CARDAMOM LANDSCAPE MANAGEMENT TO SUSTAIN BIODIVERSITY AND ECONOMIC RETURNS IN CAMBODIA

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Sun Hean

Abstract

Today, there are few large landscapes that remain to support biodiversity. Their preservation is especially difficult in developing countries, where population growth is high and there is a great demand for land for increased production. The Cardamom landscape in Cambodia is one place where ecosystem preservation has become a national concern. Stakeholders have argued over the management of the landscape that features intact natural forest, valuable biodiversity, and ecosystem services. The private sector, along with several government agencies, is pushing for industrial development. Donor communities and none-governmental organizations want preservation. Finally, several government agencies such as the Ministry of Environment prefer to balance the two different interests. However, the most important question to ask is how we should develop this important landscape in an environmentally sound and economically efficient manner. To answer this question, I created three landscape management scenarios: strong development, strong conservation, and mixed conservation and development based on current government policy, development pressure, and donor community and NGO's arguments. I used GIS, InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs), and other models, to evaluate monetary values of carbon sequestration, biodiversity, hydropower, and agriculture returns under each scenario and compared the returns across scenarios. Changes in elephant population and revenue from four ecotourism projects were used to convert biodiversity habitat scores into monetary values. I found that the strong conservation scenario provided the greatest economic return and at the same time sustained biodiversity in the landscape. Carbon sequestration was the most influential ecosystem service with a large difference in monetary returns between the conservation scenario and the development scenario. The results of this dissertation provide support for recommending that the Cambodian government should strongly protect the Cardamom landscape instead of managing it in other directions.

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List of Abbreviations

ADB	:	Asian Development Bank
AET	:	Annual Actual Evapotranspiration
AWC	:	Plant Available Water Content
BCI	:	Biodiversity Corridors Initiative
CBD	:	Convention on Biological Diversity
CCCSP	:	Cambodian Climate Change Strategic Plan
CCX	:	Chicago Climate Exchange
CDC	:	Council for Development of Cambodia
CITES	:	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMDGs	:	Cambodian Millennium Development Goals
COR	:	Community Road Development
ELCs	:	Economic Land Concessions
ETo	:	Reference Evapotranspiration
FA	:	Forestry Administration
FFI	:	Flora and Fauna International
FiA	:	Fisheries Administration
GEF	:	Global Environment Facility
GHG	:	Green house gas
GIS	:	Global Information System
GMS	:	Greater Mekong Subregion
HYD	:	Hydropower development
IBA	:	Important Bird Area
ICEM	:	International Centre for Environmental Management
ILE	:	Illegal land encroachment
InVEST	:	Integrated Valuation of Environmental Services and Tradeoffs
IRD	:	Irrigation development
IUCN	:	International Union for Conservation of Nature
JICA	:	Japanese International Cooperation Agency
Kc	:	Evaporation Factor
LDCs	:	Least Developed Countries
LULC	:	Land Use Land Cover
MAFF	:	Ministry of Agriculture, Forestry and Fisheries
MCD	:	Mixed Conservation and Development Scenario
MEF	:	Ministry of Economic and Finance
MIME	:	Ministry of Industrial, Mine and Energy
MLMUPC	:	Ministry of Land Management, Urban Planning and Construction
MoC	:	Ministry of Commerce
MoE	:	Ministry of Environment
MoT	:	Ministry of Tourism
MOWRAM	:	Ministry of Water Resources and Meteorology

MPWT	:	Ministry of Public Works and Transportation
MRD	:	Ministry of Rural Development
NAR	:	National road development
NBSAP	:	National Biodiversity Strategy and Action Plan
NEAP	:	National Environmental Action Plan
NFP	:	National Forest Program
NGOs	:	Non-Governmental Organizations
NPASMP	:	National Protected Area Strategic Management Plan
NPCA	:	Nature Protection and Conservation Administration
NPV	:	Net Present value
NSDP	:	National Strategic Development Plan
NTFPs	:	Non-Timber Forest Products
NWAP	:	National Wetland Action Plan
OT	:	Overall Target
PES	:	Payment for Ecosystem Service
RAMSAR	:	Convention on Wetlands of International Importance
RAW	:	Railway development
REDD	:	Reducing Emissions from Deforestation and Degradation
RGC	:	Royal Government of Cambodia
RS	:	Rectangular Strategy
SCO	:	Strong Conservation Scenario
SDE	:	Strong development Scenario
SEDP	:	Social-Economic Development Plan
SEZ	:	Special economic zone
UNCCD	:	United Nation Convention to Combat Desertification
UNCED	:	United Nations Conference on Environment and Development
UNDP	:	United National Development Program
UNFCCC	:	United Nation Framework Convention for Climate Change
UNFF	:	United Nation Forum on Forests
URD	:	Urban Development
VID	:	Village Development

Introduction

Today, there are few large landscapes that remain to support biodiversity. Their preservation is especially difficult in developing countries, where population growth is high and there is a great demand for land for increased production (Critical Ecosystem Partnership Fund [CEPF], 2010; Edmond, 2008). The Cardamom landscape in Cambodia is one place where ecosystem preservation has become a national concern (Asian Development Bank [ADB], 2008; Halperin & Turner, 2013; Sarou, 2009; Wildlife Alliance, 2011, 2012). Stakeholders have argued over the management of the landscape that features intact natural forest, valuable biodiversity, and ecosystem services. The private sector, along with several government agencies, is pushing for industrial development. Donor communities and none-governmental organizations (NGOs) want preservation. Finally, several government agencies such as the Ministry of Environment prefer to balance the two different interests (Pittock, 2011).

When it comes to the Cardamom landscape, the private sector believes that development is the right direction to take. Its stance is to urbanize, creating areas for residences, industrial development, modern agriculture, mining concessions, highways, an airport, and luxury resorts (Hance, 2012; Open Development Cambodia, 2014b). Currently, the private sector has the backing of various government ministries such as the Council for Development of Cambodia (CDC), Ministry of Economic and Finance (MEF), Ministry of Commerce (MoC), Ministry of Industrial, Mine and Energy (MIME), Ministry of Rural Development (MRD), and the Ministry of Public Works and Transportation (MPWT).

In contrast, biodiversity and ecosystem conservation is strongly recommended by donor communities and NGOs, who are contributing billions of dollars per year to Cambodia. They argue that the Cardamom landscape is the largest natural landscape remaining in Southeast Asia, rich in biodiversity and ecosystem types and must be protected (Asian Development Bank [ADB], 2008; Grieg-Gran, HarpeJohn, & Bond, 2008; Wildlife Alliance, 2009, 2010, 2011). The donors and NGOs also complain that

present development activities and plans have threatened the Cardamom landscape's natural resources. This group of stakeholders have confirmed that the landscape is home to many endangered species through biodiversity surveys (Coudrat, Rogers, & Nekaris, 2011; Daltry & Momberg, 2000; J. L. Grismer, Grismer, & Chav, 2010; L. L. Grismer & Neang, 2008; Holden & Neang, 2009; Mulligan, Rours, Sun, Sam, & Goes, 2012; Neang et al., 2010; Neang, Grismer, & Daltry, 2012; Rawson & Senior, 2005; Royan, 2010, 2009; Sitha, Yoeung, Chamnan, Sokhron, & Kagna, 2007; Stuart & Emmett, 2006; Webb, 2005). Others have provided financial and technical support to protect the landscape through conservation programs (Conservation International, 2014; Wildlife Alliance, 2011, 2012).

Furthermore, balancing between development and conservation in the Cardamom landscape becomes the interest of a few government agencies such as the Ministry of Environment (MoE), Ministry of Tourism (MoT), and other international institutions. The UNDP, World Bank and Asian Development Bank (ADB) support sustainable development and work with the Royal Government of Cambodia (RGC) to adopt and implement the Cambodian Millennium Development Goals, green development, and climate change policies and action plans. This group of stakeholders established significant legal frameworks for protecting the Cardamom landscape such as the creation of the conservation area systems and related regulations (Kingdom of Cambodia, 1993a, 1996, 2001a, 2002, 2006, 2008). The ADB has even supporting the implementation of the biodiversity corridors initiative (BCI) projects to ensure the wilderness of the Cardamom landscape (Asian Development Bank [ADB], 2005a, 2005b, 2007, 2008).

However, the most important question to ask is how we should develop this important landscape in an environmental and economical way. This means we need to integrate these two objectives, environmental protection and economic development together to ensure the long term sustainability of the area. All ecosystem services should be evaluated and compared for decision making.

Several studies already have been conducted in the area. The most comprehensive evaluation of ecosystem services in the Cardamom landscape was made by Soussan and

Sam (2011) in partnership with the Cambodian Ministry of Agriculture, Forestry and Fisheries, the Global Mechanism, Conservation International and the Asian Development Bank (ADB). This study included 5 services: timber and crop, NTFPs, watershed protection, biodiversity, and carbon sequestration values and estimated all in monetary term. However, the evaluation was made on a lump sum basis without any spatial analysis, included only the Central Cardamom area, and did not include hydropower value (Soussan & Sam, 2011). Other studies include the estimation of carbon credits from Reducing Emissions from Deforestation and Degradation (REDD) in the Southern Cardamoms (van Beukering, Grogan, Hansfort, & Leeuw, 2009), payment for ecosystem services benefiting hydropower generation (Arias, Cochrane, Lawrence, Killeen, & Farrell, 2011), payment for biodiversity conservation (Clements et al., 2010), community-level payment for environmental services (Milne & Adams, 2012), and local livelihood (Sarou, 2009; Sophat, Chandara, & Vibol, 2012).

For this study, I create three landscape management scenarios: strong development (SDE), strong conservation (SCO), and mixed conservation and development (MCD) based on current government policy, development pressure, and donor community and NGO's arguments. I used Global Information System (GIS) and Integrated Valuation of Environmental Services and Tradeoffs (InVEST) tools to evaluate carbon sequestration, hydropower value, biodiversity habitat, and agriculture return of each scenario and make a comparison. Chapter 1 is a literature review to explore all related information to create the three landscape scenarios and provide the required data for my models. Chapter 2 evaluates ecosystem services under the three scenarios and finally, I discuss sustainable management of the Cardamom landscape and provide recommendations in Chapter 3.

Chapter 1: Conservation and Development in the Cardamom Landscape: History and Current Context

1.1- Introduction

The Cardamom landscape is located in the southwest of Cambodia. The landscape extends over 8 administrative provinces and can be accessed from Phnom Penh by national roads 4, 5, and 48. The area is bordered by Samlaut Multiple Use Zone, Pailin, and Battambang provinces to the north; national road 5, Pursat, and Kampong Chhnang provinces to the east; Bokor, Ream National Parks, Kampot, and Preah Sihanouk provinces to the south; and Samkos, Peam Krasop Wildlife Sanctuaries, Botum Sakor National Park, Thailand, and the Gulf of Thailand to the west (Figure 1).

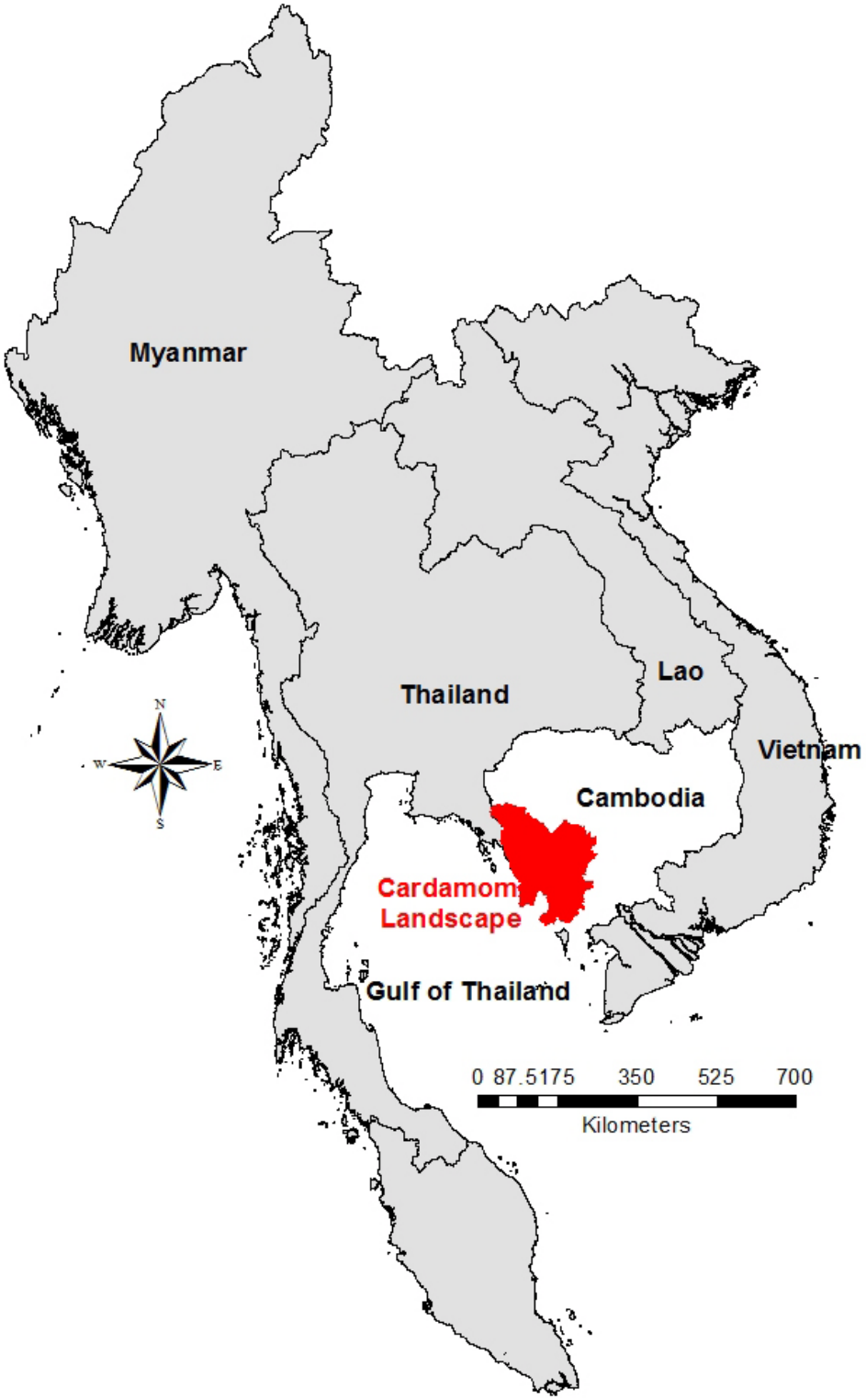
1.1.1- Geological and Climatic Information

This landscape consists of a combination of several mountain ranges and valleys: Samkos, Aural, Elephant, and Bokor. The two highest mountains are Aural and Samkos with elevations of 1,813 and 1,717 meters, respectively (International Centre for Environmental Management [ICEM], 2003a). The Elephant and Bokor Mountains have elevations between 500 and 1,000 meters, which is also the average elevation of the landscape. These mountain ranges form a separate drainage divide. To the east, the rivers flow into the Tonle Sap basin, while to the west they flow into the Gulf of Thailand (Clausen, 2009). However, due to the topography toward the southern end of the Elephant Mountains, some small rivers flow southward on the eastern side of the divide.

