, although local temperature changes could affect farming practices and water needs and will have a major impact on local biodiversity. However, as the runoff reaches the river banks, the geomorphology could be severely affected, especially at the Mekong, and the hydraulics of the river altered affecting the entire Tonle Sap Basin. These effects could be far reaching and significant, including spoiling fish migration courses and spawning grounds, depleting soil nutrients, and most significantly perhaps, increasing the flood plain, which could be quite extensive and damaging, especially as populations continue to grow within the area.

On the other hand there are reports of reduced flow in the Mekong due to dam construction causing a reduction in the Tonle Sap floodplain by as much as 5%. This, in turn, is already creating a significant loss in fisheries production (Sarkkula et al, 2010). It is doubtful that the increased discharge to the Mekong from Siem Bok (a), due to this scenario would help offset the situation, but the possibility should not be ignored at this time.

In addition, the silt loads into the rivers will increase, further altering the river dynamics, effecting biodiversity and increasing river maintenance such as dredging needs and costs. While not within the scope of this study, one of the area’s most vulnerable to any change to the upstream discharge and quality of the Mekong, is the Mekong Delta. Reportedly, upgradient dams are intercepting some of the silt, which if correct, may have beneficial effects within the Phnom Penh area, but deleterious effects to the Delta where the silt contributes to the rich soil. The contribution of increased suspended solids to the river could increase the net negative impact on both areas, but the magnitude is beyond the scope of this study.

In light of the proposed dams and irrigations systems discussed in the Baseline section 4.2.1, there are some potential compensating benefits of increased loads making up for the sediments retained by the dams. On the other hand, the area necessary to be cleared to make up for the sediments retained may be too great and project specific environmental assessments would be necessary to determine the net effect. Or as in the case of proposed St. Treng and Kratie dams, all the runoff sediments from Prey Lang Siem Bok(a) might make up for the sediments retained by St. Treng, only to be captured by the downgradient Sambor dam. The proposed systems in St. Sen and Chinit are different, and the dams and reservoir could become silted up very fast.

There is not a lot of information regarding aquifer water quality, and as discussed in Section 4.2.4 most of the wells used for a domestic water supply are most likely in shallow water table aquifers, especially those within the Tonle Sap flood plain. In general, the water quality of water withdrawn from shallow water table aquifers is poor due infiltration of surface contaminants (e.g. fecal coliform). As agriculture activity increases as a result of deforestation, the potential for contamination increases, with the increase in fertilizers and pest control, the natural controls being lost with the forest.

Moreover, as agriculture increases, the demand for irrigation will increase, which will require additional surface water storage capacity and could tap into groundwater. While it is anticipated to be a long time before over pumping the groundwater would be considered a problem, the potential increases with increased farming, industrial, and residential usage.

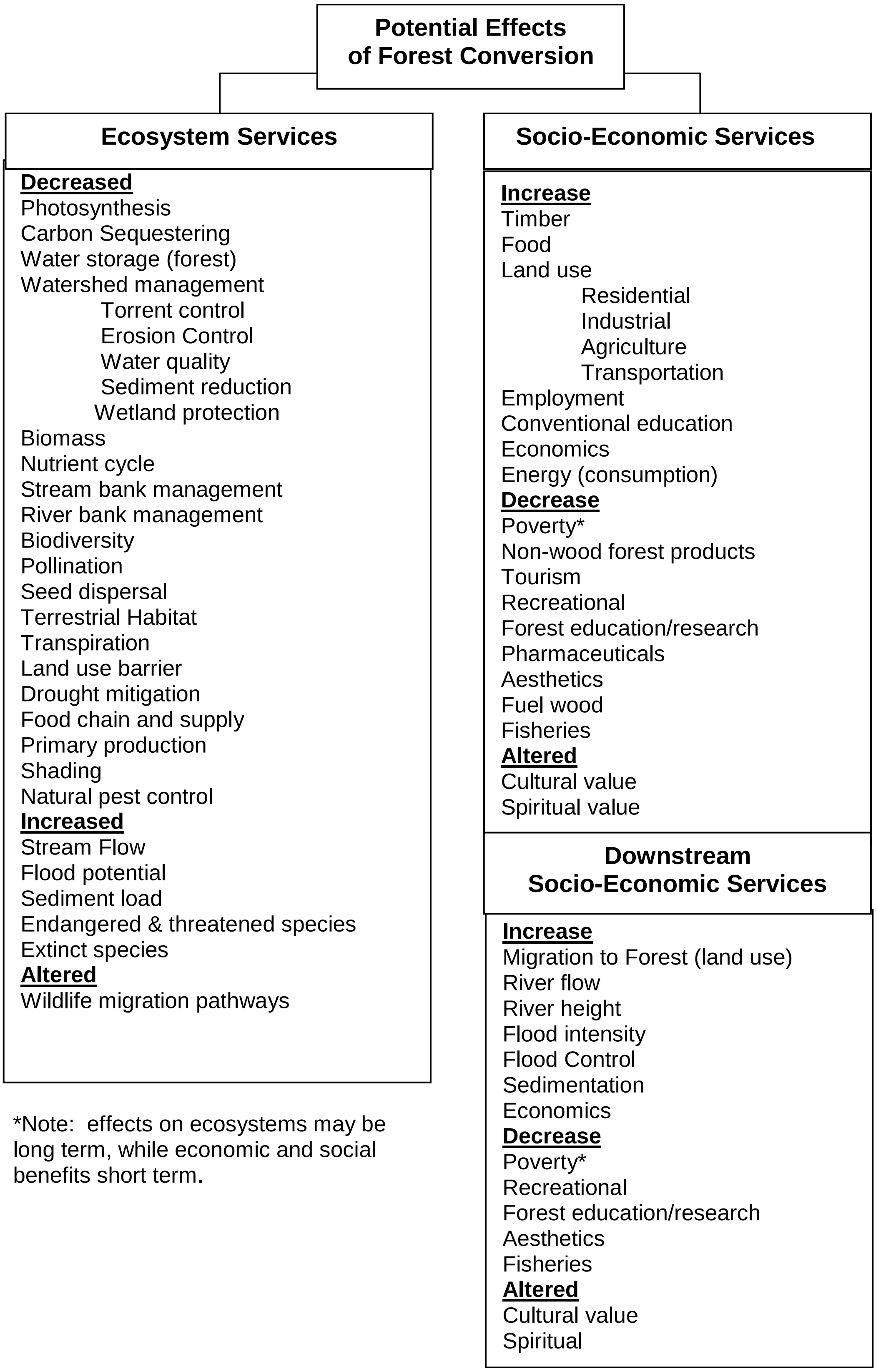
The existence of deeper high yield aquifers is not known. Deeper confined (artesian) aquifers can provide a good source of reliable high quality water, although natural contaminants such as arsenic and fluoride can be a problem with wells drawing water from fractures in granite. Recharge of these aquifers can be from the lake and rivers as well as direct rainfall into geologic surface outcrops. Depending on the source of recharge, excess deforestation can impact both quality and quantity of the water. It is not known if this is the case for the Prey Lang Forest, and deep aquifers were not considered in the BCA.

There is not a high level of mining activity within the forest itself, but there is relatively high level of mining activity north of the forest in the Stung Sen watershed, and there are some reports of potential mining prospects in the Siem Bok and Stung Chinit watersheds. Determining the impacts of mining within the study area, would take a focused assessment similar to this report, as discussed earlier. It is assumed that any timber covering mining surface would be logged for its economic value, and due to the low topography the increase in area runoff, should not cause a major problem to the mine operations. However, upgradient mining activities could affect water quality, especially if open pit mining and ancillary ore processing mills close by. These effects would be increased as the area of deforestation increases, or as mining activities were expanded but based on current levels and locations, they are not included in this study.

The extensive biodiversity within the Prey Lang forest is well recorded and includes both flora, including some tree species to be logged, some of which have been identified as endangered or threatened; and endangered fauna, the most prevalent are the variety of fish in the Tonle Sap basin, the Central Section of the Mekong River, and Stung Chinit. The magnitude of the impact of logging the Prey Lang on biodiversity is dependent on the degree of habitat loss, change in ecology, alteration of the water dynamics, interfering with food chain, and destruction of migration paths. While many of these impacts would occur regardless of changes in hydrology, those changes certainly directly and indirectly influence the net result. The greater the forest area lost, the higher the impact on all these alterations. How to quantify them is a difficult task and beyond the scope of this assessment, but is addressed on a qualitative basis in the weighted matrix score (see Section 6.0).

Figure 5.4 provides a partial list of how the base services provided by the forest might be affected by conversion. Table 5.3 presents the projected TEV for conversion and Table 5.4 presents the conversion sustainability score.

Figure 5.4 Potential Effects of Forest Conversion



Potential Effects of Forest Conversion

Ecosystem Services

Decreased

- Photosynthesis
- Carbon Sequestering
- Water storage (forest)
- Watershed management
  - Torrent control
  - Erosion Control
  - Water quality
  - Sediment reduction
  - Wetland protection
- Biomass
- Nutrient cycle
- Stream bank management
- River bank management
- Biodiversity
- Pollination
- Seed dispersal
- Terrestrial Habitat
- Transpiration
- Land use barrier
- Drought mitigation
- Food chain and supply
- Primary production
- Shading
- Natural pest control

Increased

- Stream Flow
- Flood potential
- Sediment load
- Endangered & threatened species
- Extinct species

Altered

- Wildlife migration pathways

Socio-Economic Services

Increase

- Timber
- Food
- Land use
  - Residential
  - Industrial
  - Agriculture
  - Transportation
- Employment
- Conventional education
- Economics
- Energy (consumption)

Decrease

- Poverty*
- Non-wood forest products
- Tourism
- Recreational
- Forest education/research
- Pharmaceuticals
- Aesthetics
- Fuel wood
- Fisheries

Altered

- Cultural value
- Spiritual value

Downstream Socio-Economic Services

Increase

- Migration to Forest (land use)
- River flow
- River height
- Flood intensity
- Flood Control
- Sedimentation
- Economics

Decrease

- Poverty*
- Recreational
- Forest education/research
- Aesthetics
- Fisheries

Altered

- Cultural value
- Spiritual

*Note: effects on ecosystems may be long term, while economic and social benefits short term.

Table 5.4 Scenario 1: Conversion BCA

USES	Scenario 1		
	Economic Value (2010) (USD Millions)	**Benefits NPV** (USD Millions)	**Costs NPV** (USD Millions)
Direct (DU)			
Timber	$682	$4,867	$0
NTFP	$17	$69	**$112**
Fisheries	$50	$195	$927
Tourism	$5.7	$22	$108
Agriculture	$49	$357	$1,705
Community Forest (PES)	$0.2	$1.0	$2
Subtotal DUV	*$803*	*$5,511*	$2,854
Indirect (IUV)			
Carbon	$0	$219	$501
Biodiversity	$23	$90	$1,202
Forest Ecosystem Services (FES)	$99	$390	$5,410
Subtotal IUV	*$122*	*$699*	$7,112
SUBTOTAL TEV	**$924**	**$6,210**	**$9,966**
BCR			0.62

Note: IRR not applicable.

Table 5.5 Scenario 1: Conversion Sustainability Score

Potential Forest Impacts	Conversion												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**
Economics	3	3	0.6	215	3	3	0.6	163	3	2	0.6	141	**519**
Social	3	3	0.6	199	3	3	0.6	176	3	2	0.7	159	**535**
Environmental	3	2	0.6	134	3	3	0.6	175	3	2	0.7	135	**443**
Average CL/Total S			0.6	**548**			0.6	**514**			0.7	**435**	**1497**

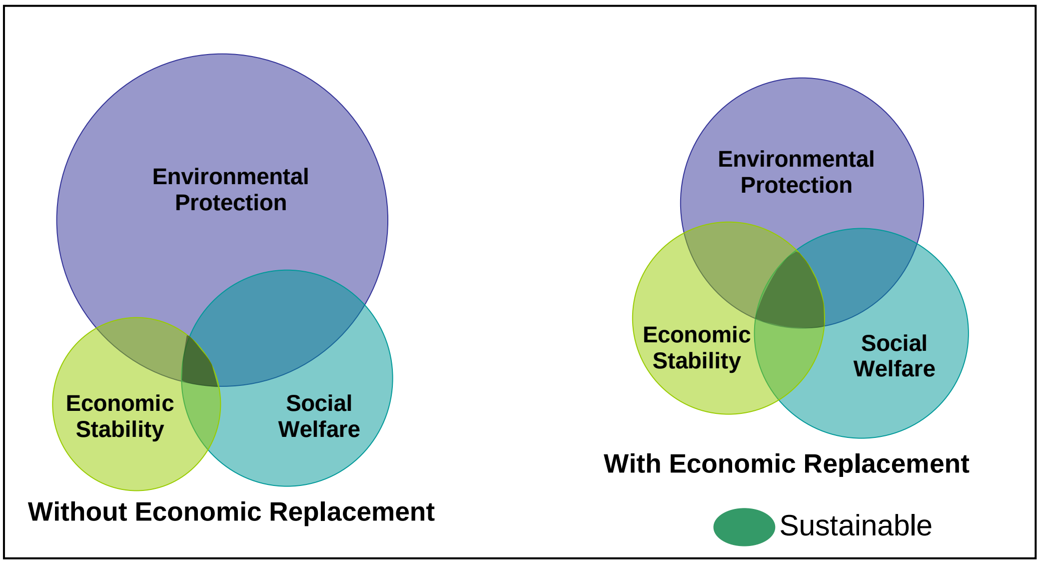
The Benefit Cost Ratio (BCR) as discussed in Section 6.0 is less than one indicating it is not a viable option. The sustainability score is less than the baseline on all accounts. This is primarily due to the relatively high Confidence Level (CL) for the baseline studies and the relatively low CL for Scenario 1; and the consistent negative effect of the environmental factors on nearly all the parameters, while the positive economic and social affects were somewhat limited. Obviously the score would be higher with a higher confidence level, but it is uncertain whether or not the revised score would surpass baseline. However, it appears that the highest improvement would be significantly less then current estimated scores projected for either Scenario 2 or 3, and would not affect the BCA

5.2.2 Scenario 2: Preservation

Scenario 2 is referred to as “preservation”. Preservation within the context of this report assumes there are sufficient public and governmental support and willingness to pay to fully protect the Prey Lang Forest from development and exploitation through policy, funding, regulation and enforcement. While some level development has occurred in the forest, it still contains a large area of pristine forest that is highly valued in its virgin condition, not only important to Cambodia, but the entire Southeast Asia region, if not the world at large.

Whereas Scenario 1 strategy focuses on economics and social aspects with little consideration given the environment, Scenario 2 concentrates on the value of the environment as enveloped by the forest and it social aspects, with little consideration given the economic aspects of opportunity costs, other than ability to pay in order for preservation to be viable and sustainable, as presented in Figure 5.5.

Figure 5.5 Preservation Sustainability Interactions



ECONOMICS

In a complete and absolutely protected forest, all land use, including residential, farming, NTFP, mining, would be prohibited and are assumed to be as such in this case. However, only the Prey Lang forestry and NTFP are addressed in this assessment. Frequently, variances are allowed for indigenous peoples living in and relying on protected resources, such as Community Forest cooperatives and the value of which are considered in all scenarios as part of the Sustainability Matrix evaluation.

The direct economic losses, as a result of preserving the forest in its current state, are equivalent to the economic gain realized in Scenario 1. Parts of preservation losses are recovered by maintaining fisheries, which are reduced in Scenario 1. In addition, it is assumed that the preserved forest would attract tourism, and with the preservation of the Irrawaddy dolphins and Tonle Sap ecosystems, tourism would increase.

In order to maintain the forest and ensure sustainability, replacement sources for logging revenue need to be identified. It is believed that for preservation to be sustainable, the economic losses by prohibited deforestation would have to be made up through other means. Ecotourism may be a potential viable option, although it too has its costs. And, if modeled after Costa Rica, modified to complement Cambodia’s economic, social and environmental culture, and ecological differences, Cambodia could become the ecoculture center of SE Asia. This assessment assumes that ecotourism is developed to the extent necessary to make up the loss of forestry revenues that Scenario 1 would have generated.

SOCIAL

Without the means to replace the economic revenues (industry profits, royalties and taxes) gained through Scenario 1 or make up for the loss capital expenditures injected into social programs such as schools, employment and infrastructure improvements (e.g. roads and utilities), the financial and social benefits from preservations may not be immediately apparent. However, the local indigenous people may be better able to preserve their identity and culture. In addition, there may be international recognition for the awareness Cambodia has initiated to protect its natural resources, and along with Costa Rica, become a model for other countries to follow.

With a means to replace Scenario 1 economic revenues, the social programs, indigenous welfare and the international model will all be attainable, and many of the social costs associated with Scenario 2 will be mitigated. In general, the economic benefits achieved by Scenario 1 are replaced in Scenario 2 by maintaining the value of the environmental services, which can only be sustained, if costs to maintain the services can be paid for. Theoretically, in terms of TEEB method for valuing ecosystems services (See Section 2.4.3), the value of the Prey Lang Forest, would be the cost to replace the forest ecosystem services lost as a result of exploitation as determined in the BCA as discussed in Section 6.0. By including the values of the services in Scenario 2, accounting for them as loss of services in Scenario 1, the benefits of the ecosystem services to society is compounded and the net benefits of preservation would exceed those of conversion.

ENVIRONMENTAL

The value of environmental aspects is often based on willingness to pay (WTP) surveys of the public and/or government officials. The WTP consensus becomes an indication of the value placed on the aspect in question. Cambodia already has protected forests areas, as well as other ecologically sensitive and important biomes including marine, landscape, biodiversity, wild life and fish sanctuaries, and wetlands (Ramsar, both in Tonle Sap and north of the Center Section of the Mekong above StungTreng). All these protected ecosystems involve opportunity cost forgone in favor of the social and environmental value, indicating Cambodia recognizes the environmental services provided by its natural resources. Prey Lang Forest is a good candidate for this type of consideration.

Removal of the forest means a loss of the services provided by it, as discussed for Scenario 1 and listed in Figure 5.2. The consequence of these losses can be quite profound and have global consequences. The three aspects, for which economic values have been estimated, are carbon sequestering, watershed protection, and biodiversity, which are accounted for in Section 4.0 (regarding baseline), and Section 6.0 (regarding Decision Analysis).

The Sustainability Matrix addresses many of the services and considerations, which are not accounted for monetarily but have known important consequences. An example might be loss of wetland services due to siltation, resulting in loss of biodiversity, as well as endangered fish species and productivity. Besides the measured loss of revenues from fisheries, the more vital loss of Cambodia’s primary source of protein, without which children are susceptible to malnutrition and vulnerable to premature death, will not be accounted for.

Another potential indirect loss as a result of the loss of recreational and/or ecotourism revenue might be the loss of the forest as an educational, aesthetical, spiritual, and cultural resource.

An example of a possible worse case might be the country of Haiti before the 2010 earthquake; an example of the best case could be Costa Rica.

Figure 5.6 provides a partial list of how the base services provided by the forest might be affected by preservation. Table 5.5 presents the projected TEV for preservation and Table 5.6 presents the preservation sustainability score.

Figure 5.6 Potential Effects of Forest Preservation

Potential Effects of Forest Preservation

Ecosystem Services

Increase/Sustained

- Photosynthesis
- Carbon Sequestering
- Watershed management
  - Torrent control
  - Erosion Control
  - Water quality
  - Sediment reduction
  - Wetland protection
- Biomass
- Nutrient cycle
- Stream bank management
- River bank management
- Biodiversity
- Pollination
- Seed dispersal
- Terrestrial Habitat
- Transpiration
- Land use barrier
- Drought mitigation
- Food
- Primary production
- Shading
- Stream Flow
- Flood potential
- Sediment load
- Endangered species
- Natural pest control
- Wildlife migration pathways

Socio-Economic Services

Increase

- Aesthetics
- Non-wood forest products
- Tourism
- Recreational
- Farming yield
- Employment* (with ecotourism)
- Economics* (with ecotourism
- Forest education/Research
- Pharmaceuticals

Decrease

- Poverty (with ecotourism)
- Timber
- Land use
  - Residential
  - Industrial
  - Agriculture
  - Transportation
- Energy (consumption)
- Fuel wood
- Fisheries

Altered

- Cultural value

Downstream Socio-Economic Services

Increase

- Recreational
- Migration to Forest (recreation)
- Fisheries
- Economics
- Employment

Decrease

- Poverty
- River hydraulic impacts
- Flood intensity
- Sedimentation

Altered

- Cultural value
- Spiritual

*Note: Increase in ecosystem services during recovery and regrowth stage, after which sustained as long as society willing and able to pay. Economics and employment decreases can be mitigated with replacement alternatives (e.g. ecotourism).

Table 5.6 Scenario 2: Preservation BCA

USES	**Scenario 2**		
	Economic Value (2010) (USD Millions)	**Benefits NPV** (USD Millions)	**Costs NPV** (USD Millions)
Direct (DU)			
Timber	$0	$0	$4,867
NTFP	$17	$181	$199
Fisheries	$49	$1,122	$0
Tourism	$5.7	$130	$0
Agriculture	$49	$1,108	$954
Community Forest (PES)	$0.2	$2.8	$0
Subtotal DUV	*$121*	*$2,544*	$6,020
Indirect (IUV)			
Carbon	$0	$720	$0
Biodiversity	$23	$1,292	$0
Forest Ecosystem Services (FES)	$99	$5,800	$0
Subtotal IUV	*$122*	*$7,812*	$0
SUBTOTAL TEV	**$242**	**$10,356**	**$6,020**
BCR			1.72
IRR			4%

Table 5.7 Scenario 2: Preservation Sustainability Score

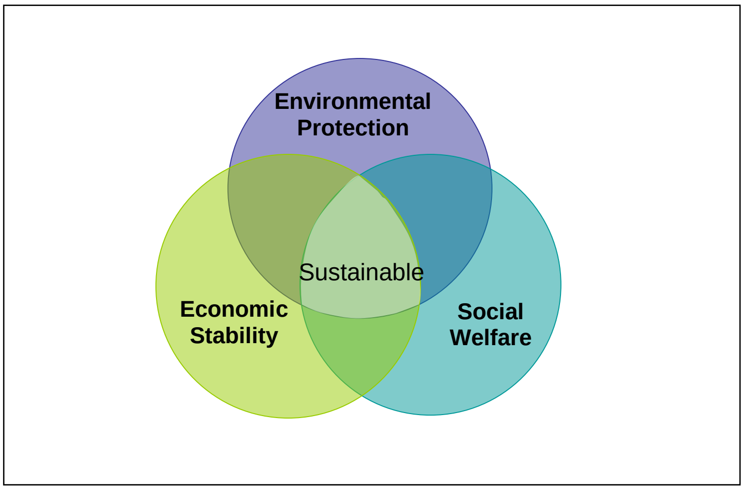
Potential Forest Impacts	**Scenario 2 Preservation**												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**
Economics	3	3	0.6	201	3	3	0.6	165	3	3	0.7	273	**639**
Social	3	3	0.6	225	3	3	0.6	165	3	4	0.7	305	**695**
Environmental	3	3	0.6	257	3	3	0.6	168	3	4	0.7	355	**780**
Average CL/Total S			0.6	**684**			0.6	**497**			0.7	**932**	**2113**

The BCR is greater than one and therefore Scenario 2 is a viable option. The sustainability score is quite a bit higher than the baseline in regard environmental as would be expected. The baseline and social scores are slightly lower. This is due in part to the relatively high CL for the baseline studies and the relatively low CL for Scenario 2. With more information and data, Preservation would most likely exceed baseline enough to be a scenario worthy to consideration. This is especially true if a high revenue economic replacement alternative, such as ecotourism, is developed as discussed above. This specific sub scenario was not evaluated discretely in this assessment, but does determine that ecotourism would have to increase by enough to overcome opportunity cost associated with timber revenues realized in Scenario 1.

5.1.4 Scenario 3: Conservation

If Scenario 1 and 2 are the extremes, from complete conversion of the forest to its full protection, in essence the RWC and RBC, neither being likely, Scenario 3 is a strategy to conserve the best aspects of both in order to conserve the forest and all resources, while obtaining sustainable socio-economic benefits that will improve the social welfare of society as a whole. This alternative essentially implements an optimization program that addresses all the probable outcomes, potential risks and as best able, and identifies the good and bad unintended consequences, such as implementing water resource management tactics to mitigate the potential affects in the changing hydrology and consequently river hydraulics, to protect fish migration paths and spawning grounds. Its Venn diagram (Figure 5.7) comes closest to meeting the optimum balance of prime aspects of sustainability.

Figure 5.7 Conservation Sustainability Interactions



Conservation, in the context of Scenario 3, does not preclude development of resources as preservation does, but prevents uncontrolled exploitation as full conversion might. The objective is to develop the resources to the benefit of society only to the point that it does not harm the environment to the detriment of society. The fact is that the three aspects, economics, society and the environmental are inextricably linked. Conservation can only be optimized by considering how changes in one might affect the others.

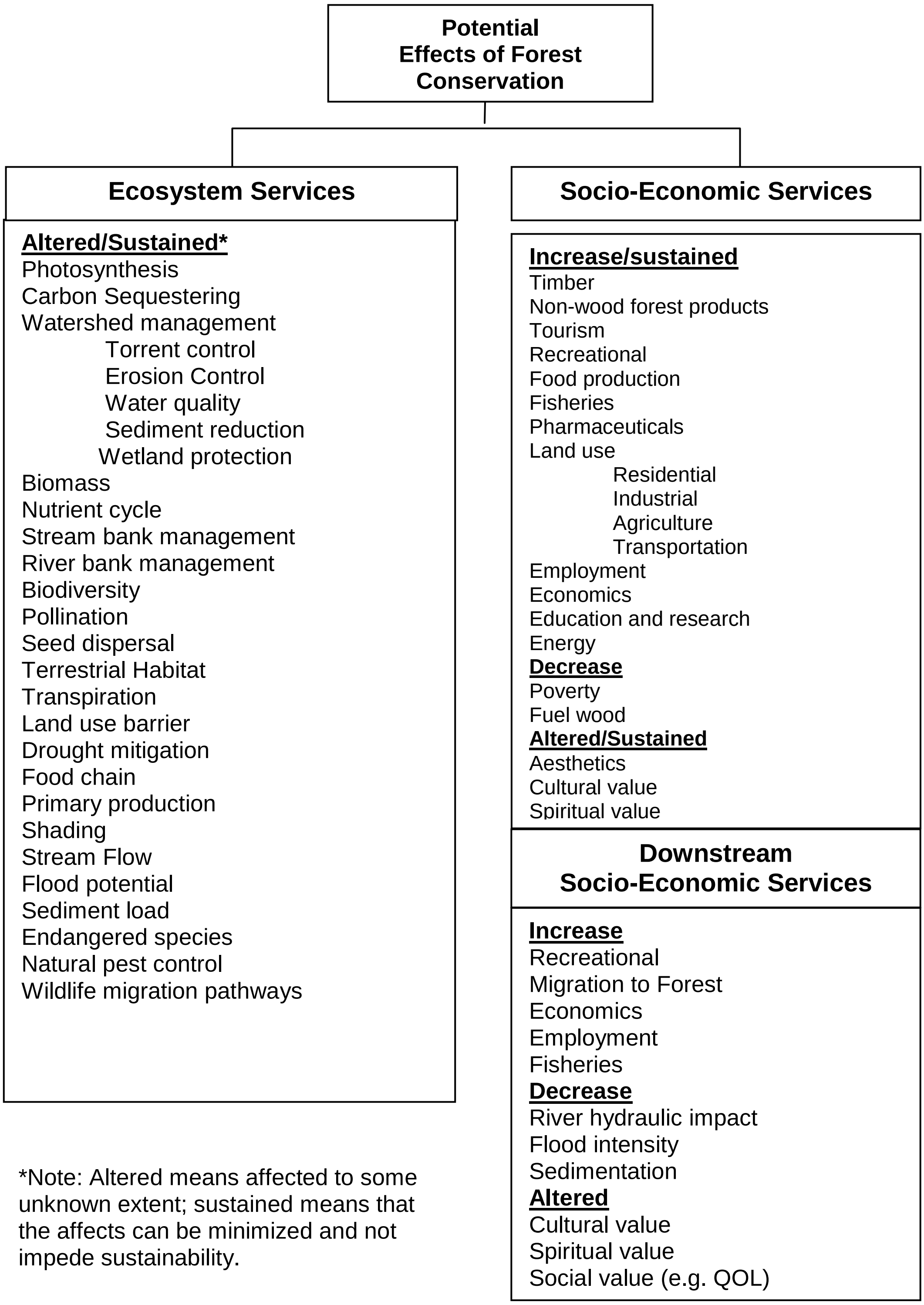
Conversion, as used in this assessment, implies converting from one land use (e.g. forestry or mining) to another (e.g. agriculture), on a grand scale. In the case of forestry development, there need not be conversion to a new land use. With careful, conscientious planning and management, the forest remains a true renewable resource. In the case of mining, there is an unavoidable conversion to a new land state, but with careful conscientious planning and management, the land can be reclaimed to improved conditions equivalent, if not equal, to its original state (sans ore) and is consequently transformed into a renewable resource. In both cases, the exploitation is accomplished in such a way as to sustain the availability of the resource as long as possible, while maintaining the ecological balance. This will not only be the responsibility of the operations, but also the public and government.

Conservation optimization is a combination of strategic resource and management tools such as systems dynamics, decision analysis, risk assessment, Total Economic Value (TEV), Ecosystem Evaluation (e.g. TEEB), Benefit Cost Analysis (BCA), Strategic Resource Management Plan (SRMP including all renewable and non-renewable resources), Strategic Environmental Assessment (SEA), and Sustainable Development Extension Planning (Sudex) utilizing participatory approaches at all levels including local communities, advocacy groups, and economic enterprises, as well as local through national government.

Additional project specific plans, such as Environmental Impact Assessment (EIA), Return on Investment (ROI), Feasibility Studies, and Project Management (PM) can be incorporated into a comprehensive long term holistic and sustainable optimization model for the prudent exploration, exploitation, production, management and closure of resource projects which maximizes the economic, social and environmental benefits and minimizes respective costs. By doing so, it is anticipated the TEV and BCA, will far exceed those of Scenario 1 or 2.

Figure 5.8 provides a partial list of how the base services provided by the forest might be affected by conservation.

Figure 5.8 Potential Effects of Forest Conservation



Potential Effects of Forest Conservation

Ecosystem Services

Altered/Sustained*
- Photosynthesis
- Carbon Sequestering
- Watershed management
  - Torrent control
  - Erosion Control
  - Water quality
  - Sediment reduction
  - Wetland protection
- Biomass
- Nutrient cycle
- Stream bank management
- River bank management
- Biodiversity
- Pollination
- Seed dispersal
- Terrestrial Habitat
- Transpiration
- Land use barrier
- Drought mitigation
- Food chain
- Primary production
- Shading
- Stream Flow
- Flood potential
- Sediment load
- Endangered species
- Natural pest control
- Wildlife migration pathways

Socio-Economic Services

Increase/sustained
- Timber
- Non-wood forest products
- Tourism
- Recreational
- Food production
- Fisheries
- Pharmaceuticals
- Land use
  - Residential
  - Industrial
  - Agriculture
  - Transportation
- Employment
- Economics
- Education and research
- Energy

Decrease
- Poverty
- Fuel wood

Altered/Sustained
- Aesthetics
- Cultural value
- Spiritual value

Downstream Socio-Economic Services

Increase
- Recreational
- Migration to Forest
- Economics
- Employment
- Fisheries

Decrease
- River hydraulic impact
- Flood intensity
- Sedimentation

Altered
- Cultural value
- Spiritual value
- Social value (e.g. QOL)

*Note: Altered means affected to some unknown extent; sustained means that the affects can be minimized and not impede sustainability.

Table 5.8 presents the projected TEV and BCA for conservation and Table 5.9 presents the conservation sustainability score.

Table 5.8 Scenario 3: Conservation BCA

USES	Scenario 3		
	Economic Value (2010) (USD Millions)	**Benefits NPV** (USD Millions)	**Costs NPV** (USD Millions)
Direct (DU)			
Timber	$82	$1,076	$3,791
NTFP	$17	$380	$0
Fisheries	$49	$1,122	$0
Tourism	$5.7	$130	$0
Agriculture	$49	$2,062	$0
Community Forest (PES)	$0.2	$2.8	$0
Subtotal DUV	*$203*	*$4,774*	$3,791
Indirect (IUV)			
Carbon	$0	$673	$47
Biodiversity	$23	$589	$703
Forest Ecosystem Services (FES)	$99	$4,180	$1,620
Subtotal IUV	*$122*	*$5,441*	$2,370
SUBTOTAL TEV	**$324**	**$10,215**	**$6,161**
BCR			**1.66**
IRR			5%

Table 5.9 Scenario 3: Conservation Sustainability Score

Potential Forest Impacts	**Conservation**												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**
Economics	3	4	0.6	261	3	4	0.6	227	3	4	0.7	323	**811**
Social	3	4	0.6	264	3	4	0.6	234	3	4	0.7	318	**816**
Environmental	3	4	0.7	247	3	3	0.6	189	3	4	0.7	376	**812**
Average CL/Total S			0.6	**772**			0.6	**650**			0.7	**1018**	**2439**

Like Scenario 2 the BCR is greater than one and therefore a viable option. The sustainability score for conservation is quite a bit higher than the baseline in all aspects and Scenario 1, and slightly higher than Scenario 2. Therefore, it is anticipated that with more information and data to increase the CL, conservations scores would strongly favor scenario 3. This is supported by the higher Internal Rate of Return (IRR) as discussed in more detail in the following section.

6.0 DECISION CRITERIA

To evaluate the three forest management scenarios in any meaningful manner is precarious at best, since the advantages and disadvantages of each are not necessarily compatible with the others. Strategy 1 (conversion) may significantly increase the economic contribution of forest to the GDP of Cambodia while it lasts, without exhibiting substantial disadvantages until long after the economic ones have been spent. Conversely, Strategy 2 (preservation) may not provide any immediate economic benefits, and the environmental advantages may not be fully appreciated until several generations into the future. Based only on solely economic factors in the present, Strategy 1 may seem like the only logical alternative. However, if the advantages and disadvantages can be normalized so that a common measure is used to compare both, not only intra-scenario, but inter-scenario as well, then a different assessment may be reached. Using a monetary value is one method, in which direct values are determined based on market economics and financial considerations, while indirect uses, for which there are not market forces to establish value, are monetized using economic rationales to establish a hypothetical value for the environmental services provided. This can be very difficult and contentious. A well meaning environmentally responsible logging company may value the natural services provided by the forest well below the value placed on it by a conservative environmentalist. However, working together they may well come to an acceptable compromise. This study applies two economic or market based methods to determine the viability of the strategies. They are Total Economic Value (TEV) and Benefit Cost Analysis (BCA) as described in Section 2 and discussed in Section 6 to weigh Scenario 2 and Scenario 3.

The disadvantages of both are similar in that there is limited information available to be able to place a monetary value on the multitude of indicator parameters that need to be considered to reach a decision adequately addressing the concerns of all. Therefore, a multi-criteria analysis (MCA) is introduced to weigh an unlimited number of factors, which is the referred to as the Sustainability Matrix as discussed below.

Generally, there are a host of constraints to the amount of trees which can be harvested. These include the diameter of the trees at breast height (DBH) as a basis for tree maturity and Cambodia’s FA policy limits 30% of harvesting of standing volume with a selective growing cycle of 25 years with the goal to restore from the current tree coverage of 59% to 60% (Sasaki, 2010). Various studies have used different areas, from a hectare to the full estimated acreage of the forest. Essentially there are three types of forests, which are characterized as production, protected and conservation forests, which are equivalent to the three scenarios addressed in this study, that is Scenarios 1, 2, 3 respectively (Kim Phat, 2004). While logging for all intents and purposes is confined to the production forest, the carbon impacts and gains apply to all three (although payment on REDD may only apply to legal production). In addition, beyond some threshold volume of harvested forest, uncontrolled excessive logging can result in complete collapse in the ecosystem threatening the remaining immature growth and making restoration and recovery extremely difficult.

This report uses the estimated existing forest area as a quantity baseline as discussed in Section 4.0, so that the applicable limits and thresholds are implicitly accounted for, in addition to the baseline for comparative purposes. With respect to environmental impacts, Scenario 1 is the worst case assuming removal of the entire forest directly or indirectly as a result of logging, increasing the demands for the remaining forest for fire wood; while the best environmental case is to preserve the forest in its entirety, although economic and social costs are incurred. In addition, the value of the carbon is based on above ground stock and does not include the below ground carbon storage due to lack of information, but would serve only to increase the hypothetical carbon value, but would not affect the comparison analysis of the three scenarios. Three methodological decision approaches have been used on which to determine appropriate socio-economical and environmental strategies. These include:

- Total Economic Value analysis
- Benefit cost analysis
- Multi-criteria analysis

6.1 TOTAL ECONOMIC VALUE

Total Economic Value (TEV) analysis is the collective economic value of the primary services provided by an environmental ecosystem, in the case of this report, the forest. **It is important to note that it is not the forest, per se, that is being valued but the independent elements of ecosystem services provided by the system.** One of those services is the buffering capacity the forest provides in relation to the hydrology as outlined in earlier sections. In a sense, “total economic” value is a misnomer, implying complete and accurate monetary valuation of the forest based on its services. This is not the case. While the direct uses do indeed have a measurable economic value, the indirect services require some method of subjective approximation to establish a perceived monetary value and not all indirect services are included. It is not feasible to be able to place any value on which all agree on all services. Nonetheless, TEV in total does provide a basis for establishing a baseline value of the forest discussed in Section 4.0. Therefore, for the purposes of this report TEV is used as a benchmark for comparative analysis using BCA and MCA extrapolation to compare the different scenarios. Table 6.1 summarizes the BCA for the various baseline and Scenario forest direct and indirect services.

As discussed in Sections 2.0 and 4.0, three discounted rates (DCR) were considered, 3%, 8%, and 12% in determining NPV. However, the use of any DCR is arguable depending upon the reference, can be quite contradictory. The calculations are very sensitive to the varying of any of the variables (DCR, ABC, AWC, and ALC as defined below). The 8% DCR was applied for the purposes of the BCA and TEV used it this report since it is believed to be a conservative representation of stable economic development in developing countries (Sasaki, 2010) and reflective of Cambodia’s potential.

6.2 BENEFIT COST ANALYSIS

BCA builds upon the TEV using the monetary value of the benefits compared to the monetary values of the cost of achieving the benefits. TEV monetary values are based on economic market values for direct use considerations, timber, NTFP etc.; whereas non-market based indirect uses require indirect means such as WTP surveys or travel cost approximations, to estimate potential dollar values. These methods require interaction with the various stakeholders to obtain consensus on what the range of values might be. Without such information, this study relies on ranges of estimated best case - worse case analysis. Typically, these estimates would be based on quantitative analysis of the field investigation data and surveys from which probability and risk analysis are conducted using statistical methods and expected values based on probabilities of occurrence and reliability. The probabilities can also be determined by stakeholder surveys to determine a reasonable best case and reasonable worse as well as potential or reasonable likely case (Forbes, 2009). Without the benefit of these field investigation surveys, a broader more subjective speculative approach has been developed using Game Theory techniques when there is uncertainty due to incomplete or imperfect information. See Section 2.4.4. In this situation possible outcomes are assigned relative affects as a result of taking a certain action. The optimal strategy is the one that yields the best expected values.

What is known for any set of conditions is that there are best and worst cases that define some upper and lower bounds of probabilities, whose reasonableness is dependent upon availability and reliability of information. The objective of this analysis is to evaluate the perceived benefits and costs of the different scenarios; therefore, as long as the basis for the bounds are reasonable and represent a composite of stakeholders perceptions to balance biases, a relative benefit cost ratio (BCR) can be obtained, at the very least to indicate potential acceptable decisions. Since this report does not have sufficient information to define “reasonable” best and worst cases, “assumed” relative best case and worst case (ABC and AWC respectively) are established for each benefit category as discussed in the Section 2.4.4, from which the expected values is used to define the assumed likely case (ALC) (i.e. average of AWC and ABC). Table 6.2 summarizes the assumptions used to determine ABC and AWC in order to arrive at the BCA as summarized in Table 6.1. Section 2.4.4 provides an example of these calculations. The full matrix for each of the scenarios can be found in Appendix B.

The difference between the benefits and the costs is the net benefit (or cost). If the benefits are greater than costs then the scenario is a viable economic option; otherwise, it is not. However, since the total NPV benefit value is based on assumed effects, the difference is not the actual “real” value. Therefore, the ratio of the benefits to costs (BCR) provides a less ambiguous determinant. If the ratio is greater than 1, the scenario is a viable economic option, as in the case of both Scenario 2, and 3 (1.72, 1.63 respectively). See Table 6.1. If it is less than one, as in the case of the baseline and Scenario 1, it is not a viable option.

Since both Scenario 2 and 3 are viable options, it is difficult to determine which of the two is the better option. The fact the BCR are relatively close makes it all the more difficult since a small change in any of the parameters could sway the balance and using a different DCF could result in significant shifts. Therefore, internal rate of return (IRR) was calculated as discussed in Section 2.4.2.

If two or more scenarios have positive NPVs as is the case here, the IRR can be used to rank them. In the context of this study, the IRR for Scenarios 2 and 3 are 4% and 5% respectively. This is the rate at which the benefits and costs breakeven, beyond which a return on the investment is realized. Consequently, Scenario 3 is the more favorable option.

The IRR difference also reflects the relative potential risks. Considering that Scenario 2 is highly dependent on the REDD+, which is uncertain as addressed in Section 1.0, and is only sustainable as long as the international institutions are willing and able to support it, or when and if a self-sufficient market is in fact created. However, created markets are fickle and susceptible to changes in priorities relative to the global economic market and institutional policies. On the other hand, the market uncertainty and risk can be reduced if not eliminated by finding a stable replacement (e.g. ecotourism) to make up for the loss of revenues from banning logging and the REDD+ program if it does not materialize. While this assessment does address ecotourism, it relies on the REDD+ program and therefore there is an inherent greater risk and uncertainty associated with Scenario 2 then Scenario 3. The difference is reflected in their respective IRR.

Table 6.1 Summary of BCA Results

USES	**Baseline**			**Scenario 1**			**Scenario 2**			**Scenario 3**		
	Economic Value (2010)	**Benefits NPV**	**Costs NPV**	**Economic Value (2010)**	**Benefits NPV**	**Costs NPV**	**Economic Value (2010)**	**Benefits NPV**	**Costs NPV**	**Economic Value (2010)**	**Benefits NPV**	**Costs NPV**
Direct (DU)												
Timber	$68	$487	$4,380	$682	$4,867	$0	$0	$0	$4,867	$82	$1,076	$3,791
NTFP	$17	$114	$266	$17	$69	$112	$17	$181	$199	$17	$380	$0
Fisheries	$49	$352	$770	$50	$195	$927	$49	$1,122	$0	$49	$1,122	$0
Tourism	$6	$49	$81	$5.7	$22	$108	$5.7	$130	$0	$5.7	$130	$0
Agriculture	$49	$348	$1,714	$49	$357	$1,705	$49	$1,108	$954	$49	$2,062	$0
PES	$0.2	$1	$1	$0.2	$1	$2	$0.2	$2.8	$0	$0.2	$2.8	$0
Subtotal DUV	*$189*	*$1,352*	*$7,213*	*$803*	*$5,511*	$2,854	*$121*	*$2,544*	$6,020	*$203*	*$4,773*	$3,791
Indirect (IUV)												
Carbon	$0	$671	$48	$0	$219	$501	$0	$720	$0	$0	$673	$47
Biodiversity	$23	$156	$1,136	$23	$90	$1,202	$23	$1,292	$0	$23	$589	$703
FES	$99	$676	$5,124	$99	$390	$5,410	$99	$5,800	$0	$99	$4,180	$1,620
Subtotal IUV	*$122*	*$1,503*	*$6,309*	*$122*	*$699*	*$7,112*	*$122*	*$7,812*	*$0*	*$122*	*$5,442*	*$2,370*
TOTAL TEV	**$311**	**$2,855**	**$13,521**	**$924**	**$6,210**	**$9,966**	**$242**	**$10,356**	**$6,020**	**$324**	**$10,215**	**$6,161**
	BCR		**0.21**	**BCR**		**0.62**	**BCR**		**1.72**	**BCR**		**1.66**
	IRR		**na**	**IRR**		**na**	**IRR**		**4%**	**IRR**		**5%**

Table 6.2a Summary of Assumptions – Basis for ABC and AWC Impacts

Scenario 1 Conversion (S1)	Scenario 2 Preservation (S2)	Scenario 3 Conservation(S3)
Timber	**Timber**	**Timber**
Production rate (10% of available baseline forest remains constant (assumes no improved harvesting efficiency)	No forestry production	Assume Optimum Production rate = 1.2% of available baseline forest to maintain 30% limit in 25 year cycle and attain 60% cover target.
Available for market after 40% wastage (assume no improvement)		Available for market with improved production efficiency overtime starting at baseline (60%) to maximum of 90% (i.e. 3%/year)
NTFP	**NTFP**	**NTFP**
Available forest for NTFP based on constant 10% annual loss of forest due of logging production rate	ABC-Available forest for NTFP increases by 3% due to improved practices (1%); improved ecosystems (1%) and watershed management (1%). {Note: Less than S3 since assume restricted, if not banned.}	ABC-Available forest for NTFP increases by 6% due to improved practices (2%, improved ecosystems (2%) and watershed management (2%).
	AWC-only slight increase in NTFP (1%)	AWC-slight improvement over Preservation (3%)
Fisheries	**Fisheries**	**Fisheries**
ABC-fish yield decreases by 33% of logging production rates due to affect on watershed discharge and sedimentation (equivalent to -3.3% annually).	ABC-fish catch increase 6% per year due improved forest services 2%, 2% due to improved fishing practices, and 2% due to better water management and quality.	ABC-fish catch increase 6% per year due improved forest services (2%), 2% due to improved fishing practices, and 2% due to better water management and quality.
AWC-fish yield decreases by 100% of logging production rates due to affect on watershed discharge, i.e. -10%..	AWC-fish catch improvement 3% overall.	AWC-fish catch improvement 3% overall.
Tourism	**Tourism**	**Tourism**
ABC- tourism decrease by 33% of annual production rate due affects on aethetics without affecting other attractions, i.e. -3.3%.	ABC- tourism increases by 3% annually due sustained aethetics of forest and 3% due to developed ecotourism market for a total of 6%.	ABC- tourism increases by 3% annually due sustained aethetics of forest and 3% due to developed ecotourism market for total of +6%.
AWC assumes tourism affected by both loss of forest aesthetics and effects on watershed discharge (fishing and dolphins), equivalent to 100% of production rate (-10%).	AWC assumes 3% increased due to sustained aethetics without ecotourism development.	AWC assumes 3% increased due to sustained aethetics without ecotourism development.
Agriculture (based on rice production)	**Agriculture (based on rice production)**	**Agriculture (based on rice production)**
ABC-Ag increases by 1% annually as new land availabe, but limited due to poor soil, water management, and farming practices.	ABC-no increased land use, but existing farms remain and 6% yield improvement; 2% due to improved farming practices, 2% due to increased forest services, and 2% due to improved water management.	ABC-Increase by 2% due to increased land use, 2% due to improved farming practices, 2% due to increased forest services, and 2% due to improved water management for at total of 8%.
AWC-Increase affected by losses of forest services including effects on existing farming and assumed to be -1%.	AWC- Ag remains constant with baseline production since no new land available, with slight improved practices, assume +3%.	AWC-Ag slight improvement 4% overall

Table 6.2b Summary of Assumptions – Basis for ABC and AWC Impacts (Con't)

Carbon	**Carbon**	**Carbon**
Yearly logging production at 10% of baseline volume (m^3)	Yearly logging production rate 0% of baseline volume (m^3)	Logging annual production rate 1% of baseline volume (m3)
Standing volume relative to production.	Standing volume remains constant, since no logging.	ABC- As efficiencies increase, watershed management and biodiversity improves, and regrowth rates increase and standing volume increases by a assumed 1% of production rate, which is a carbon gain equivalent to a loss of 1% in production rate.
		AWC-Yearly logging production at 1% of baseline volume (m^3), assume remains constant equivalent to baseline.
Biodiversity	**Biodiversity**	**Biodiversity**
ABC-Biodiversity value decreases by 33% of volume of forest depleted, i.e. -3.3%.	ABC-Biodiversity value increases 3% annually as volume of forest is restored, 4% due to improved ecosystems (2%) and watershed (2%) conditions, and by an additional 2% due improved wildlife management and protection initiatives. Assume habitat impacts significantly reduced due to be improved conditions, for a total of +9%.	ABC-Biodiversity value increases 2% annually as volume of forest is restored, 3% due to improved ecosystems (1.5%) and watershed (1.5%) conditions, and by an additional 1.5% due improved wildlife management and protection initiatives. {It is assumed that habitat impacts significantly reduced due to be improved conditions, but not equal to Scenario 2, therefore, used +6.5%.
AWC-biodiversity value decreases by 100% forest depletion, i.e. -10%.	AWC-biodiversity value only slightly improved as a result of no logging, assume +3%.	AWC-biodiversity value slight improvement as a result of controlled logging and improved ecosystems.
PES	**PES**	**PES**
ABC- Assume protected Community Forest (CF), therefore no affect on CF revenues {Note; alternative BC may be that CF receive full market value from logging companies, but with loss of forest; assumed not likely.}	ABC- Assume CF would increase consistent with improved land management practice by 2%, and less dependency on fire wood, and CF encouraged increasing by 2% for total increase of 4%.	ABC- Assume CF would increase consistent with improved land management practice by 2%, and less dependency on fire wood, and CF encouraged increasing by 2%, for a total of 4%.
AWC-Loss CF to logging interest at production rates	AWC-assumes only slight improvement over baseline of 2%.	AWC-assumes only slight improvement over baseline at 2%.
Forest Ecosysterm Service (FES)	**Forest Ecosysterm Service (FES)**	**Forest Ecosysterm Service (FES)**
ABC-Loss of forest services decreases by 33% of rate forest depleted, i.e. -3.3%.	ABC-Forest services increases by 5% annually (slightly higher than Scenario 3) as forest restored naturally and by an additional 4% applying best management practices to accelerate restoration (2%) and ensure optimum sustainable ecosystems (2%), for a total of + 9%.	ABC-Forest services increases by 4% annually as forest restored naturally and by an additional 4% applying best management practices to accelerate restoration (2%) and ensure optimum sustainable ecosystems (2%) for a total of 8%.
AWC-Loss of forest services decreases by 100% of rate forest depleted, i.e. -10%.	AWC-gain of forest services slight improvement over baseline, use +4%.	AWC-gain of forest services slight improvement over baseline at 4%.

6.3 MULTI CRITERIA ANALYSIS

TEV and BCA consider the implications of adopting a scenario in terms of the potential economic impacts on different stakeholders, but do not take into account the many factors and secondary effects that cannot converted to monetary terms. Therefore, to ensure the many interests and concerns of a wide variety of stakeholders are addressed an MCA was conducted, as shown in the Sustainability Matrices (Tables 6.3-6.7). The Sustainability Matrix covers a wide range of attributes or indicator parameters not addressed in the economic analysis. Its objective is to provide a means to consider the multi-criteria as a single indicator or score, in much the same way the BCA can be summarized as a single ratio. MCA offers a way of combining expert and non expert scientific information and understanding into a format or matrix that complements BCA and aids in the decision process (Turner, 2008). The matrix method is described in detail in Section 2.0 and the large worksheet files are included in the appendix.

Neither BCA or MCA is a substitute for the other, but collectively attempt to provide a holistic comprehensive basis for making decisions to optimize social, economic and environmental welfare maximizing equitable allocation of benefits to where will do the greatest good within three themes, while minimizing the cost, ensuring sustainability.

The results of the Sustainability Matrix are summarized for the baseline each of the each of the Scenarios in Tables 6.3 - 6.6. Table 6.7 is an idealistic Target Score which can be used for Strategic Planning. The Matrix is unique in that it integrates economic, social and environmental themes into one score, which can also be considered individually either as theme or IP. The matrix is adapted from Sudex (Forbes, 2009) with a composite list of IP derived from SuDeX, UC and HWI as discussed in Section 2.0); the revised short list includes 112 parameters. The following is a brief overview of the Matrix taken for Section 2.0 which provided more details.

Table 6.3 Sustainability Matrix - Baseline Score

Potential Forest Impacts	**BASELINE**												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**SCORE**
Economics	3	3	0.8	264	3	3	0.8	270	3	2	0.9	204	**739**
Social	3	3	0.7	157	3	3	0.7	176	3	3	0.8	206	**540**
Environmental	3	3	0.7	246	3	3	0.7	246	3	3	0.9	275	**767**
Average CL/Total S			0.7	**667**			0.7	**692**			0.8	**685**	**2045**

Table 6.4 Sustainability Matrix - Scenario 1 Score

Potential Forest Impacts	**SCENARIO 1: CONVERSION (S1)**												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**SCORE**
Economics	3	3	0.6	215	3	3	0.6	163	3	2	0.6	141	**519**
Social	3	3	0.6	199	3	3	0.6	176	3	2	0.7	159	**535**
Environmental	3	2	0.6	134	3	3	0.6	175	3	2	0.7	135	**443**
Average CL/Total S			0.6	**548**			0.6	**514**			0.7	**435**	**1497**

Table 6.5 Sustainability Matrix - Scenario 2 Score

Potential Forest Impacts	**SCENARIO 2: PRESERVATION (S2)**												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**SCORE**
Economics	3	3	0.6	201	3	3	0.6	165	3	3	0.7	273	**639**
Social	3	3	0.6	225	3	3	0.6	165	3	4	0.7	305	**695**
Environmental	3	3	0.6	257	3	3	0.6	168	3	4	0.7	355	**780**
Average CL/ Total S			0.6	**684**			0.6	**497**			0.7	**932**	**2113**

Table 6.6 Sustainability Matrix - Scenario 3 Score

Potential Forest Impacts	**SCENARIO 3: CONSERVATION (S3)**												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**SCORE**
Economics	3	4	0.6	261	3	4	0.6	227	3	4	0.7	323	**811**
Social	3	4	0.6	264	3	4	0.6	234	3	4	0.7	318	**816**
Environmental	3	4	0.7	247	3	3	0.6	189	3	4	0.7	376	**812**
Average CL/Total S			0.6	**772**			0.6	**650**			0.7	**1018**	**2439**

Table 6.7 Sustainability Matrix - Target Score

Potential Forest Impacts	**TARGET**												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**SCORE**
Economics	3	5	0.9	499.5	3	5	0.9	499.5	3	5	0.9	499.5	**1499**
Social	3	5	0.9	445.5	3	5	0.9	445.5	3	5	0.9	445.5	**1336**
Environmental	3	5	0.9	526.5	3	5	0.9	526.5	3	5	0.9	526.5	**1580**
Average CL/Total S			0.9	**1472**			0.9	**1472**			0.9	**1473**	**4415**

As mentioned the method is discussed in detail in Section 2.0 but is reviewed here for convenience. The short list of potential forest impacts is subdivided into the three pillar themes and an attempt was made to prioritize their importance: Economic, Environmental and Social. A scale of 1-3 for each parameter was established, with 3 being the very important and 1 the least. However, “least” important does not mean “unimportant”, and once again, it is felt that Cambodians are best qualified to establish relative importance.

Finally a value (V) was assigned for each parameter relative to its potential impact as a result of each of the scenario strategies relative to each of the pillar themes. The values range from 1-5 based on degree of negative or positive impact (1= substantial negative impact and 5=significant positive impact.

The score (S) for each theme under each scenario is determined by multiplying I x V x CL and then the total score (S) is determined for each parameter by summing each of the S's. The subtotals are added for each parameter theme and the CL is averaged to determine the overall CL of the assessment as a whole for future analysis as discussed below, which were not conducted as part of this study. Finally the subtotals are added to reach the Total Grand Score for each scenario.

Theoretically, the comparative total scores provide a qualitative determination for which scenario presents the best outcome. However, one matrix completed by one evaluator is not sufficient to rely on and the matrix included in the report is included for illustrative purposes only.

Both a baseline and target matrix is included for relative comparative purposes. Their respective V scales were retained but the definitions were changed from importance to good, although held constant at 3 for baseline and 5 for target. The confidence level of 0.9 was used as a default. Both the tables could be used for performance measurement monitoring and evaluation over time and the target score could be used as a base to lower the S scale to percent.

The suggested next step is for those stakeholders interested in the final analysis, to fill out the matrix with an agreed upon set of parameters. Teams within each group of stakeholders can either fill out the matrix individually or in-group brainstorming sessions until they reach a consensus and then the same process is conducted using the individual group's consensus until there is one master consensus. Further, "target scenarios" can be created by policy makers and used as a planning tool.

The matrix as presented is not intended as a terminal point, but rather as a beginning step in the assessment and decision process, especially when the available information is inadequate to reach a quantitative decision. It is relatively easily expandable and serves as a screening tool providing a way and means to establish priorities, evaluate thematic interrelations, and identify the most helpful information gaps, which need to be filled for more quantitative studies. In addition, with the appropriate data gaps filed, it provides a good foundation for systems analysis to assess quantitative alternatives and reach optimum decisions.

7.0 CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

The objective of this study was to conduct a preliminary socio-economic hydrological analysis of the internal and external natural and social aspects of the Prey Lang Forest, and to assess net negative and positive impacts on the forest and downstream ecosystems (economic as well as ecological). The study focused specifically on the hydrological aspects of the forest, as a whole, on which to build an optimum strategic decision model to maximize prudent sustainable forest utilization without devaluating the natural capital and services provided by the forest. The study was carried in collaboration with the Royal Government of Cambodia (RGC) Forest Administration and USAIDs Micro, Small and Medium Enterprises (MSME) initiative. It assessed three forest management strategies, from absolute exploitation of the forest, to total preservation and a balanced approach between these extremes with respect to socio-economic and environmental tradeoffs relative to the hydrology cycle.

The Study Area was defined by three watershed boundaries in which the Prey Lang Forest is located, for which baseline economic, social and environmental conditions are established based on available information. The current baseline conditions for the year 2010 were defined by Total Economic Values (TEV), using direct and indirect uses of the forest. Then using the baseline TEV, each of the forest management strategies were evaluated with respect to internal and external benefits and costs for following 10 years through the year 2020 applying a benefit cost analysis (BCA) approach and the benefit cost ratio (BCR) was determine for each scenario including baseline (status quo), uncontrolled exploitation, total preservation and optimum conservation of the forest. Both baseline and uncontrolled exploitation BCR were less than one indicating that neither strategy was a sustainable beneficial option, while both preservation and conservation generated positive ratios (i.e. greater than one). Because the BCR does not provide a clear cut preference between preservation and conservation, internal rate of return (IRR) was calculated indicating that conservation was the preferred choice due to uncertainty and potential risks of relying on nonexistent carbon credit program.

A “sustainable development extension” or SuDeX Method was applied using well established economic, social and environmental models used by the Asian Development Bank, the US Environmental Protection Agency, the World Bank the UN, as well as the Mekong River Commission. These models include TEV, BCA and MCA used to conduct environmental impact and resource development studies. Since the economic base analysis can only address those indirect forest uses to which monetary values can be estimated, multi criteria analysis (MCA) was conducted to generate a SuDeX matrix to consider a myriad of socio-economic and environmental parameters that otherwise would not have been addressed. The matrix is a unique tool which integrates economic, social and environmental themes into one score. Whereas TEV and BCA do not provide a ranking of options the SuDeX Matrix does and collectively the integrated models indicate the optimum ranking of conservation, preservation, baseline, and uncontrolled exploitation.

CONCLUSION

This assessment concludes that the optimum Prey Lang forest management strategy is Scenario 3: Conservation.

This conclusion is subject to the limitations and qualifications discussed within the report which is based on the information discovered during this rapid assessment. Before a quantitative conclusion can be reached additional investigation is necessary to fill information gaps, and stakeholder participation is necessary to ensure all issues are addressed.

RECOMMENDATIONS

The conclusion of this report is not intended as a terminal point, but rather as a intermediary step in resource management assessment and decision process when information is not sufficient to reach a definitive decision. Using the SuDeX Method as discussed in this report as a model, the methods can be extended to serve as a screening tool providing a way and means to establish priorities, evaluate thematic interrelations, and identify the most helpful information needed. As a reliable and credible information base is created, a phased comprehensive interagency national integrated resource management program can be prepared to ensure Cambodia's social, economic and environment goals are attained prudently and sustainably.

Building upon the RGC National Forest Programme and this study, the following actions are recommended:

- Conduct workshops to train the Forest Administration personnel in the application of methodologies used in the report, so they can further develop and incorporate this analytical approach into economic decision analysis by Cambodian policy makers.
- Conduct stakeholder participation workshops to establish parameters that best represent Cambodia's best interest.
- Identify information gap priorities and organize funding sources, academic and government institutions and NGOs to conduct the research and investigation necessary to ensure the quality of the information is sufficient to reach sound decisions with the highest level of confidence.
- Using the data base from above establish values for Cambodia's ecosystems that are uniquely applicable to Cambodia to ensure that the values and costs are adequately accounted for in the decision analysis process.
- Prepare a holistic integrated resource management plan starting with the Prey Lang Forest as a model including but not limited to:
    - Community Forests
    - Surface and ground water hydrology
    - Enhanced agricultural practices and food security
    - Land use practices
    - River dynamics hydraulics
    - Tonle Sap/Mekong River protection
    - Fish Habitat and migration path protection
    - Biodiversity protection
    - Concession management
        - Mining
        - Plantation
    - Rigorous performance measurements, monitoring and evaluation are critical to early detection of problems, and proactive followup with vigorous follow-through is essential to resolving the problems.

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APPENDIX A:

Hydrological & Meteorological Data

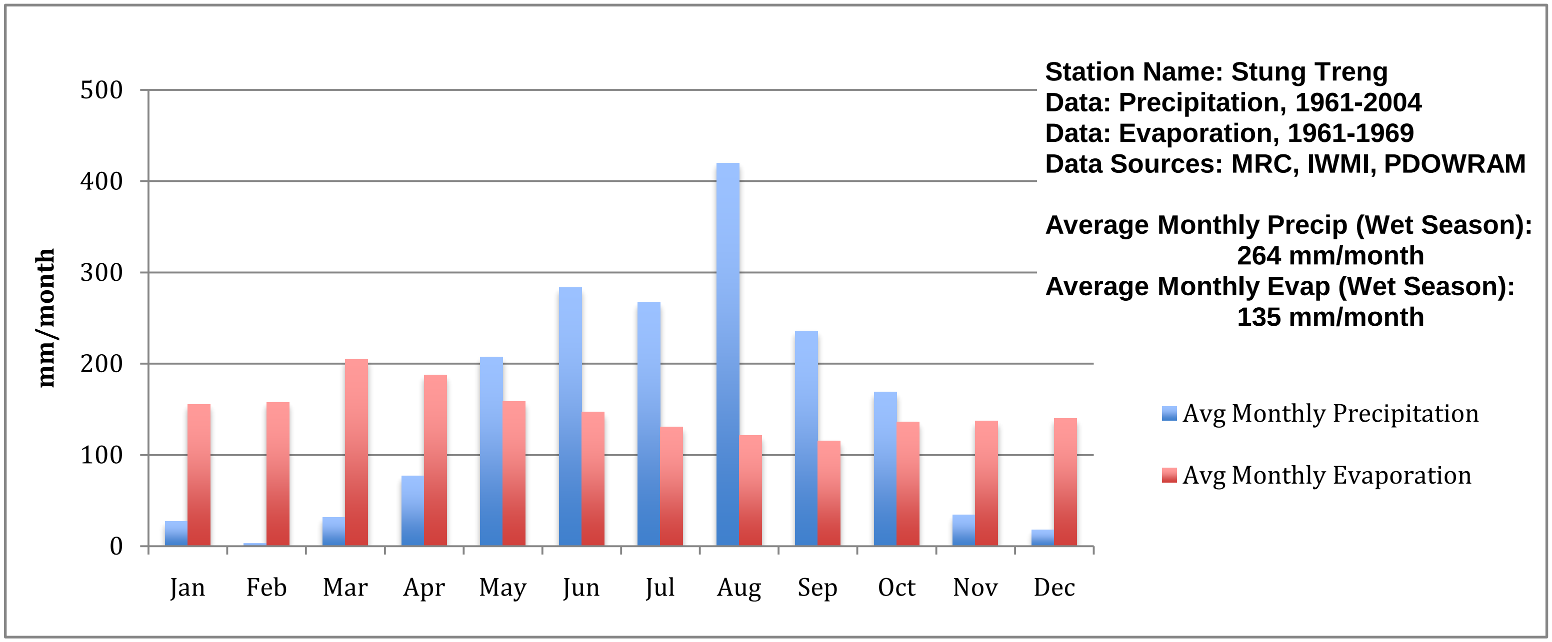
APPENDIX A – 1: STATION SUMMARY

							Appendix A-3	Appendix A-4	Appendix A-5	Appendix A-6		Appendix A-7	
Station Name	**Location**	**River**	**Watershed**	**Zero Gauge above MSL HaTien (m)**	**Flood Level (m)**	**Drainage Area (km^2)**	**MRC Average Discharge**	**Average Annual Rainfall**	**Average Annual Evaporation**	**Average Annual Gage Height**		**Average Annual TSS**	**Average Annual pH**
							(m^3/sec)	**millimeters**	**millimeters**	**G.H. (m)**	**Avg GH above MSL (m)**	**mg/l**	**-**
Stung Treng	Lat: 13 32' 00"' N Long: 105 56' 07"E	Mekong River / Se Kong	Siem Bok	+36.79	12	635,000	13,122	1708	1683	4.28	41.07		
Kratie	Lat: 12 28' 06"N Long: 106 00' 9"E	Mekong River	Siem Bok	-1.08	23	646,000	12,731	1623	1815	10.57	9.49	120.6	7.26
Kampong Cham	Lat: 11 59' 07" N Long: 105 27' 09"E	Mekong River	Siem Bok	-0.93	16.2	660,000	15,576	1372	1708	6.55	5.62	119.77	7.33
Phnom Penh – Mekong	Lat: 11 35' 07" N Long: 104 56' 33"E	Mekong River	Siem Bok	-1.08	ND	663,000	12,476	1250	1604	5.03	3.95	81.83	7.48
Phnom Penh – Bassac (Pochetong)	Lat: 11 33' 07" N Long:104 55' 09"E	City of Phnom Penh	Siem Bok	-1.02	12	ND	2,600	1275	1967	5.07	4.05	113.83	7.24
Phnom Penh – Tonle Sap (Phnom Penh Port)	Lat: 11 34' 03" N Long: 104 55' 09"E	Tonle Sap River	Siem Bok	0	ND	ND	ND	1325	1594	3.92	3.92	73.27	7.19
Kampong Thom	Lat: 12 42' 09"N Long: 104 52' 08"E	Stung Sen	Stung Sen	-0.82	ND	14,000	197	1456	1604	6.93	6.11	ND	ND
Sandan	Lat: 13 10' 00"N Long: 105 25' 00" E	Stung Sen	Stung Sen	ND	ND	ND	ND	1420	1511	12.86	ND	ND	ND
Kampong Putrea	Lat: 13 31' 00"N Long: 105 12' 00"E	Stung Sen	Stung Sen	ND	ND	ND	203	1498	1532	4.55	ND	ND	ND
TaingKrosang	Lat: 12 57' 1" Long: 105 05' 7"	Stung Sen	Stung Sen	ND	ND	ND	ND	1463	1537	2.08	ND	ND	ND
Kampong Thmar	Lat: 12 29' 45"N Long: 105 07' 33"E	Stung Chinit	Stung Chinit	ND	ND	4130	43.2	1459	1543	ND	ND	ND	ND
Stung Chinit	Lat: 12 51' 0"N Long: 105 14' 7"N	Stung Chinit	Stung Chinit	ND	ND	ND	ND	1350	1531	2.67	ND	ND	ND
Data Sources:	**MRC Hydro Yearbooks**	**MRC Hydro Yearbooks**	**MRC Hydro Yearbooks**	**MRC Hydro Yearbooks**		**MRC Hydro Yearbooks**	**MRC Hydro Yearbooks**	**MRC Hydro Yearbooks, PDOWRAM (K. Thom), IWMI World Water & Climate Atlas**	**MRC Hydro Yearbooks, PDOWRAM (K. Thom), IWMI World Water & Climate Atlas**	**MRC Hydro Yearbooks, PDOWRAM (K. Thom)**		**MRC Hydro Yearbooks**	**MRC Hydro Yearbooks**

Appendix A-2: Station Precipitation & Evaporation Charts

Station: Stung Treng

	Monthly Averages (mm)												Average May-Oct (mm/mo)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precipitation	27	3	32	77	207	283	267	420	236	169	34	18	264
Evaporation	155	158	205	188	158	147	131	121	115	136	137	140	135

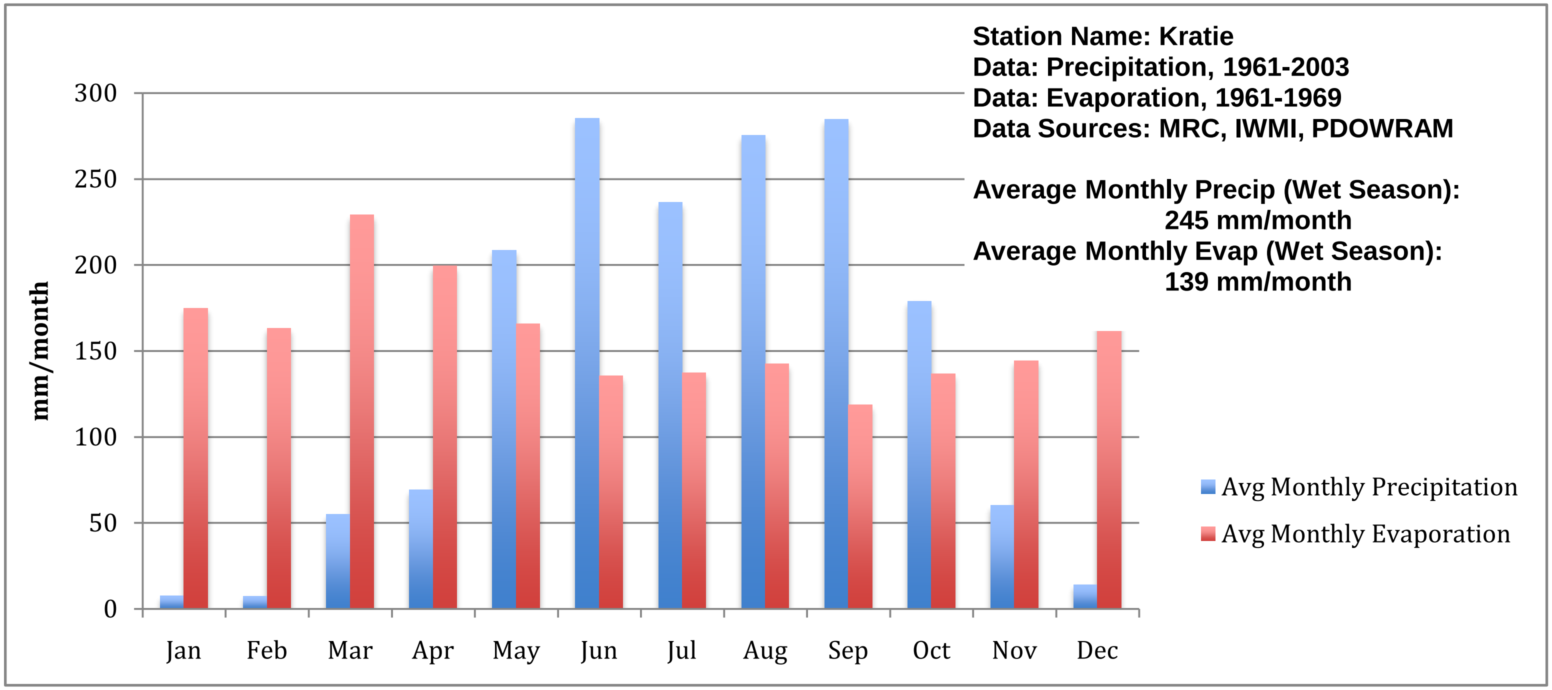


Station Name: Stung Treng
Data: Precipitation, 1961-2004
Data: Evaporation, 1961-1969
Data Sources: MRC, IWMI, PDOWRAM

Average Monthly Precip (Wet Season):
264 mm/month
Average Monthly Evap (Wet Season):
135 mm/month

Station: Kratie

	Monthly Averages (mm\												Average May-Oct (mm/mo)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precipitation	8	7	55	69	209	285	236	275	285	179	60	14	245
Evaporation	175	163	229	200	166	136	137	143	119	137	144	167	139

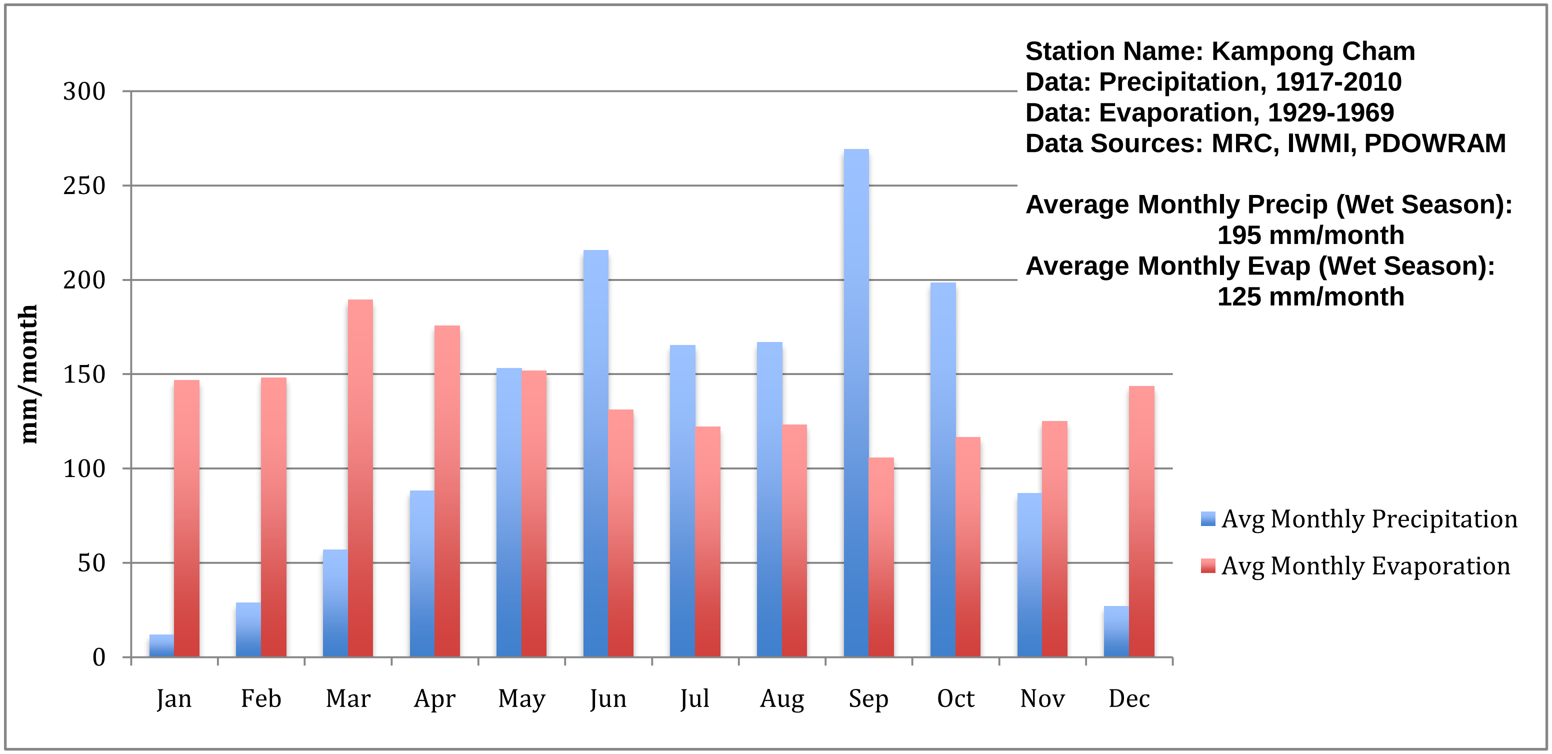


Station Name: Kratie
Data: Precipitation, 1961-2003
Data: Evaporation, 1961-1969
Data Sources: MRC, IWMI, PDOWRAM

Average Monthly Precip (Wet Season):
245 mm/month
Average Monthly Evap (Wet Season):
139 mm/month

Station: Kampong Cham

	Monthly Averages (mm)												Average May-Oct (mm/mo)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precipitation	12	29	57	88	153	216	165	167	269	199	87	27	195
Evaporation	147	148	189	176	152	131	122	123	106	117	125	144	125

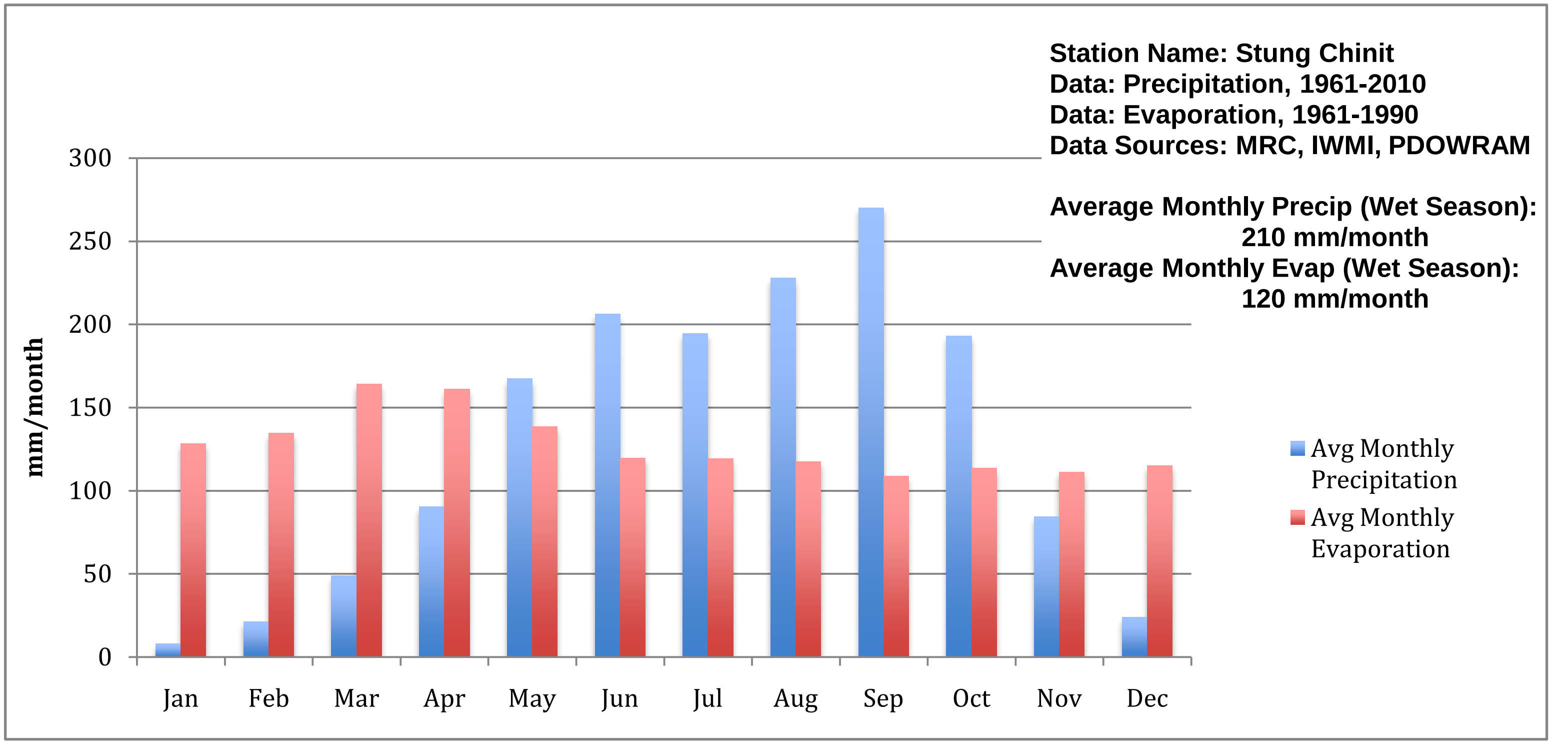


Station Name: Kampong Cham
Data: Precipitation, 1917-2010
Data: Evaporation, 1929-1969
Data Sources: MRC, IWMI, PDOWRAM

Average Monthly Precip (Wet Season): 195 mm/month
Average Monthly Evap (Wet Season): 125 mm/month

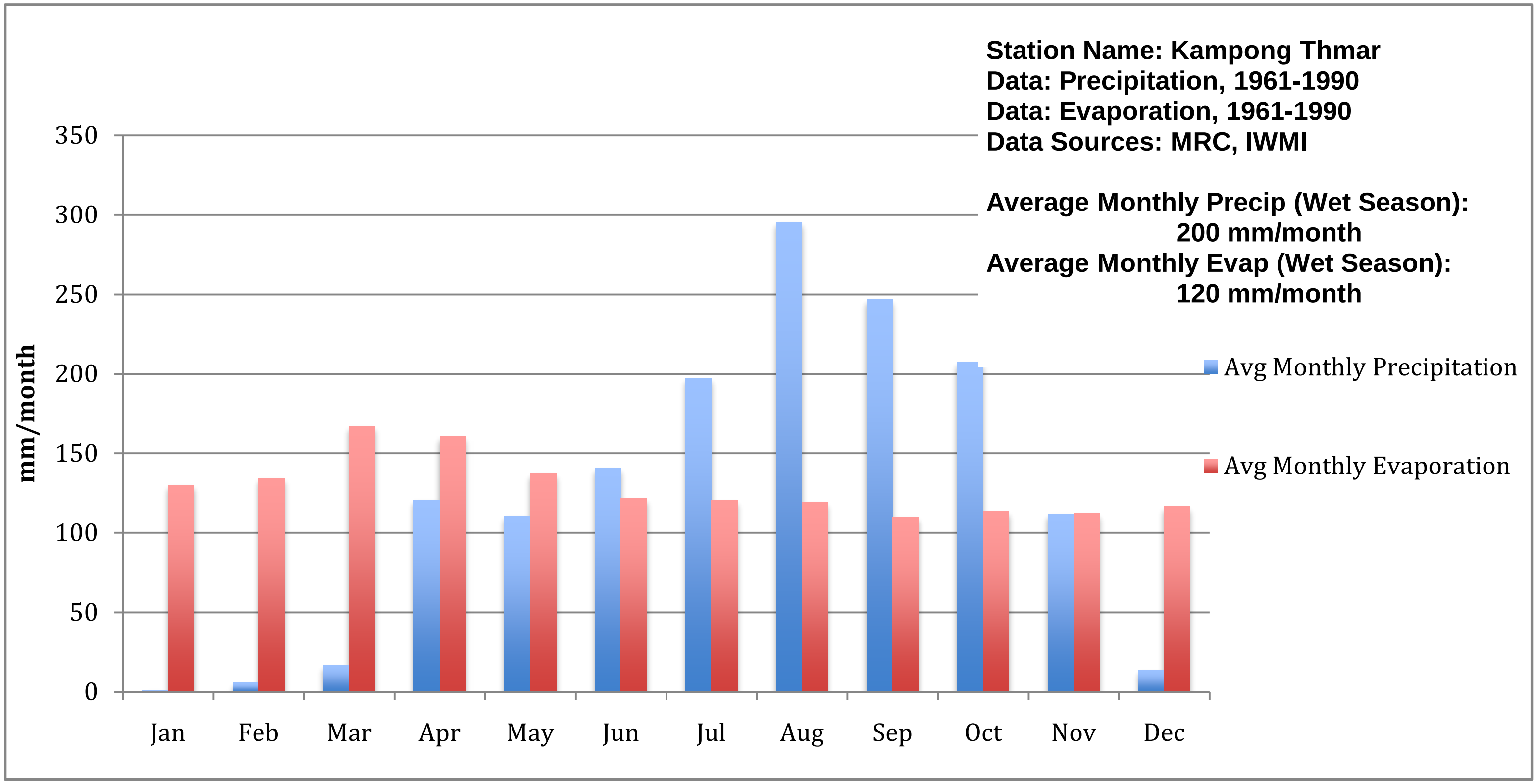
Station: Stung Chinit

	Monthly Averages (mm)												Average May-Oct (mm/mo)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precipitation	8	21	49	91	167	206	195	228	270	193	84	24	210
Evaporation	128	135	164	161	139	120	119	117	109	113	111	115	120



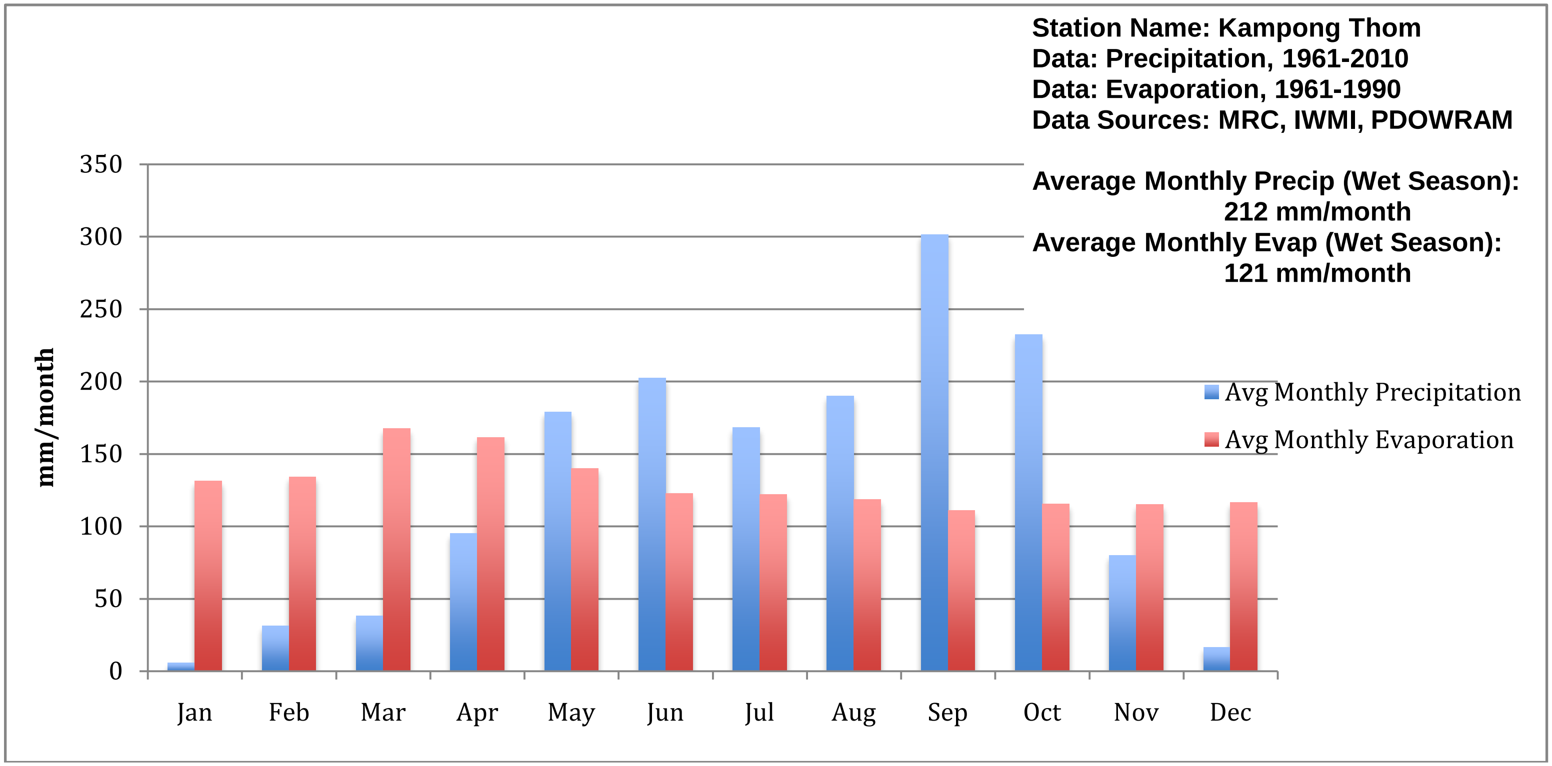
Station: Kampong Thmar

	Monthly Averages (mm)												Average May-Oct (mm/mo)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precipitation	1	6	17	121	111	141	197	295	247	207	112	13	200
Evaporation	130	134	167	161	137	122	120	119	110	113	112	117	120



Station: Kampong Thom

	Monthly Averages (mm)												Average May-Oct (mm/mo)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precipitation	6	31	38	95	179	202	168	190	301	232	80	16	212
Evaporation	131	134	167	161	140	123	122	118	111	115	115	116	121