The area was formed during the Himalayan uplift that occurred from the middle of the Jurassic period to the Pliocene period. The landscape is composed of a large Mesozoic and Cenozoic sedimentary basin superimposed over a Proterozoic continental nuclear land mass that was compressed after the formation of the Indochina peninsula (Ashwell, 1997). The magma eruptions that occurred from the end of the Pliocene period to the beginning of the Pleistocene period in the third episode of the Himalayan movement explain the presence of some isolated basalt formations of this landscape (Ashwell, 1997).

The majority of soil in the landscape consists of unfertile mixtures of gravel, stone, and sandstone that do not provide favorable conditions for agricultural cultivation.

Figure 1: Location of the Cardamom landscape



The soil was developed as a result of natural geological processes and the decomposition of acid and basic rocks under a humid to sub-humid tropical climate with alternate wet and dry conditions (Ashwell, 1997). However, there are 38 different types of vegetation that grow on this soil (Japan International Cooperation Agency [JICA], 2003) (Figure 2). The three dominant land covers are lowland moist evergreen forest (37%), deciduous forest (19%), and submontane moist evergreen forest (10%) (Table 1). As a result of the poor soil and the rich biodiversity, people residing in this area are often dependent on natural resources (Sarou, 2009; Sophat et al., 2012). They are practicing slash-and-burn agriculture and collecting NTFPs for their daily livelihoods. Low education on modern agriculture techniques and unavailability of high yield varieties prevent them from practicing permanent agriculture in the landscape.

Like the rest of Southeast Asia, the Cardamom landscape's climate is dominated by the monsoons, which are known as tropical wet and dry because of the distinctly marked seasonal differences. The monsoonal airflows are caused by annual alternating high pressure and low pressure over the Central Asian landmass. In summer, moisture-laden air called the southwest monsoon is drawn landward from the Indian Ocean (Clausen, 2009). The flow is reversed during winter, and the northeast monsoon sends back dry air. The southwest monsoon brings the rainy season from mid-May to mid-September or to early October, and the northeast monsoon flow of drier and cooler air lasts from early November to March. Short transitional periods, which are marked by some differences in humidity but by little change in temperature, intervene between the alternating seasons (Clausen, 2009).

Temperatures are fairly uniform throughout the entire landscape, with only small variations from the average annual mean of around 25°C. The maximum mean is about 28°C; the minimum mean is about 22°C. Maximum temperatures of higher than 32°C, however, are common and just before the start of the rainy season, they may rise to more than 38°C. Minimum temperatures rarely fall below 10°C. January is the coldest month and April is the warmest (Ministry of Water Resources and Meteorology [MOWRAM], 2011).

Figure 2: Vegetation covers of the Cardamom landscape

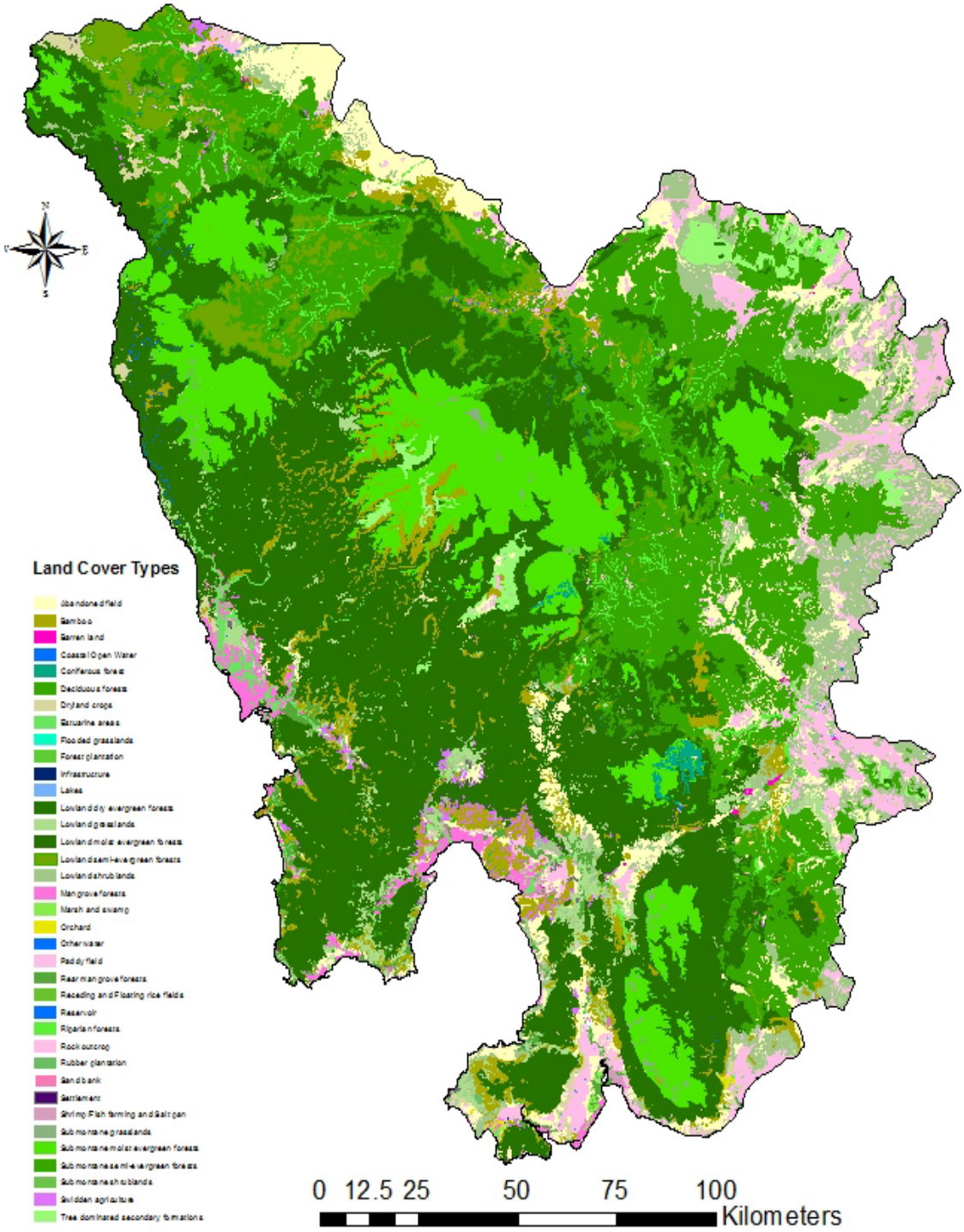


Table 1: LULC types in the Cardamom Landscape

LULC Code	LULC Name	Area (Ha)	Percentage
13	Lowland moist evergreen forests	1,353,369.87	37.34%
42	Deciduous forests	686,635.49	18.94%
35	Submontane moist evergreen forests	373,814.66	10.31%
1	Abandoned field	214,619.29	5.92%
15	Lowland shrublands	212,008.13	5.85%
22	Bamboo dominated secondary formations	155,628.56	4.29%
21	Paddy field	151,111.96	4.17%
14	Lowland semi-evergreen forests	149,567.31	4.13%
12	Lowland grasslands	73,214.10	2.02%
39	Tree dominated secondary formations	47,034.86	1.30%
26	Riparian forests	35,230.39	0.97%
16	Mangrove forests	33,407.87	0.92%
43	Dryland crops	32,850.22	0.91%
23	Rear mangrove forests	25,199.64	0.70%
44	Estuarine areas	19,662.49	0.54%
38	Swidden agriculture	19,185.99	0.53%
41	Coniferous forest	8,647.99	0.24%
11	Lowland dry evergreen forests	7,006.23	0.19%
34	Submontane grasslands	5,606.71	0.15%
20	Other water	3,791.14	0.10%
37	Submontane shrublands	2,549.32	0.07%
31	Shrimp/Fish farming and Salt pan	2,171.73	0.06%
36	Submontane semi-evergreen forests	2,153.20	0.06%
17	Marsh and swamp	1,903.80	0.05%
33	Barren land	1,881.14	0.05%
19	Orchard	1,547.82	0.04%
30	Settlement	1,142.95	0.03%
27	Rock outcrop	1,024.74	0.03%
10	Lakes	711.10	0.02%
5	Forest plantation	568.63	0.02%
29	Sand bank	422.85	0.01%
28	Rubber plantation	355.35	0.01%
25	Reservoir	239.05	0.01%
6	Infrastructure	52.46	0.00%
3	Flooded grasslands	33.89	0.00%
24	Receding and Floating rice fields	31.24	0.00%
40	Coastal Open Water	32.44	0.00%
4	Flooded shrublands	23.90	0.00%

This climatic condition provides the Cardamom landscape an annual rainfall from 900 to 4,100 millimeters of precipitation (Ministry of Water Resources and Meteorology [MOWRAM], 2011). The southern part of the landscape such as the provinces of Kampot, Preah Sihanouk, and Koh Kong received the maximum rainfall as the southwest monsoon first reaches the coast. This area of greatest rainfall, however, drains mostly to the sea; only a small quantity goes into the rivers flowing into the Tonle Sap basin.

The relative humidity is high at night throughout the year; usually it exceeds 90 percent. During the daytime in the dry season, humidity averages about 50 percent or slightly lower, but it may remain about 60 percent in the rainy period (Ministry of Water Resources and Meteorology [MOWRAM], 2011).

1.1.2- Biodiversity Status

With more than 2.5 million hectares of continuous rainforest cover, the Cardamom landscape is the largest area of evergreen forest in Cambodia and represents one of the seven remaining elephant corridors in Southeast Asia (Asian Development Bank, 2005; Wildlife Alliance, 2009, 2010, 2011, 2012). It provides habitats for 97 species of mammals, 322 species of birds, 100 species of reptiles, 44 species of amphibians, and more than 500 species of insect, as well as hundreds of species of fish (Asian Development Bank [ADB], 2005a; Daltry, 2008). Of these, 33 mammals, 53 birds, and 18 reptiles species are considered of international conservation concern by the International Union for Conservation of Nature (IUCN) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Convention on International Trade in Endangered Species of Wild Fauna and Flora [CITES], 2013; International Union for Conservation of Nature [IUCN], 2012) (Appendix 1, 2, & 3). In addition, among the 2,300 species of Cambodia's plants, over half are found in the Cardamom landscape and more than 100 species of them are endemic to the area (Ashwell, 1997; Asian Development Bank [ADB], 2005b; Dy Phon, 1982; Royal Government of Cambodia [RGC], 2002a).

The Cardamom landscape has been recognized to be the most important area in Cambodia for mammal species, which are often used as indicators to reflect the environmental 'health' of local habitats. Such species include the Indochinese Tiger (Panthera tigris) and the Asian Elephant (Elephas maximus). The last estimate of the tiger population was no more than 130 breeding individuals (Cutter & Sun, 2010). The area has also been recognized as a Level I tiger conservation unit (TCU) (Eric Dinerstein, 1997) with significant prey such as Gaur (Bos guarus), Banteng (Bos javanicus), Sambar Deer (Cervus unicolor), and Wild Pig (Sus scrofa) (Sun, 2000). The Level I TCU is one of the three levels that offer the highest probability of persistence of tiger populations over the long term. They are essential for a global tiger conservation strategy. The TCU was first defined in 1995 by the World Wildlife Fund and Wildlife Conservation Society to guide and prioritize in situ tiger conservation efforts across Asia. It was then updated to tiger conservation landscapes (TCLs) in 2006 (E. Dinerstein et al., 2006).

Although the Elephant population has been decreasing, it is still a good number. Flora and Fauna International (FFI) genetic study in 2007 estimated that more than 200 elephants still remain in the area and it is one of the largest populations in Indochina. The area also provides the best habitat and is home to one of the largest populations of Pileated Gibbon (Hylobates pileatus) in the region. In a recent survey, Coudrat et al. (2011) found 3,100 groups of this sepcies just inside the Samkos wildlife sanctuary, suggesting this landscape is extremely important for the conservation of this species and other primates. Other mammal species of international conservation concern, like the Javan Rhinoceros (Rhinoceros sondaicus) and the Khting Vor (Pseudonovibos spiralis), are listed in Appendix 1 of this dissertation (Daltry & Momberg, 2000; WildAid, 2003).

The Cardamom landscape is also home to many birds of global and regional conservation concern, including the White-winged Duck (Cairina scutulata), the Masked Finfoot (Heliopais personata), the Sarus Crane (Grus antigone), the Black-necked Stork (Ephippiorhynchus asiaticus), the Lesser Adjutant (Leptoptilos javanicus), the Great Hornbill (Buceros bicornis), the Green Peafowl (Pavo muticus), the Chestnut-headed

Partridge (Arborophila cambodiana), and others as shown in Appendix 2 (Bauld & Sovan, 2004; Daltry & Momberg, 2000; Mulligan et al., 2012; Royan, 2009).