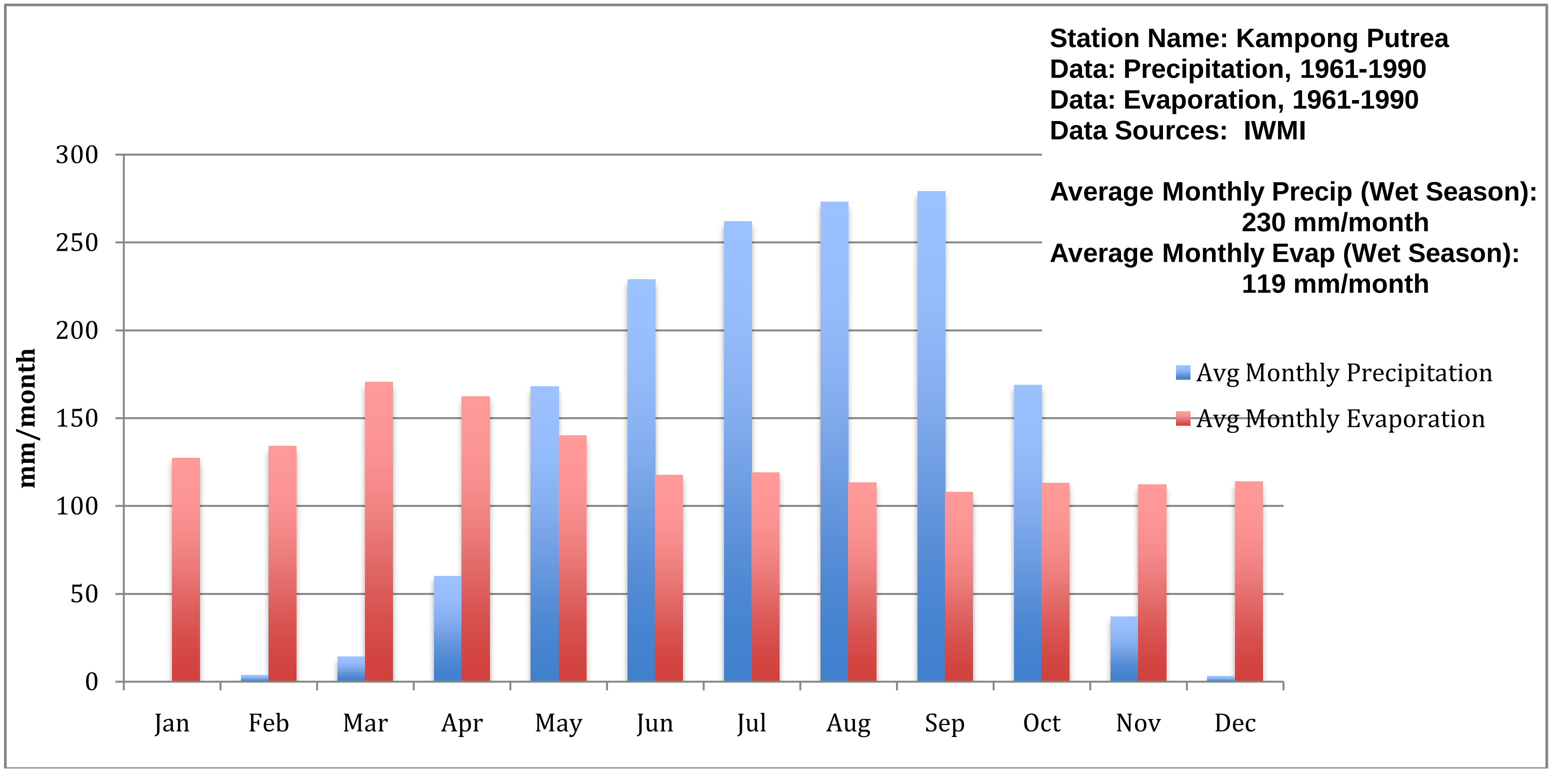


Station Name: Kampong Thom
Data: Precipitation, 1961-2010
Data: Evaporation, 1961-1990
Data Sources: MRC, IWMI, PDOWRAM

Average Monthly Precip (Wet Season): 212 mm/month
Average Monthly Evap (Wet Season): 121 mm/month

Station: Kampong Putrea

	Monthly Averages (mm)												Average May-Oct (mm/mo)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precipitation	0	4	14	60	168	229	262	273	279	169	37	3	230
Evaporation	127	134	171	162	140	118	119	113	108	113	112	114	119

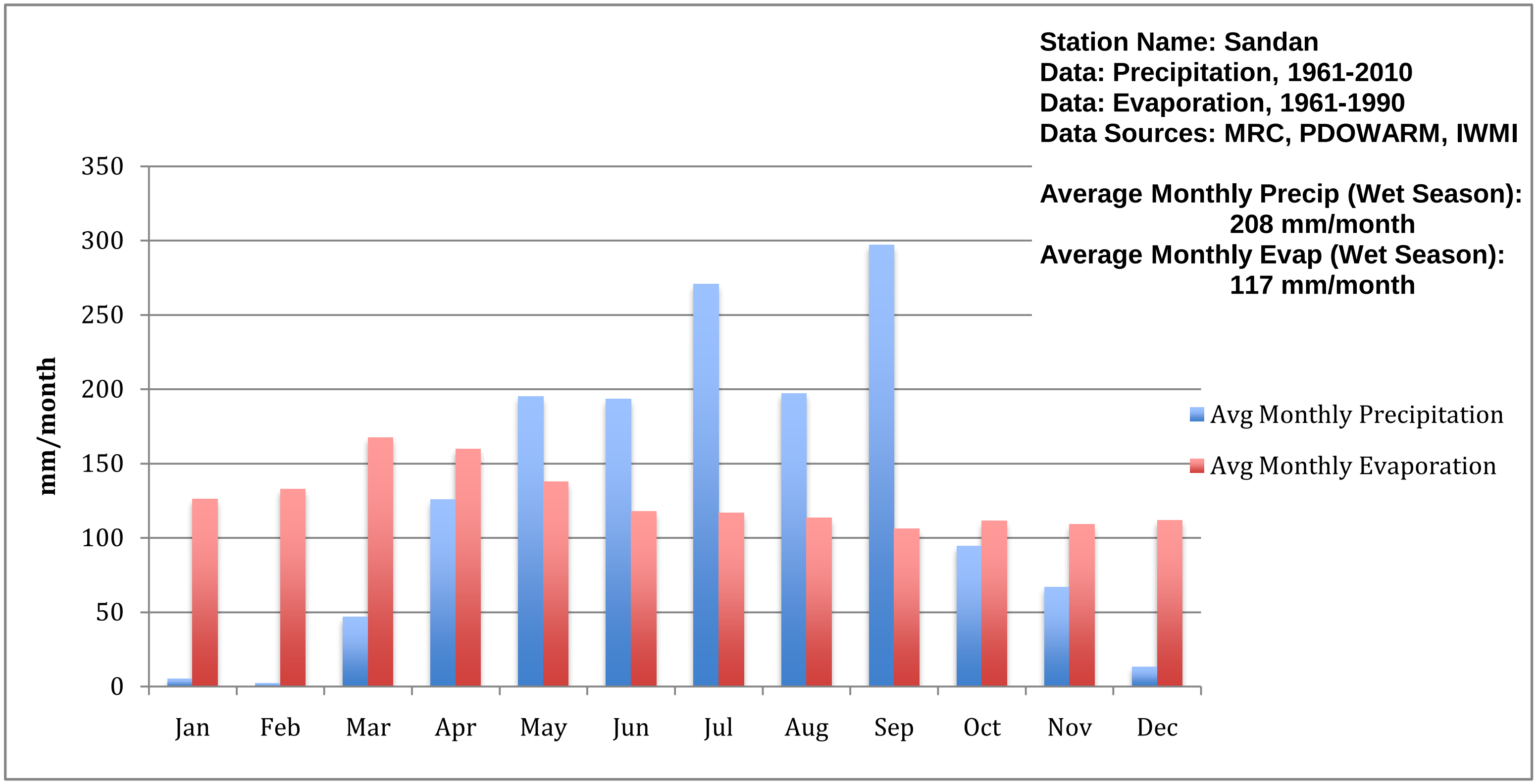


Station Name: Kampong Putrea
Data: Precipitation, 1961-1990
Data: Evaporation, 1961-1990
Data Sources: IWMI

Average Monthly Precip (Wet Season):
230 mm/month
Average Monthly Evap (Wet Season):
119 mm/month

Station: Sandan

	Monthly Averages (mm)												Average May-Oct (mm/mo)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precipitation	5	2	47	126	195	193	271	197	297	94	67	13	208
Evaporation	126	133	167	160	138	118	117	113	106	111	109	112	117

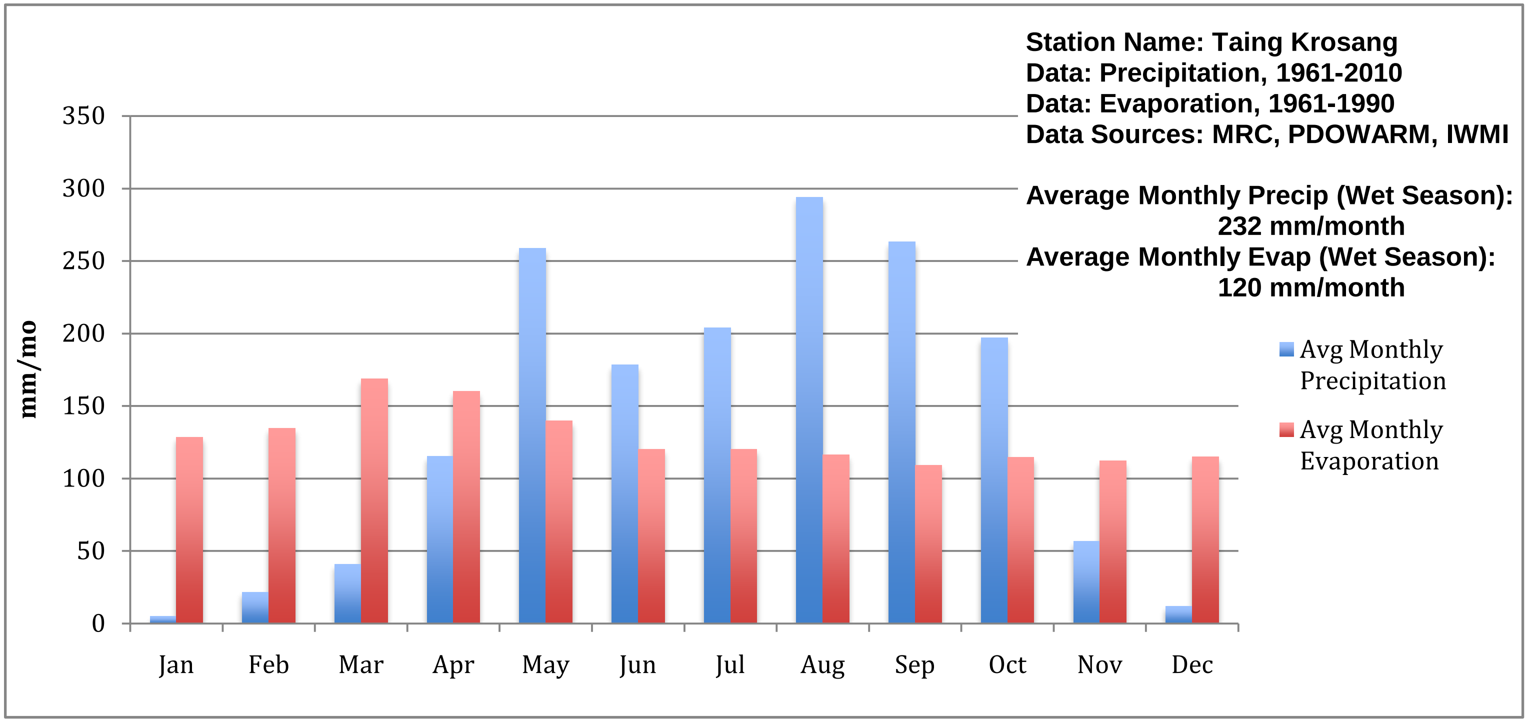


Station Name: Sandan
Data: Precipitation, 1961-2010
Data: Evaporation, 1961-1990
Data Sources: MRC, PDOWARM, IWMI

Average Monthly Precip (Wet Season):
208 mm/month
Average Monthly Evap (Wet Season):
117 mm/month

Station: Taing Krosang

	Monthly Averages (mm)												Average May-Oct (mm/mo)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precipitation	5	22	41	115	259	178	204	294	263	197	57	12	232
Evaporation	128	134	169	160	140	120	120	116	109	114	112	115	120



Source for all: MRC Hydrology Yearbooks, IWMI Water & Climate Atlas, Kampong Thom PDOWRAM

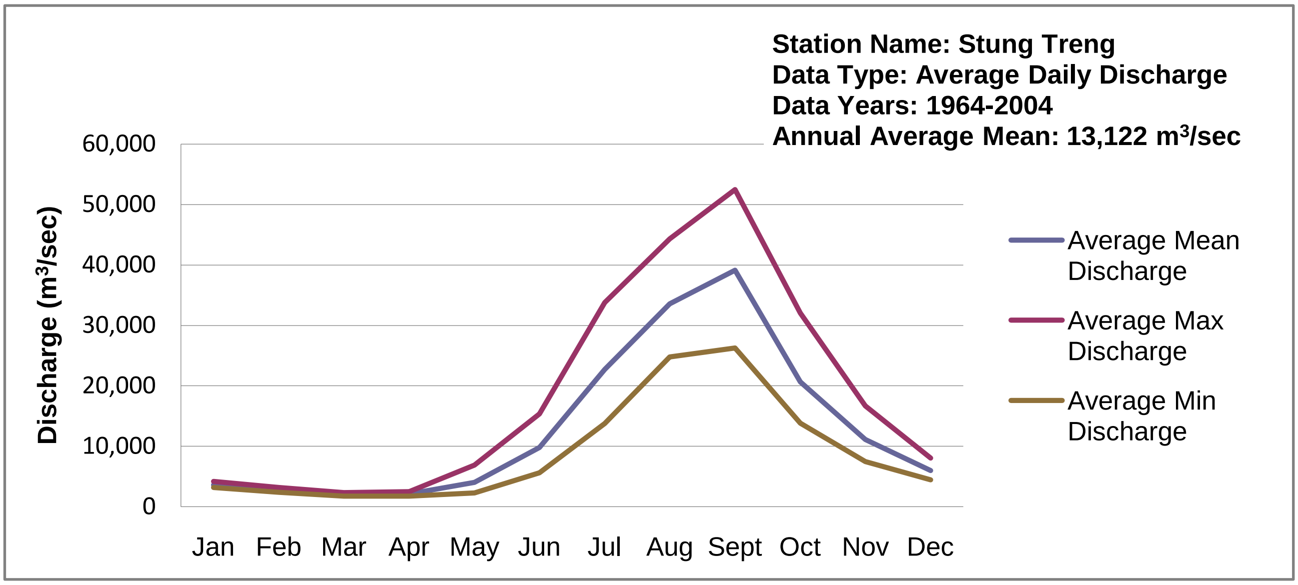
Appendix A-3: Selected Stations Average Daily Discharge

Station: Stung Treng

Year	Mean Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2004	343	285	219	249	415	1307	1967	4169	4328	1725	755	-
2003	-	402	340	328	421	1004	1597	2940	3989	1842	785	477
1998	3,747	2,804	2,096	2,249	3,512	6,036	17,651	20,401	26,925	12,784	9,266	6,337
1996	-	-	-	-	6,197	8,765	19,638	39,208	47,615	27,834	18,673	8,644
1994	3,670	2,830	1,950	2,690	3,520	16,100	34,300	42,200	44,600	21,800	8,170	5,970
1969	3,240	2,570	1,610	1,490	1,830	10,800	28,600	37,600	32,400	16,300	8,350	4,360
1968	3,260	2,670	1,760	1,823	3,540	6,610	13,600	29,100	36,700	16,100	8,050	3,510
1966	4,150	3,170	2,680	2,360	5,100	10,500	25,500	39,100	47,800	19,200	9,850	5,660
1964	3,680	2,560	1,960	1,930	4,350	9,810	19,800	27,400	37,900	30,700	15,300	7,220
Average	**3,625**	**2,767**	**2,009**	**2,090**	**4,007**	**9,803**	**22,727**	**33,573**	**39,134**	**20,674**	**11,094**	**5,957**

Year	Max Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2004	343	285	219	249	415	1307	1967	4169	4328	1725	755	-
2003	-	402	340	328	421	1004	1597	2940	3989	1842	785	477
1998	4,254	3,213	2,480	3,086	5,433	7,253	22,150	26,966	33,912	21,153	15,742	10,480
1996	-	-	-	-	9,436	12,732	41,397	52,503	69,222	48,975	28,874	12,680
1994	4,550	2,940	2,340	3,350	5,840	25,900	46,900	56,200	53,100	34,000	11,700	6,440
1969	3,520	2,940	2,110	1,560	2,340	20,800	42,200	44,000	43,200	23,600	11,500	5,370
1968	3,440	3,260	2,100	2,240	4,890	10,000	17,600	46,900	53,500	22,500	11,000	4,260
1966	4,770	3,640	2,780	2,530	9,750	18,100	40,800	44,900	57,400	29,200	13,900	7,740
1964	4,440	2,960	2,120	2,080	10,400	12,800	25,500	38,600	56,900	44,900	24,000	9,160
Average	**4,162**	**3,159**	**2,322**	**2,474**	**6,870**	**15,369**	**33,792**	**44,296**	**52,462**	**32,047**	**16,674**	**8,019**

Year	Min Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2004	343	285	219	249	415	1307	1967	4169	4328	1725	755	-
2003	-	402	340	328	421	1004	1597	2940	3989	1842	785	477
1998	3,213	2,480	1,712	1,536	2,538	5,204	7,509	13,569	19,689	8,297	6,421	4,290
1996	-	-	-	-	3,086	5,587	9,576	32,824	26,832	20,172	12,525	6,544
1994	3,000	2,510	1,770	1,950	2,400	6,070	22,300	35,400	37,800	12,500	6,230	5,100
1969	3,000	2,200	1,340	1,440	1,470	2,690	16,000	30,900	22,100	11,800	5,370	3,560
1968	3,290	2,160	1,480	1,520	2,070	4,120	9,710	14,900	20,700	11,200	4,400	2,380
1966	3,530	2,790	2,530	2,280	2,480	8,940	18,600	31,400	29,800	13,900	7,900	4,300
1964	3,000	2,150	1,840	1,830	2,120	6,720	12,500	14,400	26,800	18,800	9,490	5,200
Average	**3,172**	**2,382**	**1,779**	**1,759**	**2,309**	**5,619**	**13,742**	**24,770**	**26,246**	**13,810**	**7,477**	**4,482**

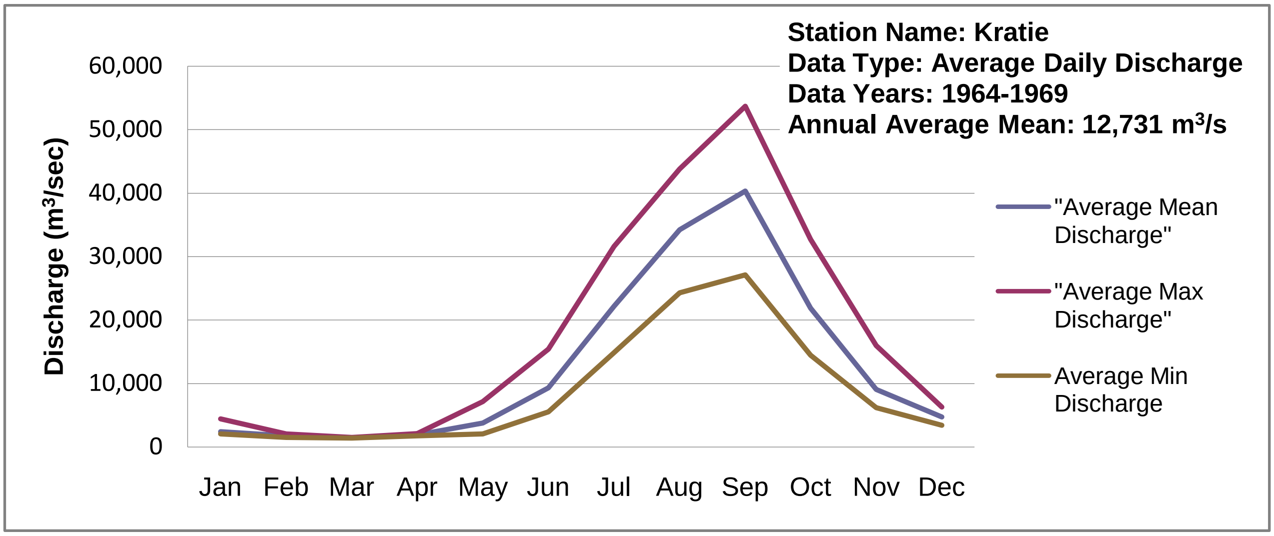


Station: Kratie

Year	Mean Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1969	0	0	0	1,560	1,930	10,400	29,000	39,400	35,300	18,000	0	0
1968	2,960	1,930	1,550	1,760	3,560	6,810	14,300	30,300	38,500	18,200	9,780	5,100
1966	4,200	3,220	2,720	2,410	5,190	10,600	26,100	39,900	49,650	19,400	10,600	6,350
1964	3,690	2,520	1,970	1,850	4,230	9,370	19,300	27,300	37,900	31,800	15,700	7,410
Average	**2,387**	**1,717**	**1,423**	**1,895**	**3,728**	**9,295**	**22,175**	**34,225**	**40,338**	**21,850**	**9,020**	**4,715**

Year	Max Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1969	4,660	0	0	1,640	2,330	20,800	41,100	45,100	45,600	27,400	12,900	0
1968	3,690	2,350	1,600	2,060	4,850	11,600	18,500	46,200	54,700	24,900	13,100	6,440
1966	4,800	3,680	2,830	2,600	11,000	17,000	41,800	46,200	58,500	30,900	14,500	8,690
1964	4,640	2,900	2,130	2,030	10,400	12,200	25,000	37,800	56,000	47,600	23,400	9,890
Average	**4,383**	**2,010**	**1,477**	**2,083**	**7,145**	**15,400**	**31,600**	**43,825**	**53,700**	**32,700**	**15,975**	**6,255**

Year	Min Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1969	0	0	0	1,480	1,550	2,360	17,600	33,000	26,300	13,000	0	0
1968	2,380	1,570	1,520	1,560	2,050	4,040	10,600	16,700	22,400	13,800	6,520	3,750
1966	3,710	2,850	2,600	2,300	2,530	9,080	19,100	32,600	32,700	12,100	8,010	4,770
1964	2,950	2,150	1,860	1,660	2,080	6,500	12,100	14,800	27,000	18,800	10,200	5,130
Average	**2,030**	**1,473**	**1,373**	**1,750**	**2,053**	**5,495**	**14,850**	**24,275**	**27,100**	**14,425**	**6,183**	**3,413**



*MRC State of the Basin Report 2010, Figure 3.1.1 shows that the average maximum flow rate is 50,400m^3/sec for the years 1960-2007. This graph shows the peak of maximum flow rate for 1964-1969 as 53,700m^3/sec.

MRC's Overview of the Hydrology of the Mekong River Basin, 2005, Figure 4.1 shows the average mean discharge rate as just under 40,000m^3/sec. The above data and graph show the average mean discharge rate as 40,338m^3/sec.

MRC's Overview of the Hydrology of the Mekong River Basin, 2005, Table 4.2 shows the annual average mean flow rate from 1960-2004 as 13,200m^3/sec. The above data and graph show the annual average mean flow rate as 12,731m^3/sec.

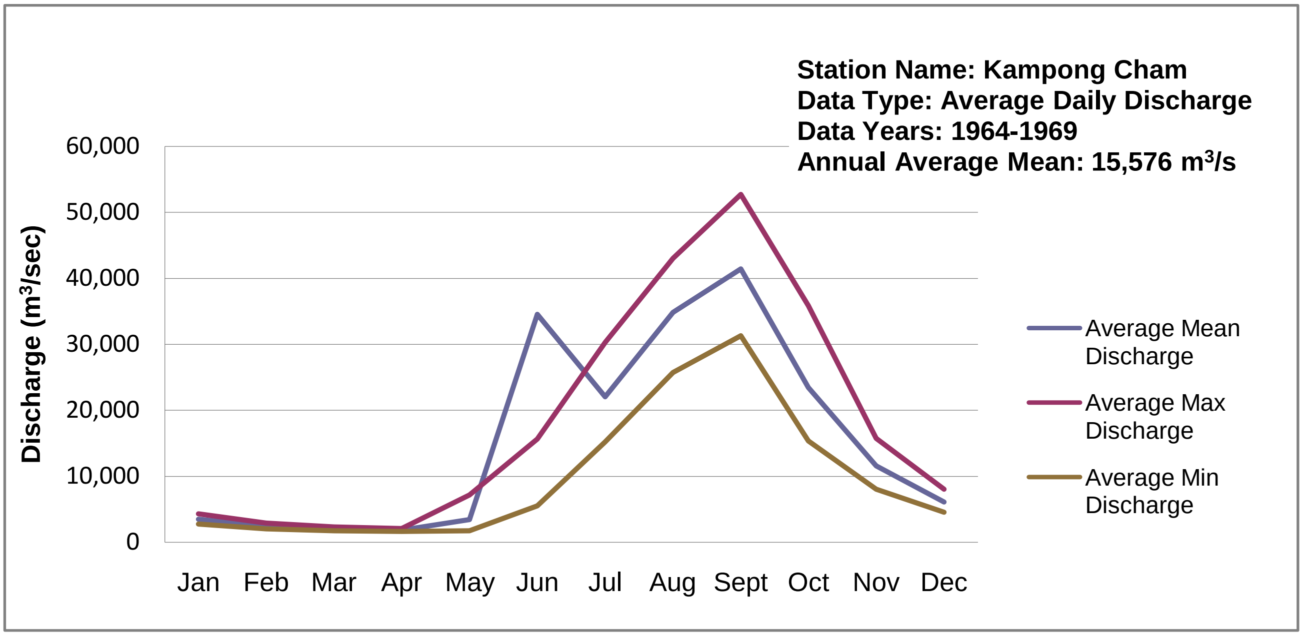
Station: Kampong Cham

Year	Mean Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	3180	1980	1650	1670	1630	10700	29300	40700	36500	19400	10600	5310
1968	2,730	1,950	1,660	1,770	3,280	6,820	14,800	30,900	39,800	18,900	9,910	5,050
1966	4,380	3,260	2,420	1,990	4,470	10,200	24,300	40,100	50,500	22,400	11,100	7,090
1964*	3,590	2,550	1,990	1,840	4,220	110,300	19,700	27,600	38,800	33,000	14,700	6,950
Average	**3,470**	**2,435**	**1,930**	**1,818**	**3,400**	**34,505**	**22,025**	**34,825**	**41,400**	**23,425**	**11,578**	**6,100**

Year	Max Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	3990	2490	2190	2020	1920	22400	39400	44400	44500	28400	13800	6900
1968	3,570	2,430	2,200	2,210	4,790	11,800	19,600	44,100	55,000	28,800	13,200	6,800
1966	5,100	3,800	2,730	2,090	11,000	15,800	37,700	45,400	57,000	37,200	15,500	9,380
1964	4,600	2,930	2,150	1,960	11,000	12,600	24,300	38,200	54,300	49,000	20,400	9,000
Average	**4,315**	**2,913**	**2,318**	**2,070**	**7,178**	**15,650**	**30,250**	**43,025**	**52,700**	**35,850**	**15,725**	**8,020**

Year	Min Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	2090	1630	1320	1450	1400	1700	18900	34300	30300	13900	7090	4040
1968	2,020	1,540	1,400	1,520	1,520	3,980	11,000	17,800	25,500	13,700	6,870	3,700
1966	3,820	2,750	2,300	1,860	2,060	8,880	17,800	33,800	39,200	15,300	8,700	5,200
1964	2,930	2,170	1,860	1,660	1,950	7,500	13,000	17,000	30,100	18,400	9,500	5,150
Average	**2,715**	**2,023**	**1,720**	**1,623**	**1,733**	**5,515**	**15,175**	**25,725**	**31,275**	**15,325**	**8,040**	**4,523**

*Second source could not be found to confirm or deny the discharge data value recorded in the MRC Hydrology Yearbook in June 1964 for Kampong Cham. Data was included in Average Mean Daily Discharge calculation, and can be seen as an abnormal peak in graph below.

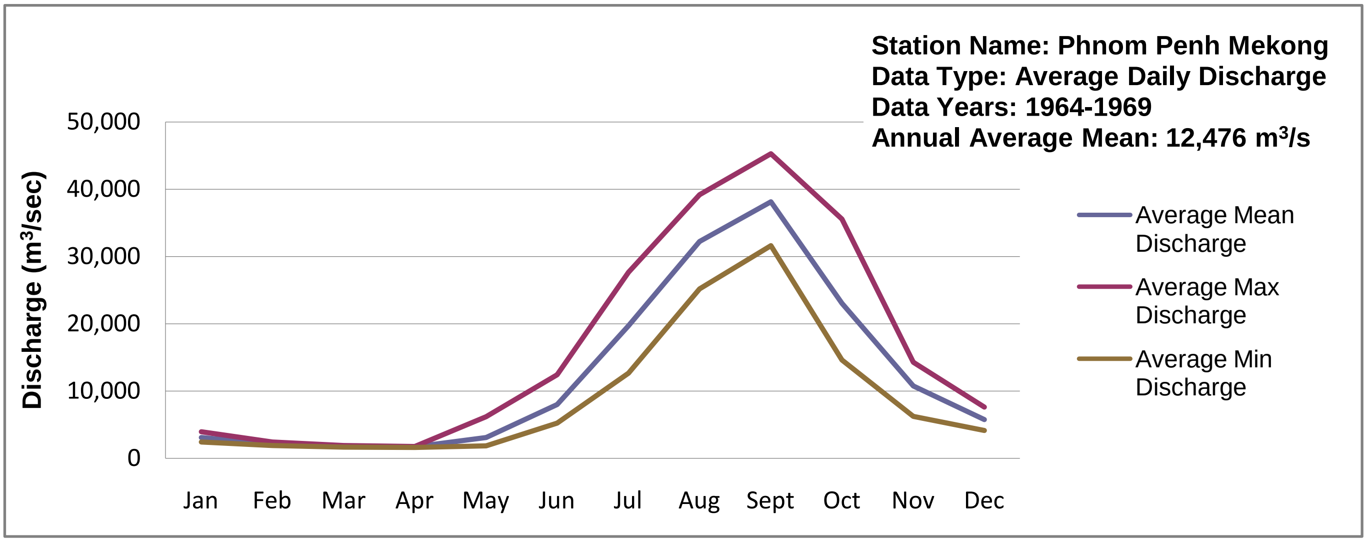

Station Name: Kampong Cham
Data Type: Average Daily Discharge
Data Years: 1964-1969
Annual Average Mean: 15,576 m³/s
Discharge (m³/sec)
60,000
50,000
40,000
30,000
20,000
10,000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
Average Mean Discharge
Average Max Discharge
Average Min Discharge

Station: Phnom Penh Mekong

Year	Mean Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	2,660	1,900	1,720	1,630	1,690	8,370	25,400	38,000	37,300	21,400	9,550	5,040
1968	2,300	1,840	1,710	1,660	3,040	5,560	12,300	27,800	37,400	16,700	8,310	4,280
1966	3,720	2,220	1,800	1,700	4,300	9,540	23,200	37,800	42,400	22,100	11,200	6,560
1964	3660	2600	2010	1860	3420	8620	18100	25500	35600	32100	14100	7190
Average	**3,085**	**2,140**	**1,810**	**1,713**	**3,113**	**8,023**	**19,750**	**32,275**	**38,175**	**23,075**	**10,790**	**5,768**

Year	Max Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	3,480	2,090	1,750	1,780	2,220	17,100	35,900	40,500	40,600	35,500	12,900	6,840
1968	2,850	1,960	1,800	1,760	4,580	8,860	16,100	40,200	46,800	30,500	11,300	5,800
1966	4,900	2,830	2,020	1,740	9,940	13,000	36,600	42,200	48,600	32,800	15,600	8,400
1964	4700	2980	2190	1900	8200	10800	22100	34000	45200	43600	17400	9500
Average	**3,983**	**2,465**	**1,940**	**1,795**	**6,235**	**12,440**	**27,675**	**39,225**	**45,300**	**35,600**	**14,300**	**7,635**

Year	Min Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	2,100	1,740	1,650	1,500	1,540	2,500	15,600	35,100	34,700	13,400	6,960	3,560
1968	1,930	1,740	1,540	1,570	1,620	3,780	9,280	15,500	27,200	11,600	5,880	2,900
1966	2,860	1,940	1,660	1,620	2,400	8,660	14,700	32,000	34,100	16,000	8,400	4,960
1964	2980	2210	1880	1860	1920	6100	11200	18300	30600	17600	3800	5150
Average	**2,468**	**1,908**	**1,683**	**1,638**	**1,870**	**5,260**	**12,695**	**25,225**	**31,650**	**14,650**	**6,260**	**4,143**

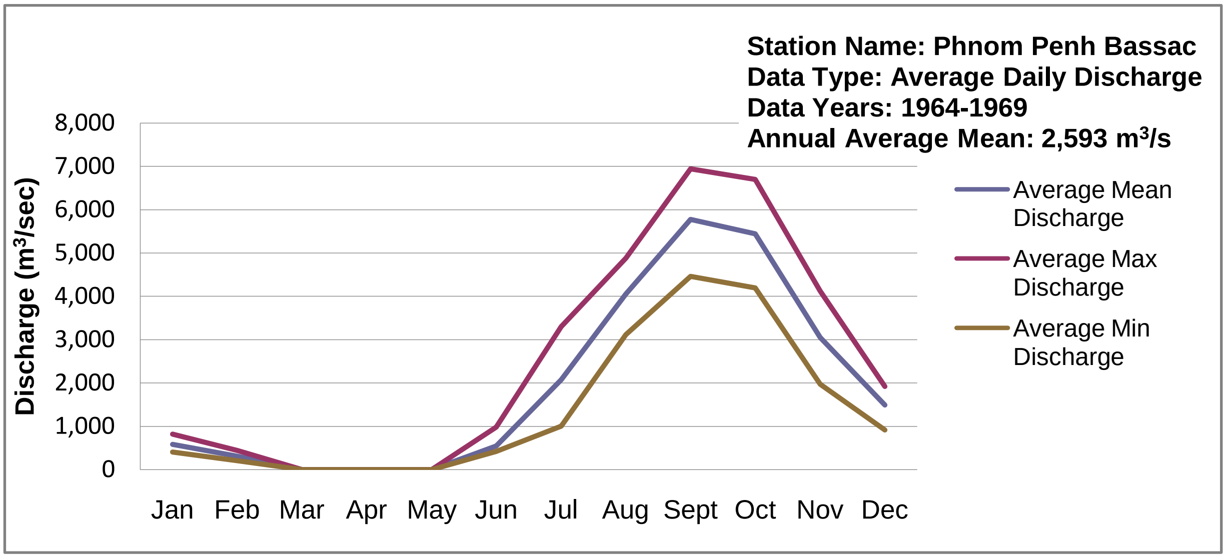

Station Name: Phnom Penh Mekong
Data Type: Average Daily Discharge
Data Years: 1964-1969
Annual Average Mean: 12,476 m³/s
Discharge (m³/sec)
50,000
40,000
30,000
20,000
10,000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
Average Mean Discharge
Average Max Discharge
Average Min Discharge

Station: Phnom Penh Bassac

Year	Mean Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	-	-	-	-	-	-	2,500	4,740	5,540	4,670	2,430	-
1966	632	311	-	-	-	576	2180	4730	7280	5710	2920	1410
1964	532	-	-	-	-	520	1,550	2,700	4,510	5,950	3,800	1,570
Average	**582**	**311**	**-**	**-**	**-**	**548**	**2,077**	**4,057**	**5,777**	**5,443**	**3,050**	**1,490**

Year	Max Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	-	-	-	-	-	1,320	3,870	5,160	6,090	5,800	3,460	1,380
1966	870	445	-	-	-	895	3930	5460	8370	7710	4280	1990
1964	776					720	2,090	4,030	6,360	6,580	4,630	2,380
Average	**823**	**445**	**-**	**-**	**-**	**978**	**3,297**	**4,883**	**6,940**	**6,697**	**4,123**	**1,917**

Year	Min Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	-	-	-	-	-	-	1,180	4,060	4,600	3,510	1,430	-
1966	457	204	-	-	-	511	1080	3740	5010	4390	1990	875
1964	361	-	-	-	-	337	748	1,550	3,760	4,680	2,480	955
Average	**409**	**204**	**-**	**-**	**-**	**424**	**1,003**	**3,117**	**4,457**	**4,193**	**1,967**	**915**

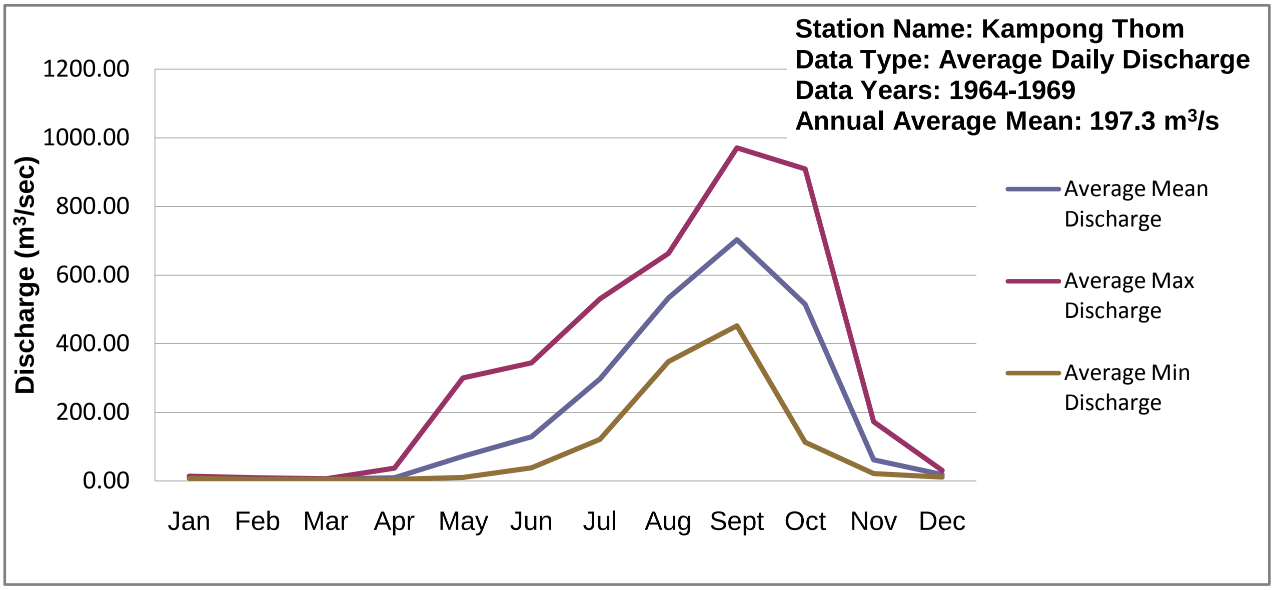


Station: Kampong Thom

Year	Mean Daily Discharge (m³/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	17.9	8.3	5.7	5.3	24.3	120.0	385.0	372.0	568.0	654.0	82.9	13.6
1966	5.1	7.6	6.8	18.9	155.0	63.8	334.0	849.0	839.0	377.0	39.2	10.7
1964	14.1	7.0	5.1	5.1	38.0	202.5	174.2	381.3	-	-	62.9	32.1
Average	**12.4**	**7.6**	**5.9**	**9.8**	**72.4**	**128.8**	**297.7**	**534.1**	**703.5**	**515.5**	**61.7**	**18.8**

Year	Max Daily Discharge (m³/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	23.0	11.3	6.7	8.2	116.0	312.0	512.0	567.0	882.0	932.0	277.0	21.4
1966	7.5	9.0	7.8	95.2	337.0	222.0	862.0	865.0	1060.0	886.0	152.0	27.0
1964	12.6	8.7	5.6	9.1	448.0	500.0	218.0	557.0	-	-	88.2	43.2
Average	**14.4**	**9.7**	**6.7**	**37.5**	**300.3**	**344.7**	**530.7**	**663.0**	**971.0**	**909.0**	**172.4**	**30.5**

Year	Min Daily Discharge (m³/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	11.9	6.8	4.3	4.4	11.3	21.0	192.0	146.0	105.0	166.0	9.6	6.4
1966	2.7	2.3	6.0	6.8	9.7	16.0	55.2	771.0	799.0	60.7	11.0	4.6
1964	9.0	5.6	4.8	4.5	9.4	77.0	118.0	127.0	-	-	43.2	23.3
Average	**7.9**	**4.9**	**5.0**	**5.2**	**10.1**	**38.0**	**121.7**	**348.0**	**452.0**	**113.4**	**21.3**	**11.5**

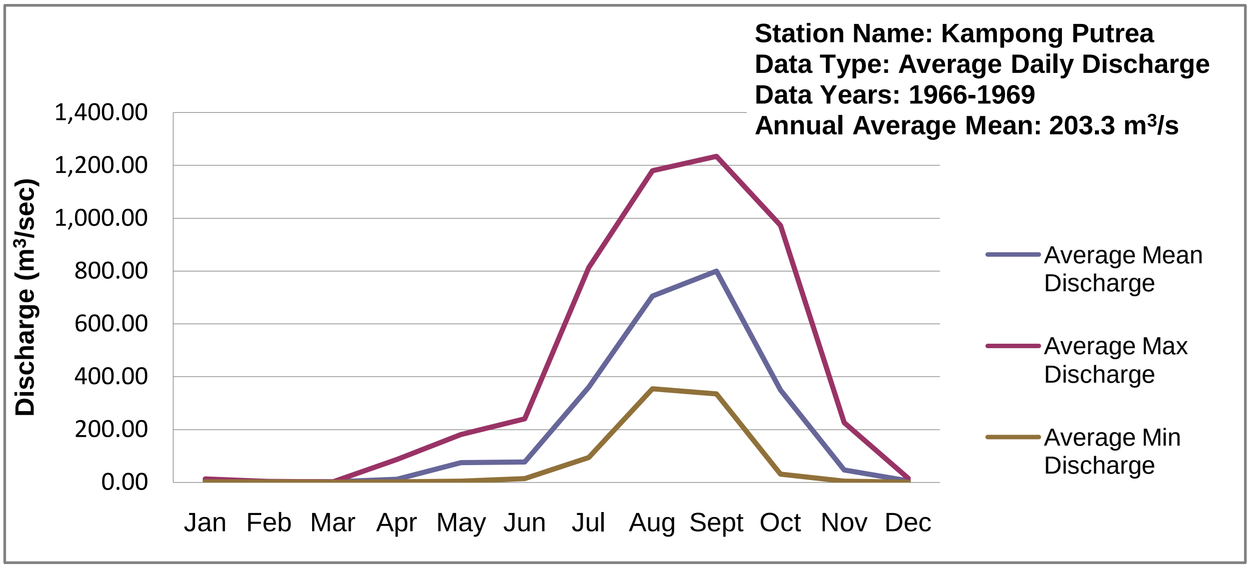


Station: Kampong Putrea

Year	Mean Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	-	-	-	7.5	10.4	117.0	324.0	220.0	622.0	525.0	76.9	2.5
1966	4.9	2.7	1.9	15.5	139.0	37.9	397.0	1190.0	977.0	174.0	17.3	7.4
Average	**4.9**	**2.7**	**1.9**	**11.5**	**74.7**	**77.5**	**360.5**	**705.0**	**799.5**	**349.5**	**47.1**	**4.9**

Year	Max Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	-	-	-	54.0	29.8	339.0	486.0	722.0	1170.0	1210.0	386.0	4.3
1966	13.1	3.3	2.2	120.0	332.0	142.0	1140.0	1640.0	1300.0	738.0	67.0	26.2
Average	**13.1**	**3.3**	**2.2**	**87.0**	**180.9**	**240.5**	**813.0**	**1181.0**	**1235.0**	**974.0**	**226.5**	**15.3**

Year	Min Daily Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1969	-	-	-	1.0	4.4	20.7	154.0	14.7	11.5	27.6	3.7	1.5
1966	2.7	2.2	1.5	3.6	5.9	9.0	35.0	694.0	658.0	36.2	7.1	2.6
Average	**2.7**	**2.2**	**1.5**	**2.3**	**5.2**	**14.9**	**94.5**	**354.4**	**334.8**	**31.9**	**5.4**	**2.0**


Station Name: Kampong Putrea
Data Type: Average Daily Discharge
Data Years: 1966-1969
Annual Average Mean: 203.3 m³/s
Discharge (m³/sec)
1,400.00
1,200.00
1,000.00
800.00
600.00
400.00
200.00
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
Average Mean Discharge
Average Max Discharge
Average Min Discharge