The presence of the critically endangered Royal Turtle (Batagur baska), which has been rediscovered in the Southern Cardamoms in the lower Sre Ambel valley (Platt, Stuart, Sovannara, Kheng, & Kimchay, 2003; WildAid, 2003), adds more conservation value to the landscape. This is because the species has disappeared in the wild outside of Cambodia, except for small populations in India, Bangladesh, and Malaysia. Siamese Crocodiles (Crocodylus siamensis) are also globally critically endangered and were assumed to be extinct until surviving and breeding populations were identified in the central and southern parts of the landscape (Daltry & Momberg, 2000). Other reptile species of global and regional conservation concern are listed in Appendix 3. A good population of Asian Arowana (Schleropages formosus), which is a CITES Appendix I species, is also present in the landscape and has breeding populations in most of the rivers. It is also important for the conservation of the IUCN critical endangered Agarwood (Aquilaria crassna) and other threatened species of orchids, pitcher plants, and cycads in this area.

The landscape also provides a variety of non-timber forest products (NTFPs) for local community livelihoods including Rattan (Korthalsia spp.) stems for canes and wickers for furniture production; agarwood (Aquilaria crassna) infected wood for valuable wood and extraction of essential oil; Mreah Prew Phnom (Cinnamomum parthenoxylon) wood for extraction of another essential oils; yellow vine (Coscinium spp.) stems for medicinal products; Tep Porou (Cinnamomum tetragonum) bark for coloring drinking water; Samraang (Scaphium macropodum) fruit for boiled seeds; Kuy (Willoughbeia edulis) fruit for local consumption; and ant plants (Myrmecodia spp. and Hydnophytum spp.) epiphyte roots for medicine (Ashwell, 1997; Dy Phon, 1982; WildAid, 2003).

1.1.3- Ecosystem Functions, Goods, and Services

The Cardamom landscape contains 16 ecosystems ranging from wetlands and coastal mangrove forests to grasslands, lowland forests, and evergreen dense forests (WildAid, 2003). Ecosystems functions in the Cardamom landscape provide a wide variety of goods and services. These functions can be defined in four categories: regulatory, habitat, production and information (Groot, Wilson, & Boumans, 2002). Regulation functions relate to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems through bio-geochemical cycles and other biospheric processes. For example, gas and climate regulation, disturbance prevention, water regulation, supply and treatment, soil retention and formation, pollination, and biological control are included in this category. Habitat functions occur when ecosystems provide refuge and reproduction habitat to wild plants and animals which includes refugium and nursery functions. Production functions occur when photosynthesis and nutrient uptake by autotrophs converts energy, carbon dioxide, water and nutrients into a wide variety of carbohydrate structures which are then used by secondary producers to create an even larger variety of living biomass. Goods that are provided under these functions include foods, raw materials, genetic, medicinal, and ornamental resources. Information functions contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, recreation and aesthetic experience. Values that are provided under these functions consist of aesthetic, cultural and artistic, spiritual and historic information, recreation, science and education. Table 2 was adopted from Groot et al. (2002) and integrated goods and services provided by the Cardamom landscape ecosystems.

Today, the Cardamom landscape is a vital strategic reserve and several sectors of the economy, including energy, agriculture, forestry, fisheries, ecotourism, and local livelihoods depend on the maintenance of its ecosystems even if they have been modified. Its rainforests are of critical importance to Cambodia's water security, food security, and adaptation to climate change. The Cardamom landscape is an essential life support to a large portion of the Cambodian population and the national economy

because of its capacity, supplies enormous amounts of water in order to produce electricity to support national development priorities.

The Cardamom contains the largest waterway system in the country, with more than 200 tributaries and the massive amounts of water that the region supplies on a continuous basis. It is of strategic importance to the government for developing the country's agriculture and fisheries. The north supports the fisheries of the flooded forest of Tonle Sap Lake and the vast rice plains of Pailin, Battambang, Pursat, and Kampong Chhnang provinces, while the south supports 155 km of coastal fisheries and six major riparian fisheries in the provinces of Koh Kong, Preah Sihanouk, Kampot, and Kampong Speu.

Furthermore, this landscape also contributes to the maintenance of local and regional climate. With its abundant rainfall, the Cardamom Mountains serve as a climate regulator for the region, providing regular rainfall and cooling of the atmosphere while shielding the central rice fields from ocean storms originating in the Gulf of Thailand.

Table 2: Ecosystem functions, goods, and services of the Cardamom landscape

No.	Function	Processes, Good, and Services (Examples)
	Regulatory Functions	Maintenance of essential ecological processes and life support systems
1	Gas regulation	Role of ecosystems in bio-geochemical cycles that maintains good air quality (Cardamom landscape provides fresh & clean air)
2	Climate regulation	Influence of land cover and biological mediated processes that maintains a favorable climate (Cardamom landscape maintains suitable temperature and rainfall)
3	Disturbance prevention	Influence of ecosystem on environmental disturbances (Cardamom landscape protects the middle plain from storms and floods)
4	Water regulation	Role of land cover in regulating runoff (Cardamom landscape provides drainage, natural irrigation, and medium for transport)
5	Water supply	Filtering, retention and storage of fresh water for consumptive use (drinking, irrigation, aquaculture, industrial uses)
6	Soil retention	Role of vegetation root matrix and soil biota that prevents damage from erosion/siltation (vegetation covers along rivers prevent soil from running into all waterways)

7	Soil formation	Weathering of rock, accumulation of organic matter to maintain productivity on arable land (natural productive soils in Thmar Bang, Kirirom etc.)
8	Nutrient regulation	Role of biota in storage and re-cycling of nutrients that maintains healthy soils and productive ecosystems (rich species diversity in the Cardamom)
9	Waste treatment	Role of vegetation and biota in removal of xenic nutrients and compounds, pollution control/detoxification, filtering of dust particles (clean water in Kbal Chhay watershed was well treated by the surrounding forests and the water plants)
10	Pollination	Role of biota in movement of floral gametes of wild plants and crops (Cardamom tree distribution, crop production in the landscape such as mango, durian, rambutan etc.)
11	Biological control	Role of a population control of pests and diseases, or reduces herbivory (birds of prey control rat population that destroy rice fields)
	Habitat Functions	Providing habitat (suitable living space) for wild plant and animal species
12	Refugium function	Suitable living space for wild plants and animals (Cardamom landscape is a storehouse for maintaining the Elephant population, half of Cambodia birds and other endemic species)
13	Nursery function	Suitable reproduction habitat (Cardamom landscape reproduces NTFPs for local livelihood, mangrove wood and other species for charcoal and foods)
	Production Functions	Provision of natural resources
14	Food	Conversion of solar energy into edible plants and animals (bush-meats, fish, spices, wild fruits, mushrooms, young leaves, flowers, and young fruits for vegetable)
15	Raw materials	Conversion of solar energy into biomass for human construction and other uses (timber for all kinds of construction; grass and leaves for roofing; fuel wood for cooking; krill, leaves, and litter for animal feed and fertilizer)
16	Genetic resources	Genetic material and evolution in wild plants and animals (Wild Cardamom is a great genetic resource for commercial reproduction)
17	Medicinal resources	Variety in (bio)chemical substances in, and other medicinal uses of, natural biota (Yellow Vine (Coscinium spp.) for medicinal products and Mreah Prew Phnom (Cinnamomum parthenoxylon) for essential oil and drugs)
18	Ornamental resources	Variety of biota in natural ecosystems with (potential) ornamental use (agarwood, orchids, animal and plant specimens)
	Information Functions	Providing opportunities for cognitive development
19	Aesthetic information	Attractive landscape features (enjoyment of beautiful intact rainforests, Tatay river, scenic of road and bridge, and wildlife)

20	Recreation	Variety in landscapes with (potential) recreational uses (getways to a green adventure at Chi Phat, Trapeang Rung, and Tatay)
21	Cultural and artistic information	Variety in natural features with cultural and artistic value (use of Cardamom landscape as motive in books, film, songs, and ecotourism advertising)
22	Spiritual and historic information	Variety in natural features with spiritual and historic value (Ghost Mountain, historical jars and coffins)
23	Science and education	Variety in nature with scientific and educational values (many biological and social research opportunities provided by the Cardamom landscape)

1.1.4- Social and Economic Information

Human density in the Cardamom landscape is extremely low compared to other locations in the country, less than one person per hectare of land. The livelihood of the locals depends on using natural resources for survival such as logging and hunting, non-timber forest product collection, and clearing forest for slash-burn agriculture (Sophat et al., 2012). Other livelihoods include animal husbandry, fishing, supply and sales of local products, and government employment. Large scale development such as resort, casino, and industrial zone development along the Thai border; hydropower development and logging in the reservoirs; sand dredging along main waterways; and economic land concession development operate in the area. Green businesses such as community ecotourism, guest houses, and home stays in several attractive locations were just recently introduced by conservation NGOs (Wildlife Alliance, 2012).

1.1.5- Impacts/Threats

Threats and impacts to the Cardamom landscape are driven by many factors (Halperin & Turner, 2013) such as country political instability, human population growth, government policies, bad governance, investment pressure etc. Daltry and Momberg (2000) discussed hunting for local consumption, national and international trade, habitat loss, road construction, habitat degradation, and lack of education as the main impacts and threats to biodiversity in the area. Sophat et al. (2012) found that illegal logging by new migrants and hydropower development are the biggest threats that lead to forest degradation. Sarou (2009) discussed the challenges and the impacts of different

government natural resource management policies, NGOs, and external actors on the indigenous people's livelihood. Puthea (2008) identified soil erosion and deforestation as being widespread and of particular concern in Cambodia, jeopardizing both agricultural productivity and the integrity of a number of ecosystems. The same report identifies a range of causes of land degradation, a number of which characterize the study area in the Cardamom Mountains. These include recent influxes of external migrants to the area, increasing resource pressures and leading to new forms of land resource exploitation and encroachment. Based on a literature review, it is clearly seen that threats to the Cardamom landscape include both drivers that produced access to the landscape and direct impacts that took place in the access areas. These threats include urban and community development, infrastructure expansion, hydropower and irrigation system development, economic land concessions (ELCs), and illegal land encroachment.

1.2- Key Institutions, Policies, and Regulations

In order to understand the current situation of the landscape and to create the Mixed Conservation and Development (MCD) scenario for the study, this section will review all key government institutions, policies, and regulations that are currently in place for the management of the Cardamom landscape. As with other nations, the Cambodian National Constitution is the top legislation, providing a clear framework for managing natural resources in Cambodia as well as in the Cardamom landscape. Article 58 states "land, mineral resources, mountains, sea, underwater, continental shelf, coastline, airspace, islands, rivers, canals, streams, lakes, forests, natural resources…" are state property. Article 59 obligates the state to protect "the environment and balance of abundant natural resources and establish a precise plan of management of land, water, air, wind, geology, ecological system, mines, energy, petrol and gas, rocks and sand, gems, forests and forestry products, wildlife, fish, and aquatic resources" (Kingdom of Cambodia, 1993b). Based on this constitution, the state has established the following institutions, policies, and regulations to manage the country's natural resources and the following are related to the Cardamom landscape.

1.2.1- Management Institutions of the Cardamom Landscape

The following are government agencies responsible for managing and monitoring of the Cardamom landscape. These institutions each have eight provincial departments with the exception of the Council for Development of Cambodia (CDC) and provincial authorities.

Council for Development of Cambodia (CDC) is responsible for making all decisions regarding rehabilitation, development, and investment activities as well as for providing guidance on the preparation of development strategies and the utilization of all public and private resources. . CDC also coordinates donor support, and facilitates inter-ministerial activities (Kingdom of Cambodia, 1994a, 2003). This council is chaired by the Prime Minister and has all line ministries as its members. CDC has the ability to approve all kind of investment projects in 45 days. So, it is extremely important that the relevant line ministry representatives have the ability and capacity to provide comments and discuss the cost and benefit correctly and comprehensively on each proposed project that will be permitted or rejected by the council. Line ministries frequently send their low level representatives to participate in the meetings and did not share professional comments, leading to the improper approval of projects. Moreover, corruption often influences decision making and public consultations are rarely conducted even though required by several regulations. As a result, these issues led to future conflicts and caused severe environmental impacts.

Ministry of Environment (MoE) plans, manages, and monitors environment sector as stated in the Law on Environmental Protection and Natural Resources Management (Kingdom of Cambodia, 1996), the Protected Area Law (Kingdom of Cambodia, 2008), National Environmental Action Plan (NEAP), National Wetland Action Plan (NWAP), National Biodiversity Strategy and Action Plan, and Cambodian Climate Change Strategic Plan (CCCSP) that was recently launched by the RGC. Responsibilities on the ground are mostly carried out by the Nature Protection and Conservation Administration (NPCA). The NPCA is responsible for assisting the MoE with managing a particular protected area system created in 1993 (Kingdom of

Cambodia, 1993a), developing and implementing the Protected Areas Strategic Management Plan and coordinating other conservation works in the country. According to the Sub-decree on Environmental Impact Assessment Process, MoE has the authority to make the decision on whether or not a development project is approved based on review of the submitted environmental impact assessment report.

Ministry of Agriculture, Forestry and Fisheries (MAFF) plans and manages the agricultural, forestry and fisheries sectors with three central departments specifically: the Forestry Administration (FA), the Fisheries Administration (FiA), and the General Department of Rubber Plantation. FA is responsible for managing protected forests and areas outside the protected areas managed by MoE, preparing protective policies and regulations, developing management plans, and supporting the rehabilitation of forests and wildlife resources as stated in the Forestry Law (Kingdom of Cambodia, 2002), the Sustainable Forest Management Plan, and the Nation Forest Sector Policy of the RGC. FiA is responsible for managing mangrove forests, developing plans for the protection, management, and rehabilitation of fishery resources as stated in the Fisheries Law (Kingdom of Cambodia, 2006). The General Department of Rubber Plantation is responsible for managing rubber plantations in the landscape. The FA and FiA assist MAFF to manage forests and fisheries in the area through de-concentrated single-line organizations. A de-concentrated single-line organization is a term that the RGC uses to describe management structure from central to provincial to community levels.

Ministry of Land Management, Urban Planning and Construction (MLMUPC) is responsible for general land management, urbanization, and construction as stated in the Land Law (Kingdom of Cambodia, 2001a). MLMUPC is also responsible for providing land title and land registration including the social and economic land concessions in the area. Recently, this ministry has been working with provincial authorities and Wildlife Alliance to allocate three social land concessions in the Cardamom landscape that might add more pressure on biodiversity and ecosystem conservation.