Appendix A-4: Selected Stations Precipitation Data

Station: Stung Treng

Year	Precipitation (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	-	0	0	88	141	306	175	438	207	126	9	-	1490
1994	-	-	73	160	238	368	243	404	190	107	3	10	1796
1992	27	-	-	8	158	289	159	538	14	-	-	1	1194
1990	-	1	64	39	268	377	370	336	217	450	105	-	2227
1969	-	-	11	117	213	375	406	205	404	194	9	2	1933
1968	-	-	-	86	296	130	189	767	224	79	2	-	1772
1966	-	6	28	59	164	164	287	379	327	57	70	72	1612
1961-1990	-	5	14	61	180	256	310	294	304	171	42	5	1641
Average	**27**	**3**	**32**	**77**	**207**	**283**	**267**	**420**	**236**	**169**	**34**	**18**	**1708**

Station: Kratie

Year	Precipitation (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2003	-	0	93	139	271	341	283	268	182	67	24	-	1668
1998	-	0	-	75	314	145	99	362	487	170	196	22	1869
1996	12	-	47	-	-	272	246	162	345	213	81	11	1389
1994	-	-	71	56	205	330	242	307	281	132	6	4	1633
1992	0	-	-	8	42	365	142	469	368	302	9	2	1708
1969	18	-	21	48	337	468	302	235	270	258	20	-	1976
1966	-	27	85	104	136	173	368	191	93	77	65	29	1347
1961-1990	1	3	13	56	156	188	210	210	253	212	82	15	1399
Average	**8**	**7**	**55**	**69**	**209**	**285**	**236**	**275**	**285**	**179**	**60**	**14**	**1623**

Station: Kampong Thom

Year	Precipitation (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2010	24	-	1	28	129	223	185	-	-	-	-	-	591
2009	-	130	46	132	268	165	81	144	500	182	69	-	1716
2008	23	49	30	114	291	98	51	266	350	316	88	4	1678
2007	-	-	66	158	174	110	168	95	281	198	105	-	1355
2006	-	113	16	177	314	74	272	451	289	194	39	7	1945
2005	-	-	14	34	140	176	299	99	243	119	142	7	1273
2004	-	7	0	97	85	414	116	176	291	127	15	1	1329
2003	-	-	144	48	256	212	224	156	189	144	13	-	1386
2002	-	-	11	100	160	327	94	150	473	163	45	2	1524
2001	6	0	194	5	228	174	66	237	160	419	109	3	1600
2000	-	1	0	94	141	336	282	211	338	243	59	7	1712
1999	3	-	6	227	266	207	167	141	177	233	358	89	1874
1998	-	-	0	47	95	166	215	344	359	98	187	0	1509
1997	0	15	90	123	146	90	192	100	171	158	2	-	1085
1996	0	0	1	156	338	186	196	132	315	338	97	41	1798
1995	0	-	48	29	175	221	156	193	444	375	16	2	1658
1994	-	-	183	21	207	351	152	321	378	248	-	6	1867
1993	7	-	59	67	185	294	219	122	244	250	26	35	1507
1992	1	-	-	88	73	192	122	406	172	248	-	5	1305
1991	-	0	0	89	123	145	222	245	384	206	0	-	1413
1990	0	-	8	99	181	226	103	105	171	58	43	0	994
1989	-	-	21	82	122	154	185	226	459	252	73	-	1574
1988	-	-	-	177	35	238	208	153	253	192	65	0	1321
1987	-	-	-	87	126	186	57	78	311	156	238	-	1238
1986	-	-	0	37	230	204	91	427	391	354	74	24	1832
1985	-	-	1	223	230	143	188	67	382	316	54	2	1606
1984	-	-	50	131	222	128	148	173	315	257	6	12	1442
1983	-	-	-	3	177	249	140	185	233	384	123	-	1493
1982	-	-	18	186	138	292	86	169	283	308	38	-	1518
1981	-	-	6	27	182	174	122	65	300	253	102	-	1232
1969	-	-	-	-	-	141	227	138	359	-	-	-	863
1966	-	23	33	100	135	188	309	83	170	202	64	89	1395
1961-1990	1	4	17	60	156	188	203	225	262	217	64	7	1404
Average	**6**	**31**	**38**	**95**	**179**	**202**	**168**	**190**	**301**	**232**	**80**	**16**	**1456**

Station: Kampong Cham

Year	Precipitation (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2010	29	-	27	20	105	126	96	-	-	-	-	-	403
2009	-	95	40	87	164	145	166	183	629	180	23	-	1711
2008	-	40	83	134	189	129	73	93	309	333	189	-	1571
2007	8	-	77	61	152	137	197	194	251	176	85	-	1337
2006	-	13	20	134	89	212	156	191	258	257	-	12	1343
2005	-	-	-	10	119	339	274	73	304	110	174	7	1411
2004	5	-	2	35	173	411	157	151	274	81	9	-	1298
2003	-	-	167	6	148	124	310	104	158	89	15	-	1121
2002	-	-	6	123	115	265	48	211	332	127	67	8	1303
2001	21	-	190	25	161	200	58	212	101	426	31	-	1423
2000	-	25	88	197	120	187	257	191	139	240	93	31	1568
1999	-	1	12	163	262	303	220	200	162	257	165	85	1828
1998	-	-	-	100	73	154	79	235	361	71	149	-	1221
1997	-	44	11	109	224	148	238	160	254	214	21	-	1424
1994	-	-	81	167	179	424	118	102	289	148	-	32	1539
1961-1990	2	4	17	59	139	138	142	151	222	236	103	21	1234
1917-1963	7	9	34	72	192	225	225	219	263	231	94	20	1590
Average	**12**	**29**	**57**	**88**	**153**	**216**	**165**	**167**	**269**	**199**	**87**	**27**	**1372**

Station: Kampong Thmar

Year	Precipitation (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1998	-	7	-	182	71	114	213	397	246	194	148	17	1590
1961-1990	1	4	17	59	150	168	182	194	247	220	76	10	1328
Average	**1**	**6**	**17**	**121**	**111**	**141**	**197**	**295**	**247**	**207**	**112**	**13**	**1459**

Station: Phnom Penh Bassac, Mekong, Tonle Sap

Year	Precipitation (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004 (110450)	6	0	0	22	116	87	76	114	165	160	26	-	772
2003 (110450)	-	1	11	33	150	85	202	100	144	190	16	-	932
1994 (PP Bassac)	0	-	164	61	158	106	97	154	333	127	6	18	1224
1992 (Bassac)	-	0	-	29	-	-	-	133	250	192	12	10	626
1992 (110450)	3	3	1	35	89	114	220	200	211	200	21	2	1097
1990 (Bassac)	-	-	0	19	156	85	347	184	180	179	129	-	1278
1990 (PP Airport)	-	-	0	19	156	85	347	184	180	179	129	-	1278
1969 (PP Airport)	3	10	4	27	224	263	214	178	249	243	143	54	1610
1961-1990	3	5	19	63	155	152	152	176	237	247	99	17	1325
Average	**3**	**3**	**25**	**34**	**150**	**122**	**207**	**158**	**217**	**191**	**65**	**20**	**1127**

Station: Sandan

Year	Precipitation (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2010	13	-	-	165	133	197	313	-	-	-	-	-	822
2009	-	1	117	157	228	180	349	145	587	18	68	-	1849
2008	-	-	39	121	363	88	254	171	373	117	75	-	1600
2007	-	-	4	175	338	152	253	245	310	86	62	-	1627
2006	-	3	18	246	120	177	358	234	423	57	-	3	1639
2005	-	-	3	5	77	133	294	94	264	79	111	8	1067
2004	-	-	-	74	95	335	444	247	183	6	38	-	1422
2003	-	-	79	36	181	215	246	158	284	93	4	-	1295
2002	-	-	0	148	148	199	143	243	255	86	11	0	1233
2001	0	-	163	5	195	244	186	348	267	107	56	0	1571
2000	-	2	34	327	234	279	347	253	144	162	16	15	1812
1999	8	0	42	113	307	202	309	135	249	128	246	62	1800
1997	-	-	-	-	145	93	45	40	245	102	-	-	669
1961-1990	0	4	15	61	166	215	249	252	275	185	48	5	1476
Average	**5**	**2**	**47**	**126**	**195**	**193**	**271**	**197**	**297**	**94**	**67**	**13**	**1420**

Station: Kampong Putrea

Year	Precipitation (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1961-1990	0	4	14	60	168	229	262	273	279	169	37	3	1498

Station: Stung Chinit

Year	Precipitation (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2010	9	-	12	59	122	147	-	-	-	-	-	-	350
2009	-	33	85	75	266	134	187	220	390	50	1	-	1440
2008	20	58	36	80	211	276	67	328	242	228	131	-	1676
2007	-	10	70	114	280	258	335	293	336	154	80	-	1929
2006	-	14	19	166	159	187	250	532	285	176	22	-	1811
2005	-	-	5	23	109	115	343	105	271	208	117	22	1316
2004	-	33	11	70	75	282	224	130	201	127	5	-	1158
2003	-	-	183	16	263	277	210	224	197	172	16	-	1558
2002	-	-	6	202	87	312	88	153	450	139	10	7	1453
2001	-	1	177	37	306	161	138	246	195	410	60	-	1732
2000	1	23	8	185	125	311	376	221	321	277	54	50	1951
1999	12	-	110	290	357	166	176	221	121	199	374	62	2087
1998	-	7	-	162	106	114	253	383	277	219	148	17	1686
1997	-	30	-	83	122	224	302	277	270	108	1	-	1416
1996	-	-	20	71	240	391	174	228	260	307	247	20	1958
1995	-	-	56	14	199	172	219	319	461	342	29	4	1815
1994	-	-	-	-	-	-	175	136	303	47	-	33	694
1993	-	-	-	-	-	-	157	193	-	-	-	-	350
1991	0	-	1	82	89	246	166	187	-	-	-	-	770
1990	-	-	29	71	195	147	105	130	166	248	49	0	1140
1989	14	-	37	35	98	98	126	129	146	213	39	-	935
1988	-	-	-	49	59	143	76	126	234	140	-	-	827
1987	-	-	-	49	59	143	76	126	234	140	-	-	827
1986	-	-	-	-	-	246	236	341	321	138	160	41	1483
1961-1990	1	4	16	59	157	190	213	222	261	204	61	7	1394
Average	**8**	**21**	**49**	**91**	**167**	**206**	**195**	**228**	**270**	**193**	**84**	**24**	**1350**

Station: Tang Krosaing

Year	Precipitation (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2010	24	-	-	123	126	160	-	-	-	-	-	-	434
2009	-	64	88	112	2030	195	199	164	451	189	41	-	3533
2008	21	105	13	113	200	214	56	197	414	286	97	2	1718
2007	1	22	130	115	172	115	194	267	254	191	76	-	1535
2006	-	40	1	93	166	95	260	399	308	181	1	1	1544
2005	-	-	3	23	136	194	270	138	170	92	122	3	1151
2004	1	2	37	22	191	302	170	233	220	83	8	0	1269
2003	-	-	97	90	198	138	238	167	143	121	15	0	1207
2002	-	-	2	107	153	239	102	161	442	93	15	14	1327
2001	1	0	168	31	220	135	58	231	165	269	28	-	1306
2000	0	21	0	263	96	308	274	216	317	233	46	16	1790
1999	1	0	58	378	20	263	179	120	312	282	265	61	1940
1998	0	0	-	48	133	154	197	242	350	150	132	2	1408
1997	0	0	8	186	247	169	244	270	240	256	8	-	1628
1996	-	1	6	123	207	188	364	182	300	311	119	35	1837
1995	-	-	24	32	253	236	171	1980	404	304	12	8	3423
1994	-	-	-	-	-	-	-	202	134	153	-	20	509
1993	6	-	31	186	207	186	284	-	156	200	-	-	1258
1992	-	-	-	-	-	-	-	290	141	121	1	-	553
1991	-	-	1	111	122	108	200	172	249	243	0	0	1205
1990	4	-	57	96	271	168	157	195	185	229	37	-	1398
1989	-	-	37	105	128	96	210	192	188	173	32	-	1160
1988	-	-	-	-	-	58	230	208	240	170	86	-	992
1961-1990	0	4	16	59	158	198	222	236	265	198	53	5	992
Average	**5**	**22**	**41**	**115**	**259**	**178**	**204**	**294**	**263**	**197**	**57**	**12**	**1463**

Source for all: MRC Hydrology Yearbooks, Kampong Thom PDOWRAM, IWMI Water & Climate Atlas

Appendix A-5: Selected Stations Evaporation Data

Station: Stung Treng

	Monthly Total Evaporation (mm)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	162	-	193	203	179	-	-	151	112	139	138	147	1424
1966	174	177	213	182	146	164	117	106	114	148	140	132	1812
1968	164	164	244	206	173	164	160	117	129	150	165	173	2009
1961-1990 (ETo)	122	132	169	160	136	113	116	111	106	109	105	108	1486
Average	**155**	**158**	**205**	**188**	**158**	**147**	**131**	**121**	**115**	**136**	**137**	**140**	**1683**

Station: Kratie

	Monthly Total Evaporation (mm)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	186	195	256	239	186	-	143	170	111	147	146	199	1980
1968	215	-	266	200	175	152	150	140	135	153	179	190	1955
1961-1990 (ETo)	123	132	165	159	136	119	119	118	110	110	108	111	1510
Average	**175**	**163**	**229**	**200**	**166**	**136**	**137**	**143**	**119**	**137**	**144**	**167**	**1815**

Station: Kampong Cham

	Monthly Total Evaporation (mm)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	136	147	191	206	191	155	144	148	126	140	138	169	1890
1968	-	152	211	168	174	164	142	139	119	134	139	141	1683
1961-1990 (ETo)	130	136	166	162	137	122	121	122	112	112	112	118	1552
1929-1960	174	157	189	168	105	84	81	84	66	81	111	146	1445
Average	**147**	**148**	**189**	**176**	**152**	**131**	**122**	**123**	**106**	**117**	**125**	**144**	**1643**

Station: Phnom Penh Airport

	Monthly Total Evaporation (mm)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969 (Actual)	193	203	272	287	235	137	182	186	133	148	159	207	2341
1961-1990 (ETo)	137	138	167	161	138	128	125	126	113	116	119	126	1594
Average	**165**	**170**	**219**	**224**	**187**	**133**	**153**	**156**	**123**	**132**	**139**	**166**	**1967**

Source for all: MRC Hydrology Yearbooks, IWMI Water & Climate Atlas

Appendix A-6: Selected Stations Gage Height

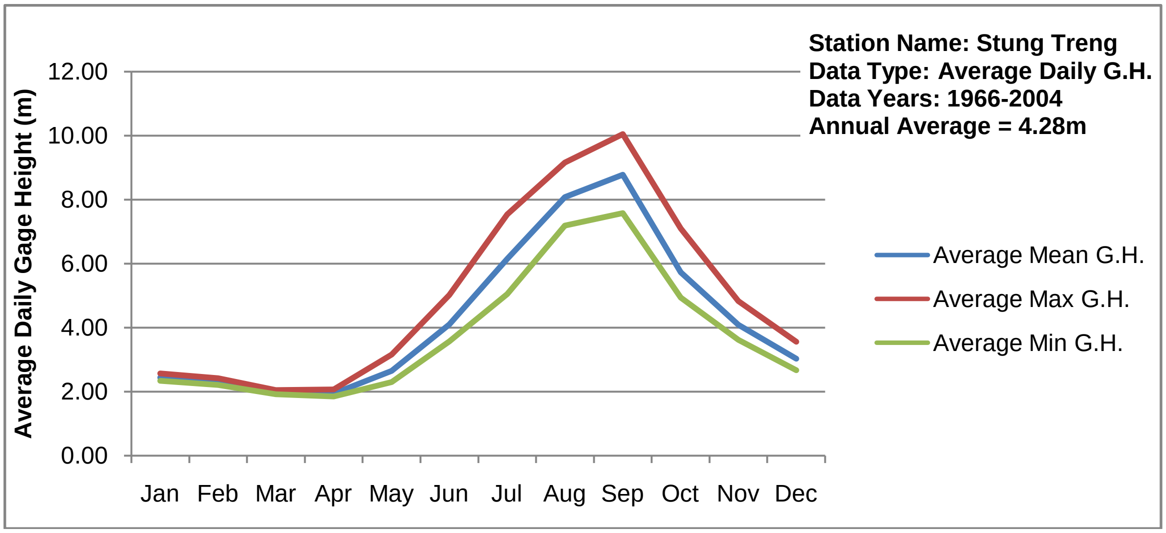
Station: Stung Treng

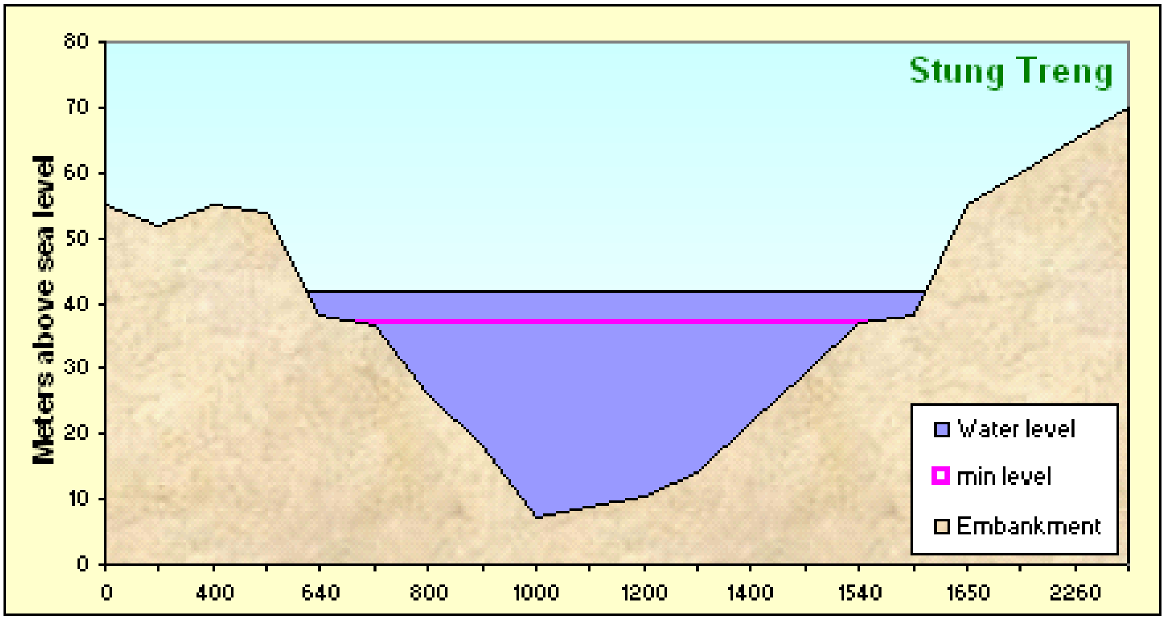
Year	Mean Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	2.00	2.00	2.00	2.00	3.00	5.00	6.00	9.00	9.00	5.00	4.00	-
2003	-	3.00	2.00	2.00	3.00	4.00	5.00	7.00	9.00	6.00	4.00	-
1998	2.52	2.23	1.98	2.03	2.44	3.14	5.46	5.94	6.95	4.58	3.86	3.12
1996	-	-	-	-	3.08	3.71	5.52	8.63	9.46	7.43	5.67	3.82
1994	2.48	2.22	1.92	2.18	2.42	5.13	7.98	9.05	9.36	6.13	3.63	3.11
1969	2.48	2.24	1.77	1.71	1.91	4.23	7.38	8.72	8.01	5.40	3.81	2.82
1968	2.49	2.25	1.90	1.93	2.53	3.39	4.97	7.50	8.62	5.45	3.79	2.53
1966	2.75	2.30	2.07	1.82	2.90	4.26	6.97	8.85	9.89	5.87	4.04	2.80
1964*	252.5	216.4	181.0	172.3	263.5	397.0	587.9	711.4	649.6	758.2	509.2	340.4
Average	**2.45**	**2.32**	**1.95**	**1.95**	**2.66**	**4.11**	**6.16**	**8.09**	**8.79**	**5.73**	**4.10**	**3.03**

Year	Max Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	2.00	2.00	2.00	2.00	3.00	5.00	6.00	9.00	9.00	5.00	4.00	-
2003	-	3.00	2.00	2.00	3.00	4.00	5.00	7.00	9.00	6.00	4.00	-
1998	2.67	2.36	2.12	2.32	2.99	3.44	6.24	6.98	7.97	6.08	5.16	4.15
1996	-	-	-	-	3.93	4.60	8.96	10.32	12.19	11.14	7.26	4.59
1994	2.74	2.26	2.06	2.39	3.08	6.82	9.66	10.77	10.40	7.98	4.39	3.23
1969	2.57	2.38	2.05	1.76	2.15	6.20	9.35	9.57	9.78	6.67	4.50	3.10
1968	2.51	2.45	2.05	2.10	2.94	4.25	5.74	10.09	11.03	6.55	4.46	2.76
1966	2.98	2.51	2.12	1.96	4.25	5.90	9.41	9.60	11.08	7.46	4.95	3.58
1964*	277.0	233.0	193.0	186.0	411.0	459.0	688.0	880.0	983.0	960.0	664.0	384.0
Average	**2.58**	**2.42**	**2.06**	**2.08**	**3.17**	**5.03**	**7.55**	**9.17**	**10.06**	**7.11**	**4.84**	**3.57**

Year	Min Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	2.00	2.00	2.00	2.00	3.00	5.00	6.00	9.00	9.00	5.00	4.00	-
2003	-	3.00	2.00	2.00	3.00	4.00	5.00	7.00	9.00	6.00	4.00	-
1998	2.36	2.12	1.84	1.77	2.14	2.93	3.50	4.76	5.87	3.68	3.24	2.68
1996	-	-	-	-	2.26	3.03	3.96	7.82	6.96	5.92	4.56	3.27
1994	2.28	2.12	1.85	1.92	2.08	3.14	6.25	8.18	8.50	4.54	3.18	2.89
1969	2.48	2.08	1.99	1.74	1.95	3.88	5.79	7.80	7.56	4.95	3.62	2.52
1968	2.46	2.07	1.77	1.79	2.04	2.72	4.17	5.24	6.25	4.50	2.80	2.15
1966	2.48	2.08	1.99	1.74	1.95	3.88	5.79	7.80	7.56	4.95	3.62	2.52
1964*	234.0	194.0	164.0	163.0	189.0	329.0	453.0	491.0	1.0	571.0	391.0	292.0
Average	**2.34**	**2.21**	**1.92**	**1.85**	**2.30**	**3.57**	**5.06**	**7.20**	**7.59**	**4.94**	**3.63**	**2.67**

*There is not a second source to confirm that the gage heights for 1964 are accurate as recorded in the MRC Hydrology Yearbook. Therefore they have not been included in the Avg Daily Gage Height calculation.


Station Name: Stung Treng
Data Type: Average Daily G.H.
Data Years: 1966-2004
Annual Average = 4.28m
Average Daily Gage Height (m)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Average Mean G.H.
Average Max G.H.
Average Min G.H.

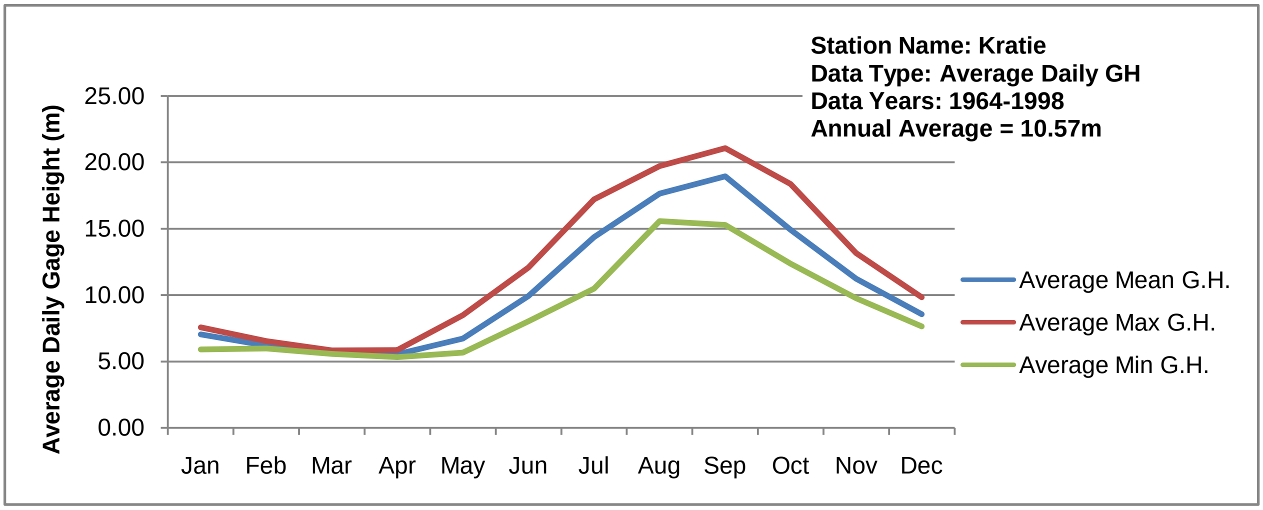

Stung Treng
Meters above sea level
80
70
60
50
40
30
20
10
0
0
400
640
800
1000
1200
1400
1540
1650
2260
Water level
min level
Embankment

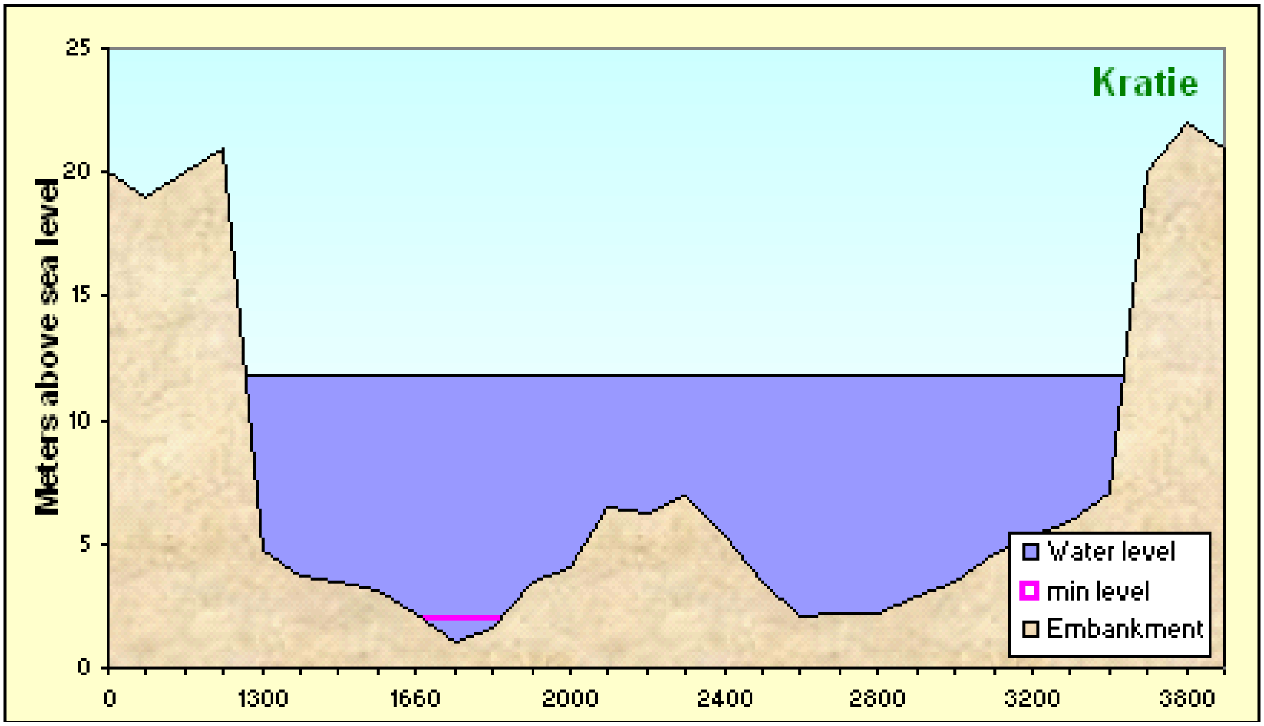
Station: Kratie

Year	Mean Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	7.08	6.42	6.04	6.09	6.74	8.38	12.81	14.06	16.08	12.18	10.00	8.72
1996	7.35	6.56	6.27	-	-	9.51	12.74	18.86	19.72	17.56	14.10	-
1994	6.84	6.17	5.69	6.02	6.53	12.11	17.64	19.75	20.51	15.30	9.73	8.39
1969	7.38	-	5.37	5.04	5.46	10.16	16.37	19.15	18.39	13.77	11.11	-
1968	6.45	5.46	5.04	5.27	6.86	8.76	11.70	16.63	18.72	13.71	10.22	7.91
1966	7.22	6.57	5.80	5.50	7.51	10.59	15.58	19.19	20.96	14.41	10.67	8.61
1964	7.01	6.06	5.49	5.37	7.22	10.10	13.70	16.00	18.30	17.50	12.80	9.15
Average	**7.05**	**6.21**	**5.67**	**5.55**	**6.72**	**9.94**	**14.36**	**17.66**	**18.95**	**14.92**	**11.23**	**8.56**

Year	Max Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	7.44	6.67	6.21	6.52	7.98	8.90	14.32	16.64	17.82	15.42	12.45	11.82
1996	7.88	6.77	6.49	-	-	11.16	18.66	20.65	23.02	22.62	16.80	-
1994	7.47	6.30	6.04	6.44	7.95	15.48	20.04	21.65	21.48	19.26	11.74	8.58
1969	7.68	-	5.42	5.13	5.88	14.16	19.25	20.07	20.20	16.67	11.67	-
1968	7.03	5.90	5.09	5.60	7.80	10.55	13.44	20.20	21.50	16.08	11.58	8.68
1966	7.77	7.02	5.80	5.75	10.80	13.00	19.37	20.28	22.16	17.91	12.62	9.79
1964	7.67	6.42	5.68	5.57	10.50	11.30	15.40	18.70	21.40	20.70	15.30	10.30
Average	**7.56**	**6.51**	**5.82**	**5.84**	**8.49**	**12.08**	**17.21**	**19.74**	**21.08**	**18.38**	**13.17**	**9.83**

Year	Min Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	6.67	6.19	5.91	5.86	6.17	7.94	8.70	11.73	14.24	9.88	8.71	7.43
1996	6.80	6.50	6.06	-	-	8.29	10.27	18.01	16.48	14.86	11.82	-
1994	6.34	6.10	5.53	5.60	5.86	8.04	14.74	18.64	19.70	11.98	8.64	7.94
1969	6.99	-	5.31	4.96	5.03	5.91	13.18	17.87	16.60	11.76	10.51	-
1968	5.93	5.06	5.00	5.04	5.59	7.28	1.57	12.90	15.08	11.83	8.72	7.07
1966	2.18	6.23	5.80	5.35	5.63	9.97	13.67	17.65	18.32	12.05	9.48	7.75
1964	6.46	5.70	5.37	5.12	5.62	8.71	11.20	12.20	6.58	14.20	10.40	7.96
Average	**5.91**	**5.96**	**5.57**	**5.32**	**5.65**	**8.02**	**10.48**	**15.57**	**15.29**	**12.37**	**9.75**	**7.63**


Station Name: Kratie
Data Type: Average Daily GH
Data Years: 1964-1998
Annual Average = 10.57m
Average Daily Gage Height (m)
25.00
20.00
15.00
10.00
5.00
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Average Mean G.H.
Average Max G.H.
Average Min G.H.

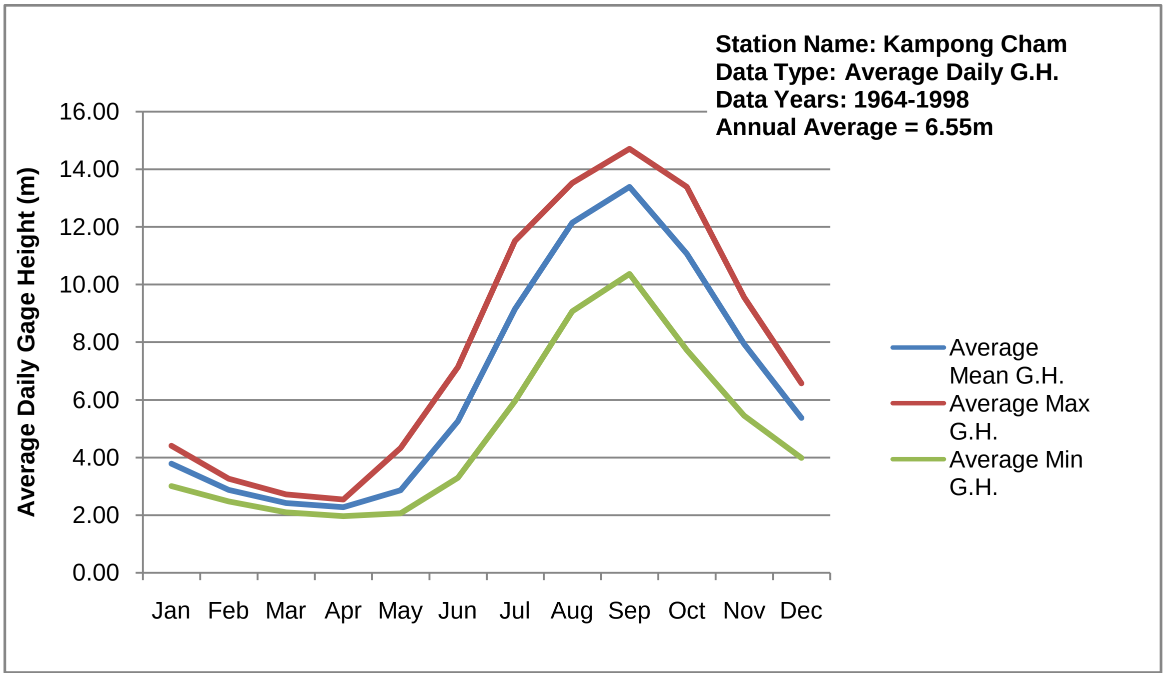

Kratie
Meters above sea level
25
20
15
10
5
0
0
1300
1660
2000
2400
2800
3200
3800
Water level
min level
Embankment

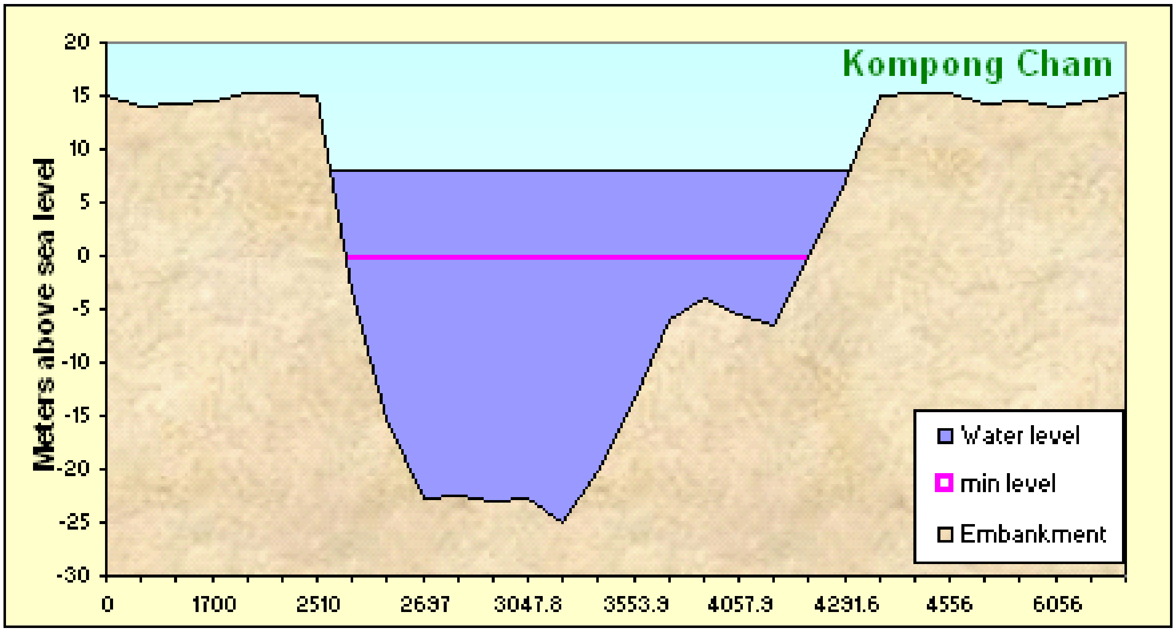
Station: Kampong Cham

Year	Mean Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	3.83	2.91	2.42	2.27	2.67	4.10	7.89	8.97	10.89	8.53	6.50	5.36
1996	4.25	3.24	2.63	2.54	3.84	5.06	7.77	13.17	13.85	13.07	10.51	-
1994	3.52	2.65	2.32	2.31	2.50	7.03	11.90	13.98	14.66	11.47	7.04	5.32
1969	3.53	2.66	2.32	2.11	2.10	5.35	10.86	13.57	13.29	10.44	7.40	4.92
1968	3.23	2.58	2.31	2.26	2.76	4.16	7.03	11.21	13.28	9.95	6.84	4.61
1966	4.22	3.19	2.53	2.24	3.20	5.78	10.03	13.55	14.90	11.19	7.96	5.88
1964	3.89	2.91	2.42	2.20	3.02	5.40	8.61	10.60	12.90	12.90	9.35	6.18
Average	**3.78**	**2.88**	**2.42**	**2.28**	**2.87**	**5.27**	**9.16**	**12.15**	**13.40**	**11.08**	**7.94**	**5.38**

Year	Max Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	4.41	3.37	2.76	2.51	3.74	4.59	9.26	10.59	12.24	10.83	8.14	7.92
1996	4.89	3.55	2.90	2.75	5.66	6.46	12.67	14.07	16.11	16.02	12.16	-
1994	4.22	3.01	2.64	2.58	3.57	10.06	13.77	15.10	15.17	14.24	8.86	5.86
1969	4.06	2.91	2.51	2.52	2.41	8.98	13.14	13.89	14.14	12.30	8.83	5.86
1968	3.72	2.95	2.52	2.49	3.44	5.89	8.46	13.84	14.98	12.02	8.38	5.56
1966	4.88	3.71	2.94	2.46	5.92	7.62	13.19	14.28	15.44	13.63	9.67	6.93
1964	4.66	3.34	2.73	2.48	5.56	6.36	10.10	12.90	14.90	14.70	10.90	7.33
Average	**4.41**	**3.26**	**2.71**	**2.54**	**4.33**	**7.14**	**11.51**	**13.52**	**14.71**	**13.39**	**9.56**	**6.58**

Year	Min Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	3.40	2.57	2.14	2.05	2.20	3.76	4.26	7.16	9.34	6.77	5.54	4.09
1996	3.59	2.93	2.29	2.28	2.44	4.10	5.84	12.39	11.93	11.18	8.85	-
1994	3.04	2.41	2.05	2.01	2.08	3.61	9.65	13.28	14.25	8.98	5.94	4.78
1969	2.90	2.38	2.11	1.74	1.76	2.25	8.27	12.86	12.62	8.96	5.94	4.10
1968	2.72	2.35	1.89	1.96	2.02	3.00	5.86	8.05	10.69	5.59	2.26	3.78
1966	2.16	2.16	2.16	1.86	1.94	2.16	2.16	2.16	2.16	2.16	2.16	2.16
1964	3.33	2.61	2.13	1.92	2.04	4.27	5.66	7.60	11.60	10.50	7.53	5.05
Average	**3.02**	**2.49**	**2.11**	**1.97**	**2.07**	**3.31**	**5.96**	**9.07**	**10.37**	**7.73**	**5.46**	**3.99**


Station Name: Kampong Cham
Data Type: Average Daily G.H.
Data Years: 1964-1998
Annual Average = 6.55m
Average Daily Gage Height (m)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Average Mean G.H.
Average Max G.H.
Average Min G.H.

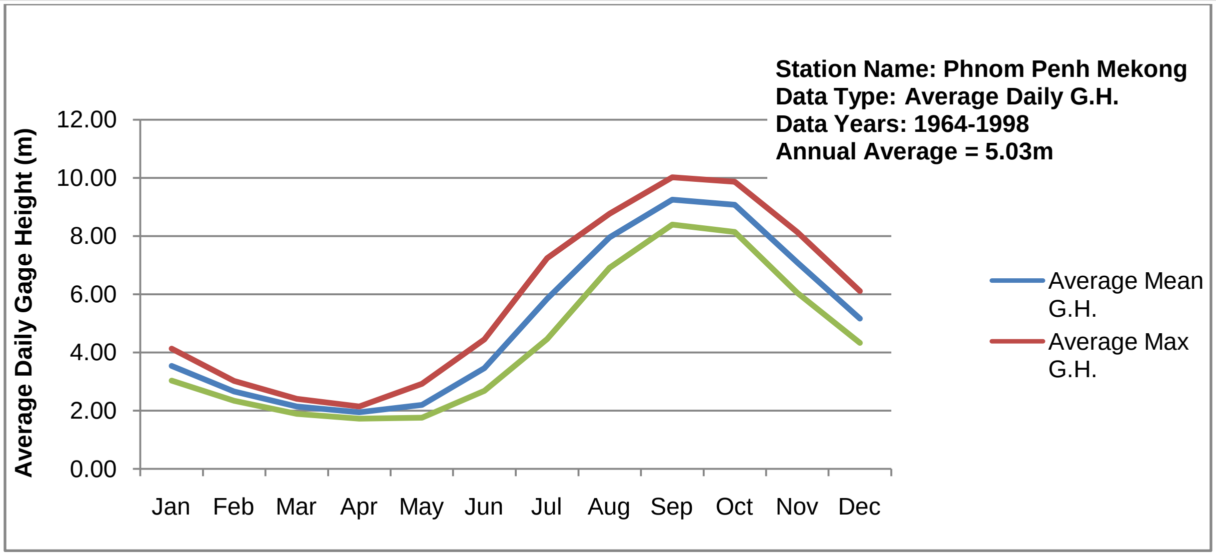

Kompong Cham
Meters above sea level
20
15
10
5
0
-5
-10
-15
-20
-25
-30
0
1700
2510
2637
3047.8
3553.9
4057.9
4231.6
4556
6056
Water level
min level
Embankment

Station: Phnom Penh – Mekong

Year	Mean Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	3.53	2.62	2.07	1.84	1.96	2.60	4.91	5.73	7.23	6.99	5.57	4.59
1996	4.02	3.01	2.35	2.16	2.68	3.40	5.04	8.50	9.43	10.30	9.11	6.72
1994	3.35	2.54	2.08	2.00	2.00	4.40	7.53	9.37	10.32	9.63	6.59	4.94
1969	3.30	2.46	2.04	1.82	1.81	3.49	6.82	9.00	9.51	8.90	6.70	4.62
1968	3.00	2.35	2.03	1.90	2.21	2.90	4.51	7.15	9.00	8.33	6.20	4.24
1966	3.94	2.93	2.25	1.99	2.42	3.85	6.48	8.92	10.51	9.58	7.28	5.38
1964	3.69	2.72	2.18	1.94	2.33	3.64	5.65	7.00	8.76	9.80	8.14	5.69
Average	**3.55**	**2.66**	**2.14**	**1.95**	**2.20**	**3.47**	**5.85**	**7.95**	**9.25**	**9.08**	**7.08**	**5.17**

Year	Max Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	4.10	3.08	2.40	2.08	2.40	2.87	5.70	6.84	7.96	7.82	6.18	5.83
1996	4.59	3.40	2.64	2.27	3.64	4.19	7.93	8.89	10.94	11.00	9.88	7.92
1994	4.00	2.73	2.28	2.18	2.50	6.16	8.72	9.74	10.58	10.57	8.08	5.47
1969	3.84	2.82	2.12	2.19	2.11	5.44	8.34	9.17	9.89	9.70	7.82	5.52
1968	3.45	2.60	2.24	2.14	2.66	3.76	5.29	8.81	9.79	9.14	7.36	5.00
1966	4.55	3.42	2.70	2.10	3.84	4.65	8.33	9.51	11.02	10.66	8.60	6.30
1964	4.45	3.13	2.52	2.10	3.40	4.15	6.40	8.40	9.95	10.20	9.00	6.75
Average	**4.14**	**3.03**	**2.41**	**2.15**	**2.94**	**4.46**	**7.24**	**8.77**	**10.02**	**9.87**	**8.13**	**6.11**

Year	Min Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	3.11	2.25	1.90	1.65	1.71	2.39	2.70	4.30	6.36	5.96	5.02	3.65
1996	3.44	2.66	2.02	1.96	2.00	3.00	4.05	7.92	8.72	9.66	8.01	5.64
1994	2.74	2.30	1.95	1.81	1.73	2.52	6.20	8.63	9.69	8.20	5.50	4.39
1969	2.83	2.10	1.87	1.47	1.45	1.88	5.20	8.52	8.76	7.98	5.58	3.88
1968	2.58	2.10	1.60	1.67	1.79	2.32	3.87	5.21	7.50	7.46	5.04	3.50
1966	3.44	2.56	1.90	1.80	1.75	3.65	5.00	8.14	9.59	8.70	6.30	4.58
1964	3.13	2.45	2.00	1.75	1.88	3.00	4.25	5.70	8.15	9.04	6.85	4.69
Average	**3.04**	**2.35**	**1.89**	**1.73**	**1.76**	**2.68**	**4.47**	**6.92**	**8.40**	**8.14**	**6.04**	**4.33**

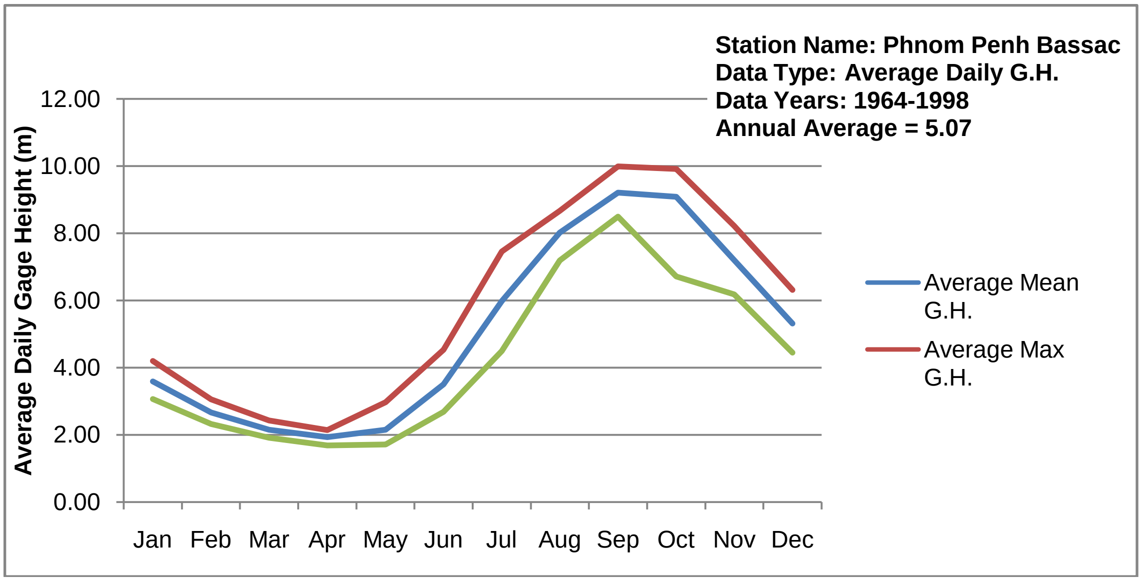

Station Name: Phnom Penh Mekong
Data Type: Average Daily G.H.
Data Years: 1964-1998
Annual Average = 5.03m
Average Daily Gage Height (m)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Average Mean G.H.
Average Max G.H.