Ministry of Water Resources and Meteorology (MOWRAM) is responsible for water resources management and meteorology as started in the Law on Water Resources Management (Kingdom of Cambodia, 2007) and the Strategic Development Plan on Water Resources and Meteorology 2009-2013, and the Climate Change Strategic Plan on Water Resources Sector 2013-2017. This ministry is also responsible for permitting sand dredging projects in waterways in the Cardamom landscape, many of which affect ecosystem and local communities.

Ministry of Industrial, Mine and Energy (MIME) is responsible for energy development including hydropower, coal burning, diesel power stations, and transmission lines. In addition, this ministry oversees mine exploring and exploitation as stated in the Law on Mineral Resource Management and Exploitation (Kingdom of Cambodia, 2001b). Both energy development and mineral exploration existed in the Cardamom landscape. Hydropower has great potential to be developed in the landscape; however, mining is a controversial issue in Cardamom natural resource management. Given that underground resources are governed by another separate law, conflicts occur between MIME and other aboveground, natural resource management institutions.

Ministry of Tourism (MoT) is responsible for managing and developing the tourism sector in the country. Ecotourism is critically important for the Cardamom landscape sustainable management. Even though a Cambodian tourism law is not in effect, this ministry has been trying to get involved in ecotourism projects in the area, especially with the three community-based ecotourism projects that are being established by Wildlife Alliance in Chi Phat, Trapeang Rung, and Tatay communes.

The **Eight Provincial Authorities** are responsible for community development, including resettlement, infrastructure, and land expansion in each individual province in the landscape. These authorities, in cooperation with other institutions, development partners, and NGOs, implement the central government policies and regulations, improve community development and people's livelihood, and in the same time protect natural resources and the environment. As previously mentioned, many of the line ministries

have their departments under the provincial authorities, assisting the governors to develop and govern their provinces based on each policy sector.

1.2.2- Policies and Regulations related to the Cardamom Landscape

Cardamom landscape management is directed by a number of major national policies, regulations, strategies, and action plans. The following is a review of the documents that are currently in place and implemented.

Cambodian Millennium Development Goals (CMDGs): CMDGs were first developed in 2001 in cooperation with the United Nations and had the merit of laying the foundations of future reporting and sensitizing a large audience of stakeholders. The current 2003 CMDGs were developed based on medium-term planning exercises of the Cambodian's Social-Economic Development Plan II and the National Poverty Reduction Strategy (Council for Social Development, 2003). In 2003, the Ministry of Planning took a further step in setting medium-term targets and defining national monitoring and evaluation indicators when it developed its own set of national development goals for 2015. These were based on the Millennium Development Goals agreed at the United Nation Millennium Summit in 2000 to which Cambodia was a signatory along with all other countries (United Nations General Assembly, 2000). In addition to the eight agreed goals of the United Nations, Cambodia has added an additional goal, related to removal of mining explosives (Royal Government of Cambodia [RGC], 2003a). Based on this review, Cambodian Millennium Development Goals (CMDG) 1 and 7 are strongly related to Cardamom landscape management (Table 3). CMDG 1 is aimed at eradicating extreme poverty and hunger through eight targets under two overall targets (OT). OT 1 focuses on the proportion of people whose income is less than the national poverty line. The goal is to halve the 39% of Cambodian people whose income is less than poverty line in 2003 by 2015. According to the Japan International Cooperation Agency's study on Cambodia poverty profiles in 2007, poverty lines in Phnom Penh, other urban areas, and rural areas were US$0.76, US$0.66, and US$0.57 per day respectively (Japan International Cooperation Agency [JICA], 2010). In the Cardamom landscape, rates of

poverty vary from eight percent in Koh Kong to 97 percent in Pailin. OT 2 halves, between 1993 and 2015, the proportion of people who suffer from hunger.

CMDG 7 is aimed at ensuring environmental sustainability and has 14 targets under four overall targets as presented in Table 3. OT 13 integrates the principles of sustainable development into country policies and programs and reverses the loss of environmental resources. Target 7.1 under OT 13 sets a goal of maintaining forest coverage at the 2000 level of 60% of total land area. The Cardamom landscape has great potential to lead Cambodia to reaching these goals and targets (Royal Government of Cambodia [RGC], 2010; United Nations, 2013), especially the target of extending forest cover and reversing the loss of environmental resources. OT 14 halves by 2015 the proportion of people without sustainable access to safe drinking water. OT 15 also halves by 2015 the proportion of people without sustainable access to improved sanitation. OT 16 increases the proportion of the population in both urban and rural areas with access to land security by 2015.

Table 3: Related Cambodian Millennium Development Goals

CMDG1: Eradicate extreme poverty and hunger
Overall target 1: Halve, between 1993 and 2015, the proportion of people whose income is less than the national poverty line
Target 1.1: Decreasing the proportion of people whose income is less than the national poverty line from 39% in 1993 to 19.5% in 2015
Target 1.2: Increasing the share of poorest quintile in national consumption from 7.4% in 1993 to 11% in 2015
Target 1.3: Decreasing the proportion of working children aged between 5-17 years old from 16.5% in 1999 to 8% in 2015
Overall target 2: Halve, between 1993 and 2015, the proportion of people who suffer from hunger
Target 1.4: Decreasing the prevalence of underweight (weight for age <2 SD) children under-five years of age from 45.2% in 2000 to 22% in 2015
Target 1.5: Decreasing the proportion of population below the food poverty line from 20% in 1993 to 10% in 2015
Target 1.6: Decreasing the prevalence of stunted (height for age <2 SD) children under five years of age from 44.6% in 2000 to 22% in 2015
Target 1.7: Decreasing the prevalence of wasted (weight for height <2 SD) children under five years of age from 15% in 2000 to 9% in 2015

Target 1.8: Increasing the proportion of households using iodized salt from 14% in 2000 to 90% in 2015
CMDG7: Ensure environmental sustainability
Overall target 13: Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources
Target 7.1: Maintaining forest coverage at the 2000 level of 60 % of total land area through 2015
Target 7.2: Maintaining the surface of 23 protected areas at the 1993 level of 3.3 million ha through 2015
Target 7.3: Maintaining the surface of 6 new forest-protected area at the present level of 1.35 million ha through 2015
Target 7.4: Increasing the number of rangers in protected areas from 600 in 2001 to 1,200 by 2015
Target 7.5: Maintaining the number of rangers in forest protected areas at the level of 500 through 2015
Target 7.6: Increasing the proportion of fishing lots released to local communities from 56% in 1998 to 60% in 2015
Target 7.7: Increasing the number of community-based fisheries from 264 in 2000 to 589 in 2015
Target 7.8: Increasing the surface of fish sanctuaries from 264500 ha in 2000 to 580800 ha in 2015
Target 7.9: Reducing the fuel wood dependency from 92% of households in 1993 to 52% in 2015
Overall target 14: Halve by 2015 the proportion of people without sustainable access to safe drinking water
Target 7.10: Increasing the proportion of rural population with access to safe water source from 24% in 1998 to 50% in 2015
Target 7.11: Increasing the proportion of urban population with access to safe water source from 60% in 1998 to 80% in 2015
Overall target 15: Halve by 2015 the proportion of people without sustainable access to improved sanitation
Target 7.12: Increasing the proportion of rural population with access to improved sanitation from 8.6% in 1996 to 30% in 2015
Target 7.13: Increasing the proportion of urban population with access to improved sanitation from 49% in 1998 to 74% in 2015
Overall target 16: Increase the proportion of the population in both urban and rural areas with access to land security by 2015
Target 7.14: Increase the percentage of land parcels having titles in both urban and rural areas from 15% in 2000 to 65% in 2015

Rectangular Strategy (RS): This strategy provides the platform for national development. The RS I was transformed from the Triangle Strategy of the Second Legislature of the national assembly (1998-2003) and implemented during the Third Legislature (2003-2008). The RS II was implemented during the Fourth Legislature (2008-2013). RS III is in the process of being implemented under the Fifth Legislature (2013-2018). All RSs have the same structure. In RS III, the core of the rectangular strategy which is about good governance and the first strategic rectangle which is about promotion of agriculture sector are strongly related to the Cardamom landscape management. This is because good governance is the key issue to everything, including fighting corruption, legal and judicial reforms, public administration reform, and reform of armed forces that direct sustainable management of natural resources. Under the promotion of the agriculture sector strategic rectangle; the first side is about improved productivity, diversification and commercialization, the second is about promotion of livestock farming and aquaculture, the third is about land reform and clearance of mines, and the fourth is about sustainable management of natural resources.

To achieve this objective, the RGC is implementing a comprehensive and cross-cutting approach, aimed at improving the effectiveness and equity in the exploitation of natural resources, by: 1) clearly determining the ownership of natural resources; 2) developing an appropriate incentive scheme for the conservation of natural resources and empowering the sub-national government, communities and individuals to participate in their conservation by focusing on training, information sharing as well as strengthening social capital, and institutional accountability and transparency; and 3) stepping up cooperation with concerned stakeholders under the framework of green growth and climate change.

The RGC places priority on further managing forest and wildlife resources in accordance with the National Forest Program 2010-2029, fishery resources in line with the Strategic Planning Framework for Fisheries Sector 2010-2019 and the Declaration on the National Policy for Fisheries Sector, and protected area systems, wetlands, biodiversity as stated in the Law on the Environmental Protection and the Management of

Natural Resources and Law on Protected Natural Areas" and Guideline on the Development of Coastal Areas in the Kingdom of Cambodia. The RGC is also stepping up cooperation with relevant development stakeholders under the framework of the National Policy on Green Development" and the "National Strategic Plan on Green Growth 2013-2030 through the development of regulatory frameworks and mechanisms for carbon trading, strengthening the capability, preparation and implementation of climate change adaptation measures.

National Strategic Development Plan (NSDP): This plan plays a central role as the main policy tool in implementing national development visions pronounced in political platform and national development strategies of the RGC such as the RS. The NSDP was renamed from the Social-Economic Development Plans (SEDP), which were implemented previously (SEDP I 1996-2000, SEDP II 2001-2006). The NSDP 2006-2010 was developed based on the RS framework and RGC led the process of the preparation of the plan while ensuring participation of and consultations with all stakeholders. To ensure consistency in terms of hierarchy, role, substance, coherence, and synchronization between the RS, NSDP, and other sectoral development policies and strategies; during the first meeting of the Fourth Legislature, the Prime Minister called for a review of the timeframe of the NSDP, and the NSDP Update 2009-2013 was formulated and still under implementation, while NSDP 2014-2018 is in the development process and not yet published. The NSDP Update 2009-2013 detailed and placed priority on land, forestry and fisheries reforms separately as presented in the RS II. This plan also included the development sections such as rehabilitation and construction of transport infrastructure, development of water, energy and information and communication technology sectors. This plan tried to improve the country's economy and livelihood of the people based on those reforms after the effect of the global economic crises and did not clearly target sustainable natural resource management, especially biodiversity and ecosystem conservation as the key solution to the sustainable development. Hopefully, the NSDP 2014-2018 will include clear sustainable natural resource management guidelines because this is already presented the RS III.

National Policy and Strategic Plan on Green Growth 2013-2030: This plan was approved on 01 March 2013 by the RGC, aiming at developing the economy with consideration for environment and natural resources sustainability. The national policy targets a balance between economic development and environmental protection, culture preservation, social stability and sustainable consumption of natural resources to improve people's living conditions and welfare. The 2013-2030 green growth plan aims to develop a green economy through the effective use of natural resources, environmental sustainability, green jobs, green technologies, green finance, green credit, and green investment. Prior to these, Cambodia had already adopted several legal instruments to promote the green growth, including the roadmap for green growth, the memorandum of understanding on green growth cooperation between Cambodia and the Republic of Korea's Global Green Growth Institute and the establishment of the National Council on Green Growth and the General Secretariat for Green Growth. Moreover, workshops and meetings with relevant stakeholders on inclusive green growth were conducted to gather inputs, raise awareness at the national and sub-national level, increase capacity building, mobilize domestic financial and human resources, promote balanced integration of economic, environmental, social and cultural dimensions into the overall development of Cambodia. It was understood that inclusive green growth is a means to achieve sustainable development, mainstreaming green growth in NSDP 2014-2018 and in all developmental sectors, and establishing Law on Green Growth is critically important for the implementation of this policy and strategy plan.

Cambodia Climate Change Strategic Plan 2014-2023 (CCCSP): This strategic plan was officially launched and strongly supported by the Prime Minister in November 2013. The plan captures the main strategic objectives and directions for a climate-smart development of Cambodia in the next 10 years. It builds synergies with existing government policies to ensure a strategic cohesion to address a wide range of climate change issues linked to adaptation, greenhouse gas (GHG) mitigation, and low-carbon development. The CCCSP covers eight strategic objectives: 1) promote climate resilience through improving food, water and energy security, 2) reduce vulnerability of sectors,

regions, gender and health to climate change impacts, 3) ensure climate resilience of critical ecosystems such as the Cardamom landscape, biodiversity, protected areas, and cultural heritage sites, 4) promote low-carbon planning and technologies to support sustainable development of the country, 5) improve capacities, knowledge and awareness for climate change responses, 6) promote adaptive social protection and participatory approaches in reducing loss and damage, 7) strengthen institutions and coordination frameworks for national climate change responses, and 8) strengthen collaboration and active participation in regional and global climate change processes. Based on this policy, the Cambodian Cardamom landscape should be managed to mitigate GHG by promoting carbon sequestration trading and low-carbon development. This also means that the RGC will not deforest the landscape and stop granting any ELCs in the area.

Several other environmental sector strategies and action plans exist. Although many of these are out of date or in the amendment process, they include the National Environmental Action Plan 1998-2002, the National Biodiversity Strategy and Action Plan (NBSAP) (2002), the Ministry of Environment Strategic Plan 2001-2003, and the National Wetland Action Plan (NWAP). The NBSAP (2002) was one of the important tools to elaborate the convention on biodiversity by aiming to ensure that the benefits of sustainable biological resource use contribute to poverty reduction and the improved quality of life for all Cambodians.