Station: Phnom Penh – Bassac

Year	Mean Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	3.52	2.62	2.13	1.90	1.99	2.63	4.84	5.75	7.16	7.02	5.55	4.63
1996	4.00	2.99	2.32	2.13	2.65	3.37	4.99	8.40	9.36	10.25	9.09	6.72
1994	3.26	2.38	2.10	1.96	1.93	4.32	7.42	9.27	10.26	9.62	6.61	4.95
1969	3.26	2.42	2.02	1.70	1.71	3.38	6.71	8.90	9.44	8.79	6.69	4.55
1966	3.90	2.87	2.15	1.99	2.31	3.76	6.37	8.86	10.41	9.50	7.22	5.41
1964	3.61	2.70	2.16	1.91	2.32	3.59	5.59	6.97	8.67	9.36	8.08	5.64
Average	**3.59**	**2.66**	**2.15**	**1.93**	**2.15**	**3.51**	**5.99**	**8.03**	**9.22**	**9.09**	**7.21**	**5.32**

Year	Max Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	4.11	3.10	2.46	2.16	2.44	2.90	5.62	6.68	7.92	7.78	6.24	6.16
1996	4.60	3.34	2.57	2.26	3.60	4.16	7.82	8.79	10.85	10.94	9.86	7.91
1994	3.90	2.76	2.37	2.18	2.46	6.12	8.61	9.65	10.53	10.52	8.08	5.52
1969	3.78	2.70	2.16	2.14	1.97	5.35	8.17	9.20	9.79	9.62	7.78	5.43
1966	4.50	3.35	2.58	2.05	3.76	4.55	8.23	9.40	10.93	10.60	8.54	6.22
1964	4.29	3.07	2.41	2.07	3.60	4.15	6.33	8.32	9.94	10.06	8.82	6.68
Average	**4.20**	**3.05**	**2.43**	**2.14**	**2.97**	**4.54**	**7.46**	**8.67**	**9.99**	**9.92**	**8.22**	**6.32**

Year	Min Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	3.12	2.26	1.97	1.69	1.76	2.42	2.69	4.76	6.32	5.94	5.00	3.64
1996	3.38	2.61	2.05	1.91	1.98	2.94	4.02	7.78	8.68	9.62	8.02	5.64
1994	2.77	2.09	1.89	1.70	1.66	2.44	6.00	8.56	9.58	8.20	5.59	4.39
1969	2.70	2.13	1.89	1.33	1.44	1.78	5.11	8.35	8.80	7.83	5.50	3.82
1966	3.39	2.42	1.78	1.77	1.64	3.57	4.92	8.05	9.52	8.63	6.22	4.51
1964	3.07	2.44	1.94	1.72	1.84	2.99	4.22	5.65	8.08	0.06	6.79	4.67
Average	**3.07**	**2.33**	**1.92**	**1.69**	**1.72**	**2.69**	**4.49**	**7.19**	**8.50**	**6.71**	**6.19**	**4.45**

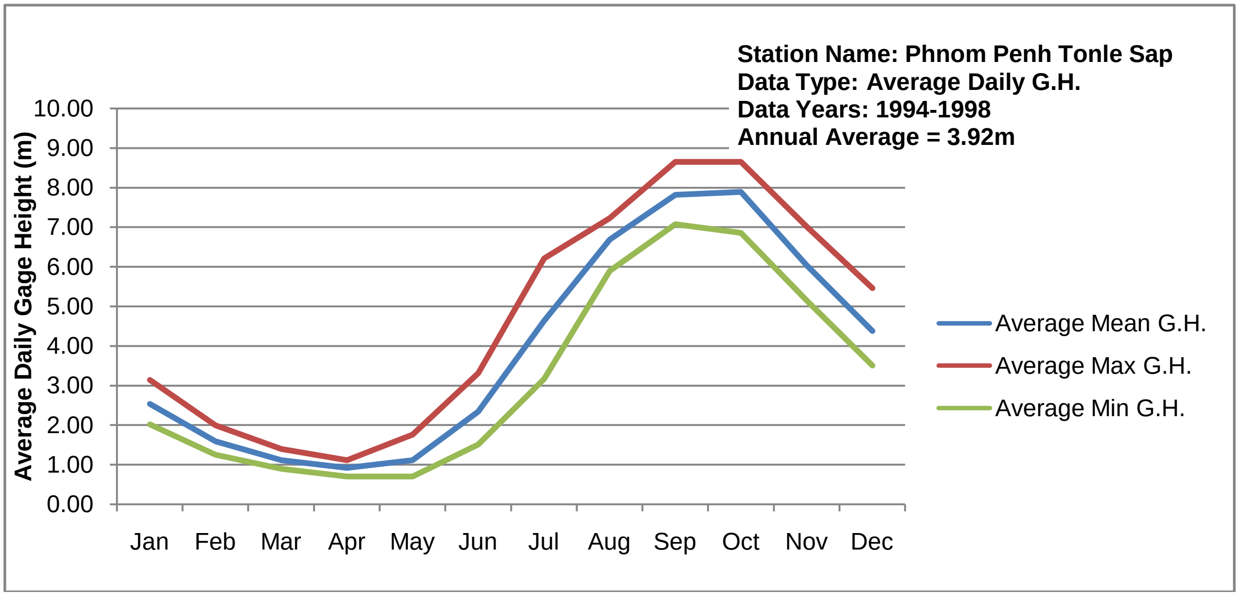

Station Name: Phnom Penh Bassac
Data Type: Average Daily G.H.
Data Years: 1964-1998
Annual Average = 5.07
Average Daily Gage Height (m)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Average Mean G.H.
Average Max G.H.

Station: Phnom Penh – Tonle Sap

Year	Mean Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	2.45	1.51	1.02	0.79	0.88	1.53	3.72	4.64	6.03	5.92	4.46	3.54
1996	2.97	1.96	1.30	1.09	1.54	2.24	3.92	7.31	8.26	9.17	8.05	5.67
1994	2.17	1.30	1.01	0.87	0.90	3.24	6.27	8.12	9.15	8.58	5.58	3.92
Average	**2.53**	**1.59**	**1.11**	**0.92**	**1.11**	**2.34**	**4.64**	**6.69**	**7.81**	**7.89**	**6.03**	**4.38**

Year	Max Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	3.07	2.00	1.35	1.04	1.33	1.80	4.52	5.54	6.75	6.67	5.15	5.04
1996	3.59	2.31	1.55	1.22	2.50	3.04	6.71	7.70	9.75	9.84	8.82	6.83
1994	2.77	1.68	1.28	1.08	1.44	5.09	7.40	8.44	9.45	9.44	7.05	4.50
Average	**3.14**	**2.00**	**1.39**	**1.11**	**1.76**	**3.31**	**6.21**	**7.23**	**8.65**	**8.65**	**7.01**	**5.46**

Year	Min Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	2.02	1.15	0.86	0.59	0.64	1.31	1.58	3.64	5.20	4.84	3.93	2.58
1996	2.35	1.59	1.01	0.88	0.85	1.82	2.94	6.68	7.58	8.56	6.94	4.56
1994	1.69	1.01	0.80	0.63	0.62	1.40	4.97	7.35	8.44	7.17	4.56	3.37
Average	**2.02**	**1.25**	**0.89**	**0.70**	**0.70**	**1.51**	**3.16**	**5.89**	**7.07**	**6.86**	**5.14**	**3.50**

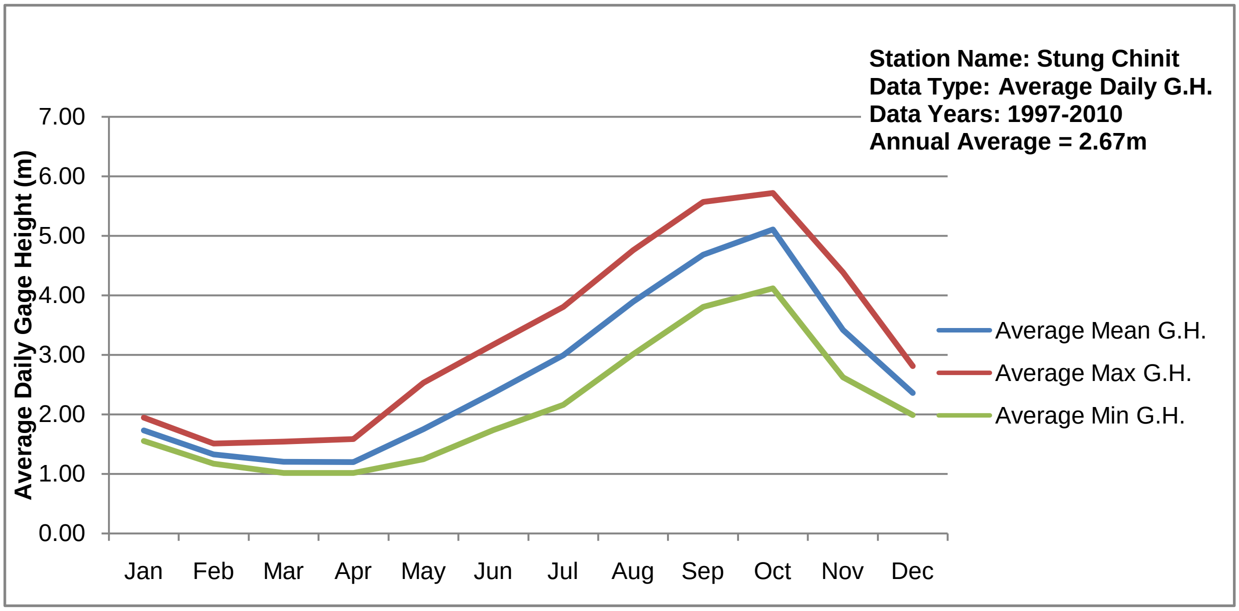


Station: Stung Chinit

Year	Mean Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	2.72	2.19	1.58	1.07	1.82	2.26	1.45	-	-	-	-	-
2009	1.63	1.23	1.35	1.49	2.71	4.04	4.99	4.41	6.86	6.98	4.77	3.32
2008	1.88	1.83	1.34	1.50	2.08	2.17	1.80	2.55	3.36	3.94	3.32	2.14
2007	1.62	1.31	1.05	0.98	2.48	2.22	3.71	4.36	4.82	6.17	3.61	2.32
2006	-	0.80	0.81	0.89	1.15	0.91	3.45	4.70	5.64	5.58	2.66	1.88
2005	1.19	0.99	0.92	0.83	1.02	1.15	3.20	2.82	3.87	3.81	3.17	2.42
2004	1.23	1.05	0.91	0.87	1.04	2.72	2.04	4.73	4.57	3.96	1.96	1.50
2003	1.45	1.22	1.25	1.15	1.38	1.98	2.63	3.64	4.29	4.36	2.24	1.55
2002	1.79	1.49	1.22	1.14	1.23	2.29	2.28	3.13	4.92	4.88	3.02	1.96
2001	2.02	1.61	1.93	1.51	1.90	2.13	3.26	3.34	4.91	5.84	4.10	2.46
2000	2.38	-	1.49	1.74	2.35	4.35	5.44	5.47	5.75	5.71	4.10	2.73
1999	1.56	1.18	0.96	1.42	3.13	4.10	3.58	4.60	4.50	5.18	5.70	3.91
1998	1.33	1.10	0.91	0.84	0.96	1.03	1.52	2.26	3.01	5.15	3.12	2.83
1997	-	-	-	1.40	1.33	1.71	2.62	4.61	4.38	4.86	2.71	1.71
Average	**1.73**	**1.33**	**1.21**	**1.20**	**1.76**	**2.36**	**3.00**	**3.89**	**4.68**	**5.11**	**3.42**	**2.36**

Year	Max Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	3.00	2.57	2.57	1.41	2.22	2.80	2.07	-	-	-	-	-
2009	2.03	1.33	1.82	1.94	5.18	4.86	5.58	5.30	7.70	7.65	6.18	3.71
2008	2.04	2.05	1.84	1.90	2.44	2.95	2.16	3.16	3.90	4.12	4.52	2.31
2007	1.70	1.47	1.10	1.06	4.44	2.74	4.25	4.93	5.58	6.55	4.61	2.60
2006	-	0.83	0.83	0.98	1.36	1.34	4.74	6.03	6.40	6.29	3.62	2.10
2005	1.29	1.08	0.98	0.89	1.44	1.72	3.86	3.84	4.95	4.12	3.57	2.58
2004	1.35	1.12	0.98	0.93	1.28	4.54	2.98	5.76	5.00	4.78	2.56	1.70
2003	1.60	1.33	2.04	1.77	1.85	2.95	3.51	4.22	5.13	5.38	2.82	1.80
2002	1.98	1.64	1.34	1.64	1.69	4.02	3.34	4.28	6.06	6.17	4.02	2.30
2001	2.28	1.72	2.92	1.94	3.06	3.14	3.76	4.70	5.90	6.28	5.35	2.99
2000	2.80	-	1.62	2.71	2.91	4.96	6.01	5.90	5.95	6.11	5.22	3.15
1999	1.84	1.80	1.03	1.91	4.22	4.86	4.88	5.36	4.93	5.82	6.54	5.16
1998	1.47	1.18	1.00	1.19	1.74	1.18	2.06	3.18	5.59	5.82	4.31	4.16
1997	-	-	-	1.95	1.63	2.39	4.11	5.24	5.40	5.34	3.72	2.04
Average	**1.95**	**1.51**	**1.54**	**1.59**	**2.53**	**3.18**	**3.81**	**4.76**	**5.58**	**5.73**	**4.39**	**2.82**

Year	Min Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	2.56	1.35	1.10	0.95	1.40	1.90	1.20	-	-	-	-	-
2009	1.34	1.18	1.12	1.26	1.58	3.55	3.82	3.54	5.00	6.11	3.73	3.02
2008	1.80	1.72	1.00	1.20	1.80	1.36	1.52	2.06	2.44	3.70	2.30	2.04
2007	1.48	1.10	0.95	0.94	1.06	1.91	2.36	3.77	4.25	4.88	2.62	2.09
2006	-	0.78	0.80	0.83	0.88	0.75	2.05	3.06	4.85	3.72	2.13	1.70
2005	1.09	0.91	0.88	0.78	0.74	0.89	1.90	2.40	2.42	3.32	2.61	2.24
2004	1.12	0.98	0.86	0.82	0.81	1.09	1.48	3.10	4.06	2.60	1.70	1.30
2003	1.34	1.12	0.97	1.03	1.04	1.24	1.95	2.84	3.15	2.86	1.84	1.35
2002	1.64	1.34	1.11	1.07	1.09	1.44	1.67	2.03	4.16	4.08	2.31	1.61
2001	1.72	1.50	1.39	1.30	1.23	1.62	2.56	2.22	4.38	4.95	3.03	2.06
2000	2.01	-	1.32	1.22	2.04	3.41	4.43	5.06	5.46	5.22	3.20	2.30
1999	1.33	1.04	0.88	0.97	1.95	3.19	2.73	3.77	4.03	4.04	4.28	2.82
1998	1.19	1.01	0.82	0.75	0.74	0.88	1.11	1.67	1.73	4.28	2.30	1.88
1997	-	-	-	1.11	1.12	1.12	1.52	3.67	3.62	3.82	2.07	1.48
Average	**1.55**	**1.17**	**1.02**	**1.02**	**1.25**	**1.74**	**2.16**	**3.01**	**3.81**	**4.12**	**2.62**	**1.99**

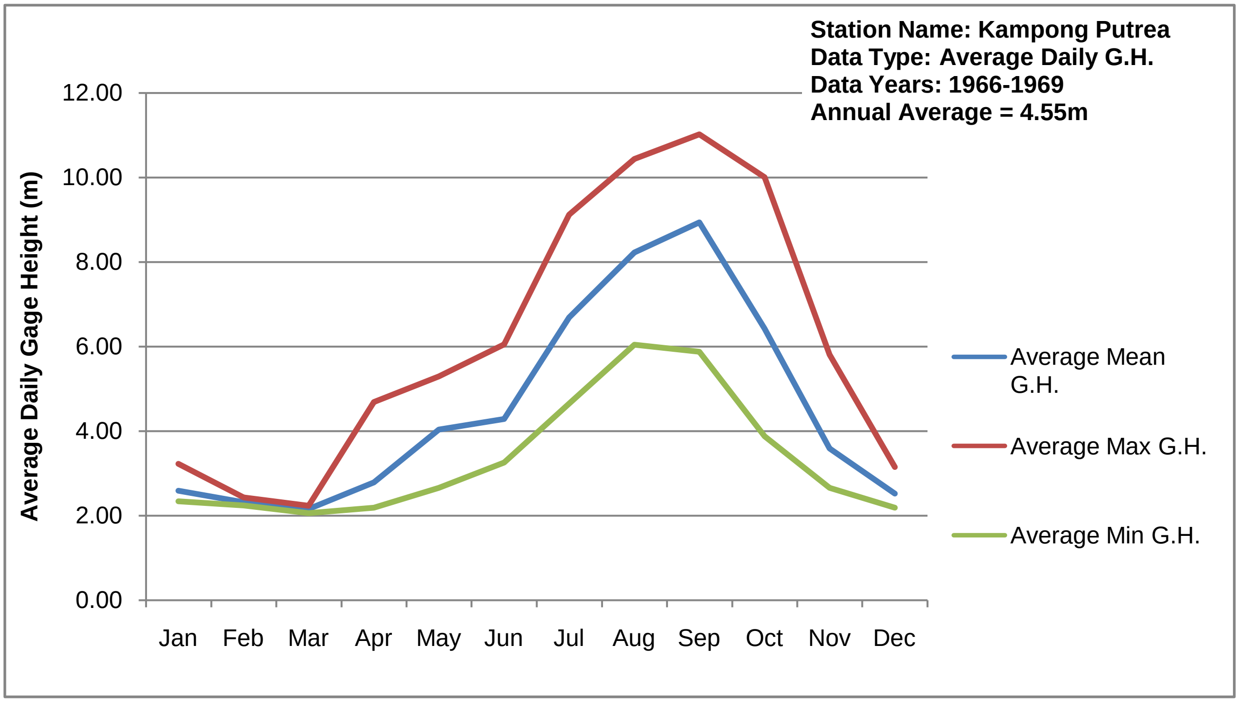


Station: Kampong Putrea

Year	Mean Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1969	2.59	2.32	2.16	2.94	5.04	3.81	6.74	10.73	9.91	5.36	3.28	2.78
1966	-	-	-	2.63	3.03	4.77	6.64	5.72	7.96	7.49	3.90	2.27
Average	**2.59**	**2.32**	**2.16**	**2.79**	**4.04**	**4.29**	**6.69**	**8.23**	**8.94**	**6.43**	**3.59**	**2.53**

Year	Max Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1969	3.22	2.43	2.23	5.07	6.76	5.29	10.55	11.98	11.20	8.95	4.50	3.72
1966	-	-	-	4.30	3.82	6.81	7.69	8.89	10.84	11.06	7.12	2.57
Average	**3.22**	**2.43**	**2.23**	**4.69**	**5.29**	**6.05**	**9.12**	**10.44**	**11.02**	**10.01**	**5.81**	**3.15**

Year	Min Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1969	-	-	-	1.90	2.58	3.54	5.34	3.31	3.15	3.77	2.48	2.06
1966	2.34	2.24	2.06	2.47	2.74	2.97	3.95	8.77	8.59	3.98	2.84	2.32
Average	**2.34**	**2.24**	**2.06**	**2.19**	**2.66**	**3.26**	**4.65**	**6.04**	**5.87**	**3.88**	**2.66**	**2.19**



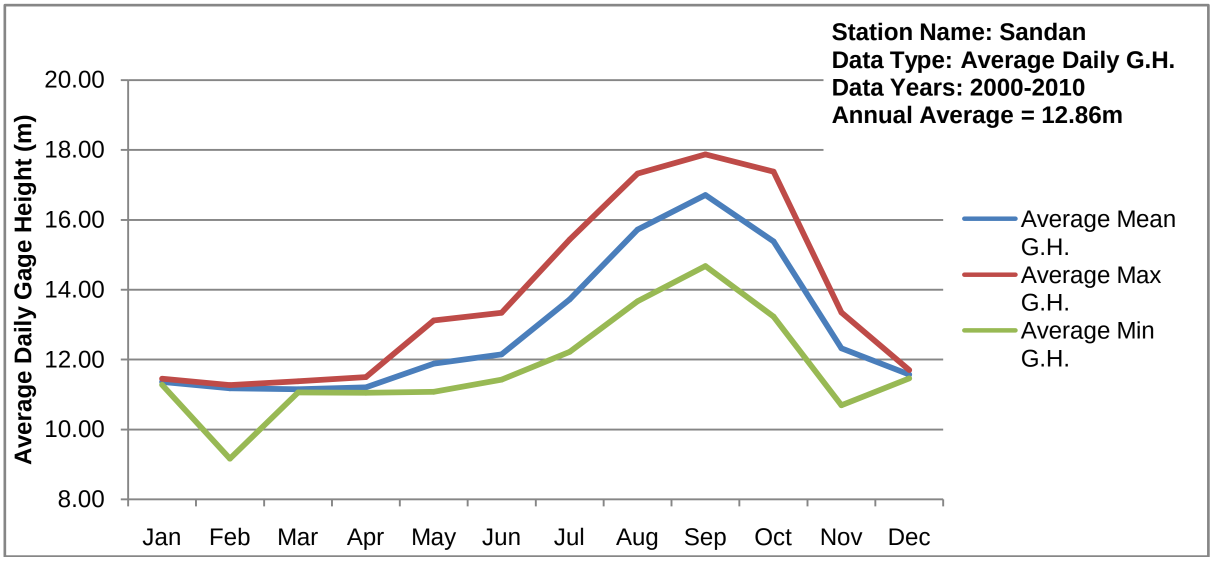
Station: Sandan

Year	Mean Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	12.76	12.63	12.53	12.41	12.36	12.31	12.33	-	-	-	-	-
2009	11.59	11.49	11.73	11.85	11.90	11.81	14.73	15.69	17.75	18.49	14.12	12.92
2008	11.81	11.74	11.70	11.72	13.78	12.83	12.61	16.10	16.69	15.44	12.92	11.74
2007	11.02	10.93	10.86	10.84	12.72	10.71	13.32	17.62	16.91	15.58	12.22	11.90
2006	11.49	11.00	11.26	11.86	12.20	12.03	13.61	15.34	16.73	17.20	11.93	11.13
2005	11.10	11.04	11.00	10.94	11.24	11.06	14.31	13.65	16.34	13.74	12.32	11.72
2004	11.69	11.56	11.47	11.61	11.72	13.30	12.58	16.89	14.81	13.11	11.27	11.17
2003	11.37	11.22	11.27	11.28	11.34	12.06	12.12	12.86	15.95	13.86	11.97	11.82
2002	10.92	10.77	10.60	10.65	11.15	12.60	12.06	15.36	17.79	15.52	11.83	11.55
2001	9.86	9.41	9.09	8.89	10.43	12.71	15.42	17.41	16.98	15.86	13.32	11.24
2000	-	-	-	-	-	-	17.87	16.22	17.12	14.99	11.32	10.48
Average	**11.36**	**11.18**	**11.15**	**11.21**	**11.88**	**12.14**	**13.72**	**15.71**	**16.71**	**15.38**	**12.32**	**11.57**

Year	Max Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	12.84	12.68	12.58	12.48	12.46	12.38	13.00	-	-	-	-	-
2009	11.64	11.54	12.50	11.92	12.42	12.34	17.97	18.03	19.27	19.76	15.72	13.06
2008	11.84	11.78	11.72	11.78	17.00	13.31	13.70	17.21	18.52	18.32	14.00	11.93
2007	11.06	10.96	10.90	10.86	16.28	12.10	14.49	19.12	17.78	17.01	12.92	11.96
2006	11.58	11.40	11.32	12.20	12.50	12.79	15.53	17.44	17.53	18.02	13.39	11.20
2005	11.12	11.06	11.02	10.96	12.00	11.66	16.32	14.96	17.38	16.37	12.58	11.86
2004	11.74	11.62	11.60	11.75	12.12	15.10	15.81	17.88	16.18	15.69	11.34	11.20
2003	11.46	11.26	11.50	11.72	11.84	13.40	13.66	14.69	17.57	16.08	12.23	11.86
2002	11.02	10.82	10.70	12.28	11.97	14.15	14.12	17.61	18.57	19.03	12.39	11.62
2001	10.16	9.55	9.96	9.05	12.60	16.10	16.86	18.10	17.66	17.01	15.77	11.50
2000	-	-	-	-	-	-	18.27	18.14	18.28	16.44	13.16	10.78
Average	**11.45**	**11.27**	**11.38**	**11.50**	**13.12**	**13.33**	**15.43**	**17.32**	**17.87**	**17.37**	**13.35**	**11.70**

Year	Min Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	12.68	12.60	12.48	12.34	12.26	12.26	12.24	-	-	-	-	-
2009	11.54	1.46	11.46	11.80	11.64	11.40	11.30	13.60	14.26	15.88	13.09	12.84
2008	11.79	11.72	11.68	11.66	11.83	12.40	12.05	13.83	14.52	12.81	1.97	11.66
2007	10.98	10.90	10.82	10.82	10.84	10.00	10.54	13.04	15.80	13.12	11.98	11.86
2006	11.42	1.34	11.20	11.23	11.88	11.82	12.58	13.07	15.08	14.01	11.23	11.08
2005	11.08	11.02	10.98	10.92	10.88	10.55	12.16	12.85	13.45	12.22	11.88	11.60
2004	11.64	11.48	11.40	11.40	11.58	11.75	11.41	15.95	12.95	11.35	11.22	11.14
2003	11.26	11.18	11.14	11.16	11.11	11.53	11.41	11.81	13.06	12.29	11.88	11.78
2002	10.84	10.72	10.52	10.50	10.06	11.08	11.07	11.92	16.74	11.99	11.62	11.48
2001	9.56	9.23	8.92	8.66	8.66	11.42	12.33	16.00	16.03	15.04	11.23	11.02
2000	-	-	-	-	-	-	17.33	14.62	14.86	13.56	10.80	10.18
Average	**11.28**	**9.17**	**11.06**	**11.05**	**11.07**	**11.42**	**12.22**	**13.67**	**14.68**	**13.23**	**10.69**	**11.46**

*Highlighted gage heights are inconsistent with typical monthly values, however, a second source could not be found to confirm or deny accuracy of data record from PDOWRAM. Values have been included in the Avg Gage Height calculation.

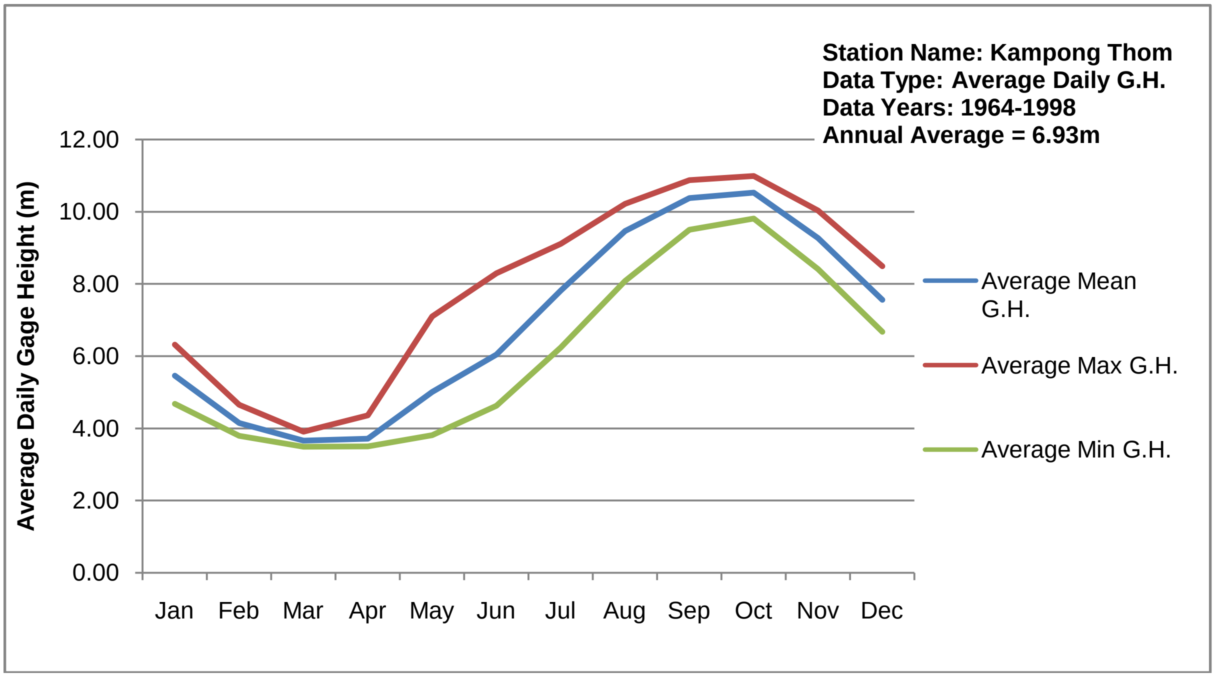


Station: Kampong Thom

Year	Mean Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	3.11	2.36	1.96	1.80	1.86	2.40	4.21	4.95	5.95	5.87	4.88	4.09
1996	7.99	6.30	5.34	5.27	7.30	9.26	8.75	11.27	12.16	13.16	12.82	10.97
1994	6.71	5.71	5.55	5.86	6.03	7.90	10.49	11.38	13.02	12.85	11.03	9.19
1969	4.57	3.32	3.00	2.89	3.82	5.10	9.02	9.50	10.21	10.79	8.85	6.46
1966	5.47	3.76	3.13	3.60	6.11	4.92	7.83	11.05	11.07	10.62	9.08	7.32
1964	4.97	3.5	3.02	2.92	4.94	6.74	6.65	8.66	9.91	9.92	8.99	7.35
Average	**5.47**	**4.16**	**3.67**	**3.72**	**5.01**	**6.05**	**7.83**	**9.47**	**10.39**	**10.54**	**9.28**	**7.56**

Year	Max Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	3.62	2.80	2.31	2.12	2.24	2.63	4.90	5.68	6.44	6.32	5.30	5.24
1996	8.87	7.04	5.67	5.92	9.72	11.99	10.40	11.71	12.86	13.38	13.19	11.80
1994	7.48	6.10	5.92	6.36	7.46	11.21	11.48	12.35	13.26	13.36	11.93	10.04
1969	5.40	3.63	3.14	3.03	5.50	6.90	9.97	10.20	11.15	11.26	10.32	7.44
1966	6.45	4.43	3.28	5.45	8.35	7.41	10.58	11.18	11.27	11.25	9.93	8.20
1964	6.12	3.93	3.15	3.31	9.35	9.68	7.34	10.2	10.3	10.4	9.57	8.26
Average	**6.32**	**4.66**	**3.91**	**4.37**	**7.10**	**8.30**	**9.11**	**10.22**	**10.88**	**11.00**	**10.04**	**8.50**

Year	Min Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	2.78	2.00	1.71	1.66	1.57	2.18	2.43	4.14	5.32	5.16	4.50	3.29
1996	7.11	5.68	5.04	5.02	5.68	6.82	7.25	9.93	11.01	12.90	11.86	10.08
1994	6.04	5.52	5.43	5.66	5.40	6.10	9.67	9.68	12.49	12.00	10.11	8.29
1969	3.69	3.15	2.83	2.81	3.47	3.78	7.45	8.79	8.73	9.98	7.50	5.46
1966	4.47	3.29	3.03	3.04	3.41	3.80	4.84	10.02	10.00	9.99	8.26	6.51
1964	4	3.16	2.94	2.83	3.34	5.12	5.8	5.93	9.46	8.84	8.26	6.43
Average	**4.68**	**3.80**	**3.50**	**3.50**	**3.81**	**4.63**	**6.24**	**8.08**	**9.50**	**9.81**	**8.42**	**6.68**

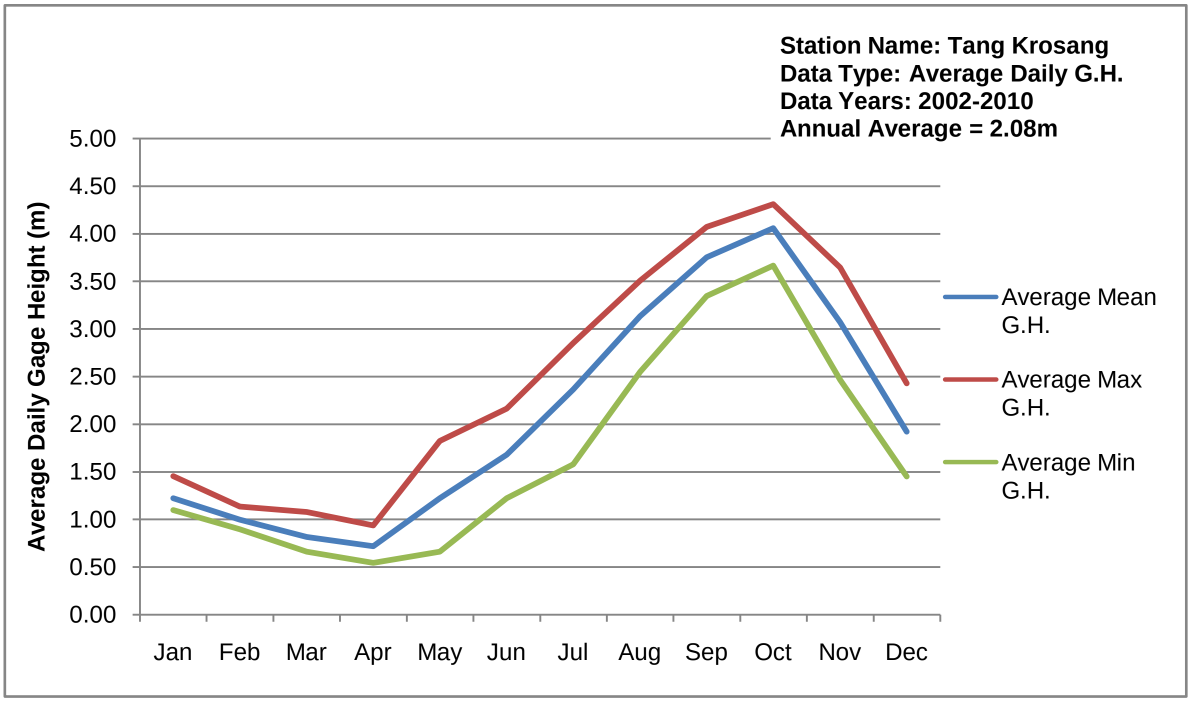

Station Name: Kampong Thom
Data Type: Average Daily G.H.
Data Years: 1964-1998
Annual Average = 6.93m
Average Daily Gage Height (m)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Average Mean G.H.
Average Max G.H.
Average Min G.H.

Station: Tang Krosaing

Year	Mean Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	1.58	1.15	0.79	0.53	0.80	0.96	1.54	2.53	-	-	-	-
2009	1.83	1.76	1.38	0.99	1.85	2.82	3.18	3.09	3.91	4.23	3.34	2.27
2008	1.60	1.39	1.20	1.15	2.00	2.25	1.49	3.07	3.73	3.91	3.70	2.56
2007	1.18	0.90	0.77	0.65	2.08	2.01	3.13	3.60	3.71	4.11	3.46	2.47
2006	0.84	0.63	0.57	0.61	0.83	0.67	2.86	3.62	3.94	4.16	3.17	1.85
2005	0.81	0.67	0.54	0.45	0.61	0.85	2.27	2.61	3.64	4.05	3.17	1.68
2004	0.87	0.69	0.55	0.51	0.63	2.17	1.94	3.42	3.86	3.77	2.14	1.14
2003	1.06	0.80	0.74	0.86	0.99	1.71	2.52	3.13	3.49	3.70	2.37	1.42
2002	-	-	-	-	-	-	-	-	-	4.54	3.23	1.99
Average	**1.22**	**1.00**	**0.82**	**0.72**	**1.22**	**1.68**	**2.37**	**3.13**	**3.75**	**4.06**	**3.07**	**1.92**

Year	Max Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	1.83	1.48	0.96	0.58	1.04	1.20	1.77	2.97	-	-	-	-
2009	1.92	1.88	1.74	1.19	3.01	3.06	3.45	3.42	4.28	4.44	3.86	2.72
2008	1.85	1.68	1.64	1.48	2.76	2.56	1.99	3.70	3.88	3.98	3.98	3.19
2007	1.36	0.98	0.98	1.00	3.14	2.43	3.50	3.88	3.94	4.33	3.90	2.94
2006	1.28	0.65	0.62	0.70	1.14	1.15	3.48	4.07	4.12	4.34	3.92	2.44
2005	0.93	0.72	0.61	0.47	1.08	1.11	3.00	2.86	4.26	4.24	3.59	2.37
2004	1.02	0.76	0.63	0.56	0.84	3.28	2.71	3.78	4.15	4.18	2.98	1.45
2003	1.45	0.92	1.43	1.51	1.58	2.52	2.94	3.40	3.90	3.96	3.06	1.84
2002	-	-	-	-	-	-	-	-	-	5.04	3.89	2.49
Average	**1.46**	**1.13**	**1.08**	**0.94**	**1.82**	**2.16**	**2.86**	**3.51**	**4.08**	**4.31**	**3.65**	**2.43**

Year	Min Daily Gage Height (m)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	1.51	0.97	0.50	0.40	0.64	0.73	1.20	1.31	-	-	-	-
2009	1.77	1.70	1.20	0.67	0.72	2.62	2.85	2.86	3.24	3.89	2.76	1.88
2008	1.51	1.17	0.87	0.86	1.09	1.77	1.30	2.05	3.43	3.81	3.22	1.96
2007	0.98	0.82	0.65	0.47	0.76	1.77	2.20	3.44	3.52	3.94	2.99	1.88
2006	0.66	0.60	0.54	0.53	0.62	0.42	0.68	3.13	3.80	3.97	2.46	1.37
2005	0.73	0.61	0.48	0.42	0.45	0.66	0.99	2.04	2.88	3.64	2.50	1.09
2004	0.76	0.63	0.48	0.44	0.44	0.79	1.38	2.70	3.43	3.04	1.46	0.94
2003	0.88	0.69	0.58	0.57	0.58	1.04	2.04	2.89	3.13	3.12	1.81	1.02
2002	-	-	-	-	-	-	-	-	-	3.93	2.54	1.49
Average	**1.10**	**0.90**	**0.66**	**0.55**	**0.66**	**1.23**	**1.58**	**2.55**	**3.35**	**3.67**	**2.47**	**1.45**



Source for all: MRC Hydrology Yearbooks, www.mrc.org, Kampong Thom PDOWRAM

Appendix A-7: Selected Stations Water Quality Data

Station Name	Station Location	Year	Date of Data Collection	Temp	pH	TSS	Cond	Ca	Mg	Na	K	ALK	Cl	SO$_4$	Fe	NO$_{3-2}$	NH$_4$H	PO$_4$P	Tot.P	SI	O$_2$	CODMn
				°C	-	mg/l	mS/m	meq/l	meq/l	meq/l	mg/l	meq/l	meq/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Kratie	Lat. 12 28.6'N, Long. 106 00.9'E	1998	Jan-98	29.0	8.15	29.0	19.0	1.158	0.641	0.230	0.030	1.519	0.179	0.253	0.12	0.070	0.040	0.009	0.010	6.32	7.51	1.0
			Feb-98	29.0	8.14	7.3	20.0	1.245	0.602	0.350	0.030	1.525	0.202	0.382	0.06	0.020	0.040	0.006	0.010	6.65	7.31	1.7
			Mar-98	30.8	8.24	50.0	20.2	1.184	0.641	0.310	0.040	1.569	0.256	0.228	0.28	0.650	0.090	0.009	0.020	6.00	7.58	1.6
			Apr-98	30.8	8.29	2.0	22.5	1.232	0.500	0.460	0.040	1.602	0.268	0.360	0.13	0.180	0.000	0.010	0.010	5.50	8.62	1.8
			May-98	31.0	7.29	23.0	21.6	1.106	0.539	0.500	0.040	1.472	0.245	0.384	0.60	0.340	0.020	0.005	0.020	5.00	7.49	2.2
			Jun-98	31.0	7.60	64.0	14.5	0.773	0.272	0.340	0.040	0.946	0.186	0.330	1.61	0.330	0.006	0.040	0.040	1.91	6.93	4.9
		1996	Jan-96	27.2	8.40	10.0	17.4	0.993	0.405	0.350	0.030	1.343	0.181	0.175	0.32	0.100	0.010	0.010	0.020	5.62	7.15	0.8
			Feb-96	27.8	7.42	0.0	19.4	1.030	0.287	0.370	0.030	1.447	0.191	0.224	0.95	0.037	0.080	0.001	0.007	5.05	7.90	3.2
			Mar-96	29.8	7.05	9.0	19.7	1.093	0.423	0.390	0.030	1.505	0.216	0.245	1.50	0.274	0.100	0.017	0.020	5.41	6.60	3.2
			Apr-96	30.5	7.27	6.0	20.2	1.036	0.488	0.400	0.040	1.500	0.256	0.255	0.49	0.065	0.010	0.002	0.009	4.38	7.18	3.2
			May-96	30.0	7.13	103.0	16.1	0.862	0.346	0.420	0.040	1.145	0.188	0.222	1.25	0.097	0.040	0.003	0.010	4.40	6.42	2.2
			Jun-96	30.5	6.52	55.0	11.7	0.579	0.256	0.260	0.040	0.786	0.163	0.165	1.88	0.237	0.049	0.020	0.030	3.15	6.88	2.6
			Jul-96	30.0	7.11	150.0	13.6	0.655	0.257	0.370	0.040	0.918	0.243	0.152	2.08	0.141	0.020	0.020	0.020	4.64	7.00	1.6
			Aug-96	31.0	6.97	188.0	8.1	0.505	0.198	0.160	0.010	0.695	0.055	0.080	1.84	0.143	0.040	0.010	0.020	2.43	7.12	1.2
			Sep-96	30.5	6.76	680.0	6.7	0.408	0.150	0.160	0.030	0.570	0.045	0.057	0.25	0.200	0.060	0.030	0.050	2.05	7.07	3.1
			Oct-96	29.5	6.87	6.0	8.6	0.436	0.221	0.200	0.030	0.698	0.089	0.053	2.32	0.016	0.020	0.003	0.006	4.73	6.92	1.8
			Nov-96	28.0	6.87	132.0	10.4	0.469	0.187	0.260	0.030	0.742	0.173	0.054	1.47	0.151	0.130	0.010	0.020	5.33	7.35	4.1
			Dec-96	26.4	6.75	112.0	13.5	0.612	0.290	0.360	0.040	0.921	0.275	0.123	2.05	0.164	0.020	0.020	0.020	5.60	7.72	1.6