Private Sector Investment Policy: This policy allows for investment by any entity. The policy framework includes a liberal foreign investment regime that allows a 100% foreign equity ownership investment. except the ownership of land. It also includes free remittance of foreign currencies abroad, no price controls on products or services, equal treatment of all investors, no nationalization adversely affecting the property of investors, and no foreign exchange controls on current account transactions. The Private Sector Investment Policy allows for investment in agriculture and agro-industry, energy, processing, tourism, and mining sectors. In addition, natural resources such as land, beaches, oil and gas, and minerals such as bauxite, gold, iron, manganese, phosphate rock, silica, and zircon can also be invested in (Sophal, 2010). The majority of these

resources now only remain in the Cardamom landscape and investment can even take place inside the sustainable use zone of any protected areas (Kingdom of Cambodia, 2008). It is extremely important that this policy be implemented in conjunction with the sustainable management of natural resources as specified in the RS and environment sectoral laws, policies, strategies, and action plans.

Law on Investment in the Kingdom of Cambodia: This law was first adopted in 1994 (Kingdom of Cambodia, 1994b) and amended in 2003 (Kingdom of Cambodia, 2003). The laws aim to govern all qualified investment projects and define procedures by which any person establishes a qualified investment project. Only qualified investment projects are entitled to the benefits subject to the scope of these laws. The CDC is obligated to be the sole and one-stop service organization responsible for the evaluation, decision making, monitoring of all rehabilitation, development and investment projects in Cambodia. Provisions on investment procedures, guarantees, and incentives, land ownership and use; employment practices; and disputes and dissolution are also clearly stated in these laws. With the new amendment, clear deadlines for decision making have been stated to encourage investors and avoid corruption. For example, the conditional registration certificate or a letter of non-compliance shall be issued to the applicant within three working days by the CDC after the receipt of the investment proposal. The laws also stated that all government entities responsible for issuing any related authorization, clearance, license, permit or registration shall be issued no later than the 28th working day from the date of the conditional registration certificate. Any government official who, without proper reason, fails to respond to an applicant's request by this deadline shall be punished by law. However, investment projects that are related to natural resource use should be strictly evaluated and monitored, especially those in the Cardamom landscape to avoid unsustainable use and resource depletion.

Environmental Protection and Natural Resources Law (1996): This law establishes the basic provision for environmental protection and preservation of natural resources within Cambodia, including important provisions on the requirement for

environmental impact assessments. This law focuses on MoE's responsibilities over pollution control issues and calls for the development of a National Environmental Plan.

Protected Area Law of 2008: The development of Cambodia's PA Law was initiated in 2001 and adopted in 2008. Some PAs are of special regional and/or international significance like the Biosphere Reserve comprising the Tonle Sap Multiple-Use Area. Cambodia has Ramsar sites that are, like PAs, under the jurisdiction of the MoE. These sites include the Boeung Tonle Chmar core zone of the Tonle Sap Multiple-Use Area, the Koh Kapik wetland and associated islets in the Peam Krasop Wildlife Sanctuary, and stretches of the Mekong River area between Stung Treng and the border with Lao PDR.

Article 11 provides instruction on PA zoning that each protected area shall be divided into four management zoning systems: 1) **core zone**–area(s) of high conservation value containing threatened and critically endangered species and fragile ecosystems–cannot be accessed except the NCPA's officials and researchers who, with prior permission from the MoE, 2) **conservation zone**–area(s) of high conservation value containing natural resources, ecosystems, watershed areas, and natural landscape located adjacent to the core zone–can be accessed only with prior consent of the NCPA and small-scale community uses of NTFPs to support local ethnic minorities' livelihood may be allowed under strict control, 3) **sustainable use zone**–area(s) of high economic value for national economic development and conservation of this area itself thus contributing to the local communities' livelihood–can be **permitted for development and investment activities**, and 4) c**ommunity zone**–area(s) for socio-economic development of the local communities and may contain existing residential lands, paddy field and field garden–can be issued land title or permission to use land in this zone in accordance with the land law.

The law on protected areas also stated that the MoE shall develop a National Protected Area Strategic Management Plan (NPASMP) and ensure that the plan is compatible and consistent with national plans such as the National Environment Action

Plan, NBSAP and the National Wetland Action Plan. The NPASMP should be adopted by the Royal Government of Cambodia at the request of the Ministry of Environment.

It is stated in the protected area law that the NPCA shall develop for each protected area an action plan to be approved by the Ministry of Environment and in accordance with the NPASMP. The process for the development of these plans shall involve coordination and consultations with local authority, local community, indigenous ethnic minorities' community and stakeholders. Article 20 also authorized the establishment of a National Committee for Conflict Resolution on Protected Area Management, chaired by the Minister of Environment with participation by relevant ministries and institutions, to assist in the discussion, consultation and conflict resolution on protected areas. The law also authorizes the NPCA to offset national community protected areas so that local people can sustainably use resources for their livelihoods, but only in the community use zones. These agreements last no more than 15 years.

Statement of the Royal Government on National Forest Sector Policy: The RGC has worked to accomplish forest resource conservation, good governance, social economic development, and poverty reduction since 2002. For forest resource conservation, the RGC is trying to reclassify and dedicate the major part of remaining natural forest stands to their ecosystems protection and biodiversity conservation functions; promote conservation and protection strategies such as protected forests, watershed management, genetic and wildlife resources conservation, eco-tourism, and special management areas with a maximum participation of the local population; implement the strict application of the Code of Practice as the regulatory framework for the sustainable management of forest resources and forest concessions; and conduct extension, education and public awareness campaigns at all levels of Cambodian society.

In good governance; the RGC has committed to implement capacity building, institutional strengthening and research programs at all levels; conduct education, training and public awareness campaigns, with particular regard to the participation of local populations within conservation and sustainable forest management plans; establish a forest administration in which necessary steps of devolution of decision-making power

can take place and in which functional procedures for multi-institutional collaborations are grounded; encourage, implement and coordinate multi-stakeholder processes that enable the harmonization of the different perceptions, interests and objectives of the various forest interest groups at local, regional and international levels; and promote transparent information for the forest sector.

Commitment to socio-economic development includes the promotion of high socio-economic value of forest ecosystems protection and biodiversity conservation functions of natural forest resources, the substitution of timber supply from natural forest stands by timber plantations through encouraging private investment and public participation, and the optimization of the use, processing and marketing system for forest products especially plantation forest products to support domestic demand and export.

The RGC's endeavor in poverty reduction is to legally recognize and protect the traditional rights of local populations to use forest resources under the framework of food security and poverty reduction considerations and to optimize the benefits to local populations from the use and management of forest resources through the implementation of forestry and wildlife conservation concept based on the participation of local populations.

In addition to the set of national goals directed towards the development framework for the conservation and sustainable management of forest resources, the RGC acknowledges international issues, processes and commitments occurring as a result of the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992 and its follow-up processes relevant to the country's forest resources. The RGC envisions that a long term National Forest Program (NFP) will be implemented consistent with the framework of the Intergovernmental Panel on Forests/Intergovernmental Forum on Forests promoted by the International Arrangement on Forests with the United Nations Forum on Forests and the Collaborative Partnership on Forests.

Forestry Law: This law is the major legal instrument for the Cardamom landscape, defining forest land classifications, management systems, enforcement, fiscal,

and other regulatory mechanisms. The objective of this law is to “ensure the sustainable management of the forests for their social, economic, and environmental benefits, including conservation of biological diversity and cultural heritage” (Kingdom of Cambodia, 2002). The Law outlines general rules and regulations related to administration and management of the permanent forestry estates within Cambodia, with management jurisdiction granted to the FA (except for those areas that fall within PAs under the MoE). The Forestry Law outlines the implementation of a resource-based approach and establishes a de-concentrated single-line organization. Public participation is provided for in the decision-making processes - classification of forests into categories for production, protection, and conversion purposes - and acknowledges traditional user rights of local communities. The basic structures, functions, and responsibilities of the FA are set forth along with the basic rules and regulations related to concession management, community forestry, traditional user rights, wildlife management, and forest crimes. It also ensures customary user rights of forest products and by-products for local communities.

National Forest Program 2010-2029: This program was adopted in 2010 by the RGC. The national program was developed to address, among other things, the National Forest Policy Statement of the RGC, the CMDGs, and the NSDP Update 2009-2013. The overall mission of the program is to achieve the sustainable management and development of forests for their contribution to poverty alleviation, enhanced livelihoods, economic growth and environmental protection, including conservation of biological diversity and cultural heritage. The objectives of this program are to: 1) maximize sustainable forest contributions to poverty alleviation, enhanced livelihoods and equitable economic growth, 2) adapt to climate change and mitigate its effects on local livelihoods, 3) integrate macro land-use planning that allows for holistic planning across sectors, jurisdictions and local government borders, 4) implement forest governance, law and enforcement at all levels, 5) develop a conflict management system, 6) raise awareness, capacity of institutions and quality of education to implement this program, 7) ensure environmental protection and conservation of forest resources, 8) apply modern

sustainable management models adaptive to changing context, and 9) develop sustainable financing systems. There are a total of 6 programs and 25 sub-programs targeted in this document and will be updated every 5 years. These include forest demarcation, classification and registration; conservation and development of forest resource and biodiversity; forest law enforcement and governance; community forestry programs; capacity and research development; and sustainable forest financing. The program also set a target to establish three million hectares of protected forests by 2029, which is critically important to turn all intact forest areas remaining in the Cardamom landscape to be protected forest. In general, this program is useful and has been implemented in cooperation with the Wildlife Alliance and CI for sustainable forest management in the Cardamom landscape.

Land Policy: The statement of the RGC on land policy highlights the need for coordination of land use planning with natural resource management in a harmonized legal framework that is directed towards enabling the achievement of national goals of economic development, poverty reduction, and good governance. The objectives are to: strengthen land tenure security and land markets; prevent or resolve land disputes, manage land and natural resources in an equitable, sustainable and efficient manner; and promote land distribution with equity.

Land Law: This law was adopted in 2001 (Kingdom of Cambodia, 2001a) to set out a comprehensive system of land classification and land ownership rights. It includes important provisions on social and economic land concessions (ELCs), indigenous land rights, land registration, and land dispute resolution. The land law also authorizes the enactment of a series of important sub-decrees and other legislation. The significant elements of this law for the forestry sector as well as the Cardamom landscape are three-fold: definition of state public property, definition of state private property, and definition of indigenous property under the collective ownership category.

The law distinguishes between state land in the public domain, such as forests and protected areas, and state land in the private domain, which is used to provide land for economic and social development. Indigenous property is a communal title, which is

vested in an incorporated community with bylaws, so the land registration certificate is to be considered equal to the right of a private person. The lands in the communal title that are part of the permanent forest estates may either be converted to private state land or remain public land meaning that the government can take back the land in the communal title which is state public land. The Sub-Decree on State Land Management provides the framework for state land identification, mapping, registration, and classification and notes where additional administrative guidelines are required.

The land law authorizes the granting of land concessions for either social or economic purposes. Land concessions must be based on a specific legal document, issued by the competent authority (in the case of forest, either MAFF or MoE) prior to the occupation of the land, and must be registered with the MLMUPC. There are three main types of land concessions in Cambodia, but all types are limited to an area of 10,000 hectares, and a maximum duration of 99 years: social land concessions–under which beneficiaries can build residential constructions and/or cultivate state lands for their subsistence; economic land concessions–under which beneficiaries can clear land for industrial or agricultural businesses; and use, development, or exploitation concessions–includes fishing, mining concessions, port concessions, airport concessions, and industrial development concessions. The Sub-Decree for Social Land Concessions (Royal Government of Cambodia [RGC], 2003b) regulates allocation of state private land to poor communities and households. The Council for the Development of Cambodia is responsible for authorizing investment projects to be implemented under concession contracts. In general, these apply to infrastructure projects.

Sub-Decree on Economic Land Concessions: The Sub-Decree on ELCs (Royal Government of Cambodia [RGC], 2005) was adopted in 2005 to provide criteria for granting ELCs. According to the land law, ELCs can only be granted over state private land. Although concessions cannot establish ownership rights over land, concessionaires are vested with all other rights associated with ownership during the term of the contract. ELCs granted prior to the passage of the land law are to be reduced to comply with the area limit, although an exemption may be granted if the reduction will compromise

exploitation in progress. Article 59 of the land law further prohibits the granting of concessions in several locations, jointly exceeding the 10,000 ha size limit, to the same person(s) or different legal entities controlled by the same person(s).

Article 4 of the Sub-Decree on ELCs states that an ELC may be granted only on land that meets all of the following five criteria: 1) the land has been registered and classified as state private land in accordance with the Sub-decree on State Land Management and the Sub-decree on Procedures for Establishing Cadastral Maps and Land Register or the Sub decree on Sporadic Registration, 2) a land use plan for the land has been adopted by the Provincial-Municipal State Land Management Committee and the land use is consistent with the plan, 3) environmental and social impact assessments have been completed with respect to the land use and project's development plan, 4) land that has solutions for resettlement issues and has no conflict with local communities, and 5) land for which there have been public consultations, with regard to the concession projects or proposals, with territorial authorities and residents of the locality.

Evaluation of ELC proposals shall be based on the following criteria: increase in agricultural and industrial-agricultural production by using modern technology, creation of increasing employment, promotion of living standards of local and indigenous people, continuous environmental protection and natural resources management, avoidance or minimization of adverse social impacts, linkages and mutual support between social land concessions and ELCs, and processing of raw agricultural materials to be specified in the concession contract.

ELCs must be exploited within 12 months of being granted, or will be considered cancelled. Concessions granted prior to the land law must be exploited within 12 months of the law's entry into force, or shall be cancelled. Any failure to fulfill the conditions of a concession shall be grounds for its withdrawal and concessionaires are not entitled to seek compensation for any damages resulting from the withdrawal of a concession. Article 18 of the land law states that land concessions that fail to comply with the above provisions are null and void and cannot be made legal in any form. Article 55 provides that concessions may be revoked by the government for non-compliance with legal

requirements and the concessionaire may appeal this decision. Further, a court may cancel the concession if a concessionaire does not comply with clauses specified in the contract. However, these regulations are not well implemented and due to the bad governance and corruption, hundreds of ELCs were granted to local tycoons, government high ranking officers or persons with close personal affiliation to leading politicians just holding them for future benefits, blocking other real investors from investing. Furthermore, ELCs granted in the Cardamom landscape always overlapped with natural forest covers that are home to rich biodiversity as presented in Appendix 1, 2, and 3 of this dissertation.

1.3- Conservation Status and Mechanism

For the creation of Strong Conservation Scenario (SCO), this section will review international instruments that the RGC has ratified and conservation status and mechanisms that have been implemented under the support of donor communities and in cooperation with conservation NGOs in the landscape.

1.3.1- International Instruments and Royal Government of Cambodia Obligations

In addition to national policies and regulations, Cambodia has also committed to international conventions, protocols, treaties, and agreements as shown in Appendix 4. Many of these instruments are related to the management of the Cardamom landscape.

Global Environment Facility (GEF): Cambodia became a member of GEF in 1995. The GEF provides grants and concessional funding for projects and programs that protect the global environment and promote sustainable development. It is the designated financial mechanism for the UN Framework Convention on Climate Change, the Convention on Biological Diversity, the Stockholm Convention on Persistent Organic Pollutants, and the Convention to Combat Desertification. GEF funds are only given for activities that benefit the global environment in six focal areas: biological diversity, climate change, international waters, the ozone layer, persistent organic pollutants, and land degradation (Ministry of Environment [MoE], 2002). In order to receive full support

and eligibility for this funding, Cambodia also signed most of the conventions as described above. As a result, Cambodia has received many short and medium term grants for projects such as sustainable forest management, community-ecotourism, and others (CEPF, 2010).

United Nation Framework Convention for Climate Change (UNFCCC): This convention was ratified by Cambodia in 1995 as a Non-Annex I party. A Non-Annex I party is recognized by the convention as being especially vulnerable to the adverse impacts of climate change with low-lying coastal areas or prone to desertification and drought. The objective of this agreement is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, to achieve such a level within a time frame sufficient to allow ecosystems to naturally adapt to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner. Being one of the 49 parties classified as a least developed countries (LDCs) by the United Nations, Cambodia is given special consideration under the convention on account of its limited capacity to respond to climate change and adapt to its adverse effects.

As a party to this convention, Cambodia is also obligated to reach the goals of reducing climate change impacts of critical natural and societal systems and most vulnerable groups and to shift towards a green development path by promoting low-carbon development and technologies. To fulfill these commitments, on 19 Nov 2013 during the High Level Segment of the United Nations Climate Change Conference in Warsaw, Cambodian Minister of Environment recognized that the increase of temperature will have catastrophic impacts for LDCs and requested Annex I Parties (developed countries) must strengthen their political commitments, leadership and willingness to increase the level of GHG mitigation ambition for the pre-2020 period in order to hold the global average temperature below 1.5° C above preindustrial level by 2100.

The Cambodian minister also called upon all parties to understand the sense of urgency to work towards a 2015 agreement, which should incorporate a broad range of commitments by all parties, in particular leadership of all countries to contribute to global climate action as indicated in Article 4.7 of the UNFCCC. The minister also requested for a comprehensive finance roadmap to provide new, additional and predictable public finance to developing countries to fill the gaps between 2013 and 2020 and encouraged developed countries to provide financial support of US$100 billion annually to developing countries by 2020 as indicated in the Copenhagen Accord.

Furthermore, Cambodia has recently adopted the Climate Change Strategic Plan 2014-2023 to guide climate-smart development of Cambodia in the next 10 years and the Strategic Plan on Green Growth 2013-2030 to navigate the country's economic development with consideration for environment and natural resources sustainability. However, the implementation of these plans is just starting and there are many obstacles such as lack of human and financial resources which might prevent Cambodia from the successful implementation of the plans as well as fulfilling its UNFCCC obligation. To date, the obligation to the UNFCCC has produced little result in preventing deforestation and forest degradation in the Cardamom landscape. Even though hundreds of thousands of hectares of forest areas were offset for carbon credit sale under several international agreements, hundred thousand hectares of forest also have been cleared every year under illegal logging, conversion to urbanization areas, sugarcane and other agro-industrial plantations (Open Development Cambodia, 2014a).

Kyoto Protocol to the UNFCCC: This protocol was ratified by Cambodia in 2002. The objectives of this agreement are: 1) to reduce or limit the emission of gases contributing to the greenhouse effect and causing climate change in the industrialized countries; 2) to enhance individual and combined effectiveness in scientific research and technology, the dissemination of technology and the application of ecologically sound practices and procedures; and 3) to encourage the development of systems to reduce uncertainties related to the climate system, the adverse effects of climate change, and its economic and social impact.

This Kyoto Protocol has the same objectives, principles and institutions as the UNFCCC convention, but significantly reinforces the convention by committing the parties under Annex I to individual, legally binding objectives for the reduction or limiting of their greenhouse gas emissions. However, only those parties to the convention who also become parties to the protocol are bound by the protocol commitments. The individual objectives represent a total reduction of greenhouse gases by at least 5% in relation to the 1990 levels in the commitment period 2008-2012.

Being a party to this protocol, Cambodia has developed policies and regulations to sell carbon sequestered to Annex I parties (developed countries) of the convention. In this context, the Cardamom landscape plays an important role in earning financial revenue for the country as well as for supporting sustainable forest or protected areas system management in the country. There are three main NGOs working with FA and MoE for carbon credits in the Cardamom landscape: 1) the Wildlife Alliance and FA are responsible for the Southern Cardamom Protected Forest, 2) CI and FA are responsible for the Central Cardamom Protected Forest, and 3) the FFI and MoE are responsible for Samkos and Aural Wildlife Sanctuaries. However, to date, no carbon credits have been traded and precise plan for benefit sharing with local communities was not yet developed.

United Nation Forum on Forests (UNFF): This instrument was created in 2000 and a comprehensive agreement was reached in 2007on a framework for an international agreement on forests. It was not legally binding, but the scope and issues were agreed by 192 countries in the United Nations and endorsed by the UN General Assembly. The agreement is now referred to informally as the forest instrument. The other important agreement reached was on setting four global objectives. One objective describes forest financing to reverse the decline in official development assistance for sustainable forest management and mobilize significantly increased, new, and additional financial resources from all sources for the implementation of sustainable forest management. Cambodia is still committed to this forum by implementing the national forest program 2010-2029 and seeks solutions for financial and technical assistance from the international community for its sustainable forest management.

Convention on Biological Diversity (CBD): This convention was ratified by Cambodia in 1995. The objective of this convention is to ensure the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. It is also to anticipate, prevent and attack the causes of significant reduction or loss of biological diversity.

Being a party to this convention, Cambodia is obligated to develop national strategies, plans, or programs for the conservation and sustainable use of biodiversity and integrate them as far as possible and as appropriate into relevant sectoral and cross-sectoral strategies, plans and policies. The country shall also ensure the success of conducting in situ conservation and ex situ conservation, improving public education and awareness, adopting incentive measures, promoting research and training, operating environmental impact assessment and minimizing adverse impacts, providing access to genetic resources and technology, exchanging information, and strengthening scientific cooperation on the conservation and sustainable use of biodiversity.

To implement this convention, the MoE was assigned by the RGC to be the focal point and lead a national committee to develop the Cambodian NBSAP as already reviewed above and coordinates the implementation of this strategy and action plan with relevant line-ministries. It seems that all the obligations have been slowly targeted and achieved with technical and financial support from governmental and non-governmental organizations. These are because central government support and leadership, long-term and consistent international support, and cross-sectoral consistency are not effectively integrated for the implementation of this convention.

Cartagena Protocol on Biosafety to the Convention on Biological Diversity: This protocol was ratified by Cambodia in 2003. It is a multilateral agreement that aims to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. The protocol also ensures adequate level of protection for the transfer, handling, and use of genetically modified organisms that may

have adverse effects on the environment and human health, specifically focusing on transboundary movements.

Responsibility for the implementation of this protocol is under the MoE who is the focal point of the CBD and MAFF who has its phytosanitary inspection agents in all international border check points. However, the capacity and capability of the inspection agents are limited. In addition, bad governance and corruption can make it virtually impossible to control the transboundary movements of the genetically modified organism production across Cambodia.

United Nations Convention to Combat Desertification (UNCCD): This convention was ratified by Cambodia in 1997. The objective of this convention is to combat desertification and mitigate the effects of drought in countries experiencing serious drought through international cooperation and partnership with a view to achieving sustainable development; to implement long-term integrated strategies that focus simultaneously on improved productivity of land and the rehabilitation, conservation and sustainable management of land and water resources, leading to improved living conditions; and to encourage the use of existing financial mechanisms.

In the spirit of the convention, combating desertification includes activities that are part of the integrated development of land in arid, semi-arid and dry sub-humid areas and are aimed at prevention and/or reduction of land degradation, rehabilitation of partly degraded land, and reclamation of decertified land. The Convention is being implemented through national, sub-regional and regional programs designed to form an integral part of a country's national sustainable development policy. They are updated under an ongoing participative process in the light of work on the ground and the results of research.

Under a 10-year Strategic Plan and Framework to enhance the implementation of the convention for 2008–2018, adopted at the eighth Conference of the Parties in Spain in 2007, the UNCCD aims to forge a global partnership to reverse and prevent desertification/land degradation and to mitigate the effects of drought in order to support poverty reduction and environmental sustainability. The Strategic Plan and Framework supports the development and implementation of national and regional policies, programs

and measures to prevent, control and reverse desertification/land degradation; and to mitigate the effects of drought through scientific and technological excellence, raising public awareness, standard-setting, advocacy and resource mobilization.

Being a party to this convention, the RGC has nominated MAFF to be the focal point of the UNCCD and developed policies, strategies, and programs such as the Cambodian National Program 2011-2018 to improve the living conditions of communities and ecosystems facing land degradation and climate change, the Strategy on Agriculture and Water, and other polices that already integrated into the NSDP as well as the RS.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES): This convention was ratified by Cambodia in 1997. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. This convention works by subjecting international trade in specimens of selected species to certain controls. All import, export, re-export, and introduction from the sea of species covered by the convention has to be authorized through a licensing system. Each party to the convention must designate one or more Management Authorities in charge of administering the licensing system and one or more Scientific Authorities to advise them on the effects of trade on the status of the species.

CITES Appendix I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances. Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival. Appendix III contains species that are protected in at least one country, which has asked other CITES parties for assistance in controlling the trade. Changes to Appendix III follow a distinct procedure from changes to Appendices I and II, as each Party is entitled to make unilateral amendments to it.

To implement this convention, the RGC has issued a Sub-decree on Implementation of CITES in Cambodia that assigned MAFF to be the Management Authority and FA and FiA as the Scientific Authorities. These authorities have identified

specimens of Cambodian species that related to the convention and restricted international trade through its licensing system. However, scientific findings for the conservation and sustainable use of long-tailed macaque, several reptiles, marine species and amphibian in Cambodia are a serious problem to be addressed.

Convention on Wetlands of International Importance (RAMSAR): This convention was ratified by Cambodia on 23 Oct 1999. The Convention provides a framework for national action and international cooperation for the conservation and sustainable use of wetlands and their resources. Contracting parties are also expected to manage all wetlands within their territories, in accordance with the principles of sustainable use, and to engage in international cooperation to further the convention's objectives. It calls upon contracting parties to recognize the interdependence of humans and the environment as well as the ecological functions of wetlands, such as wildlife habitat, nutrient cycling, and flood control. The Ramsar Convention is the oldest multilateral international conservation convention and the only one to deal with one habitat or ecosystem type, wetlands. As of August 2013 there are 168 contracting parties and 2,127 designated sites covering 205,448,714 hectares (507,674,830 acres) of wetland under this conservation.

Being a party to this convention and with technical support from Wetland International, Cambodia has designated three Ramsar sites with an area of 54, 600 ha under this convention. One of the three Ramsar sites is located in the Cardamom landscape, Koh Kapik that is described in the conservation areas section below. In addition, the National Wetland Action Plan has been adopted by MoE for the sustainable management of wetland in Cambodia. However, due to the lack of funding, comprehensive ground activities have not yet been conducted for the protection of the three sites as well as other important wetland areas in the country.

1.3.2- Conservation Areas

Cambodia has a long history of creating and managing protected area systems. In 1925 during the period of France domination, Cambodia declared 10,800 hectares of

forests surrounding Angkor Temple as the first national park in Southeast Asia (Wager, 1995). By the close of the 1950s, the French continued surveys, defined important forest and wildlife areas, and classified nearly one third of Cambodia land into 173 forest (3.9 million hectares) and six wildlife (2.2 million hectares) reserves (International Centre for Environmental Management [ICEM], 2003b).