Station Name	Station Location	Year	Date of Data Collection	Temp	pH	TSS	Cond	Ca	Mg	Na	K	ALK	Cl	SO_4	Fe	NO_{3-2}	NH_4H	PO_4P	Tot.P	SI	O_2	CODMn
				°C	-	mg/l	mS/m	mg/l	mg/l	meq/l	mg/l	meq/l	meq/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Kampong Cham	Lat. 11 59.7 N, long. 105 27.9'E	1998	Jan-98	29.3	8.20	2.5	18.9	1.166	0.669	0.200	0.030	1.498	0.175	0.245	0.19	0.220	0.020	0.010	0.020	6.00	7.34	2.2
			Feb-98	30.0	8.17	6.7	19.8	1.284	0.571	0.330	0.030	1.540	0.133	0.437	0.10	0.230	0.030	0.009	0.010	6.80	7.26	1.7
			Mar-98	31.0	8.10	5.0	20.2	0.833	0.998	0.420	0.040	1.608	0.219	0.250	0.07	0.180	0.100	0.008	0.010	16.25	7.63	1.6
			Apr-98	31.5	8.35	0.3	22.1	1.234	0.480	0.440	0.040	1.568	0.255	0.300	0.07	0.070	0.005	0.010	0.010	5.25	8.77	1.5
			May-98	32.0	8.29	6.7	21.4	1.067	0.553	0.440	0.050	1.445	0.240	0.329	0.44	0.220	0.010	0.010	0.010	5.25	6.83	1.3
			Jun-98	31.5	7.23	14.0	17.6	1.006	0.357	0.340	0.040	1.189	0.397	0.173	1.56	0.300	0.005	0.020	0.030	3.95	6.75	3.8
		1996	Jan-96	27.3	8.38	1.3	17.2	0.990	0.402	0.330	0.030	1.337	0.170	0.152	0.17	0.105	0.010	0.020	0.020	5.48	6.45	0.9
			Feb-96	27.4	7.23	0.0	19.0	0.984	0.340	0.370	0.030	1.380	0.170	0.220	0.21	0.004	0.080	0.003	0.007	5.05	7.96	2.8
			Mar-96	29.5	7.94	3.0	19.6	1.061	0.496	0.339	0.030	1.471	0.228	0.223	0.24	0.181	0.080	0.003	0.010	4.52	7.28	3.0
			Apr-96	31.0	7.22	6.5	20.2	1.080	0.481	0.400	0.040	1.498	0.260	0.228	0.37	0.072	0.050	0.005	0.010	4.46	6.98	1.9
			May-96	29.6	7.17	15.0	12.1	0.557	0.330	0.440	0.040	0.880	0.141	0.251	1.35	0.102	0.020	0.010	0.030	4.30	6.32	2.8
			Jun-96	30.4	6.62	47.5	13.1	0.646	0.308	0.290	0.040	0.886	0.188	0.156	1.53	0.079	0.030	0.010	0.020	3.90	6.62	2.5
			Jul-96	31.0	7.59	185.0	14.9	0.754	0.302	0.370	0.040	1.020	0.264	0.145	2.12	0.126	0.440	0.020	0.020	2.78	6.76	1.0
			Aug-96	28.5	6.69	504.0	10.8	0.767	0.226	0.220	0.010	1.032	0.080	0.118	3.52	0.317	0.120	0.050	0.050	2.03	7.01	1.7
			Sep-96	28.2	6.48	368.0	8.8	0.554	0.152	0.200	0.060	0.717	0.076	0.090	0.45	0.231	0.030	0.050	0.060	1.95	6.91	3.1
			Oct-96	29.0	6.47	155.0	11.4	0.651	0.244	0.230	0.030	0.869	0.142	0.090	2.33	0.106	0.140	0.006	0.010	4.20	7.42	1.8
			Nov-96	28.2	7.08	87.0	13.9	0.658	0.248	0.340	0.040	0.962	0.254	0.101	1.22	0.198	0.110	0.010	0.020	5.50	7.49	4.0
			Dec-96	25.8	7.10	84.0	15.5	0.744	0.311	0.390	0.040	1.036	0.323	0.120	1.23	0.171	0.020	0.020	0.020	5.47	7.78	1.7

Station Name	Station Location	Year	Date of Data Collection	Temp	pH	TSS	Cond	Ca	Mg	Na	K	ALK	Cl	SO_4	Fe	NO_{3-2}	NH_4H	PO_4P	Tot.P	SI	O_2	CODMn
				°C	-	mg/l	mS/m	mg/l	mg/l	meq/l	mg/l	meq/l	meq/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Phnom Penh - MEKONG	Lat. 11 35' 00" N, Long. 104 56' 33" E	1998	Jan-98	29.4	7.96	4.0	19.1	1.207	0.653	0.020	0.030	1.528	0.182	0.233	0.15	0.030	0.070	0.005	0.010	6.07	7.39	1.6
			Feb-98	29.8	8.04	5.0	19.7	1.286	0.562	0.320	0.030	1.521	0.199	0.341	0.08	0.120	0.050	0.010	0.020	6.80	7.17	1.6
			Mar-98	30.6	8.11	3.3	20.6	1.296	0.578	0.410	0.040	1.612	0.234	0.259	0.22	0.340	0.040	0.005	0.010	6.00	7.33	1.2
			Apr-98	32.0	8.44	9.2	22.4	1.227	0.505	0.450	0.040	1.609	0.250	0.352	0.07	0.050	0.008	0.008	0.020	3.50	8.98	1.4
			May-98	32.0	8.05	7.5	21.6	1.066	0.600	0.470	0.050	1.498	0.240	0.355	0.80	0.008	0.010	0.001	0.007	4.50	7.38	2.5
			Jun-98	32.2	7.68	2.0	18.2	0.956	0.353	0.410	0.050	1.162	0.280	0.406	1.29	0.500	0.006	0.030	0.040	3.95	6.34	2.1
		1996	Jan-96	26.8	8.23	3.0	16.7	0.867	0.508	0.300	0.030	1.319	0.142	0.187	0.12	0.148	0.010	0.020	0.020	5.67	7.63	0.8
			Feb-96	28.0	8.24	0.0	19.2	0.980	0.558	0.370	0.030	1.480	0.181	0.225	0.22	0.015	0.010	0.006	0.010	5.14	7.51	0.9
			Mar-96	28.6	8.14	1.0	19.6	1.097	0.443	0.390	0.030	1.552	0.227	0.206	0.60	0.008	0.020	0.003	0.020	5.02	7.36	0.6
			Apr-96	31.2	7.64	2.0	19.1	0.864	0.619	0.370	0.040	1.448	0.232	0.202	0.54	0.018	0.030	0.003	0.010	4.49	7.05	1.1
			May-96	30.0	7.44	50.0	16.5	0.626	0.252	0.410	0.040	0.983	0.128	0.173	1.12	0.257	0.020	0.030	0.040	4.20	6.18	3.3
			Jun-96	31.0	6.95	35.0	12.9	0.668	0.272	0.290	0.040	0.878	0.183	0.170	1.12	0.255	0.050	0.030	0.040	3.90	6.73	1.8
			Jul-96	31.0	7.16	100.0	12.6	0.612	0.288	0.310	0.040	0.898	0.198	0.124	2.06	0.158	0.160	0.030	0.030	5.07	6.60	1.3
			Aug-96	28.2	6.93	228.0	10.4	0.673	0.200	0.200	0.010	0.892	0.074	0.087	0.55	0.678	0.200	0.030	0.040	2.23	6.66	1.4
			Sep-96	26.9	6.72	488.0	8.1	0.508	0.154	0.180	0.040	0.653	0.070	0.055	0.45	0.129	0.030	0.030	0.050	1.75	6.85	3.3
			Oct-96	28.6	6.96	93.0	12.4	0.696	0.279	0.260	0.030	0.937	0.149	0.096	1.48	0.174	0.010	0.009	0.010	4.63	6.87	1.9
			Nov-96	27.8	7.25	24.0	12.3	0.615	0.198	0.290	0.030	0.846	0.227	0.104	1.16	0.148	0.050	0.020	0.030	4.93	7.30	4.4
			Dec-96	26.0	7.20	28.0	15.7	0.735	0.322	0.390	0.040	1.047	0.332	0.139	0.73	0.174	0.060	0.010	0.010	5.35	7.56	2.5

Station Name	Station Location	Year	Date of Data Collection	Temp	pH	TSS	Cond	Ca	Mg	Na	K	ALK	Cl	SO_4	Fe	NO_{3-2}	NH_4H	PO_4P	Tot.P	SI	O_2	CODMn
Phnom Penh - BASSAC	Lat. 11 33.7' long. 104 55.9' E			°C	-	mg/l	mS/m	mg/l	mg/l	meq/l	mg/l	meq/l	meq/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
		1998	Jan-98	29.8	7.11	8.0	8.7	0.443	0.315	0.210	0.040	0.720	0.089	0.166	0.15	0.210	0.020	0.009	0.020	1.35	4.94	4.6
			Feb-98	29.2	7.04	26.0	9.8	0.431	0.305	0.310	0.050	0.712	0.114	0.232	0.20	0.510	0.030	0.020	0.040	1.75	4.73	5.6
			Mar-98	31.8	7.09	10.0	9.7	0.410	0.286	0.360	0.050	0.737	0.159	0.115	0.14	0.340	0.060	0.010	0.030	0.62	8.46	5.8
			Apr-98	31.6	8.23	6.0	18.8	0.962	0.449	0.510	0.040	1.354	0.239	0.541	0.17	0.140	0.000	0.006	0.030	2.80	9.25	2.7
			May-98	31.8	7.94	1.7	21.4	1.089	0.565	0.350	0.050	1.498	0.207	0.395	0.36	0.080	0.030	0.006	0.010	4.75	7.95	2.8
			Jun-98	31.2	7.76	14.0	17.00	0.872	0.374	0.390	0.040	1.118	0.256	0.368	0.89	0.390	0.010	0.040	0.050	4.10	6.48	1.9
		1996	Jan-96	27.6	7.32	13.3	8.1	0.416	0.181	0.180	0.040	0.638	0.082	0.059	0.34	0.162	0.010	0.010	0.020	9.41	5.15	3.5
			Feb-96	29.0	7.31	11.3	6.5	0.278	0.182	0.180	0.040	0.596	0.083	0.061	0.60	0.198	0.010	0.020	0.030	1.03	4.90	4.1
			Mar-96	29.0	7.27	15.0	7.6	0.330	0.189	0.210	0.040	0.597	0.096	0.054	0.73	0.348	0.030	0.030	0.030	0.98	5.33	4.3
			Apr-96	31.3	7.28	1.6	12.7	0.558	0.295	0.280	0.040	0.898	0.064	0.232	0.51	0.420	0.010	0.010	0.020	3.57	5.55	3.4
			May-96	30.2	7.67	33.0	15.9	0.810	0.320	0.340	0.050	1.092	0.221	0.151	0.00	0.258	0.020	0.020	0.030	4.65	6.35	1.6
			Jun-96	31.0	7.09	50.0	12.5	0.615	0.289	0.280	0.050	0.872	0.174	0.171	0.95	0.260	0.060	0.040	0.050	4.30	60.51	1.8
			Jul-96	31.0	7.42	120.0	14.7	0.764	0.325	0.360	0.040	1.046	0.220	0.162	2.40	0.272	0.170	0.030	0.040	4.44	6.66	1.3
			Aug-96	28.0	7.31	296.0	10.3	0.677	0.150	0.200	0.010	0.868	0.071	0.081	5.60	0.300	0.038	0.040	0.060	2.07	7.49	2.1
			Sep-96	28.2	6.70	636.0	14.1	0.715	0.247	0.210	0.030	0.895	0.070	0.097	0.20	0.213	0.030	0.030	0.040	2.40	6.91	2.5
			Oct-96	30.4	6.64	87.0	8.6	0.501	0.194	0.170	0.030	0.740	0.073	0.060	1.36	0.141	0.010	0.005	0.001	3.50	4.21	3.9
			Nov-96	28.8	7.16	88.0	8.3	0.476	0.184	0.150	0.030	0.711	0.064	0.051	2.48	0.013	0.070	0.020	0.030	2.45	5.24	5.6
			Dec-96	27.4	7.07	44.0	8.8	0.719	0.202	0.160	0.030	0.771	0.061	0.066	0.88	0.057	0.100	0.002	0.006	1.57	5.19	3.1

Station Name	**Station Location**	**Year**	**Date of Data Collection**	**Temp**	**pH**	**TSS**	**Cond**	**Ca**	**Mg**	**Na**	**K**	**ALK**	**Cl**	**SO_4**	**Fe**	**NO_{3-2}**	**NH_4H**	**PO_4P**	**Tot.P**	**SI**	**O_2**	**CODMn**
				°C	-	mg/l	mS/m	mg/l	mg/l	meq/l	mg/l	meq/l	meq/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Tonle Sap @ Phnom Penh Port	Lat. 11 35' 00" N Long. 104 56' 33" E	1998	Jan-98	29.2	6.85	38.0	7.9	0.417	0.290	0.190	0.040	0.701	0.078	0.079	1.31	0.110	0.020	0.010	0.020	1.50	4.99	3.9
			Feb-98	29.4	7.05	8.0	8.0	0.389	0.286	0.200	0.040	0.623	0.067	0.171	0.31	0.380	0.030	0.020	0.030	1.15	4.14	5.0
			Mar-98	30.6	7.35	10.0	11.6	0.602	0.357	0.250	0.050	0.901	0.126	0.161	0.14	0.230	0.010	0.010	0.030	2.75	5.55	5.2
			Apr-98	31.4	6.94	2.3	8.4	0.291	0.229	0.300	0.050	0.579	0.110	0.149	0.11	3.100	0.007	0.010	0.020	2.28	6.47	5.6
			May-98	32.6	7.98	3.7	21.2	1.080	0.530	0.410	0.050	1.462	0.205	0.393	0.53	0.040	0.030	0.007	0.010	4.25	8.80	2.6
			Jun-98	32.0	7.62	42.7	17.6	0.963	0.367	0.360	0.040	1.180	0.200	0.412	1.17	0.590	0.008	0.060	0.060	4.00	5.94	2.3
		1996	Jan-96	27.8	7.19	29.0	7.8	0.403	0.182	0.180	0.040	0.629	0.078	0.061	1.12	0.157	0.010	0.010	0.020	1.41	4.53	3.6
			Feb-96	29.0	7.37	18.0	6.4	0.283	0.159	0.180	0.040	0.506	0.063	0.056	0.67	0.160	0.040	0.020	0.040	1.09	5.07	4.3
			Mar-96	29.4	7.27	15.0	7.3	0.319	0.173	0.200	0.040	0.586	0.134	0.050	0.73	0.355	0.030	0.040	0.040	0.99	50.46	4.3
			Apr-96	31.3	6.91	5.8	6.6	0.226	0.187	0.200	0.040	0.468	0.086	0.082	0.45	0.648	0.030	0.020	0.030	2.68	3.28	5.3
			May-96	30.0	7.63	34.0	12.4	0.654	0.264	0.220	0.040	0.875	0.142	0.175	0.70	0.256	0.010	0.030	0.040	4.35	6.19	1.9
			Jun-96	31.0	7.02	5.0	15.4	0.776	0.335	0.370	0.050	0.989	0.245	0.221	0.92	0.361	0.030	0.030	0.040	4.20	6.08	1.5
			Jul-96	30.6	7.41	77.5	13.3	0.727	0.243	0.330	0.040	0.940	0.195	0.139	1.61	0.298	0.090	0.007	0.040	4.26	6.53	1.3
			Aug-96	28.2	7.15	284.0	10.5	0.685	0.204	0.200	0.010	0.882	0.059	0.104	3.96	0.417	0.140	0.030	0.050	2.20	6.65	2.2
			Sep-96	26.9	6.69	52.0	8.3	0.501	0.171	0.180	0.040	0.663	0.067	0.099	0.40	0.093	0.030	0.030	0.050	1.75	6.82	2.4
			Oct-96	29.2	7.01	98.0	8.7	0.506	0.206	0.680	0.030	0.742	0.078	0.050	1.21	0.210	0.380	0.002	0.010	3.88	4.84	1.9
			Nov-96	28.2	7.18	136.0	8.3	0.466	0.161	0.140	0.040	0.703	0.062	0.056	1.00	0.078	0.110	0.007	0.020	2.80	5.43	4.1
			Dec-96	27.3	7.22	126.0	8.6	0.491	0.198	0.170	0.030	0.751	0.068	0.055	1.04	0.041	0.320	0.003	0.005	1.53	5.04	4.2

Source: MRC Hydrology Yearbooks

APPENDIX B:

Economic Valuation

Baseline (BL)
Maximum logging assumed to be 10% of baseline forests
Discounted Rate (DCF) used 8%

ABC=Assummed best case
AWC= Assummed worst case
PLC=Possible Likely case (average of ABC and AWC NPVs) or based on extrapolation of available information, whichever is considered most representative

Cost is based on the highest PLC NPV of the the different scenarios less BL (i.e. highest opportunity cost). {Note: The production costs, e.g capital expenditures, management, O&M, etc, are assummed to be accounted for it the TEV.}

10 YEAR PROJECTION **DCF=**	**8%**	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Timber		0	1	2	3	4	5	6	7	8	9	10
Timber volume (m^3)	**87,400,000**	87,400,000										
Production rate (1% of available baseline forest per FA) remains constant (assumes no improved harvesting efficiency)	1%	874,000										
Available for market after 40% wastage (assume no improvement)	60%	524,400										
Stumpage Value ($/$m^3$)	$130	$68,172,000	$68,172,000	$68,172,000	$68,172,000	$68,172,000	$68,172,000	$68,172,000	$68,172,000	$68,172,000	$68,172,000	$68,172,000
Baseline TEV (NPV)	**$486,677,471**											
COST	**$4,380,097,243**	=S1-BL										
NTFP												
Forest area (ha)	**760,000**											
Available forest for NTFP based on constant 1% annual loss of forest due of logging production rate	1%	760,000	752,400	744,800	737,200	729,600	722,000	714,400	706,800	699,200	691,600	684,000
FV assumed to be constant over study period.	$22	$16,720,000	$16,552,800	$16,385,600	$16,218,400	$16,051,200	$15,884,000	$15,716,800	$15,549,600	$15,382,400	$15,215,200	$15,048,000
Baseline TEV (NPV)	**$114,303,064**											
COST	**$265,858,031**	=S3-BL										
Fisheries												
Fish catch for study area (tons per year)	21000											
FV of fish catch based on $ per ton assumed to remain constant over study period.	$2,350	$49,350,000	$49,350,000	$49,350,000	$49,350,000	$49,350,000	$49,350,000	$49,350,000	$49,350,000	$49,350,000	$49,350,000	$49,350,000
Baseline TEV (NPV)	**$352,307,886**											
COST	**$769,758,505**	=S2-BL										
Tourism (source MOT)												
International visitors/year (source: MOT)	13,356											
Average expenses per international visitor/year (2 days at $118/day including transportation)	$236											
FV at 5% growth rate	5%	$3,152,016	$3,309,617	$3,475,098	$3,648,853	$3,831,295	$4,022,860	$4,224,003	$4,435,203	$4,656,963	$4,889,811	$5,134,302
National visitors per year	117,187											
Average expenses per national visitor/year (1 days at $22/day including transportation)	$22											
FV at 3% growth rate	3%	$2,578,114	$2,655,457	$2,735,121	$2,817,175	$2,901,690	$2,988,741	$3,078,403	$3,170,755	$3,265,878	$3,363,854	$3,464,770
Total Tourism revenues		$5,730,130	$5,965,074	$6,210,219	$6,466,027	$6,732,985	$7,011,601	$7,302,406	$7,605,958	$7,922,841	$8,253,665	$8,599,072
Baseline TEV (NPV)	**$48,947,793**											
COST	**$81,337,644**	=S2-BL or S3-BL										
Agriculture {Note: Rice is used since Cambodia's most critical crop, accounts for conversion to other landuse e.g. plantations, etc. which would have lower economic and social (health) values.												
Study areas under cultivation (ha) assumed to remain constant over study period	39,000	39,000	39,000	39,000	39,000	39,000	39,000	39,000	39,000	39,000	39,000	39,000
Yield tons based on ton/ha (assumed to be constant).	2	78,000	78,000	78,000	78,000	78,000	78,000	78,000	78,000	78,000	78,000	78,000
FV of crop value based on $/ton)	$625	$48,750,000	$48,750,000	$48,750,000	$48,750,000	$48,750,000	$48,750,000	$48,750,000	$48,750,000	$48,750,000	$48,750,000	$48,750,000
Sliding scale assumed to be constant over study period.	0%											
Baseline TEV (NPV)	**$348,024,508**											
COST	**$1,714,432,173**	=S3-BL										
Carbon Storage (sequestering)												
Forest study area (ha)	760,000											
Density (tree volume in m^3/ha)	115											
Forest study volume(m^3)	87,400,000											
Standing Stem Volume (SV) is the remaining forest volume after assumed baseline production rate of 1%.{Note: volume loss assumed to an annual rate to account for natural decay and forest degradation due to roads, etc.)	-1%	87,400,000	86,526,000	85,660,740	84,804,133	83,956,091	83,116,530	82,285,365	81,462,511	80,647,886	79,841,407	79,042,993
Wood density (WD) is the average wood density for natural forest in SE Asia	0.57											
Biomass expansion factor (BEF) converts SV to AGB .	1.74											
Carbon factor (Cf) is the carbon stored in mt based on 0.5 C ton/SVm^3 (based on dry volume and weight)	0.5											
Above Ground Biomass (AGB= SV*WD*BEF)*Cf in (mt) = .5*SV {Note:1.74*0.57=0.99}	0.5	43,341,660	42,908,243	42,479,161	42,054,369	41,633,826	41,217,487	40,805,313	40,397,259	39,993,287	39,593,354	39,197,420
FV at Carbon value in $/ton	$3.50	Carbon Payment Program not in place until mid-2014				72,859,195	144,261,206	142,818,594	141,390,408	139,976,504	138,576,739	137,190,971
Baseline TEV (NPV)	**$671,085,247**											
COST	**$48,469,734**	=S2-BL										
Biodiversity												
Forest Study Area (ha)	760,000											
Forest loss based on annual production rate	-1%	760,000	752,400	744,876	737,427	730,053	722,752	715,525	708,370	701,286	694,273	687,330
FV biodiversity value based on $/ha.	$30	$22,800,000	$22,572,000	$22,346,280	$22,122,817	$21,901,589	$21,682,573	$21,465,747	$21,251,090	$21,038,579	$20,828,193	$20,619,911
Baseline TEV (NPV)	**$156,054,542**											
COST	**$1,136,277,006**	=S2-BL										
Payment for environmental services (PES)												
Community forests (CF=26) area within study area (ha) (assume remains constant)	100,000											
Rate of change (assume remain constant)	0%	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
FV of CF at ($/ha)	$2.00	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000
Baseline TEV (NPV)	**$1,427,793**											
COST	**$1,331,909**	=S2-BL or S3-BL										
Forest Ecosysterm Service (FES)												
Forest Area (ha)	760,000											
Forest loss based on annual production rate	-1%	760,000	752,400	744,876	737,427	730,053	722,752	715,525	708,370	701,286	694,273	687,330
FV of FES at $/ha (assumed watershed protection-$70; soil erosion $60)	$130	$98,800,000	$97,812,000	$96,833,880	$95,865,541	$94,906,886	$93,957,817	$93,018,239	$92,088,056	$91,167,176	$90,255,504	$89,352,949
Baseline TEV (NPV)	**$676,236,347**											
COST	**$5,123,754,009**	=S2 -BL										

TEV= ∑ Benefits	$2,855,064,650
∑ Costs	$13,521,316,253
NBC	($10,666,251,603)
BCR	0.21
IRR	#DIV/0!

Scenario 1 Conversion
Maximum logging assumed to be 10% of baseline forests
Discounted Rate (DCF) used 8%
Cost is based on the highest PLC NPV of the the different scenarios less the comparison scenario being evaluated (i.e. highest opportunity cost). {Note: The production costs, e.g capital expenditures, management, O&M, etc, are assummed to be accounted for it the TEV.}

ABC=Assummed best case
AWC= Assummed worst case
PLC=Possible Likely case (average of ABC and AWC NPVs) or based on extrapolation of available information, which ever is considered most representative

10 YEAR PROJECTION		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Timber		0	1	2	3	4	5	6	7	8	9	10
Timber volume (m^3)	87,400,000											
Production rate (10% of available baseline forest) remains constant (assumes no improved harvesting efficiency)	8740000											
Available for market after 40% wastage (assume no improvement)	5244000											
Stumpage Value ($/$m^3$)	130	$681,720,000	$681,720,000	$681,720,000	$681,720,000	$681,720,000	$681,720,000	$681,720,000	$681,720,000	$681,720,000	$681,720,000	$681,720,000
PLC NPV	**$4,866,774,714**											
COST	**$0**	=S2-S1 {Note: If cost =$0, then S1 NPV is either equal to or greater than comparison scenario.}										
NTFP												
Forest area (ha)	760,000											
Baseline 2010 Revenues	$16,720,000											
Baseline NPV	$114,439,997											
Available forest for NTFP based on constant 10% annual loss of forest due of logging production rate	10%	760,000	684,000	608,000	532,000	456,000	380,000	304,000	228,000	152,000	76,000	0
NTFP value per ha	$22	$16,720,000	$15,048,000	$13,376,000	$11,704,000	$10,032,000	$8,360,000	$6,688,000	$5,016,000	$3,344,000	$1,672,000	$0
PLC NPV	**$68,759,299**											
COST	**$112,162,755**	=S2-S1 {Note: If cost =$0, then S1 NPV is either equal to or greater than comparison scenario.}										
Fisheries												
Fish catch for study area (tons per year)	21000											
Value per ton	$2,350											
Baseline 2010 revenues	$49,350,000											
Baseline NPV	$352,307,886											
ABC-fish yield decreases by 33% of logging production rates due to affect on watershed discharge and sedimentation (equivalent to 3.3% annually)	-3.3%	21000	20,307	18,989	17,170	15,014	12,695	10,379	8,207	6,274	4,639	3,316
AWC-fish yield decreases by 100% of logging production rates due to affect on watershed discharge	-10%	21000	18,900	15,309	11,160	7,322	4,324	2,298	1,099	473	183	64
FV at 1% loss ABC		$49,350,000	$47,721,450	$44,623,803	$40,350,229	$35,281,895	$29,832,130	$24,391,759	$19,285,390	$14,744,845	$10,901,305	$7,793,692
FV at 10% loss (AWC… would be worse could destroy fishing in less than ten years)		$49,350,000	$44,415,000	$35,976,150	$26,226,613	$17,207,281	$10,160,727	$5,399,827	$2,582,721	$1,111,777	$430,725	$150,185
PLC NPV	**$195,005,662**	Average of ABC & AWC NPVs										
COST	**$927,060,729**	=S2-S1 {Note: If cost =$0, then S1 NPV is either equal to or greater than comparison scenario.}										
Tourism (including national and international)												
Baseline 2010 revenues	$5,730,130											
Baseline NPV	$46,401,771											
ABC- tourism decrease by 33% of annual production rate due affects on aethetics without affecting other attractions	-3%	$5,730,130	$5,541,036	$5,181,362	$4,685,148	$4,096,653	$3,463,870	$2,832,177	$2,239,266	$1,712,054	$1,265,773	$904,942
AWC assumes tourism affected by both loss of forest aesthetics and effects on watershed discharge (fishing and dolphins), equivalent to 100% of production rate	-10%	$5,730,130	$5,157,117	$4,177,265	$3,045,226	$1,997,973	$1,179,783	$626,985	$299,885	$129,091	$50,012	$17,438
ABC NPV	$27,277,235											
AWC NPV	$18,007,782											
PLC NPV	**$22,642,509**	Average of ABC & AWC NPVs										
COST	**$107,642,928**	=S2-S1 {Note: If cost =$0, then S1 NPV is either equal to or greater than comparison scenario.}										
Agriculture (based on rice production within study area) {Note: Rice is used since Cambodia's most critical crop, accounts for conversion to other landuse e.g. plantations, etc. which would have lower economic and social (health) values.												
Baseline 2010 Revenues	$48,750,000											
Baseline NPV	$348,024,508											
ABC-Ag increases by 1% annually as new land availabe, but limited due to poor soil, water management, and farming practices.	1%	$48,750,000	$49,237,500	$50,227,174	$51,749,107	$53,850,329	$56,597,237	$60,079,107	$64,412,935	$69,749,978	$76,284,524	$84,265,573
AWC-Increase affected by losses of forest services including effects on existing farming and assumed to be -1%.	-1%	$48,750,000	$48,262,500	$47,302,076	$45,897,157	$44,088,626	$41,927,845	$39,474,234	$36,792,565	$33,950,144	$31,014,042	$28,048,544
ABC NPV	$413,799,481											
AWC NPV	$300,518,811											
PLC NPV	**$357,159,146**	Average of ABC & AWC NPVs										
COST	**$1,705,297,534**	=S3-S1 {Note: If cost =$0, then S1 NPV is either equal to or greater than comparison scenario.}										
Carbon												
Baseline 2010 Revenues (Note: no revenues until program in place reported to be 6/2014)	$0											
Baseline NPV (from 6/2014-12/2020)	$662,303,084											
Total Forest area (ha)	760,000											
Baseline Forest Standing Volume (SV in m^3 using 115 m^3/ha)	87,400,000											
Yearly logging production at 10% of baseline volume (m^3)	8,740,000											
SV after logging (m^3)		87,400,000	78,660,000	69,920,000	61,180,000	52,440,000	43,700,000	34,960,000	26,220,000	17,480,000	8,740,000	0
Above ground mass (AGB = SV* WD * BEF; WD=1.74, BEF=.57; Therefore: AGB=0.99SV in mt)	0.99	86,683,320	78,014,988	69,346,656	60,678,324	52,009,992	43,341,660	34,673,328	26,004,996	17,336,664	8,668,332	0
Carbon stock (mt) (50% of AGB)	50%	43,341,660	39,007,494	34,673,328	30,339,162	26,004,996	21,670,830	17,336,664	13,002,498	8,668,332	4,334,166	0
Carbon value ($/mt)	$3.50	No Carbon revenues until 6/2014				$45,508,743	$75,847,905	$60,678,324	$45,508,743	$30,339,162	$15,169,581	$0
PLC NPV	**$218,991,506**											
COST	**$500,563,476**	=S2-S1 {Note: If cost =$0, then S1 NPV is either equal to or greater than comparison scenario.}										
Biodiversity												
Baseline 2010 Revenues	$22,800,000											
Baseline NPV	$156,054,542											
ABC-Biodiversity value decreases by 33% of volume of forest depleted	-3.3%	$22,800,000	$22,047,600	$20,616,468	$18,642,051	$16,300,450	$13,782,626	$11,269,141	$8,909,968	$6,812,208	$5,036,469	$3,600,733
AWC-biodiversity value decreases by 100% forest depletion	-10%	$22,800,000	$20,520,000	$16,621,200	$12,116,855	$7,949,868	$4,694,318	$2,494,753	$1,193,233	$513,648	$198,998	$69,386
ABC NPV	$108,535,226											
AWC NPV	$71,652,377											
PLC NPV	**$90,093,801**	Average of ABC & AWC NPVs										
COST	**$1,202,237,746**	=S2-S1 {Note: If cost =$0, then S1 NPV is either equal to or greater than comparison scenario.}										
PES												
Baseline 2010 Revenues	$200,000											
Baseline NPV	$1,427,793											
ABC- Assume protected CF, therefore no affect on CF revenues {Note; alternative BC may be that CF receive full market value from logging companies, but with loss of forest; assumed not likely.}	0%	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000
AWC-Loss CF to logging interest at production rates	-10%	$200,000	$180,000	$145,800	$106,288	$69,736	$41,178	$21,884	$10,467	$4,506	$1,746	$609
ABC NPV	$1,427,793											
AWC NPV	$628,530											
PLC NPV	**$1,028,161**	Average of ABC & AWC NPVs										
COST	**$1,731,540**	=S2-S1 {Note: If cost =$0, then S1 NPV is either equal to or greater than comparison scenario.}										
Forest Ecosysterm Service (FES)												
Baseline 2010 Revenues	$98,800,000											
Baseline NPV	$705,329,669											
ABC-Loss of forest services decreases by 33% of rate forest depleted	-3%	$98,800,000	$95,539,600	$89,338,029	$80,782,221	$70,635,282	$59,724,711	$48,832,943	$38,609,859	$29,519,569	$21,824,700	$15,603,176
AWC-Loss of forest services decreases by 100% of rate forest depleted	-10%	$98,800,000	$88,920,000	$72,025,200	$52,506,371	$34,449,430	$20,342,044	$10,810,596	$5,170,675	$2,225,806	$862,323	$300,673
ABC NPV	$470,319,313											
AWC NPV	$310,493,633											
PLC NPV	**$390,406,473**	Average of ABC & AWC NPVs										
COST	**$5,409,583,883**	=S2-S1 {Note: If cost =$0, then S1 NPV is either equal to or greater than comparison scenario.}										
TEV= ∑ Benefits	$6,210,861,272											
∑ Costs	$9,966,280,589											
NBC	($3,755,419,317)											
BCR	0.62											
IRR	#DIV/0!											

IRR=not calculatable since dcf converges on -1 (i.e. 1+r→0) .

Scenario 2 Preservarion
Allows for no further development of forest, including current logging operations.
It is assumed that NTFP can continue for the indigineous people dependent of the forest and that this accounts for 100%(?) fo the NTFP. This the real production growth versus offsetting decay is not known, but both are believed to occur, the net changes is set at zero. If the real numbers were known they would not change the final decision.

Discounted Rate (DCF) used 8%

ABC=Assummed best case
AWC= Assummed worst case
PLC=Possible Likely case (average of ABC and AWC NPVs) or based on extrapolation of available information, whichever is considered most representative

Cost is based on the highest PLC NPV of the the different scenarios less the comparison scenario being evaluated (i.e. highest opportunity cost). {Note: The production costs, e.g capital expenditures, management, O&M, etc, are assummed to be accounted for it the TEV.}

10 YEAR PROJECTION		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Timber		0	1	2	3	4	5	6	7	8	9	10
Timber volume (m^3)	87,400,000											
Baseline Production rate: NA		0	0	0	0	0	0	0	0	0	0	0
Available for market after 40% wastage: NA		0	0	0	0	0	0	0	0	0	0	0
Stumpage Value ($/$m^3$) : NA	$130	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
PLC NPV	**$0**											
COST	**$4,866,774,714**	SI-S2										
NTFP												
Forest area (ha)	760,000											
Baseline 2010 Revenues	$16,720,000											
Baseline NPV	$114,439,997											
NTFP value per ha	$22											
ABC-Available forest for NTFP increases by 3% due to improved practices(1%); improved ecosystems (1%) and watershed management (1%). {Note: Less than S3 since assume restricted, if not banned.)	3%	760,000	782,800	830,473	907,480	1,021,376	1,184,055	1,413,824	1,738,825	2,202,692	2,874,013	3,862,433
AWC-only slight increase in NTFP	1%	760,000	767,600	783,029	806,755	839,513	882,336	936,618	1,004,181	1,087,384	1,189,256	1,313,679
FV ABC @ $22/ha		$16,720,000	$17,221,600	$18,270,395	$19,964,554	$22,470,282	$26,049,215	$31,104,125	$38,254,151	$48,459,214	$63,228,282	$84,973,524
FV AWC		$16,720,000	$16,887,200	$17,226,633	$17,748,617	$18,469,282	$19,411,401	$20,605,593	$22,091,985	$23,922,454	$26,163,636	$28,900,931
ABC NPV	$219,921,495											
AWC NPV	$141,922,612											
PLC NPV	**$180,922,053**	Average of ABC & AWC NPVs										
COST	**$199,239,042**	=S3-S2 {Note: If cost =$0, then S3 NPV is either equal to or greater than comparison scenario.}										
Fisheries												
Fish catch for study area (tons per year)	21000											
Value per ton	$2,350											
Baseline 2010 revenues	$49,350,000											
Baseline NPV	$352,307,886											
ABC-fish catch increase 7% per year due improved forest services 2.3, 2.3% due to improved fishing practices, and 2.3% due to better water management and quality.	6%	21000	22260	25011	29789	37608	50328	71391	107345	171092	289057	517657
AWC-fish catch improvement 3% overall.	3%	21000	21630	22947	25075	28222	32717	39066	48046	60864	79414	106725
FV ABC		$49,350,000	$52,311,000	$58,776,640	$70,003,918	$88,378,334	$118,270,147	$167,768,464	$252,261,739	$402,066,886	$679,283,544	$1,216,493,371
FV AWC		$49,350,000	$50,830,500	$53,926,077	$58,926,481	$66,322,273	$76,885,692	$91,805,537	$112,909,231	$143,030,035	$186,621,755	$250,804,033
PLC NPV	**$1,122,066,391**	Average of ABC & AWC NPVs										
COST	**$0**	=S3-S2 {Note: If cost =$0, then S2 NPV is either equal to or greater than comparison scenario.}										
Tourism (including national and international)												
Baseline 2010 revenues	$5,730,130											
Baseline NPV	$46,401,771											
ABC- tourism increases by 3% annually due sustained aethetics of forest and 3% due to developed ecotourism market	6%	$5,730,130	$6,073,938	$6,824,677	$8,128,299	$10,261,790	$13,732,590	$19,479,941	$29,290,629	$46,684,813	$78,873,009	$141,249,547
AWC assumes 3% increased due to sustained aethetics without ecotourism development.	3%	$5,730,130	$5,902,034	$6,261,468	$6,842,075	$7,700,816	$8,927,356	$10,659,730	$13,110,123	$16,607,512	$21,669,036	$29,121,372
ABC NPV	$185,201,330											
AWC NPV	$75,369,543											
PLC NPV	**$130,285,436**	Average of ABC & AWC NPVs										
COST	**$0**	=S3-S2 {Note: If cost =$0, then S2 NPV is either equal to or greater than comparison scenario.}										
Agriculture (based on rice production within study area)												
Baseline 2010 Revenues	$48,750,000											
Baseline NPV	$348,024,508											
ABC-no increased land use, but existing farms remain and 6% yield improvement; 2% due to improved farming practices, 2% due to increased forest services, and 2% due to improved water management.	6%	$48,750,000	$51,675,000	$58,062,030	$69,152,807	$87,303,825	$116,832,212	$165,728,726	$249,194,726	$397,178,535	$671,024,778	$1,201,703,178
AWC- Ag remains constant with baseline production since no new land available, with slight improved practices.	3%	$48,750,000	$50,212,500	$53,270,441	$58,210,049	$65,515,923	$75,950,912	$90,689,360	$111,536,474	$141,291,068	$184,352,797	$247,754,744
ABC NPV	$1,575,630,020											
AWC NPV	$641,218,473											
PLC NPV	**$1,108,424,246**	Average of ABC & AWC NPVs										
COST	**$954,032,434**	=S3-S2 {Note: If cost =$0, then S2 NPV is either equal to or greater than comparison scenario.}										
Carbon												
Baseline (2010) Revenues (Note: no revenues until program in place reported to be 6/2014)	$0											
Baseline NPV (from 6/2014-12/2020)	$662,303,084											
Total Forest area (ha)	760,000											
Baseline Forest Standing Volume (SV in m^3 using 115 m^3/ha)	87,400,000											
Yearly logging production rate 0% of baseline volume (m^3)	87,400,000											
SV remains constant, since no logging.		87,400,000	87,400,000	87,400,000	87,400,000	87,400,000	87,400,000	87,400,000	87,400,000	87,400,000	87,400,000	87,400,000
Above ground mass (ABG = SV* WD * BEF; WD=0.57, BEF=1.74) (mt); =.99SV	0.99	86,683,320	86,683,320	86,683,320	86,683,320	86,683,320	86,683,320	86,683,320	86,683,320	86,683,320	86,683,320	86,683,320
Carbon stock (mt) (50% of ABG)	50%	43,341,660	43,341,660	43,341,660	43,341,660	43,341,660	43,341,660	43,341,660	43,341,660	43,341,660	43,341,660	43,341,660
Carbon value ($/$m^3$)	$3.50	No Carbon revenues until 6/2014				$75,847,905	$151,695,810	$151,695,810	$151,695,810	$151,695,810	$151,695,810	$151,695,810
PLC NPV	**$719,554,982**											
COST	**$0**	=S3-S2 {Note: If cost =$0, then S2 NPV is either equal to or greater than comparison scenario.}										
Biodiversity												
Baseline 2010 Revenues	$22,800,000											
Baseline NPV	$156,054,542											
ABC-Biodiversity value increases 3% annually as volume of forest is restored, 4% due to improved ecosystems (2%) and watershed (2%) conditions, and by an additional 2% due improved wildlife management and protection initiatives. {Note: assume habitat impacts significantly reduced due to be improved conditions.}	9%	$22,800,000	$24,852,000	$29,526,661	$38,237,883	$53,975,892	$83,048,600	$139,280,816	$254,610,781	$507,327,931	$1,101,862,123	$2,608,508,365
AWC-biodiversity value only slightly improved as a result of no logging	3%	$22,800,000	$23,484,000	$24,914,176	$27,224,392	$30,641,293	$35,521,657	$42,414,716	$52,164,751	$66,080,746	$86,220,385	$115,872,988
ABC NPV	$2,284,770,148											
AWC NPV	$299,892,947											
PLC NPV	**$1,292,331,547**	Average of ABC & AWC NPVs										
COST	**$0**	=S3-S2 {Note: If cost =$0, then S2 NPV is either equal to or greater than comparison scenario.}										
PES												
Baseline 2010 Revenues	$200,000											
Baseline NPV	$1,427,793											
ABC- Assume CF would increase consistent with improved land management practice by 2%, and less dependency on fire wood, and CF encouraged increasing by 2%.	4%	$200,000	$208,000	$224,973	$253,064	$296,049	$360,189	$455,754	$599,741	$820,787	$1,168,235	$1,729,273
AWC-assumes only sligth improvement over baseline	2%	$200,000	$204,000	$212,242	$225,232	$243,799	$269,174	$303,133	$348,205	$407,977	$487,571	$594,346
ABC NPV	$3,439,899											
AWC NPV	$2,079,504											
PLC NPV	**$2,759,701**	Average of ABC & AWC NPVs										
COST	**$0**	=S3-S2 {Note: If cost =$0, then S2 NPV is either equal to or greater than comparison scenario.}										
Forest Ecosysterm Service (FES)												
Baseline 2010 Revenues	$98,800,000											
Baseline NPV	$705,329,669											
ABC-Forest services increases by 5% annually (slightly higher than S3) as forest restored naturally and by an additional 4% applying best management practices to accelerate restoration (2%) and ensure optimum sustainable ecosystems (2%).	9%	$98,800,000	$107,692,000	$127,948,865	$165,697,491	$233,895,531	$359,877,267	$603,550,204	$1,103,313,385	$2,198,421,033	$4,774,735,867	$11,303,536,248
AWC-gain of forest services slight improvement over baseline	4%	$98,800,000	$102,752,000	$111,136,563	$125,013,519	$146,248,135	$177,933,218	$225,142,285	$296,271,888	$405,468,536	$577,108,157	$854,261,052
ABC NPV	$9,900,670,640											
AWC NPV	$1,699,310,072											
PLC NPV	**$5,799,990,356**	Average of ABC & AWC NPVs										
COST	**$0**	=S3-S2 {Note: If cost =$0, then S2 NPV is either equal to or greater than comparison scenario.}										
TEV=∑ Benefits	**$10,356,334,713**											
∑ Costs	**$6,020,046,190**											
NBC	**$4,336,288,523**											
BCR	**1.72**											
IRR	**4%**											

Scenario 3 Conservation

Allows for a balanced sustainable approach to developing the forests, at an optimum logging production rate, minimizing the negative effects (costs), while maintaining and maximizing the beneficial aspects (benefits). This includes integrating resource management plans including water, and well as assumes increasing production efficiency to reduce waste, thereby increasing yield without significant increases in overall production.

Discounted Rate (DCF) used 8%

ABC=Assummed best case
AWC= Assummed worst case
PLC=Possible Likely case (average of ABC and AWC NPVs) or based on extrapolation of available information, whichever is considered most representative

Cost is based on the highest PLC NPV of the the different scenarios less the comparison scenario being evaluated (i.e. highest opportunity cost). {Note: The production costs, e.g capital expenditures, management, O&M, etc, are assummed to be accounted for it the TEV.}

10 YEAR PROJECTION		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Timber		0	1	2	3	4	5	6	7	8	9	10
Timber volume (m^3)	87,400,000											
Assume Optimum Production rate = 1.2% of available baseline forest to maintain 30% limit in 25 year cycle and attain 60% cover target.	1.2%	1,048,800	1,048,800	1,048,800	1,048,800	1,048,800	1,048,800	1,048,800	1,048,800	1,048,800	1,048,800	1,048,800
Available for market with improved production efficiency overtime starting at baseline (60%) to maximum of 90% (i.e. 3%/year)	3%	629,280	648,158	687,631	751,393	845,700	980,398	1,170,646	1,439,747	1,823,829	2,379,683	3,198,094
Stumpage Value ($/m^3)	$130	$81,806,400	$84,260,592	$89,392,062	$97,681,120	$109,940,961	$127,451,706	$152,184,002	$187,167,127	$237,097,716	$309,358,742	$415,752,281
PLC NPV	**$1,076,015,895**											
COST	**$3,790,758,819**	=S1-S3										
NTFP												
Forest area (ha)	760,000											
Baseline 2010 Revenues	$16,720,000											
Baseline NPV	$114,439,997											
NTFP value per ha	$22											
ABC-Available forest for NTFP increases by 6% due to improved practices (2%, improved ecosystems (2%) and watershed management (2%).	6%	760,000	805,600	905,172	1,078,075	1,361,044	1,821,384	2,583,668	3,884,882	6,191,912	10,461,104	18,734,244
AWC-only slight increase in NTFP	3%	760,000	782,800	830,473	907,480	1,021,376	1,184,055	1,413,824	1,738,825	2,202,692	2,874,013	3,862,433
FV ABC @ $22/ha		$16,720,000	$17,723,200	$19,913,788	$23,717,640	$29,942,973	$40,070,453	$56,840,703	$85,467,402	$136,222,053	$230,144,293	$412,153,377
FV AWC		$16,720,000	$17,221,600	$18,270,395	$19,964,554	$22,470,282	$26,049,215	$31,104,125	$38,254,151	$48,459,214	$63,228,282	$84,973,524
ABC NPV	$540,400,696											
AWC NPV	$219,921,495											
PLC NPV	**$380,161,095**	Average of ABC & AWC NPVs										
COST	**$0**	=S2-S3 {Note: If cost =$0, then S3 NPV is either equal to or greater than comparison scenario.}										
Fisheries												
Fish catch for study area (tons per year)	21000											
Value per ton	$2,350											
Baseline 2010 revenues	$49,350,000											
Baseline NPV	$352,307,886											
ABC-fish catch increase 6% per year due improved forest services (2%), 2% due to improved fishing practices, and 2% due to better water management and quality.	6%	21000	22260	25011	29789	37608	50328	71391	107345	171092	289057	517657
AWC-fish catch improvement 3% overall.	3%	21000	21630	22947	25075	28222	32717	39066	48046	60864	79414	106725
FV ABC		$49,350,000	$52,311,000	$58,776,640	$70,003,918	$88,378,334	$118,270,147	$167,768,464	$252,261,739	$402,066,886	$679,283,544	$1,216,493,371
FV AWC		$49,350,000	$50,830,500	$53,926,077	$58,926,481	$66,322,273	$76,885,692	$91,805,537	$112,909,231	$143,030,035	$186,621,755	$250,804,033
PLC NPV	**$1,122,066,391**	Average of ABC & AWC NPVs										
COST	**$0**	=S2-S3 {Note: If cost =$0, then S3 NPV is either equal to or greater than comparison scenario.}										
Tourism (including national and international)												
Baseline 2010 revenues	$5,730,130											
Baseline NPV	$46,401,771											
ABC- tourism increases by 3% annually due sustained aethetics of forest and 3% due to developed ecotourism market	6%	$5,730,130	$6,073,938	$6,824,677	$8,128,299	$10,261,790	$13,732,590	$19,479,941	$29,290,629	$46,684,813	$78,873,009	$141,249,547
AWC assumes 3% increased due to sustained aethetics without ecotourism development.	3%	$5,730,130	$5,902,034	$6,261,468	$6,842,075	$7,700,816	$8,927,356	$10,659,730	$13,110,123	$16,607,512	$21,669,036	$29,121,372
ABC NPV	$185,201,330											
AWC NPV	$75,369,543											
PLC NPV	**$130,285,436**	Average of ABC & AWC NPVs										
COST	**$0**	=S2-S3 {Note: If cost =$0, then S3 NPV is either equal to or greater than comparison scenario.}										
Agriculture (based on rice production within study area)												
Baseline 2010 Revenues	$48,750,000											
Baseline NPV	$348,024,508											
ABC-Increase by 2% due to increased land use, 2% due to improved farming practices, 2% due to increased forest services, and 2% due to improved water management	8%	$48,750,000	$52,650,000	$61,410,960	$77,360,123	$105,247,594	$154,643,244	$245,399,394	$420,571,436	$778,448,377	$1,556,121,908	$3,359,550,486
AWC-Ag slight improvement 4% overall	4%	$48,750,000	$50,700,000	$54,837,120	$61,684,302	$72,161,909	$87,795,996	$111,089,943	$146,186,787	$200,066,712	$284,757,314	$421,510,387
ABC NPV	$3,286,437,996											
AWC NPV	$838,475,364											
PLC NPV	**$2,062,456,680**	Average of ABC & AWC NPVs										
COST	**$0**	=S2-S3 {Note: If cost =$0, then S3 NPV is either equal to or greater than comparison scenario.}										
Carbon												
Baseline (2010) Revenues (Note: no revenues until program in place reported to be 6/2014)	$0											
Baseline NPV (from 6/2014-12/2020)	$662,303,084											
Total Forest area (ha)	760,000											
Baseline Forest Standing Volume (SV in m^3 using 115 m^3/ha)	87,400,000											
Logging annual production rate 1% of baseline volume (m3), baseline remains constant	1%	874,000	882740	900483.074								
ABC- As efficiencies increase, watershed management and biodiversity improves, and regrowth rates increase, SV increases by 1% of production rate. {Note: this is equivalent to a decrease of 1% of production rate.}	-1%	874,000	865,260	848,041	822,854	790,430	751,691	707,702	659,625	608,665	556,026	502,860
SV		87,400,000	86,534,740	85,686,699	84,863,845	84,073,415	83,321,724	82,614,022	81,954,397	81,345,732	80,789,706	80,286,846
Above ground mass (ABG = SV* WD * BEF; WD=0.57, BEF=1.74) (mt) {Note: ABG=0.99SV}	0.99	86,683,320	85,825,155	84,984,068	84,167,961	83,384,013	82,638,486	81,936,587	81,282,371	80,678,697	80,127,230	79,628,494
Carbon stock (mt) (50% of ABG)	50%	43,341,660	42,912,578	42,492,034	42,083,981	41,692,007	41,319,243	40,968,293	40,641,186	40,339,349	40,063,615	39,814,247
Carbon value ($/mt) {Note: Equivalent to $7.70m^3.}	$3.50	No Carbon revenues until 6/2014				72,961,011	144,617,350	143,389,027	142,244,150	141,187,720	140,222,653	139,349,864
ABC NPV	$675,686,444											
AWC Yearly logging production at 1% of baseline volume (m^3), assume remains constant equivalent to baseline	1%											
SV decreases by constant logging production rate offset by improved regrowth of 0.2%.	874,000	87,400,000	86,526,000	85,652,000	84,778,000	83,904,000	83,030,000	82,156,000	81,282,000	80,408,000	79,534,000	78,660,000
Above ground mass (ABG = SV* WD * BEF; WD=0.57, BEF=1.74) (mt)	0.99	86,683,320	85,816,487	84,949,654	84,082,820	83,215,987	82,349,154	81,482,321	80,615,488	79,748,654	78,881,821	78,014,988
Carbon stock (mt) (50% of ABG)	50%	43,341,660	42,908,243	42,474,827	42,041,410	41,607,994	41,174,577	40,741,160	40,307,744	39,874,327	39,440,911	39,007,494
Carbon value ($/mt) {Note: Equivalent to $7.70m^3.}	$3.50	No Carbon revenues until 6/2014				$72,813,989	$144,111,020	$142,594,061	$141,077,103	$139,560,145	$138,043,187	$136,526,229
AWC NPV	$669,498,634											
PLC NPV	**$672,592,539**	Average of ABC & AWC NPVs										
COST	**$46,962,443**	=S2-S3 {Note: If cost =$0, then S3 NPV is either equal to or greater than comparison scenario.}										
Biodiversity												
Baseline 2010 Revenues	$22,800,000											
Baseline NPV	$156,054,542											
ABC-Biodiversity value increases 2% annually as volume of forest is restored, 3% due to improved ecosystems (1.5%) and watershed (1.5%) conditions, and by an additional 1.5% due improved wildlife management and protection initiatives. {Note: assume habitat impacts significantly reduced due to be improved conditions, but not equal to S2.}	6.5%	$22,800,000	$24,282,000	$27,541,251	$33,268,444	$42,798,734	$58,637,975	$85,561,149	$132,960,875	$220,049,673	$387,853,037	$728,053,467
AWC-biodiversity value slight improvement as a result of controlled logging and improved ecosystems.	3%	$22,800,000	$23,484,000	$24,914,176	$27,224,392	$30,641,293	$35,521,657	$42,414,716	$52,164,751	$66,080,746	$86,220,385	$115,872,988
ABC NPV	$878,064,424											
AWC NPV	$299,892,947											
PLC NPV	**$588,978,686**	Average of ABC & AWC NPVs										
COST	**$703,352,862**	=S2-S3 {Note: If cost =$0, then S3 NPV is either equal to or greater than comparison scenario.}										
PES												
Baseline 2010 Revenues	$200,000											
Baseline NPV	$1,427,793											
ABC- Assume CF would increase consistent with improved land management practice by 2%, and less dependency on fire wood, and CF encouraged increasing by 2%,	4%	$200,000	$208,000	$224,973	$253,064	$296,049	$360,189	$455,754	$599,741	$820,787	$1,168,235	$1,729,273
AWC-assumes only sligth improvement over baseline	2%	$200,000	$204,000	$212,242	$225,232	$243,799	$269,174	$303,133	$348,205	$407,977	$487,571	$594,346
ABC NPV	$3,439,899											
AWC NPV	$2,079,504											
PLC NPV	**$2,759,701**	Average of ABC & AWC NPVs										
COST	**$0**	=S2-S3 {Note: If cost =$0, then S3 NPV is either equal to or greater than comparison scenario.}										
Forest Ecosysterm Service (FES)												
Baseline 2010 Revenues	$98,800,000											
Baseline NPV	$705,329,669											
ABC-Forest services increases by 4% annually as forest restored naturally and by an additional 4% applying best management practices to accelerate restoration (2%) and ensure optimum sustainable ecosystems (2%).	8%	$98,800,000	$106,704,000	$124,459,546	$156,783,183	$213,301,790	$313,410,308	$497,342,771	$852,358,111	$1,577,655,378	$3,153,740,400	$6,808,688,984
AWC-gain of forest services slight improvement over baseline	4%	$98,800,000	$102,752,000	$111,136,563	$125,013,519	$146,248,135	$177,933,218	$225,142,285	$296,271,888	$405,468,536	$577,108,157	$854,261,052
ABC NPV	$6,660,514,339											
AWC NPV	$1,699,310,072											
PLC NPV	**$4,179,912,205**	Average of ABC & AWC NPVs										
COST	**$1,620,078,150**	=S2-S3 {Note: If cost =$0, then S3 NPV is either equal to or greater than comparison scenario.}										
TEV= ∑ Benefits	**$10,215,228,630**											
∑ Costs	**$6,161,152,274**											
NBC	**$4,054,076,356**											
BCR	**1.66**											
IRR	**5%**											

Economics	Social	Environmental
Population	**Access to basic needs**	**Land**
Population growth rate	% Living above national poverty line	Total area (000 ha)
Urban (% of total, 2008)	Income distribution (Ratio: top 20%:Low 20%	Land area (000 ha)
Urbanization annual growth rate (%)	Population with sufficient food (%)	Land use (%)
GDP (billion ppp, 2009)	population with adequate shelter (%)	Arable crops
annual growth (%) (	Household size	permanent crop
GDP per capita	Access to electricity (% of households)	Other (woodlands, built-on, undeveloped, roads etc)
GDP Sectors (%)	% with good sanitation facility	Irritated (000 km^2 2003)
Private	% pop with safe drinking water source	land use change
Service	Source of lighting (rural) (%)	Land degradation
Industrial	Grid electricity	Coveted land as % of total land
Phnom Penh	Generator	Natural land (000 ha)
Timber	Kerosene	Natural land as % of total land
Agriculture	Candles	Modified
Tourism	Battery	% Modified
Fisheries	Fuel wood use (rural and urban)	Cultivated
Water management	Households using wood (%)	% Cultivated
Inflation	Households using charcoal (%)	Built
Net aid as % GNI	Fuel used for cooking (approx %)	%Built
Workforce (million)	Firewood (Phnom Penh 26%)	Land Protection
Agriculture	Charcoal (PNH-30%, only Province > wood.)	Totally protected areas (000 Ha)
Industries	Kerosene	Totally protected as % of total area
Services	LPG	Partially protected areas (000 Ha)
Employment ratio	Source of water (% of households)	Partially protected as % of total area
Unemployed (%)	Surface water	Land Quality
Transportation Modal	Ground water	Total cultivated land (000 Ha)
Passenger	Distribution System	Total modified land (000 Ha)
Freight	Purchased water	Total cultivated and modified land (000 Ha)
Roadways (000, km, 2007)	Water source at household	Fertilizer use
Paved	Water source greater than 150 m and other sources(?)	Pesticide use
Unpaved	Water use per household	Soil degradation (000 Ha)
Resource use	Waste Generation	% of total
Energy	Produces kg/ capita	**Forest**
Primary energy consumption (%)	Reuse Kg/kg produced	% land covered by forest
Fuel wood	**Health**	Protected forest
rural household access to grid	<5 mortality rate	%/ year change in native forest 1980-95
Electric power stations (all diesel) number	Infant mortality rate (deaths / 1000 live births)	**Water**
Electricity annual production (billion kWh)	Maternal mortality rate (deaths/100,000)	River Conversion
Electricity annual consumption (billion kWh)	Life expectancy at birth	Gross capacity GWh/y
Electricity consumptions (kWh/yr per capita)	Total Fertility Rate (TFR)	Used cap
Electricity Consumption by sector (%)	% pop access to health care	Used % Gross capacity
Private	% children suffering from malnutrition	Inland water quality
Service	Stunting in children under 5 (%)	% of waste water treated
Industrial	Low weight for age (under 5) (%)	Heavy Metals
Phnom Penh	Low weight at birth (%)	As
Total consumption (terrajoules, 000)	Morbidity	pH
Consumption/person (population)	Population access to health care (nationally %)	Fecal coli
Timber	**Access to Information and Education**	NH3/NOx
Volume (m^3, 000)	Literacy	DO
Net annual increments (NAI) (m^3, 000)	Primary completion rate	BOD
Felling(m^3, 000)	Net enrollment rate in primary edu	TSS
Production (m^3, 000)	Net enrollment rate in secondary edu	**Air**
Imported (m^3, 000)	Net enrollment in Tertiary edu	CO2
Timber fellings + imports as % of NAI	Number of Internet users	CO2 (000 mt of C)
Timber production + imports as % of volume	Fixed phone lines	CO2/ha KgC
Agriculture	Mobile phone users	CO2/person
Harvested area (food crops) (ha, 000)	**Governance, Culture &Security**	energy
Food crop production (mt, 000)	Political Rights rating (pts)	agri
Fertilizer use (mt, 000)	Civil Liberties rating (pts)	industrial
Production mt/ harvested ha	Indigenous participation	Transportation
Fertilizer mt/harvested ha (000)	Gender equity	Suspended Particulate Material (SPM)
Pesticide Use	Press freedom rating (pts)	PM10 mean
Food production as % of supply	Corruption perception (pts)	**Biodiversity**
Fisheries	Deaths from armed conflicts per year	% of protected terrestrial area
marine catch (mt)	Military expenditure as % of GDP	Protected area management
inland water catch (mt)	Violent Crimes and Robbery per 100,000 population	area of selected key ecosystems
Total catch (mt)		Abundance of key species (flora and fauna)
fish production as % of supply		Number of threatened species
Mining		Number for fish species subject to fisheries
Ore		Number of fish species subject to overexploited
Production		**Ecological Footprint (EF)**
Water		Ecological Footprint in ha/person
Water withdrawal (WW) Km^3/y		Ecological balance in ha/Person
Total internal water resource		
Domestic WW (%)		
Agricultural (%)		
Industrial (%)		
per capita (m^3/y)		

Potential Forest Impacts	**Scenario 1 Conversion**													**Scenario 2 Preservation**													**Scenario 3 Conservation**												
	Economics				Social				Environmental					Economics				Social				Environmental					Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**
Economics																																							
Econ Indicators																																							
GDP annual growth (%)	3	5	0.7	10.5	3	5	0.7	10.5	3	1	0.8	2.4	**23.4**	3	2	0.7	4.2	3	4	0.7	8.4	3	5	0.7	10.5	**23.1**	3	4	0.6	7.2	3	4	0.7	8.4	3	5	0.7	10.5	**26.1**
GDP per capita	3	5	0.7	10.5	3	5	0.7	10.5	3	1	0.8	2.4	**23.4**	3	2	0.7	4.2	3	4	0.7	8.4	3	5	0.7	10.5	**23.1**	3	4	0.6	7.2	3	4	0.7	8.4	3	5	0.7	10.5	**26.1**
BCA a/o NPV	3	5	0.7	10.5	3	5	0.7	10.5	3	1	0.8	2.4	**23.4**	3	2	0.7	4.2	3	4	0.7	8.4	3	5	0.7	10.5	**23.1**	3	4	0.6	7.2	3	4	0.7	8.4	3	5	0.7	10.5	**26.1**
Carbon credit (NA)	3	1	0.5	1.5	3	1	0.5	1.5	3	1	0.8	2.4	**5.4**	3	5	0.5	7.5	3	5	0.5	7.5	3	5	0.8	12	**27**	3	5	0.5	7.5	3	5	0.5	7.5	3	5	0.8	12	**27**
GDP Sectors (%)																																							
Timber	3	5	0.8	12	3	4	0.8	9.6	3	1	0.8	2.4	24	3	3	0.8	7.2	3	4	0.8	9.6	3	5	0.8	12	28.8	3	4	0.8	9.6	3	4	0.8	9.6	3	4	0.8	9.6	28.8
Agriculture	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	4	0.7	8.4	**22.8**
Tourism	3	2	0.6	3.6	2	2	0.6	2.4	3	4	0.6	7.2	**13.2**	3	3	0.6	5.4	3	4	0.6	7.2	3	3	0.6	5.4	**18**	3	5	0.7	10.5	3	4	0.6	7.2	3	3	0.7	6.3	**24**
Fisheries	3	2	0.7	4.2	3	4	0.6	7.2	3	3	0.6	5.4	**16.8**	3	3	0.6	5.4	3	3	0.6	5.4	3	4	0.6	7.2	**18**	3	4	0.6	7.2	3	4	0.6	7.2	3	4	0.7	8.4	**22.8**
Employment																																							
Timber	3	5	0.8	12	3	4	0.7	8.4	3	1	0.8	2.4	**22.8**	3	1	0.8	2.4	3	2	0.7	4.2	3	5	0.7	10.5	**17.1**	3	4	0.7	8.4	3	5	0.7	10.5	3	5	0.7	10.5	**29.4**
Agriculture	3	5	0.8	12	3	4	0.7	8.4	3	3	0.7	6.3	**26.7**	3	3	0.6	5.4	3	3	0.7	6.3	3	3	0.6	5.4	**17.1**	3	4	0.7	8.4	3	5	0.7	10.5	3	4	0.6	7.2	**26.1**
Tourism	3	2	0.7	4.2	3	2	0.7	4.2	3	3	0.7	6.3	**14.7**	3	4	0.6	7.2	3	4	0.6	7.2	3	2	0.6	3.6	**18**	3	5	0.6	9	3	5	0.7	10.5	3	4	0.7	8.4	**27.9**
Fisheries	3	2	0.7	4.2	3	2	0.7	4.2	3	2	0.7	4.2	**12.6**	3	3	0.7	6.3	3	3	0.7	6.3	3	4	0.7	8.4	**21**	3	4	0.6	7.2	3	4	0.6	7.2	3	4	0.6	7.2	**21.6**
Services	2	2	0.5	2	2	3	0.5	3	2	3	0.5	3	**8**	2	3	0.5	3	2	3	0.5	3	1	3	0.5	1.5	**7.5**	3	4	0.6	7.2	3	4	0.6	7.2	2	3	0.7	4.2	**18.6**
Support Service	2	3	0.5	3	2	3	0.5	3	2	3	0.5	3	**9**	2	3	0.5	3	2	3	0.5	3	1	3	0.5	1.5	**7.5**	3	4	0.6	7.2	3	4	0.6	7.2	2	3	0.7	4.2	**18.6**
Institutional	2	4	0.5	4	2	3	0.5	3	2	3	0.5	3	**10**	3	4	0.6	7.2	2	4	0.5	4	2	4	0.5	4	**15.2**	3	4	0.7	8.4	3	4	0.6	7.2	2	3	0.7	4.2	**19.8**
Unemployed (%)	3	4	0.7	8.4	3	4	0.6	7.2	2	2	0.8	3.2	**18.8**	3	3	0.7	6.3	3	3	0.5	4.5	3	4	0.7	8.4	**19.2**	3	4	0.7	8.4	3	5	0.6	9	3	4	0.7	8.4	**25.8**
Roadways																																							
Paved	3	5	0.7	10.5	3	5	0.7	10.5	3	2	0.8	4.8	**25.8**	3	3	0.7	6.3	3	3	0.6	5.4	3	3	0.7	6.3	**18**	3	4	0.7	8.4	3	4	0.7	8.4	3	2	0.6	3.6	**20.4**
Unpaved	3	5	0.7	10.5	3	5	0.7	10.5	3	3	0.6	5.4	**26.4**	3	3	0.7	6.3	3	3	0.6	5.4	3	3	0.7	6.3	**18**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Resource use																																							
Energy consumption																																							
Timber	3	1	0.6	1.8	3	2	0.5	3	3	1	0.5	1.5	**6.3**	3	4	0.5	6	3	3	0.5	4.5	3	3	0.5	4.5	**15**	3	2	0.6	3.6	3	3	0.5	4.5	3	3	0.5	4.5	**12.6**
Agriculture	3	2	0.6	3.6	3	2	0.5	3	3	3	0.5	4.5	**11.1**	3	3	0.5	4.5	3	3	0.5	4.5	3	3	0.5	4.5	**13.5**	3	3	0.6	5.4	3	3	0.5	4.5	3	3	0.5	4.5	**14.4**
Tourism	3	3	0.5	4.5	3	2	0.5	3	3	4	0.5	6	**13.5**	3	3	0.5	4.5	3	3	0.5	4.5	3	3	0.5	4.5	**13.5**	3	2	0.6	3.6	3	3	0.5	4.5	3	3	0.5	4.5	**12.6**
Fisheries	3	2	0.6	3.6	3	2	0.5	3	3	3	0.5	4.5	**11.1**	3	4	0.5	6	3	3	0.5	4.5	3	3	0.5	4.5	**15**	3	3	0.6	5.4	3	3	0.5	4.5	3	3	0.5	4.5	**14.4**
Total consumption	3	2	0.6	3.6	3	2	0.5	3	3	2	0.5	3	**9.6**	3	3	0.5	4.5	3	3	0.5	4.5	3	3	0.5	4.5	**13.5**	3	3	0.6	5.4	3	3	0.5	4.5	3	3	0.5	4.5	**14.4**
Water withdrawal																																							
Timber	3	2	0.6	3.6	3	2	0.5	3	3	2	0.7	4.2	**10.8**	3	3	0.6	5.4	3	3	0.6	5.4	3	5	0.6	9	**19.8**	3	4	0.6	7.2	4	3	0.6	7.2	3	4	0.6	7.2	**21.6**
Agriculture	3	1	0.6	1.8	3	2	0.5	3	3	1	0.6	1.8	**6.6**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.7	6.3	**17.1**	3	4	0.6	7.2	3	3	0.6	5.4	3	3	0.6	5.4	**18**
Tourism	3	3	0.6	5.4	3	3	0.5	4.5	3	3	0.8	7.2	**17.1**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	3	0.6	5.4	3	2	0.6	3.6	**16.2**
Fisheries	3	3	0.5	4.5	3	2	0.5	3	3	1	0.6	1.8	**9.3**	3	3	0.6	5.4	3	3	0.6	5.4	3	4	0.6	7.2	**18**	3	4	0.6	7.2	3	3	0.6	5.4	3	4	0.6	7.2	**19.8**
per capita (m^3/y)	3	2	0.5	3	3	2	0.6	3.6	3	3	0.6	5.4	**12**	3	3	0.6	5.4	3	3	0.6	5.4	3	4	0.6	7.2	**18**	3	2	0.6	3.6	3	3	0.6	5.4	3	2	0.6	3.6	**12.6**
Timber																																							
Production	3	5	0.8	12	3	4	0.7	8.4	3	1	0.7	2.1	**22.5**	3	1	0.7	2.1	3	3	0.7	6.3	3	5	0.7	10.5	**18.9**	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	**25.2**
Loss of cover area	3	2	0.8	4.8	3	3	0.7	6.3	3	1	0.7	2.1	**13.2**	3	1	0.7	2.1	3	3	0.7	6.3	3	5	0.7	10.5	**18.9**	3	2	0.7	4.2	3	2	0.7	4.2	3	2	0.7	4.2	**12.6**
Food production	3	5	0.6	9	3	4	0.7	8.4	3	2	0.7	4.2	**21.6**	3	3	0.7	6.3	3	4	0.7	8.4	3	3	0.7	6.3	**21**	3	4	0.7	8.4	3	4	0.7	8.4	3	3	0.7	6.3	**23.1**
Harvested crops	3	5	0.6	9	3	4	0.7	8.4	3	2	0.7	4.2	**21.6**	3	3	0.7	6.3	3	4	0.7	8.4	3	3	0.7	6.3	**21**	3	4	0.7	8.4	3	4	0.7	8.4	3	3	0.7	6.3	**23.1**
Fertilizer use	3	2	0.7	4.2	3	2	0.7	4.2	3	1	0.7	2.1	**10.5**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	2	0.7	4.2	3	2	0.7	4.2	3	1	0.7	2.1	**10.5**
Pesticide Use	3	2	0.7	4.2	3	2	0.7	4.2	3	1	0.7	2.1	**10.5**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	2	0.7	4.2	3	2	0.7	4.2	3	1	0.7	2.1	**10.5**
Fisheries																																							
inland water catch	3	1	0.5	1.5	3	1	0.5	1.5	3	1	0.5	1.5	**4.5**	3	5	0.6	9	3	5	0.6	9	3	4	0.5	6	**24**	3	4	0.6	7.2	3	4	0.6	7.2	3	4	0.6	7.2	**21.6**
Fish production	3	1	0.5	1.5	3	1	0.5	1.5	3	1	0.5	1.5	**4.5**	3	5	0.6	9	3	5	0.6	9	3	4	0.5	6	**24**	3	4	0.6	7.2	3	4	0.6	7.2	3	5	0.6	9	**23.4**
Econ-Sustainability	3	1	0.8	2.4	3	1	0.8	2.4	3	1	0.8	2.4	**7.2**	3	2	0.7	4.2	3	3	0.7	6.3	3	5	0.8	12	**22.5**	3	4	0.8	9.6	3	5	0.8	12	3	5	0.8	12	**33.6**
Economics	3	3	0.6	215	3	3	0.6	199	3	2	0.7	134	**547.7**	3	3	0.6	201	3	3	0.6	225	3	4	0.6	257	**683.6**	3	4	0.6	261	3	4	0.6	264	3	3	0.7	247	**771.9**

Economic confidence level= 0.6 CI Range 0.5-.8

I=importance	V= assigned value for relative potential impact	CL- Confidence Level
3=Very important	5= significant positive impact (e.g. increase in GDP, decrease in pollution)	0.8 = High
2=Important	4= moderate positive impact	0.5 = Medium
1= less important	3= no significant change	0.2 = Low
	2=Moderate negative impact	
	1= significant negative impact (e.g. loss of habitat; increase in endangered species	

Potential Forest Impacts	Scenario 1 Conversion													Scenario 2 Preservation													Scenario 3 Conservation												
	Economics				Social				Environmental					Economics				Social				Environmental					Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**
Environmental																																							
Land use (%)																																							
Arable crops	3	5	0.6	9	3	5	0.7	10.5	3	2	0.8	4.8	**24.3**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	**25.2**
permanent crop	3	5	0.6	9	3	4	0.7	8.4	3	2	0.8	4.8	**22.2**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	**25.2**
Infrastructure, roads, etc.	3	5	0.6	9	3	4	0.7	8.4	3	2	0.8	4.8	**22.2**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	**25.2**
Irritated land	2	4	0.6	4.8	3	4	0.7	8.4	3	3	0.8	7.2	**20.4**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	**25.2**
Land degradation	3	1	0.8	2.4	3	1	0.7	2.1	3	1	0.8	2.4	**6.9**	3	5	0.7	10.5	3	5	0.7	10.5	3	4	0.7	8.4	**29.4**	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	**25.2**
Cultivated	3	4	0.6	7.2	3	4	0.7	8.4	3	2	0.8	4.8	**20.4**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	**25.2**
Built-on	2	4	0.6	4.8	3	4	0.7	8.4	3	2	0.8	4.8	**18**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	**25.2**
Residence	2	4	0.6	4.8	3	4	0.7	8.4	3	2	0.8	4.8	**18**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	**25.2**
Land Protection																																							
Totally protected	3	1	0.8	2.4	3	2	0.6	3.6	3	1	0.6	1.8	**7.8**	3	2	0.8	4.8	3	5	0.8	12	3	5	0.8	12	**28.8**	3	3	0.7	6.3	3	4	0.7	8.4	3	5	0.8	12	**26.7**
Partially protected	2	1	0.6	1.2	3	2	0.6	3.6	3	1	0.6	1.8	**6.6**	2	2	0.8	3.2	3	5	0.8	12	3	5	0.8	12	**27.2**	3	3	0.7	6.3	3	4	0.7	8.4	3	4	0.8	9.6	**24.3**
Land Quality																																							
Soil degradation	3	1	0.8	2.4	3	1	0.7	2.1	3	1	0.8	2.4	**6.9**	3	5	0.8	12	3	5	0.8	12	3	5	0.8	12	**36**	3	5	0.8	12	3	5	0.7	10.5	3	5	0.8	12	**34.5**
Erosion	3	1	0.8	2.4	3	1	0.6	1.8	3	1	0.8	2.4	**6.6**	3	5	0.8	12	3	5	0.8	12	3	5	0.8	12	**36**	3	5	0.8	12	3	5	0.7	10.5	3	5	0.8	12	**34.5**
Forest																																							
Forest Cover	3	2	0.6	3.6	3	1	0.8	2.4	3	1	0.8	2.4	**8.4**	3	5	0.8	12	3	4	0.7	8.4	3	5	0.8	12	**32.4**	3	5	0.8	12	3	4	0.6	7.2	3	5	0.8	12	**31.2**
Protected forest	3	2	0.6	3.6	3	1	0.8	2.4	3	1	0.8	2.4	**8.4**	3	5	0.8	12	3	4	0.7	8.4	3	5	0.8	12	**32.4**	3	5	0.8	12	3	4	0.6	7.2	3	5	0.8	12	**31.2**
Native forest depletion	3	1	0.6	1.8	3	1	0.8	2.4	3	1	0.8	2.4	**6.6**	3	5	0.8	12	3	5	0.8	12	3	5	0.8	12	**36**	3	4	0.7	8.4	3	5	0.7	10.5	3	5	0.8	12	**30.9**
Water																																							
Surface water	3	2	0.7	4.2	3	2	0.6	3.6	3	2	0.6	3.6	**11.4**	3	3	0.7	6.3	3	3	0.7	6.3	3	4	0.7	8.4	**21**	3	5	0.7	10.5	3	4	0.6	7.2	3	5	0.7	10.5	**28.2**
Groundwater	3	2	0.7	4.2	3	3	0.6	5.4	3	3	0.7	6.3	**15.9**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	4	0.7	8.4	3	4	0.6	7.2	3	3	0.7	6.3	**21.9**
Arsenic	3	2	0.6	3.6	3	2	0.6	3.6	3	2	0.6	3.6	**10.8**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	4	0.7	8.4	3	4	0.6	7.2	3	4	0.7	8.4	**24**
pH	3	3	0.6	5.4	3	3	0.7	6.3	3	3	0.7	6.3	**18**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	3	0.7	6.3	3	3	0.6	5.4	3	3	0.7	6.3	**18**
Fecal coli	3	2	0.6	3.6	3	2	0.7	4.2	3	2	0.7	4.2	**12**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	4	0.7	8.4	3	4	0.6	7.2	3	4	0.7	8.4	**24**
NH3/NOx	3	2	0.6	3.6	3	2	0.6	3.6	3	2	0.6	3.6	**10.8**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	5	0.7	10.5	3	4	0.6	7.2	3	4	0.7	8.4	**26.1**
DO	3	2	0.6	3.6	3	2	0.6	3.6	3	2	0.6	3.6	**10.8**	3	3	0.7	6.3	3	3	0.7	6.3	3	4	0.7	8.4	**21**	3	4	0.7	8.4	3	4	0.6	7.2	3	4	0.7	8.4	**24**
BOD	3	2	0.6	3.6	3	2	0.6	3.6	3	2	0.6	3.6	**10.8**	3	3	0.7	6.3	3	3	0.7	6.3	3	4	0.7	8.4	**21**	3	4	0.7	8.4	3	4	0.6	7.2	3	4	0.7	8.4	**24**
TSS	3	1	0.8	2.4	3	1	0.7	2.1	3	1	0.7	2.1	**6.6**	3	3	0.7	6.3	3	3	0.7	6.3	3	4	0.7	8.4	**21**	3	5	0.7	10.5	3	4	0.6	7.2	3	4	0.7	8.4	**26.1**
Water treatment	2	3	0.5	3	3	3	0.6	5.4	3	3	0.6	5.4	**13.8**	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	**18.9**	3	3	0.7	6.3	3	3	0.6	5.4	3	5	0.7	10.5	**22.2**
River siltation	3	1	0.7	2.1	3	1	0.7	2.1	3	1	0.7	2.1	**6.3**	3	3	0.7	6.3	3	3	0.7	6.3	3	4	0.7	8.4	**21**	3	5	0.7	10.5	3	4	0.6	7.2	3	3	0.7	6.3	**24**
Flooding	3	1	0.5	1.5	3	1	0.7	2.1	3	1	0.7	2.1	**5.7**	3	3	0.7	6.3	3	3	0.7	6.3	3	4	0.7	8.4	**21**	3	5	0.7	10.5	3	4	0.6	7.2	3	5	0.7	10.5	**28.2**
Threatened fish species	3	1	0.5	1.5	3	1	0.6	1.8	3	1	0.6	1.8	**5.1**	3	3	0.7	6.3	3	3	0.7	6.3	3	5	0.7	10.5	**23.1**	3	5	0.7	10.5	3	4	0.6	7.2	3	5	0.7	10.5	**28.2**
Air																																							
CO2 (000 mt of C)	3	1	0.7	2.1	3	1	0.7	2.1	3	1	0.7	2.1	**6.3**	3	5	0.8	12	3	5	0.7	10.5	3	5	0.8	12	**34.5**	3	5	0.7	10.5	3	5	0.7	10.5	3	5	0.7	10.5	**31.5**
C $ value	3	1	0.7	2.1	3	1	0.7	2.1	3	3	0.5	4.5	**8.7**	3	5	0.8	12	3	5	0.7	10.5	3	5	0.8	12	**34.5**	3	5	0.7	10.5	3	5	0.7	10.5	3	5	0.7	10.5	**31.5**
Air quality	3	3	0.6	5.4	3	3	0.6	5.4	3	2	0.6	3.6	**14.4**	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.8	9.6	**26.4**	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	**25.2**
Local climate change	3	2	0.6	3.6	3	2	0.6	3.6	3	2	0.6	3.6	**10.8**	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	**25.2**	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	**25.2**
Global climate change	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.7	6.3	3	3	0.7	6.3	**18**
Biodiversity																																							
Protected terrestial area	3	1	0.6	1.8	3	1	0.6	1.8	3	1	0.8	2.4	**6**	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	**24**	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	**24**
Land management	3	1	0.8	2.4	3	1	0.8	2.4	3	1	0.8	2.4	**7.2**	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	**24**	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	**24**
Area of key ecosystems	3	1	0.7	2.1	3	1	0.7	2.1	3	1	0.8	2.4	**6.6**	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	**24**	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	**24**
Abundancy-key species	3	1	0.6	1.8	3	1	0.6	1.8	3	1	0.8	2.4	**6**	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	**24**	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	**24**
Threatened species	3	1	0.5	1.5	3	1	0.5	1.5	3	1	0.5	1.5	**4.5**	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	**24**	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	**24**
ENV-Sustainability	3	1	0.8	2.4	3	1	0.8	2.4	3	1	0.8	2.4	**7.2**	3	2	0.7	4.2	3	3	0.7	6.3	3	5	0.8	12	**22.5**	3	4	0.7	8.4	3	5	0.8	12	3	5	0.8	12	**32.4**
Environmental	3	2	0.6	141.3	3	2	0.7	159	3	2	0.7	135	**435.6**	3	3	0.7	273	3	4	0.7	305	3	4	0.7	355	**932.3**	3	4	0.7	323	3	4	0.7	318	3	4	0.7	376	**1017.6**

Environmental confidence level= 0.7 CI Range 0.5-.8

I=importance
3=Very important
2=Important
1= less important

V= assigned value for relative potential impact
5= significant positive impact (e.g. increase in GDP, decrease in pollution)
4= moderate positive impact
3= no significant change
2=Moderate negative impact
1= significant negative impact (.e.g. loss of habitat; increase in endangered species

CL- Confidence Level
0.8 = High
0.5 = Medium
0.2 = Low

Potential Forest Impacts	**Scenario 1 Conversion**													**Scenario 2 Preservation**													**Scenario 3 Conservation**												
	Economics				Social				Environmental					Economics				Social				Environmental					Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**	I	V	CL	S	I	V	CL	S	I	V	CL	S	**S**
Social																																							
Access to basic needs																																							
% > national poverty line	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Income Ratio	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Food security	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
% adequate shelter	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Electricity Access (%)	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Sanitation facility(%)	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
safe drinking wate(%)	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Cooking fuel																																							
Wood	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Charcoal use	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Electricity	2	3	0.6	3.6	3	3	0.6	5.4	3	3	0.6	5.4	**14.4**	2	3	0.6	3.6	2	3	0.6	3.6	2	3	0.6	3.6	**10.8**	2	4	0.6	4.8	2	4	0.6	4.8	4	3	0.6	7.2	**16.8**
Other (propane, biogas)	1	3	0.6	1.8	3	3	0.6	5.4	3	3	0.6	5.4	**12.6**	1	3	0.6	1.8	1	3	0.6	1.8	1	3	0.6	1.8	**5.4**	1	4	0.6	2.4	1	4	0.6	2.4	5	3	0.6	9	**13.8**
Water source																																							
Surface water	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Ground water	2	3	0.6	3.6	3	3	0.6	5.4	3	3	0.6	5.4	**14.4**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Distribution Sysetm	2	3	0.6	3.6	3	3	0.6	5.4	3	3	0.6	5.4	**14.4**	2	3	0.6	3.6	2	3	0.6	3.6	2	3	0.6	3.6	**10.8**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Purchased water	1	3	0.6	1.8	3	3	0.6	5.4	3	3	0.6	5.4	**12.6**	1	3	0.6	1.8	1	3	0.6	1.8	1	3	0.6	1.8	**5.4**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Water use/ household	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Health																																							
Infant mortality rate	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Maternal mortality rate	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Life expectancy	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Total Fertility Rate	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Access to health care	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
children malnutrition	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Morbidity	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Access to Education																																							
Literacy	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
access to primary edu	2	3	0.6	3.6	3	3	0.6	5.4	3	3	0.6	5.4	**14.4**	2	3	0.6	3.6	2	3	0.6	3.6	2	3	0.6	3.6	**10.8**	2	4	0.6	4.8	3	4	0.6	7.2	3	3	0.6	5.4	**17.4**
access to secondary edu	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Tertiary edu	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Access to information																																							
Internet users	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Fixed phone lines	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Mobile phone users	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Governance																																							
Government	3	3	0.5	4.5	3	3	0.6	5.4	3	3	0.6	5.4	**15.3**	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	**16.2**	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	**19.8**
Indigenous participation	3	2	0.6	3.6	3	2	0.6	3.6	3	1	0.6	1.8	**9**	3	3	0.6	5.4	3	3	0.6	5.4	3	4	0.6	7.2	**18**	3	4	0.6	7.2	3	5	0.7	10.5	3	5	0.7	10.5	**28.2**
Gender equity	3	4	0.6	7.2	3	3	0.6	5.4	3	3	0.6	5.4	**18**	3	3	0.5	4.5	3	3	0.5	4.5	3	4	0.5	6	**15**	3	4	0.5	6	3	4	0.6	7.2	3	4	0.5	6	**19.2**
Social	3	3	0.60	163	3	3	0.6	176	3	3	0.6	175	**513.9**	3	3	0.6	165	3	3	0.6	165	3	3	0.6	168	**497.4**	3	4	0.6	227	3	4	0.6	234	3	3	0.6	189	**649.8**

Social confidence level=   CI Range 0.5-.8

I=importance	V= assigned value for relative potential impact	CL- Confidence Level
3=Very important	5= significant positive impact (e.g. increase in GDP, decrease in pollution)	0.8 = High
2=Important	4= moderate positive impact	0.5 = Medium
1= less important	3= no significant change	0.2 = Low
	2=Moderate negative impact	
	1= significant negative impact (.e.g. loss of habitat; increase in endangered species	