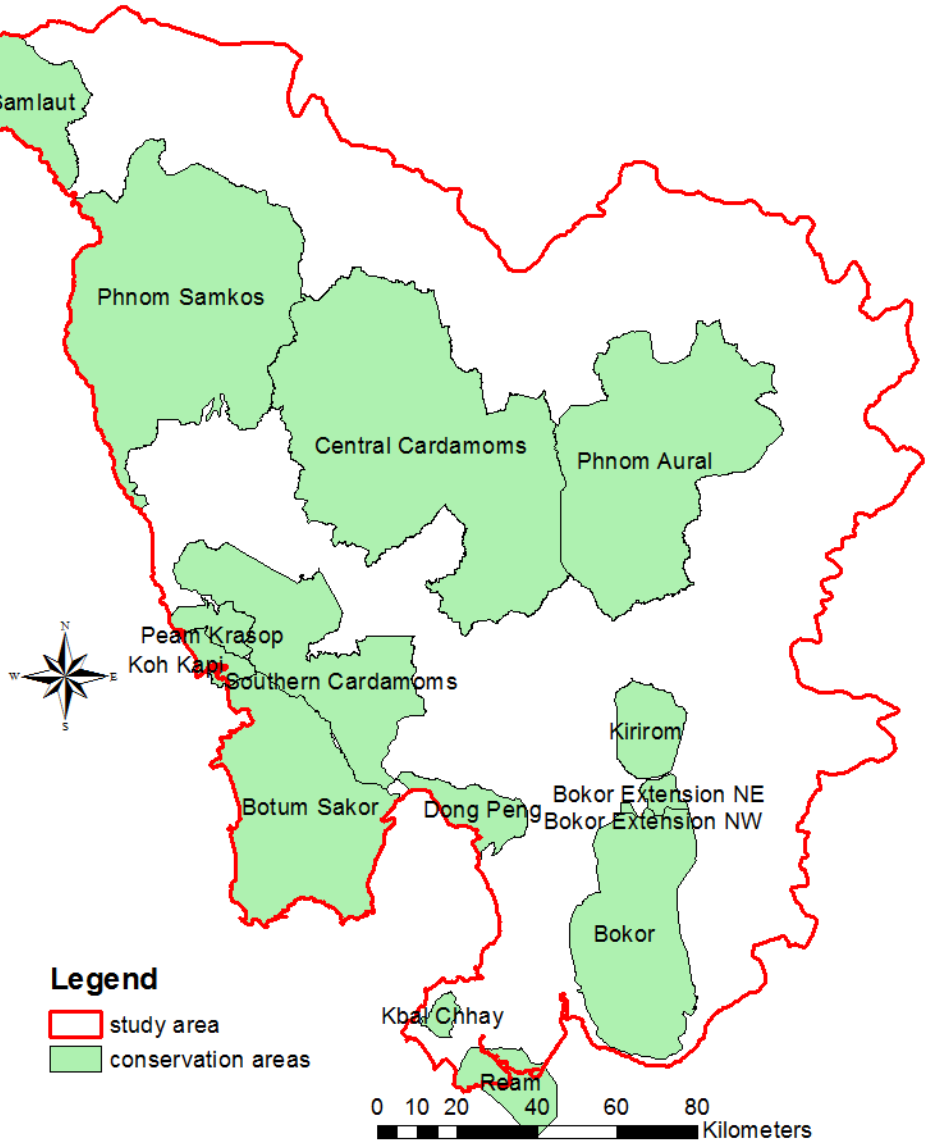
During the monarchy from 1953-1970, Cambodia's protected areas were strongly promoted as important economic and cultural national assets. The six wildlife reserves were reclassified into national parks and wildlife sanctuaries covering around 12% of the country. However, during the Khmer Republic Regime from 1970-1975, parks and sanctuaries were not staffed or managed. .

From 1975-1979, Cambodia fell under control of the Khmer Rouge Regime when about three million people were killed and national protected areas were wiped from the records. During the Vietnamese domination period from 1979-1993, the protected areas were not recognized and reestablished for 12 years. This period was very bad for Cambodian natural resources. The Forest along national roads was logged to eliminate the Khmer Rouge guerrilla, but timbers were transported to Vietnam. In addition, Russian and Thai forest concession companies began to have a significant impact on Cambodian forest cover, mainly along the border with Thailand and in selected areas relatively close to Phnom Penh.

Not until 1993, after the United Nations supervised elections in Cambodia, His Majesty King Norodom Sihanouk introduced a royal decree that designated 23 protected areas, covering about 3.3 million hectares (18.3% of the total land area) (Kingdom of Cambodia, 1993). This protected area system was put under the management of the newly established environment ministry–the MoE. Moreover, the MAFF also was given a mandate to establish fish sanctuaries, protected forests, community forests, and other site-based conservation areas. To date, after adding a growing number of fish sanctuaries, protected forests, and other site-based conservation areas, the number of environmental conservation areas has risen to a total of 32. The current level of territory set aside for conservation is at 26.3% (Dunai, 2008), among the highest national figures in the world.

Conservation areas include both protected areas that are managed by the MoE and protected forests and other site-based conservation areas that are managed by the MAFF. In the Cardamom landscape, there are a total of 15 conservation areas equal to 46% of the landscape. These conservation areas are divided into 6 categories: 3 protected forests, 3 wildlife sanctuaries, 4 national parks, 2 multiple use zones, 2 national park extensions, and 1 Ramsar site as shown in Figure 3.

Figure 3: Conservation Areas in the Cardamom Landscape



Central Cardamoms Protected Forest: This protected forest was established in 2002 with an area of 401,313 hectares (Royal Government of Cambodia [RGC], 2002b). The protected forest connects Phnom Samkos and Phnom Aural wildlife sanctuaries, forming one of Southeast Asia's largest conservation areas (Asian Development Bank [ADB], 2005a). The area contains large areas of three of the most threatened ecosystems in the region: lowland evergreen forest, riparian forests, and wetlands. Despite extensive logging, most of the forest still retains complete canopy closure, reducing fire risk and promoting natural regeneration (Soussan & Sam, 2011). It is home to the Asian Elephant, Indochinese Tiger, Pileated Gibbon, Siamese Crocodile, and other globally threatened wildlife (Coudrat et al., 2011; Daltry & Momberg, 2000; Rhim, Son, Kim, Hwng, & Lee, 2012). The Areng Valley that is located in the southeast part of this protected forest provides habitat for threatened waterbirds such as White-wing Wood Duck, Sarus Crane, Black-necked Stork, and Milky Stork and other endangered species of fish including the Asian Arowana and Back Fish (Bauld & Sovan, 2004). Threats to this area include illegal logging, hunting, and over-exploitation of natural resources. Conservation International and the FA are working together to protect the wilderness of this area through a ranger program and community-based conservation.

Southern Cardamoms Protected Forest: This protected forest was established in 2004 with an area of 144,275 hectares (Royal Government of Cambodia [RGC], 2004). Vegetation types in this area are a combination of dry evergreen forest, melaleuca woodland, and grassland. The protected forest connects the Botum-Sakor National Park to the Talam village community, Dong Peng Multiple Use Area, and Kirirom National Park. This area provides habitat for globally endangered wildlife such as the Asian Elephant, Indochinese Tiger, Pileated Gibbon, and other birds (Daltry & Momberg, 2000; WildAid, 2003). National Road 48 cuts through the southern part of the area from east to west, creating development pressure and many threats to biodiversity and ecosystem services. However, this area still plays a critical role for the Asian Elephant providing a corridor to move from the Botum Sakor all the way to the Kirirom and possibly Bokor National Parks. The area also provides ecotourism potential since it is easy to access.

The Wildlife Alliance (formally called WildAid) and the FA are working together through zoning and demarcation, ranger patrol, community agriculture development, community-based ecotourism, public education and awareness, wildlife reintroduction, and reforestation to ensure the sustainable development of the area.

Kbal Chhay Protected Forest: This protected forest was established in 1960 (before Khmer Rouge regime) and reestablished after the regime as the protected forest in 1996 with an area of more than 6,000 hectares. The area is the main watershed to supply clean water to the city of Preah Sihanouk. Construction of a reservoir for this city began in the 1960s, however, it was interrupted due to civil war, and the site became a hide-out for the Khmer Rouge. In 1997, the Cambodia government awarded a contract to the Kok An Company to develop the area for tourism (Kbal Chhay Waterfall) and supply clean water to the city. Today, this protected forest has provided and demonstrated valuable ecosystem services to the country.

Phnom Samkos and Phnom Aural Wildlife Sanctuaries: These wildlife sanctuaries were established in 1993 with areas of 333,750 hectares and 253,750 hectares, respectively (Kingdom of Cambodia, 1993a). The Phnom Samkos and Phnom Aural Wildlife Sanctuaries have similar ecosystem profiles, consisting of lowland dry dipterocarp, lowland dry evergreen, lower and upper hill evergreen, extensive pine, gallery forests (along rivers), bamboo, and some marshes and grasslands (Japan International Cooperation Agency [JICA], 2003). They contain the highest elevation forests in Cambodia and support many unique plant and animal communities (Coudrat et al., 2011; Daltry & Momberg, 2000; L. L. Grismer, Neang, Chav, & Wood, 2008; Webb, 2005). Many new species and first records of reptile and amphibian were recently found in these wildlife sanctuaries (J. L. Grismer et al., 2010; Neang et al., 2010; Neang, Chhin, Kris, & Hun, 2011; Neang et al., 2012). However, these sanctuaries are threatened by illegal logging, hunting, over-exploitation of NTFPs, and ELCs permitted by the RGC (Bradfield & Daltry, 2009; Grieg-Gran et al., 2008; Neang, 2009). The FFI and the MoE are working together through community protected areas and other programs to ensure the biodiversity conservation and sustainable development of these wildlife sanctuaries.

Peam Krasop Wildlife Sanctuary: This wildlife sanctuary was established in 1993 with an area of 23,750 hectares (Kingdom of Cambodia, 1993a). This area is completely covered by coastal wetland, including mangrove and melaleuca forests and has around 10,000 people living within its borders (International Union for Conservation of Nature [IUCN], 2009). Besides the considerable floral biodiversity, twenty-four species of mammals, at least twenty-eight species of birds, and a large number of marine species have been identified (Dara, Piseth, Mather, & Kim Sreng, 2009). The area is also home to several globally threatened species such as the Irrawaddy Dolphin, Finless Porpoise, and possibly Dugong (Beasley & Davidson, 2007). Major threats affecting biodiversity loss are illegal logging, hunting and over-fishing. Illegal land encroachment, or land grabbing, has also been and remains a problem. The mangrove forests were heavily impacted by the cutting of mangrove trees for charcoal production and shrimp farms (Razvi & Singer, 2011). The area is influenced by inter-tidal levels and water from highland areas, and provides favorable conditions for fishery and other resources. Many people reside in this area and are dependent upon the natural resources for their livelihoods, including intensive shrimp aquaculture, large scale charcoal production, and other aquatic resource collection for family consumption and sale.

Botum Sakor National Park: This national park was established in 1993 with an area of 171,250 hectares (Kingdom of Cambodia, 1993a). Satellite images in 1988/89 indicated that 87% of the area was in a natural or semi-natural state, with a large expanse of dense evergreen forest and significant areas of mangroves, dunes, and aquatic plant formations. This park provides critical habitat for the Asian Elephant to forage, especially during the dry season when the high elevation habitats dry up and also a place to escape from hunting and forest fire. Other globally threatened mammal species such as the Sunda Pangolin, Bengal Slow Loris, Indochinese Lutung, Indochinese Tiger, Pig-tailed Macaque, Dhole, Sun Bear, White-winged Wood Duck, Lesser Adjutant, Milky Stork, Green Peafowl, Silvered Pheasant, and other reptiles are found in this park (Royan, 2009, 2010). However, after the Protected Area Law was adopted in 2008, this park was significantly impacted by development. The first major project was ecotourism

development by the Union Development Group of China that developed more than 36,000 ha of coastal area to be a modern city. Other projects that threaten the park are also ELCs that were granted by the RGC for sugarcane, acacia plantations, and ecotourism. It is impossible to protect the wilderness and biodiversity of this park since so many large projects have been permitted by the RGC.

Kirirom National Park: This national park was established in 1993 with an area of 35,000 hectares. The park is largely covered by semi-evergreen forest, with drier deciduous forest at lower elevations and an extensive area of pine forest on a central plateau (Japan International Cooperation Agency [JICA], 2003). The park provides habitat for the Asian Elephant, Indochinese Tiger, Malayan Sub Bear, Pileated Gibbon, Indochinese Lutung, Pig-tailed Macaque, Stump-tailed Macaque and other globally threaded birds (Coudrat et al., 2011; Daltry & Momberg, 2000). A new species of Harrison's Tube-nosed Bat was also discovered in this park (Csobra & Bates, 2005). Moreover, ecosystem services such as the water supply for Kirirom I and III hydropower dams and ecotourism have been also provided by this park. However, similar to other conservation areas this park is facing threats such as illegal logging and hunting and land encroachment (Lacerda, Schmitt, Cutter, & Meas, 2004). The MoE is working hard to protect this park through ranger programs, public education, zoning, and demarcation.

Bokor National Park: This national park was established in 1993 with an area of 140,000 hectares. The park is dominated by evergreen forests in the south and southwest and semi-evergreen green forests in the northeast. The forests are relatively intact apart from northern areas of the park, which were heavily logged. This area is home to Indochinese Tiger, Pileated Gibbon, and other reptiles (Coudrat et al., 2011; Eames, Steinheimer, & Bansok, 2002; Rawson & Senior, 2005). Recently, the RGC has granted this park to a private company for ecotourism investment. Additionally, a hydropower plant was constructed in the southeast part of the park to utilize the water supply.

Bokor National Park Extension NE and Extension NW: These extensions were established in 2002 by a government sub-decree with areas of more than 7,000 hectares and about 1,000 hectares respectively. The purpose of these extensions is to build a

corridor reconnecting Bokor to Kirirom National Parks. Forests along national road 4 located in the middle of this corridor are heavily fragmented due to resettlement and land encroachment. The Asian Development Bank has supported BCI projects since 2005 to rebuild the corridor however efforts to regain forest cover in that corridor have been slow.

Ream National Park: This national park was established in 1993 with an area of 150,000 hectares. The park encompasses both terrestrial and marine habitats including beaches, mangrove forests, and tropical jungles. The park was reported to have Malayan sun bear, fishing cat, leopard and tiger, though leopard and tiger may be on the verge of extinction (IUCN, 1997). Notable bird species include green peafowl, Indian pied hornbill, and great hornbill. A number of large waterbird species are found in the mangroves and associated mudflats, including the endangered milky stork and lesser adjutant (ICEM, 2002). There are also reports of the endangered masked finfoot in the mangroves. Crocodiles have also been occasionally reported in the Prek Toek Sap, and at least two species of marine dolphin have also been observed (ADB, 2000; Beasley & Davidson, 2007). In February 2012, construction work and road building was going on at the southeastern tip of the park in order to create a small tourist resort. All this seems to be funded by Chinese capital. It was not clear how all this fits into the idea of protecting threatened species in the area. Park rangers stated that many animals had fled from the area since 2011.

Dong Peng Multiple Use Area: This area was established in 1993 with an area of 27,700 hectares. Part of this area also overlaps with the Important Bird Area (IBA) of Cambodia. This area mainly encompasses the Melaleuca forest and swamp which contains numerous small wetlands and grassland. The area is important for a range of large waterbird conservation such as the Milky Stork, Painted Stork, Woolly-necked Stork, Black-necked Stork and Lesser Adjutant. Because of its clarification as a multiple use zone, the area is heavy used. Illegal land encroachment, Melaleuca forest clearing, land speculation and poor governance are the main threats to this area.