Potential Forest Impacts	BASELINE													TARGET												
	Economics				Social				Environmental					Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	S	I	V	CL	S	I	V	CL	S	I	V	CL	S	S
Economics																										
Econ Indicators																										
GDP annual growth (%)	3	3	0.9	8.1	3	3	0.9	8.1	3	3	0.9	8.1	24.3	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
GDP per capita	3	3	0.9	8.1	3	3	0.9	8.1	3	3	0.9	8.1	24.3	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
BCA a/o NPV	3	3	0.5	4.5	3	3	0.5	4.5	3	3	0.5	4.5	13.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Carbon credit (NA)	3	1	0.9	2.7	3	1	0.9	2.7	3	1	0.9	2.7	8.1	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
GDP Sectors (%)																										
Timber	3	3	0.7	6.3	3	3	0.9	8.1	3	3	0.9	8.1	22.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Agriculture	3	4	0.7	8.4	3	5	0.9	13.5	3	2	0.7	4.2	26.1	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Tourism	3	4	0.7	8.4	2	3	0.9	5.4	2	3	0.8	4.8	18.6	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Fisheries	3	4	0.9	10.8	3	5	0.9	13.5	3	3	0.9	8.1	32.4	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Employment																										
Timber	3	3	0.9	8.1	3	3	0.7	6.3	3	2	0.9	5.4	19.8	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Agriculture	3	5	0.9	13.5	3	5	0.9	13.5	3	2	0.9	5.4	32.4	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Tourism	3	3	0.8	7.2	3	3	0.7	6.3	3	3	0.7	6.3	19.8	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Fisheries	3	5	0.9	13.5	3	5	0.9	13.5	3	2	0.9	5.4	32.4	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Services	2	3	0.9	5.4	2	3	0.7	4.2	2	2	0.7	2.8	12.4	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Support Service	2	3	0.7	4.2	2	3	0.7	4.2	2	2	0.7	2.8	11.2	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Institutional	2	3	0.9	5.4	2	3	0.9	5.4	2	3	0.9	5.4	16.2	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Unemployed (%)	3	3	0.7	6.3	3	3	0.7	6.3	2	3	0.9	5.4	18	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Roadways																										
Paved	3	3	0.9	8.1	3	3	0.9	8.1	3	2	0.9	5.4	21.6	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Unpaved	3	3	0.9	8.1	3	3	0.9	8.1	3	2	0.9	5.4	21.6	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Resource use																										
Energy consumption																										
Timber	3	4	0.8	9.6	3	5	0.9	13.5	3	1	0.9	2.7	25.8	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Agriculture	3	3	0.7	6.3	3	3	0.7	6.3	2	3	0.8	4.8	17.4	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Tourism	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Fisheries	3	3	0.8	7.2	3	3	0.9	8.1	3	3	0.8	7.2	22.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Total consumption	3	3	0.7	6.3	3	2	0.7	4.2	3	1	0.9	2.7	13.2	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Water withdrawal																										
Timber	3	3	0.9	8.1	3	3	0.7	6.3	3	2	0.9	5.4	19.8	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Agriculture	3	2	0.9	5.4	3	3	0.7	6.3	3	1	0.9	2.7	14.4	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Tourism	3	3	0.7	6.3	3	3	0.7	6.3	3	2	0.9	5.4	18	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Fisheries	3	3	0.7	6.3	3	3	0.7	6.3	3	2	0.9	5.4	18	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
per capita (m^3/y)	3	3	0.9	8.1	3	4	0.9	10.8	3	2	0.9	5.4	24.3	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Timber																										
Production	3	3	0.7	6.3	3	3	0.7	6.3	3	2	0.9	5.4	18	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Loss of cover area	3	2	0.7	4.2	3	2	0.8	4.8	3	2	0.9	5.4	14.4	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Food production	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.9	8.1	20.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Harvested crops	3	3	0.8	7.2	3	3	0.8	7.2	3	3	0.9	8.1	22.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Fertilizer use	3	3	0.8	7.2	3	3	0.7	6.3	3	3	0.9	8.1	21.6	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Pesticide Use	3	3	0.8	7.2	3	3	0.7	6.3	3	3	0.9	8.1	21.6	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Fisheries																										
inland water catch	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.8	7.2	19.8	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Fish production	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.8	7.2	19.8	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Econ-Sustainability	3	3	0.7	6.3	3	3	0.7	6.3	3	2	0.9	5.4	18	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Economics	2.9	3.1	0.8	**264.3**	2.9	3.2	0.78	**270**	2.8	2.4	0.8	**203.9**	**738.5**	3	5	0.9	**499.5**	3	5	0.9	**499.5**	3	5	0.9	**499.5**	**1498.5**
Social																										
Access to basic needs																										
% > national poverty line	3	2	0.7	4.2	3	2	0.7	4.2	3	3	0.7	6.3	14.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Income Ratio	3	2	0.7	4.2	3	2	0.7	4.2	3	3	0.7	6.3	14.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Food security	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
% adequate shelter	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Electricity Access (%)	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Sanitation facility(%)	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
safe drinking water(%)	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Cooking fuel																										
Wood	3	3	0.7	6.3	3	4	0.7	8.4	3	1	0.9	2.7	17.4	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Charcoal use	3	3	0.7	6.3	3	4	0.7	8.4	3	1	0.9	2.7	17.4	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Electricity	2	3	0.7	4.2	3	2	0.7	4.2	3	3	0.9	8.1	16.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Other (propane, biogas)	1	3	0.7	2.1	3	2	0.7	4.2	3	3	0.9	8.1	14.4	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Water source																										
Surface water	3	3	0.9	8.1	3	3	0.9	8.1	3	3	0.7	6.3	22.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Ground water	2	3	0.9	5.4	3	3	0.9	8.1	3	3	0.7	6.3	19.8	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Distribution System	2	3	0.9	5.4	3	3	0.9	8.1	3	3	0.9	8.1	21.6	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Purchased water	1	3	0.9	2.7	3	3	0.9	8.1	3	3	0.9	8.1	18.9	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Water use/ household	3	3	0.9	8.1	3	3	0.9	8.1	3	3	0.9	8.1	24.3	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Health																										
Infant mortality rate	3	2	0.7	4.2	3	2	0.7	4.2	3	3	0.9	8.1	16.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Maternal mortality rate	3	2	0.7	4.2	3	2	0.7	4.2	3	3	0.9	8.1	16.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Life expectancy	3	2	0.7	4.2	3	2	0.7	4.2	3	3	0.9	8.1	16.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Total Fertility Rate	3	2	0.7	4.2	3	2	0.7	4.2	3	3	0.9	8.1	16.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Access to health care	3	2	0.7	4.2	3	2	0.7	4.2	3	3	0.9	8.1	16.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
children malnutrition	3	2	0.7	4.2	3	2	0.7	4.2	3	3	0.9	8.1	16.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Morbidity	3	2	0.7	4.2	3	2	0.7	4.2	3	3	0.9	8.1	16.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Access to Education																										
Literacy	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
access to primary edu	2	3	0.7	4.2	3	3	0.7	6.3	3	3	0.7	6.3	16.8	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
access to secondary edu	2	2	0.7	2.8	2	2	0.7	2.8	2	2	0.7	2.8	8.4	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Tertiary edu	2	2	0.7	2.8	2	2	0.7	2.8	2	2	0.7	2.8	8.4	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Access to information																										
Internet users	2	2	0.7	2.8	2	2	0.7	2.8	2	3	0.9	5.4	11	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Fixed phone lines	2	2	0.7	2.8	2	2	0.7	2.8	2	3	0.9	5.4	11	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Mobile phone users	2	2	0.7	2.8	2	2	0.7	2.8	2	3	0.9	5.4	11	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Governance																										
Government	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Indigenous participation	3	2	0.6	3.6	3	2	0.6	3.6	3	3	0.7	6.3	13.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Gender equity	3	2	0.8	4.8	3	2	0.8	4.8	2	2	0.8	3.2	12.8	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Social	2.6	2.5	0.7	**157.1**	2.8	2.5	0.73	**176**	2.8	2.8	0.81	**206.3**	**539.7**	3	5	0.9	**445.5**	3	5	0.9	**445.5**	3	5	0.9	**445.5**	**1336.5**
Environmental																										
Land use (%)																										
Arable crops	3	4	0.7	8.4	3	4	0.7	8.4	3	2	0.9	5.4	22.2	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
permanent crop	3	4	0.7	8.4	3	4	0.7	8.4	3	2	0.9	5.4	22.2	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Infrastructure, roads, etc.	3	3	0.7	6.3	3	3	0.7	6.3	3	1	0.9	2.7	15.3	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Irritated land	2	3	0.7	4.2	3	3	0.7	6.3	3	3	0.9	8.1	18.6	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Land degradation	3	4	0.7	8.4	3	4	0.7	8.4	3	1	0.9	2.7	19.5	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Cultivated	3	4	0.7	8.4	3	4	0.7	8.4	3	2	0.9	5.4	22.2	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Built-on	2	3	0.7	4.2	3	3	0.7	6.3	3	2	0.9	5.4	15.9	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Residence	2	4	0.7	5.6	3	4	0.7	8.4	3	2	0.9	5.4	19.4	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Land Protection																										
Totally protected	3	3	0.7	6.3	3	3	0.7	6.3	3	5	0.9	13.5	26.1	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Partially protected	2	3	0.7	4.2	2	3	0.7	4.2	3	4	0.9	10.8	19.2	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Land Quality																										
Soil degradation	3	3	0.7	6.3	3	3	0.7	6.3	3	1	0.9	2.7	15.3	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Erosion	3	3	0.7	6.3	3	3	0.7	6.3	3	2	0.9	5.4	18	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Forest																										
Forest Cover	3	3	0.7	6.3	2	3	0.7	4.2	3	3	0.9	8.1	18.6	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Protected forest	2	3	0.7	4.2	2	3	0.7	4.2	3	4	0.8	9.6	18	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Native forest depletion	3	3	0.7	6.3	3	3	0.7	6.3	3	2	0.9	5.4	18	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Water																										
Surface water	3	5	0.9	13.5	3	3	0.9	8.1	3	3	0.9	8.1	29.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Groundwater	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.9	8.1	20.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Arsenic	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.9	8.1	20.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
pH	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.9	8.1	20.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Fecal coli	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.9	8.1	20.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
NH3/NOx	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.9	8.1	20.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
DO	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.9	8.1	20.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
BOD	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.9	8.1	20.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
TSS	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.9	8.1	20.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Water treatment	2	3	0.7	4.2	3	3	0.7	6.3	3	3	0.9	8.1	18.6	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
River siltation	3	3	0.7	6.3	3	2	0.8	4.8	3	3	0.9	8.1	19.2	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Flooding	3	3	0.7	6.3	3	2	0.8	4.8	3	3	0.9	8.1	19.2	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Threatened fish species	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.9	8.1	20.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Air																										
CO2 (000 mt of C)	3	3	0.8	7.2	3	3	0.7	6.3	3	3	0.7	6.3	19.8	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
C $ value	2	1	0.7	1.4	2	1	0.7	1.4	3	1	0.7	2.1	4.9	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Air quality	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Local climate change	3	3	0.7	6.3	3	3	0.7	6.3	3	2	0.7	4.2	16.8	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Global climate change	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Biodiversity																										
Protected terrestrial area	3	2	0.7	4.2	3	3	0.7	6.3	3	3	0.9	8.1	18.6	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Land management	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.9	8.1	20.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Area of key ecosystems	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.9	8.1	20.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Abundances-key species	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.9	8.1	20.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Threatened species	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.9	8.1	20.7	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
ENV-Sustainability	3	3	0.9	8.1	3	3	0.9	8.1	3	3	0.9	8.1	24.3	3	5	0.9	13.5	3	5	0.9	13.5	3	5	0.9	13.5	40.5
Environmental	3	3	1	**245.8**	3	3	0.7	**246**	3	3	1	**275.1**	**766.5**	3	5	0.9	**526.5**	3	5	0.9	**526.5**	3	5	0.9	**526.5**	**1579.5**
Average CL/Sum of S			0.7	**667.2**			0.7	**692**			0.8	**685**	**2045**			0.9	**1472**			0.9	**1472**			0.9	**1472**	**4415**
											BASELINE	**2045**												**TARGET**	**4415**	

Potential Forest Impacts	Scenario 1 Conversion													Scenario 2 Preservation												
	Economics				Social				Environmental					Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	S	I	V	CL	S	I	V	CL	S	I	V	CL	S	S
Economics																										
Econ Indicators																										
GDP annual growth (%)	3	5	0.7	10.5	3	5	0.7	10.5	3	1	0.8	2.4	23.4	3	2	0.7	4.2	3	4	0.7	8.4	3	5	0.7	10.5	23.1
GDP per capita	3	5	0.7	10.5	3	5	0.7	10.5	3	1	0.8	2.4	23.4	3	2	0.7	4.2	3	4	0.7	8.4	3	5	0.7	10.5	23.1
BCA a/o NPV	3	5	0.7	10.5	3	5	0.7	10.5	3	1	0.8	2.4	23.4	3	2	0.7	4.2	3	4	0.7	8.4	3	5	0.7	10.5	23.1
Carbon credit (NA)	3	1	0.5	1.5	3	1	0.5	1.5	3	1	0.8	2.4	5.4	3	5	0.5	7.5	3	5	0.5	7.5	3	5	0.8	12	27
GDP Sectors (%)																										
Timber	3	5	0.8	12	3	4	0.8	9.6	3	1	0.8	2.4	24	3	3	0.8	7.2	3	4	0.8	9.6	3	5	0.8	12	28.8
Agriculture	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Tourism	3	2	0.6	3.6	2	2	0.6	2.4	3	4	0.6	7.2	13.2	3	3	0.6	5.4	3	4	0.6	7.2	3	3	0.6	5.4	18
Fisheries	3	2	0.7	4.2	3	4	0.6	7.2	3	3	0.6	5.4	16.8	3	3	0.6	5.4	3	3	0.6	5.4	3	4	0.6	7.2	18
Employment																										
Timber	3	5	0.8	12	3	4	0.7	8.4	3	1	0.8	2.4	22.8	3	1	0.8	2.4	3	2	0.7	4.2	3	5	0.7	10.5	17.1
Agriculture	3	5	0.8	12	3	4	0.7	8.4	3	3	0.7	6.3	26.7	3	3	0.6	5.4	3	3	0.7	6.3	3	3	0.6	5.4	17.1
Tourism	3	2	0.7	4.2	3	2	0.7	4.2	3	3	0.7	6.3	14.7	3	4	0.6	7.2	3	4	0.6	7.2	3	2	0.6	3.6	18
Fisheries	3	2	0.7	4.2	3	2	0.7	4.2	3	2	0.7	4.2	12.6	3	3	0.7	6.3	3	3	0.7	6.3	3	4	0.7	8.4	21
Services	2	2	0.5	2	2	3	0.5	3	2	3	0.5	3	8	2	3	0.5	3	2	3	0.5	3	1	3	0.5	1.5	7.5
Support Service	2	3	0.5	3	2	3	0.5	3	2	3	0.5	3	9	2	3	0.5	3	2	3	0.5	3	1	3	0.5	1.5	7.5
Institutional	2	4	0.5	4	2	3	0.5	3	2	3	0.5	3	10	3	4	0.6	7.2	2	4	0.5	4	2	4	0.5	4	15.2
Unemployed (%)	3	4	0.7	8.4	3	4	0.6	7.2	2	2	0.8	3.2	18.8	3	3	0.7	6.3	3	3	0.5	4.5	3	4	0.7	8.4	19.2
Roadways																										
Paved	3	5	0.7	10.5	3	5	0.7	10.5	3	2	0.8	4.8	25.8	3	3	0.7	6.3	3	3	0.6	5.4	3	3	0.7	6.3	18
Unpaved	3	5	0.7	10.5	3	5	0.7	10.5	3	3	0.6	5.4	26.4	3	3	0.7	6.3	3	3	0.6	5.4	3	3	0.7	6.3	18
Resource use																										
Energy consumption																										
Timber	3	1	0.6	1.8	3	2	0.5	3	3	1	0.5	1.5	6.3	3	4	0.5	6	3	3	0.5	4.5	3	3	0.5	4.5	15
Agriculture	3	2	0.6	3.6	3	2	0.5	3	3	3	0.5	4.5	11.1	3	3	0.5	4.5	3	3	0.5	4.5	3	3	0.5	4.5	13.5
Tourism	3	3	0.5	4.5	3	2	0.5	3	3	4	0.5	6	13.5	3	3	0.5	4.5	3	3	0.5	4.5	3	3	0.5	4.5	13.5
Fisheries	3	2	0.6	3.6	3	2	0.5	3	3	3	0.5	4.5	11.1	3	4	0.5	6	3	3	0.5	4.5	3	3	0.5	4.5	15
Total consumption	3	2	0.6	3.6	3	2	0.5	3	3	2	0.5	3	9.6	3	3	0.5	4.5	3	3	0.5	4.5	3	3	0.5	4.5	13.5
Water withdrawal																										
Timber	3	2	0.6	3.6	3	2	0.5	3	3	2	0.7	4.2	10.8	3	3	0.6	5.4	3	3	0.6	5.4	3	5	0.6	9	19.8
Agriculture	3	1	0.6	1.8	3	2	0.5	3	3	1	0.6	1.8	6.6	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.7	6.3	17.1
Tourism	3	3	0.6	5.4	3	3	0.5	4.5	3	3	0.8	7.2	17.1	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Fisheries	3	3	0.5	4.5	3	2	0.5	3	3	1	0.6	1.8	9.3	3	3	0.6	5.4	3	3	0.6	5.4	3	4	0.6	7.2	18
per capita (m^3/y)	3	2	0.5	3	3	2	0.6	3.6	3	3	0.6	5.4	12	3	3	0.6	5.4	3	3	0.6	5.4	3	4	0.6	7.2	18
Timber																										
Production	3	5	0.8	12	3	4	0.7	8.4	3	1	0.7	2.1	22.5	3	1	0.7	2.1	3	3	0.7	6.3	3	5	0.7	10.5	18.9
Loss of cover area	3	2	0.8	4.8	3	3	0.7	6.3	3	1	0.7	2.1	13.2	3	1	0.7	2.1	3	3	0.7	6.3	3	5	0.7	10.5	18.9
Food production	3	5	0.6	9	3	4	0.7	8.4	3	2	0.7	4.2	21.6	3	3	0.7	6.3	3	4	0.7	8.4	3	3	0.7	6.3	21
Harvested crops	3	5	0.6	9	3	4	0.7	8.4	3	2	0.7	4.2	21.6	3	3	0.7	6.3	3	4	0.7	8.4	3	3	0.7	6.3	21
Fertilizer use	3	2	0.7	4.2	3	2	0.7	4.2	3	1	0.7	2.1	10.5	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
Pesticide Use	3	2	0.7	4.2	3	2	0.7	4.2	3	1	0.7	2.1	10.5	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
Fisheries																										
inland water catch	3	1	0.5	1.5	3	1	0.5	1.5	3	1	0.5	1.5	4.5	3	5	0.6	9	3	5	0.6	9	3	4	0.5	6	24
Fish production	3	1	0.5	1.5	3	1	0.5	1.5	3	1	0.5	1.5	4.5	3	5	0.6	9	3	5	0.6	9	3	4	0.5	6	24
Econ-Sustainability	3	1	0.8	2.4	3	1	0.8	2.4	3	1	0.8	2.4	7.2	3	2	0.7	4.2	3	3	0.7	6.3	3	5	0.8	12	22.5
Economics				**215**				**199**				**133.7**	**547.7**				**201**				**225.4**				**257.2**	**683.6**
Social																										
Access to basic needs																										
% > national poverty line	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Income Ratio	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Food security	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
% adequate shelter	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Electricity Access (%)	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Sanitation facility(%)	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
safe drinking water(%)	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Cooking fuel																										
Wood	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Charcoal use	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Electricity	2	3	0.6	3.6	3	3	0.6	5.4	3	3	0.6	5.4	14.4	2	3	0.6	3.6	2	3	0.6	3.6	2	3	0.6	3.6	10.8
Other (propane, biogas)	1	3	0.6	1.8	3	3	0.6	5.4	3	3	0.6	5.4	12.6	1	3	0.6	1.8	1	3	0.6	1.8	1	3	0.6	1.8	5.4
Water source																										
Surface water	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Ground water	2	3	0.6	3.6	3	3	0.6	5.4	3	3	0.6	5.4	14.4	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Distribution System	2	3	0.6	3.6	3	3	0.6	5.4	3	3	0.6	5.4	14.4	2	3	0.6	3.6	2	3	0.6	3.6	2	3	0.6	3.6	10.8
Purchased water	1	3	0.6	1.8	3	3	0.6	5.4	3	3	0.6	5.4	12.6	1	3	0.6	1.8	1	3	0.6	1.8	1	3	0.6	1.8	5.4
Water use/ household	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Health																										
Infant mortality rate	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Maternal mortality rate	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Life expectancy	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Total Fertility Rate	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Access to health care	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
children malnutrition	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Morbidity	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Access to Education																										
Literacy	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
access to primary edu	2	3	0.6	3.6	3	3	0.6	5.4	3	3	0.6	5.4	14.4	2	3	0.6	3.6	2	3	0.6	3.6	2	3	0.6	3.6	10.8
access to secondary edu	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Tertiary edu	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Access to information																										
Internet users	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Fixed phone lines	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Mobile phone users	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Governance																										
Government	3	3	0.5	4.5	3	3	0.6	5.4	3	3	0.6	5.4	15.3	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Indigenous participation	3	2	0.6	3.6	3	2	0.6	3.6	3	1	0.6	1.8	9	3	3	0.6	5.4	3	3	0.6	5.4	3	4	0.6	7.2	18
Gender equity	3	4	0.6	7.2	3	3	0.6	5.4	3	3	0.6	5.4	18	3	3	0.5	4.5	3	3	0.5	4.5	3	4	0.5	6	15
Social				**163**				**176**				**174.6**	**513.9**				**165**				**164.7**				**168**	**497.4**
Environmental																										
Land use (%)																										
Arable crops	3	5	0.6	9	3	5	0.7	10.5	3	2	0.8	4.8	24.3	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
permanent crop	3	5	0.6	9	3	4	0.7	8.4	3	2	0.8	4.8	22.2	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
Infrastructure, roads, etc.	3	5	0.6	9	3	4	0.7	8.4	3	2	0.8	4.8	22.2	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
Irritated land	2	4	0.6	4.8	3	4	0.7	8.4	3	3	0.8	7.2	20.4	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
Land degradation	3	1	0.8	2.4	3	1	0.7	2.1	3	1	0.8	2.4	6.9	3	5	0.7	10.5	3	5	0.7	10.5	3	4	0.7	8.4	29.4
Cultivated	3	4	0.6	7.2	3	4	0.7	8.4	3	2	0.8	4.8	20.4	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
Built-on	2	4	0.6	4.8	3	4	0.7	8.4	3	2	0.8	4.8	18	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
Residence	2	4	0.6	4.8	3	4	0.7	8.4	3	2	0.8	4.8	18	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
Land Protection																										
Totally protected	3	1	0.8	2.4	3	2	0.6	3.6	3	1	0.6	1.8	7.8	3	2	0.8	4.8	3	5	0.8	12	3	5	0.8	12	28.8
Partially protected	2	1	0.6	1.2	3	2	0.6	3.6	3	1	0.6	1.8	6.6	2	2	0.8	3.2	3	5	0.8	12	3	5	0.8	12	27.2
Land Quality																										
Soil degradation	3	1	0.8	2.4	3	1	0.7	2.1	3	1	0.8	2.4	6.9	3	5	0.8	12	3	5	0.8	12	3	5	0.8	12	36
Erosion	3	1	0.8	2.4	3	1	0.6	1.8	3	1	0.8	2.4	6.6	3	5	0.8	12	3	5	0.8	12	3	5	0.8	12	36
Forest																										
Forest Cover	3	2	0.6	3.6	3	1	0.8	2.4	3	1	0.8	2.4	8.4	3	5	0.8	12	3	4	0.7	8.4	3	5	0.8	12	32.4
Protected forest	3	2	0.6	3.6	3	1	0.8	2.4	3	1	0.8	2.4	8.4	3	5	0.8	12	3	4	0.7	8.4	3	5	0.8	12	32.4
Native forest depletion	3	1	0.6	1.8	3	1	0.8	2.4	3	1	0.8	2.4	6.6	3	5	0.8	12	3	5	0.8	12	3	5	0.8	12	36
Water																										
Surface water	3	2	0.7	4.2	3	2	0.6	3.6	3	2	0.6	3.6	11.4	3	3	0.7	6.3	3	3	0.7	6.3	3	4	0.7	8.4	21
Groundwater	3	2	0.7	4.2	3	3	0.6	5.4	3	3	0.7	6.3	15.9	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
Arsenic	3	2	0.6	3.6	3	2	0.6	3.6	3	2	0.6	3.6	10.8	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
pH	3	3	0.6	5.4	3	3	0.7	6.3	3	3	0.7	6.3	18	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
Fecal coli	3	2	0.6	3.6	3	2	0.7	4.2	3	2	0.7	4.2	12	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
NH3/NOx	3	2	0.6	3.6	3	2	0.6	3.6	3	2	0.6	3.6	10.8	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
DO	3	2	0.6	3.6	3	2	0.6	3.6	3	2	0.6	3.6	10.8	3	3	0.7	6.3	3	3	0.7	6.3	3	4	0.7	8.4	21
BOD	3	2	0.6	3.6	3	2	0.6	3.6	3	2	0.6	3.6	10.8	3	3	0.7	6.3	3	3	0.7	6.3	3	4	0.7	8.4	21
TSS	3	1	0.8	2.4	3	1	0.7	2.1	3	1	0.7	2.1	6.6	3	3	0.7	6.3	3	3	0.7	6.3	3	4	0.7	8.4	21
Water treatment	2	3	0.5	3	3	3	0.6	5.4	3	3	0.6	5.4	13.8	3	3	0.7	6.3	3	3	0.7	6.3	3	3	0.7	6.3	18.9
River siltation	3	1	0.7	2.1	3	1	0.7	2.1	3	1	0.7	2.1	6.3	3	3	0.7	6.3	3	3	0.7	6.3	3	4	0.7	8.4	21
Flooding	3	1	0.5	1.5	3	1	0.7	2.1	3	1	0.7	2.1	5.7	3	3	0.7	6.3	3	3	0.7	6.3	3	4	0.7	8.4	21
Threatened fish species	3	1	0.5	1.5	3	1	0.6	1.8	3	1	0.6	1.8	5.1	3	3	0.7	6.3	3	3	0.7	6.3	3	5	0.7	10.5	23.1
Air																										
CO2 (000 mt of C)	3	1	0.7	2.1	3	1	0.7	2.1	3	1	0.7	2.1	6.3	3	5	0.8	12	3	5	0.7	10.5	3	5	0.8	12	34.5
C $ value	3	1	0.7	2.1	3	1	0.7	2.1	3	3	0.5	4.5	8.7	3	5	0.8	12	3	5	0.7	10.5	3	5	0.8	12	34.5
Air quality	3	3	0.6	5.4	3	3	0.6	5.4	3	2	0.6	3.6	14.4	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.8	9.6	26.4
Local climate change	3	2	0.6	3.6	3	2	0.6	3.6	3	2	0.6	3.6	10.8	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	25.2
Global climate change	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2	3	3	0.6	5.4	3	3	0.6	5.4	3	3	0.6	5.4	16.2
Biodiversity																										
Protected terrestrial area	3	1	0.6	1.8	3	1	0.6	1.8	3	1	0.8	2.4	6	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	24
Land management	3	1	0.8	2.4	3	1	0.8	2.4	3	1	0.8	2.4	7.2	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	24
Area of key ecosystems	3	1	0.7	2.1	3	1	0.7	2.1	3	1	0.8	2.4	6.6	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	24
Abundances-key species	3	1	0.6	1.8	3	1	0.6	1.8	3	1	0.8	2.4	6	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	24
Threatened species	3	1	0.5	1.5	3	1	0.5	1.5	3	1	0.5	1.5	4.5	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	24
ENV-Sustainability	3	1	0.8	2.4	3	1	0.8	2.4	3	1	0.8	2.4	7.2	3	2	0.7	4.2	3	3	0.7	6.3	3	5	0.8	12	22.5
Environmental				**141**				**159**				**135**	**435.6**				**273**				**304.8**				**354.6**	**932.3**
Average CL/Sum of S			0.6	**519**			0.6	**535**			0.7	**443**	**1497**			0.6	**639**			0.6	**695**			0.7	**780**	**2113**
											TOTAL SCORE SCENARIO 1	**1497**												**TOTAL SCORE SCENARIO 2**	**2113**	

Potential Forest Impacts	Scenario 3 Conservation												
	Economics				Social				Environmental				
	I	V	CL	S	I	V	CL	S	I	V	CL	S	S
Economics													
Econ Indicators													
GDP annual growth (%)	3	4	0.6	7.2	3	4	0.7	8.4	3	5	0.7	10.5	26.1
GDP per capita	3	4	0.6	7.2	3	4	0.7	8.4	3	5	0.7	10.5	26.1
BCA a/o NPV	3	4	0.6	7.2	3	4	0.7	8.4	3	5	0.7	10.5	26.1
Carbon credit (NA)	3	5	0.5	7.5	3	5	0.5	7.5	3	5	0.8	12	27
GDP Sectors (%)													
Timber	3	4	0.8	9.6	3	4	0.8	9.6	3	4	0.8	9.6	28.8
Agriculture	3	4	0.6	7.2	3	4	0.6	7.2	3	4	0.7	8.4	22.8
Tourism	3	5	0.7	10.5	3	4	0.6	7.2	3	3	0.7	6.3	24
Fisheries	3	4	0.6	7.2	3	4	0.6	7.2	3	4	0.7	8.4	22.8
Employment													
Timber	3	4	0.7	8.4	3	5	0.7	10.5	3	5	0.7	10.5	29.4
Agriculture	3	4	0.7	8.4	3	5	0.7	10.5	3	4	0.6	7.2	26.1
Tourism	3	5	0.6	9	3	5	0.7	10.5	3	4	0.7	8.4	27.9
Fisheries	3	4	0.6	7.2	3	4	0.6	7.2	3	4	0.6	7.2	21.6
Services	3	4	0.6	7.2	3	4	0.6	7.2	2	3	0.7	4.2	18.6
Support Service	3	4	0.6	7.2	3	4	0.6	7.2	2	3	0.7	4.2	18.6
Institutional	3	4	0.7	8.4	3	4	0.6	7.2	2	3	0.7	4.2	19.8
Unemployed (%)	3	4	0.7	8.4	3	5	0.6	9	3	4	0.7	8.4	25.8
Roadways													
Paved	3	4	0.7	8.4	3	4	0.7	8.4	3	2	0.6	3.6	20.4
Unpaved	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Resource use													
Energy consumption													
Timber	3	2	0.6	3.6	3	3	0.5	4.5	3	3	0.5	4.5	12.6
Agriculture	3	3	0.6	5.4	3	3	0.5	4.5	3	3	0.5	4.5	14.4
Tourism	3	2	0.6	3.6	3	3	0.5	4.5	3	3	0.5	4.5	12.6
Fisheries	3	3	0.6	5.4	3	3	0.5	4.5	3	3	0.5	4.5	14.4
Total consumption	3	3	0.6	5.4	3	3	0.5	4.5	3	3	0.5	4.5	14.4
Water withdrawal													
Timber	3	4	0.6	7.2	4	3	0.6	7.2	3	4	0.6	7.2	21.6
Agriculture	3	4	0.6	7.2	3	3	0.6	5.4	3	3	0.6	5.4	18
Tourism	3	4	0.6	7.2	3	3	0.6	5.4	3	2	0.6	3.6	16.2
Fisheries	3	4	0.6	7.2	3	3	0.6	5.4	3	4	0.6	7.2	19.8
per capita (m^3/y)	3	2	0.6	3.6	3	3	0.6	5.4	3	2	0.6	3.6	12.6
Timber													
Production	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	25.2
Loss of cover area	3	2	0.7	4.2	3	2	0.7	4.2	3	2	0.7	4.2	12.6
Food production	3	4	0.7	8.4	3	4	0.7	8.4	3	3	0.7	6.3	23.1
Harvested crops	3	4	0.7	8.4	3	4	0.7	8.4	3	3	0.7	6.3	23.1
Fertilizer use	3	2	0.7	4.2	3	2	0.7	4.2	3	1	0.7	2.1	10.5
Pesticide Use	3	2	0.7	4.2	3	2	0.7	4.2	3	1	0.7	2.1	10.5
Fisheries													
inland water catch	3	4	0.6	7.2	3	4	0.6	7.2	3	4	0.6	7.2	21.6
Fish production	3	4	0.6	7.2	3	4	0.6	7.2	3	5	0.6	9	23.4
Econ-Sustainability	3	4	0.8	9.6	3	5	0.8	12	3	5	0.8	12	33.6
Economics				**261**				**264**				**246.6**	**771.9**
Social													
Access to basic needs													
% > national poverty line	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Income Ratio	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Food security	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
% adequate shelter	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Electricity Access (%)	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Sanitation facility(%)	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
safe drinking water(%)	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Cooking fuel													
Wood	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Charcoal use	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Electricity	2	4	0.6	4.8	2	4	0.6	4.8	4	3	0.6	7.2	16.8
Other (propane, biogas)	1	4	0.6	2.4	1	4	0.6	2.4	5	3	0.6	9	13.8
Water source													
Surface water	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Ground water	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Distribution System	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Purchased water	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Water use/ household	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Health													
Infant mortality rate	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Maternal mortality rate	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Life expectancy	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Total Fertility Rate	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Access to health care	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
children malnutrition	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Morbidity	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Access to Education													
Literacy	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
access to primary edu	2	4	0.6	4.8	3	4	0.6	7.2	3	3	0.6	5.4	17.4
access to secondary edu	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Tertiary edu	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Access to information													
Internet users	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Fixed phone lines	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Mobile phone users	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Governance													
Government	3	4	0.6	7.2	3	4	0.6	7.2	3	3	0.6	5.4	19.8
Indigenous participation	3	4	0.6	7.2	3	5	0.7	10.5	3	5	0.7	10.5	28.2
Gender equity	3	4	0.5	6	3	4	0.6	7.2	3	4	0.5	6	19.2
Social				**227**				**234**				**189.3**	**649.8**
Environmental													
Land use (%)													
Arable crops	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	25.2
permanent crop	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	25.2
Infrastructure, roads, etc.	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	25.2
Irritated land	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	25.2
Land degradation	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	25.2
Cultivated	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	25.2
Built-on	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	25.2
Residence	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	25.2
Land Protection													
Totally protected	3	3	0.7	6.3	3	4	0.7	8.4	3	5	0.8	12	26.7
Partially protected	3	3	0.7	6.3	3	4	0.7	8.4	3	4	0.8	9.6	24.3
Land Quality													
Soil degradation	3	5	0.8	12	3	5	0.7	10.5	3	5	0.8	12	34.5
Erosion	3	5	0.8	12	3	5	0.7	10.5	3	5	0.8	12	34.5
Forest													
Forest Cover	3	5	0.8	12	3	4	0.6	7.2	3	5	0.8	12	31.2
Protected forest	3	5	0.8	12	3	4	0.6	7.2	3	5	0.8	12	31.2
Native forest depletion	3	4	0.7	8.4	3	5	0.7	10.5	3	5	0.8	12	30.9
Water													
Surface water	3	5	0.7	10.5	3	4	0.6	7.2	3	5	0.7	10.5	28.2
Groundwater	3	4	0.7	8.4	3	4	0.6	7.2	3	3	0.7	6.3	21.9
Arsenic	3	4	0.7	8.4	3	4	0.6	7.2	3	4	0.7	8.4	24
pH	3	3	0.7	6.3	3	3	0.6	5.4	3	3	0.7	6.3	18
Fecal coli	3	4	0.7	8.4	3	4	0.6	7.2	3	4	0.7	8.4	24
NH3/NOx	3	5	0.7	10.5	3	4	0.6	7.2	3	4	0.7	8.4	26.1
DO	3	4	0.7	8.4	3	4	0.6	7.2	3	4	0.7	8.4	24
BOD	3	4	0.7	8.4	3	4	0.6	7.2	3	4	0.7	8.4	24
TSS	3	5	0.7	10.5	3	4	0.6	7.2	3	4	0.7	8.4	26.1
Water treatment	3	3	0.7	6.3	3	3	0.6	5.4	3	5	0.7	10.5	22.2
River siltation	3	5	0.7	10.5	3	4	0.6	7.2	3	3	0.7	6.3	24
Flooding	3	5	0.7	10.5	3	4	0.6	7.2	3	5	0.7	10.5	28.2
Threatened fish species	3	5	0.7	10.5	3	4	0.6	7.2	3	5	0.7	10.5	28.2
Air													
CO2 (000 mt of C)	3	5	0.7	10.5	3	5	0.7	10.5	3	5	0.7	10.5	31.5
C $ value	3	5	0.7	10.5	3	5	0.7	10.5	3	5	0.7	10.5	31.5
Air quality	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	25.2
Local climate change	3	4	0.7	8.4	3	4	0.7	8.4	3	4	0.7	8.4	25.2
Global climate change	3	3	0.6	5.4	3	3	0.7	6.3	3	3	0.7	6.3	18
Biodiversity													
Protected terrestrial area	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	24
Land management	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	24
Area of key ecosystems	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	24
Abundances-key species	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	24
Threatened species	3	2	0.6	3.6	3	4	0.7	8.4	3	5	0.8	12	24
ENV-Sustainability	3	4	0.7	8.4	3	5	0.8	12	3	5	0.8	12	32.4
Environmental				**323**				**318**				**376.2**	**1017.6**
Average CL/Sum of S			0.6	**811**			0.6	**816**			0.7	**812**	**2439**
											TOTAL SCORE SCENARIO 3	**2439**	

Baseline overall CI = 0.8

Target CI = 0.9

Notes: I included Econ sustainability and ENV sustainability , but not Social sustainability since if not Econ sustainable it will not be Soc sustainable, ;however it can be Econ. Non sustainable but can be Environ. Sustainable, such as Preservation.

I=importance	V= assigned value for relative potential impact under current conditions	CL- Confidence Level
3=Very important	5= Very Good	0.8 = High
2=Important	4= Good	0.5 = Medium
1= less important	3= Moderate	0.2 = Low
	2=Fair	
	1= Poor	

Notes: Econ sustainability and ENV sustainability included, but not Social sustainability since if not Econ sustainable it will not be Soc sustainable; however, a parameter or strategy may not be economically sustainable, while concurrently environmentally sustainable (e.g. Preservation).

Appendix C

Field Trip Summaries

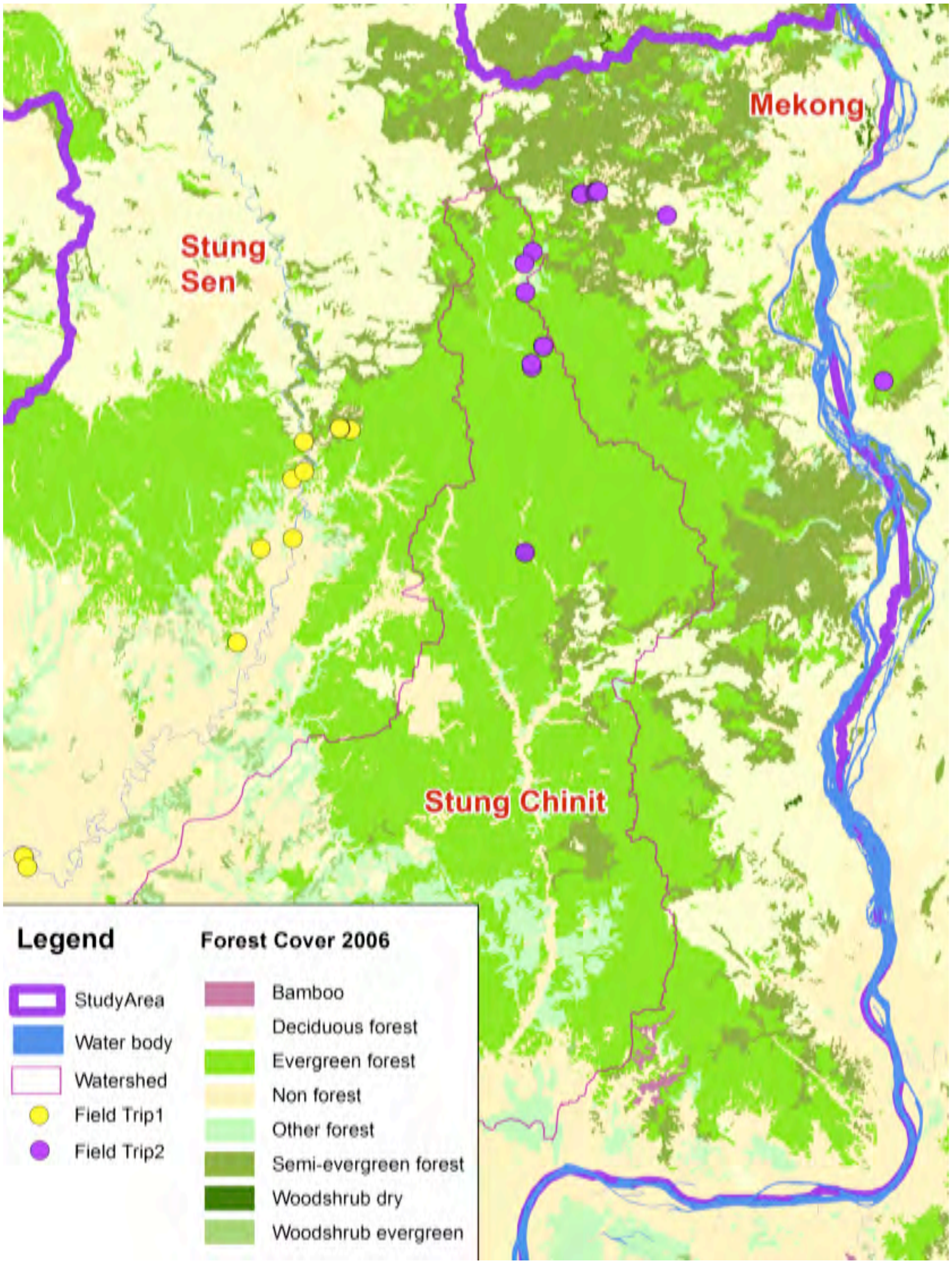


Figure 1. Field Trips Map

Trip 1: Community Forest and Buffer Zone

Dates: 13-16 September 2010

Location: Kbal Takong CF (2207.33 ha) & Kbal Ou Thnong CF (2891.63 ha)

Figure 2. Buffer Zone

Figure 3. Kbal Takong CF Visit

Figure 4. Kbal Ou Thnong CF Visit

Figure 5. Resin Tappin

Trip 2: Dry Deciduous and Evergreen Core Zone

Date: 15 – 18 March 2011

Location: Stung Treng/Northern Prey Lang forest

Figure 6. Core Zone

Figure 7. Core Zone Discussion

Figure 8. NTFP Resin Collection in Core Zone

Figure 9. Deforested Areas near Core Zone

Figure 10. Forest Walk Through

Date: Interviewee:

Location:
(CF, village, commune, district, province, ... and GPS co-ordinate if possible)

DATA SHEET FOR COMMUNITY FORESTRY VISIT

For CF committee: what are management cost per year? Where you get the money from?

* Number and names of villages that collect in this area:
* Number of people from each village:
Number of households from each village:
Percent of households that collect NTFPs (or direct number, if available):
Estimated annual income per household of NTFPs:
What % of total income is made up of NTFP collection?
** Area of collection - total NTFPs
* Size of CF
Which is the most important NTFP?
* Total number of resin trees; total per commune/family (# of families)
How often do you collect NTFPs (dry season vs wet season)
How long do you travel for (one direction)
How many days do you stay (not including travel time)
How much does it cost for a trip (food, transport, informal fees, etc); break out answers
If you were not spending time collecting NTFPs, what other work would you be doing instead? How much would you earn per day doing this other work?
What proportion of NTFPs are consumed (for own use, eating, building, etc) vs what percent are sold for cash?

Non-timer forest Product	Amount collected (per m3/kh/liter – specify)	Percent or number of households that collect	Total ha collected from*	Unit market price	Estimated average weight/volume/ number per h.a [calculate, not ask]	Total volume/weight/ number [calculate, not ask]	Total value
Volume of Fuel wood (m3)							
Number of Bamboo (trees)							
Weight of Bamboo shoot (kg)							
Weight of Mushroom (kg)							
Weight of Wild vegetable (kg)							
Volume of honey(litre)							
Volume of resin (litre)							
Weight of Wild fruit (kg)							
Weight of Traditional Medicine (kg)							
Wild meat (kg)							
Rattan (lpeak, pdao, etc) (kg)							
Other – specify (kg)							

* For total HA collected from, if it is unsure, the area of hte Community Forest (which is known) can be used for reference to estimate (eg collected from 100% of the community forest area, plus an additional area outside the community forest equivalent to 10% of the community forest area.

** This list is a guideline of some of the most important NTFPs, however, local areas may have different NTFP usage. A list can also be made from scratch with participants.

NOTE - market prices are needed even if the product is not sold by collectors.

Fish (kg) – specify different lines if aquaculture, paddy, freshwater
What percent of families fish?
How many times do you eat fish per day?
How much is eaten?
How often do you catch fish?
*Calc: kg caught per year:

What percent is consumed and what percent is sold?

What is market price of fish:

Percent of fish caught

Aquaculture 0%

Paddy 0%

Stream/river 100% name of river Stung Sen

Percent of conversion

		migrants	private company	Local communities	Hunters	Soldiers	Other
Forest clearing for land sales							
Conversion to crop land							
Conversion to settlements							
Fuel wood gathering							
Annual forest fires							
Illegal logging for commercial sale							
Timber harvesting for local use							
Economic land concessions							
Timber concession							

Inventory Data (forest walk)

Forest type (evergreen, semi-evergreen, deciduous):

Level of degradation:

% of trees lost (specify timeframe of loss)

Which species are being lost?

If there is loss, what percent is due to:

Commercial logging __________%

Subsistence use (harvest for local residents) __________%

Conversion to agriculture (famers) _________%

Conversion (business / speculation) _________%

Other _________%

Main Species	Khmer name	Latin name	Use	Percentage	Density (stems / ha)	Royalty class (FA)	Commercially logged (y/n)

Dislocation cost questions
For establishing relocation costs (they refused to answer by saying they won't let it happen)

At a village level / CF groups

Number of people effected: _______________

% that would lose their livehoods: ______________

Where they would go: ______________

What alternatives they have: ____________________

Cost of relocation (housing materials, transport)

At a district level

Cost of running education and health system & source of fundding (we can estimate an increase based on migration changes)

We should also consider acquisition of new land.

From district offic:Number of people likely to be effected / need to be relocated by concessions (if they were to go ahead). The head district offices should know this, but if not, my pass us on on the commune chiefs. One by one follow-up is time consuming - if it comes to this, we can try get them by phone. The provincial FA offices may also be able to weigh in on this issue - the FA team will know if it's worth checking with them or not.

Interviewed by: ________________________