Samlaut Multiple Use Area: This area was established in 1993 with an area of 60,000 hectares. It is located north of the Cardamom landscape. The area is the last remaining tropical rainforest in northwestern Cambodia. It is home to a wide array of rare vegetation and wildlife, including the endangered Asian Elephant. Due to the limited resources of Cambodia, this area received little government management or support for wildlife enforcement and nature conservation. In 2003, the Maddox Jolie-Pitt Foundation began to support the park. An agreement was signed by the Cambodian Ministry of Environment, the National Park Service of the United States, and Maddox Jolie-Pitt Foundation making the Sequoia and Kings Canyon National Parks sister parks to Samlaut (MoE, 2006). The agreement facilitates the sharing of experience, skills, technical knowledge, and professional abilities between the two protected areas.

Koh Kapik Ramsar Site: This site was established in 1999 with an area of about 13,500 hectares. The area encompasses alluvial islands immediately off the mainland of Koh Kong province. The site consists of two main wetland types; estuarine waters, and intertidal mud, sand or salt flats; and the extensive mangrove stand is representative of a still-functioning mangrove ecosystem in the Gulf of Thailand. The area plays a critical role in providing a nutrient source supporting coastal fishery in the near-shore and offshore waters of Cambodia. It is also home to globally threatened bird and mammal species such as the critically endangered Giant Ibis, the endangered Sunda Pangolin, and Indochinese Lutung. At present, much of the degraded mangrove area has been replanted through coordinated efforts of the agencies and local communities in the area.

1.3.3- Conservation Mechanisms

While protected areas often form the core of conservation strategies, there are other conservation strategies that complement protected areas. This section reviews other conservation approaches.

Other Site-based Approaches: A number of site-based measures have been established to contribute to integrated conservation strategies. These include community forests, community protected areas, important bird areas, no fishing areas/fish refuges,

reforestation zones, and even various agricultural systems. Many of these approaches are already part of Cardamom landscape management strategies. **Community forests** are forests owned and managed by FA. They are allocated to communities under a 15-year agreement. These forests are managed by the local communities with technical support from the FA. The management of these forests is also financially supported by several international NGOs. The primary goal of community forests is to protect and rehabilitate forests and to enhance the sustainable use of forest resources of the communities. **Community protected areas** are managed by MOE and are composed of four zones: core, conservation, sustainable use and community use. Part of the community zone can be designated as a community protected area. Similar to community forests, the goal for these areas is to promote the sustainable use of natural resources inside the protected area system. The MoE and FFI are working together to implement this mechanism in Samkos and Aural Wildlife Sanctuaries. **Important Bird Areas (IBA)** have been identified and defined by the FA with technical support from BirdLife International. As mentioned earlier, there is an IBA that is located close to and overlaps with the Dong Peng Multiple Used Area in Sre Ambel district. The purpose of IBAs is to monitor and follow up the status of important bird species. **Reforestation zones** are defined by the FA to reforest degraded areas. As stated in the CMDGs and the National Forest Program, reforestation has been targeted as a key mechanism to increase the country's forest cover to 60% by 2015. In the Cardamom landscape, there is a reforestation project that is being implemented by the Wildlife Alliance and the FA to rebuild elephant corridors in the landscape.

Species-based Approaches: Various initiatives focus conservation efforts on particular species or groups of species. Usually, species-based approaches are funding initiatives that support a variety of approaches contributing to the conservation of the target species in question. Often, targeted species are wide-ranging species for which conservation area approaches are only partially effective. One species targeted by such initiatives is the Asian Elephant. The Asian elephant is a wide-ranging species can be used as an umbrella species for other biodiversity conservation. For example, the purpose

of the establishment of the Southern Cardamom Protected Forest was to protect elephant corridors, and this objective was clearly stated in the title of the sub-decree. As a result, many conservation activities have been conducted by the FA and Wildlife Alliance such as zoning and demarcation, reforestation, public education, and alternative livelihoods for local communities in the corridors (Wildlife Alliance, 2009, 2010, 2011, 2012).

Another species targeted by the species-based approach is the Siamese Crocodile. There were two approaches. The FFI and FA's Cambodia Crocodile Conservation Program in the O'Som Commune (Veal Veng District, Pursat Province) used a participatory conservation model, which provided incentives to local communities to manage their natural resources and develop sustainable agriculture with assistance from a partner NGO, the Cambodian Centre for the Study and Development of Agriculture (Sony et al., 2009). The second approach was a direct payment scheme introduced by CI's Conservation Stewardship Program for Crocodile conservation at the Chumnoab Commune (Thmar Bang District, Koh Kong Province). It provided financial payments for community rangers to achieve conservation targets including removing wildlife snares, reducing poaching of wildlife, prohibition of illegal fishing techniques, and illegal harvest of forest products. Sony et al. (2009)'s evaluation, found that both approaches were successful in achieving Crocodile conservation goals.

Other species-based approaches have been used with tigers with funding directed toward education and the control of illegal trade, Sea Turtles with efforts to understand migration routes and increasing populations and Irrawaddy Dolphin with efforts focusing on education and community involvement in the landscape.

Ecosystem Approaches: Conservation efforts and funding are increasingly directed to ecosystem-level projects. These projects seek to recognize ecological landscape linkages in which natural systems provide services that impact different human land use regimes. Such projects are often interdisciplinary and involve the participation of diverse stakeholders including those responsible for natural resource conservation, land management, and rural development. . Current ecosystem-level projects in the Cardamom landscape include the Biodiversity Conservation Corridor Initiative (funded

by ADB). This initiative is making funds available to support the work in the Southern Cardamom landscape and the Coastal Zone Management Project (primarily funded by the Danish International Development Agency) which has supported integrated conservation and development efforts in Cambodia's coastal provinces. Conservation areas often form the core of such landscape efforts. Both planning and management of the conservation area system should encourage and support these activities.

Community Based Conservation: With the exception of very remote areas, ecological systems are fundamentally linked with and affected by people who live and work in these areas. Many of the threats to conservation features arise from anthropogenic activities incompatible with long-term conservation. Successful conservation at virtually all levels therefore requires the support and participation of local people. This approach is often closely linked with conservation area management and governance. In Cambodia, this linkage is being formalized legally through inclusion in the protected area law (Kingdom of Cambodia, 2008), officially promoted through integration with standardized protected area planning policies and has been applied as a structured component of recent protected area management planning efforts.

Policy Advocacy and Government Lobbying: Although these are often seen as sensitive or confrontational areas for engagement, they can also be powerful agents of change. Advocacy and lobbying can originate both from outside and inside government policy agencies and has resulted in a number of positive steps. Dialogue and advocacy surrounding the formulation of Cambodia's Protected Area Law (Kingdom of Cambodia, 2008) is an example of advocacy at work as many provisions of the law would not have appeared without the input of numerous stakeholders (Dunai, 2008). Cancellation of a titanium mining project and numerous ELC projects in the middle of the elephant corridor would not be possible without clear explanation of the on the ground situation to policy decision makers. Of course, a strong strategic plan for each project must be created including the involvement of donor support, scientific proof, and media witnesses. All conservation organizations that are working in the Cardamom landscape have their own styles of conducting this approach.

Education and Public Awareness: Efforts to expand conservation awareness and ensure that conservation becomes part of the country's educational system are vital long-term approaches to conservation. NGOs such as Mlup Baitong, Save Cambodia's Wildlife, and the Wildlife Alliance have been engaged in education and public outreach activities for years. Kouprey Express has been implemented by the Wildlife Alliance in the Cardamom landscape. It has been conducted through a well-equipped mobile bus with build board display, video and slide shows, and PowerPoint presentation. Recently, the FFI has committed significant resources to the establishment of a Master's degree program in Conservation Biology at the Royal University of Phnom Penh. The program has convinced many national students to be scientists. At the national level, the Ministry of Environment recently partnered with the Ministry of Education's various projects to emphasize the importance of conservation education for Cambodia's youth and the public at large. Many protected areas in Cambodia lend themselves to facilitating and encouraging conservation education and awareness-raising but development of appropriate visitor and interpretive facilities has a long way to go.

Law Enforcement: Law enforcement is needed to ensure all regulations are respected. In the Cardamom landscape, there are many ranger programs that enforce the land law, protected area laws, law on forestry and other laws. Illegal land encroachment, logging, and hunting have been identified as the main target for law enforcement in the landscape. Most of the conservation areas in the landscape consist of ranger programs that are supported by NGOs. The Wildlife Alliance supports 15 staff of the FA and about 100 military police officials to patrol the Southern Cardamom Protected Forest with six base stations located on the main waterways and roads. Conservation International has been supporting the FA a community ranger program to patrol and monitor the Central Cardamom Protected Forest. Moreover, the MoE also has its own park rangers to guard each individual protected area, though with limited capacity. However, this mechanism seems to produce few results due to the corruption and nepotism of the court system that leads to impunity of the rich and powerful and only poor people are prosecuted.

Reducing Trade in Wildlife and Other Biological Resources: Southeast Asia has an active illegal trade in wildlife and other biological resources (Mainka & Mills, 1995; Martin & Phipps, 1996; Sun, 2000). Cambodia has been involved in recent ASEAN-wide efforts to increase enforcement and strengthen regional cooperation in this area. A number of NGOs and regional governments continue to provide technical inputs for identifying and suppressing illegal trade. With large natural and semi-natural areas still intact and a potentially high level of plant endemism, Cambodia also has an incentive to carefully manage its genetic resources.

1.4- Development Status

This section will review all development activities in the landscape to create the Strong Development Scenario (SDE) for this study. There are many investment projects that have been approved in Cambodia as well as in the Cardamom landscape under the RGC's investment policies and legislation. The biggest investor in Cambodia is China with an investment capital of more than USD 7 billion (Sophal 2010) followed by Korea and Malaysia with capital investments of USD 2.8 billion and USD 2.2 billion, respectively. The main sectors attracting investment are tourism (53%), services (21%), industry (20%), and agriculture (6%).

1.4.1- Special Economic Zone (SEZ)

The SEZ scheme was reintroduced into Cambodia in December 2005. SEZs are managed by the Cambodian Special Economic Zone Board of the CDC. To govern the SEZ scheme, a Sub-Decree No. 148 on the Establishment and Management of the Special Economic Zone (Sub-Decree on SEZs) was issued on 29 December 2005. In addition, the law on the Special Economic Zones has been drafted by the CDC in 2008 and is now under examination by the RGC.

According to Sub-Decree No. 148, the SEZ refers to the special area for the development of economic sectors which brings together all industrial and other related activities and may include General Industrial Zones and/or Export Processing Zones.

Each Special Economic Zone shall have a Production Area which may have a Free Trade Area, Service Area, Residential Area and Tourist Area. The SEZ must be more than 50 hectares with precise location and geographic boundaries, a surrounding fence, management office buildings and administration offices, a water sewage network, waste water treatment network, location for storage and management of solid wastes, environment-protection measures, and other related infrastructure (RGC, 2005).

The strategic location of the Cardamom landscape next to the Gulf of Thailand makes it attractive for SEZ location. There are 12 SEZs that have been developed in the landscape to produce products and directly export through the sea (Council for the Development of Cambodia, n.d.). Six SEZs are located in Preah Sihanouk, four in Koh Kong, one in Kampot, and one in Pursat. The development of these SEZs has brought thousands of factory workers into the landscape, increased pressure on natural resource use, encouraged immigration, and polluted the landscape due to the poor governance. The RGC needs to do careful conservation planning to reduce the negative environmental impacts of development projects.

1.4.2- Mining Concessions

Mining has been prioritized by the RGC for a long term economic development. To date, there are a total of 208 concessions that have been permitted throughout Cambodia including 34 located in the Cardamom landscape (Open Development Cambodia, 2014a). These projects are small-scale quarries producing materials for construction, such as laterite, marble, granite, limestone, gravel, and sand. Compared to other countries such as Lao and Vietnam, the mining sector in Cambodia is still largely undeveloped. There has been no industrial scale extraction of precious minerals, although in recent years there have been a large number of exploration licenses granted to both local and international companies.

Due to various factors, including decades of civil war, proliferation of landmines and unexploded ordnances, and inadequate infrastructure, Cambodia lags far behind its

neighbors in development of this sector. Sand dredging is the main concern of conservation NGOs in the Cardamom landscape.

1.4.3- Economic Land Concessions (ELCs)

Under the 2001 Land Law, state land is divided into state public land and state private land. State public land is any land of natural origin (such as rivers, lakes, forests), land that provides a general public use (such as schools, hospitals, roads), and archaeological and cultural heritage sites (Kingdom of Cambodia, 2001a). State private land is any state land that does not provide a public service or come under any of the other categories of state public land. According to this land law and the sub-decree on ELCs, ELCs can only be legally granted on state private land (RGC, 2005). In addition, the law states that ELCs cannot exceed 10,000 hectares, and that the same person or legal entity cannot hold several concessions that total more than 10,000 hectares. This also applies to several legal entities controlled by the same person. ELCs can be granted for a maximum of 99 years (although 70 years is most typical) and concessionaires must begin operations within one year of the concession being granted. If a concessionaire does not comply with the legal requirements, the concession can be cancelled. According to the 2008 protected area law, ELCs can also be granted in the sustainable use zone of each protected area by the MoE (Kingdom of Cambodia, 2008).

ELC development has been one of Cambodia's controversial issues in large part because of corruption and nepotism that permits development that goes beyond the rules governing ELC development. Because of a lack of transparency in the way ELCs are granted, it is very difficult to assess exactly how many ELCs have been approved, which concessions are active, and how much state revenue has been raised. According to the MAFF website and information from the MoE, a total of 117 ELCs have been granted throughout Cambodia by the RGC and 23 ELCs are currently located in the Cardamom landscape (RGC, 2012) (Figure 4). Open Development, an international NGO, reported in 2014 that this number ELCs has increased to 36 (Open Development Cambodia, 2014a). The ELC investment includes tourism development and agro-industrial

plantations for products such as rubber, sugarcane, cassava, palm, cashews, and acacia. Ecotourism development in this context is Chinese based which usually converts the natural forest habitat into a modern resettlement. For example, the tourism project of the Union Development Group is converting more than 36,000ha of Botum Sakor National Park coastal area into a modern city, which is completely different from the western ecotourism style. For this study, 23 ELCs will be included for the current land management scenario (MCD), 36 ELCs for the SDE, and only 16 ELCs for the strong conservation scenario.

1.4.4- Social land concessions

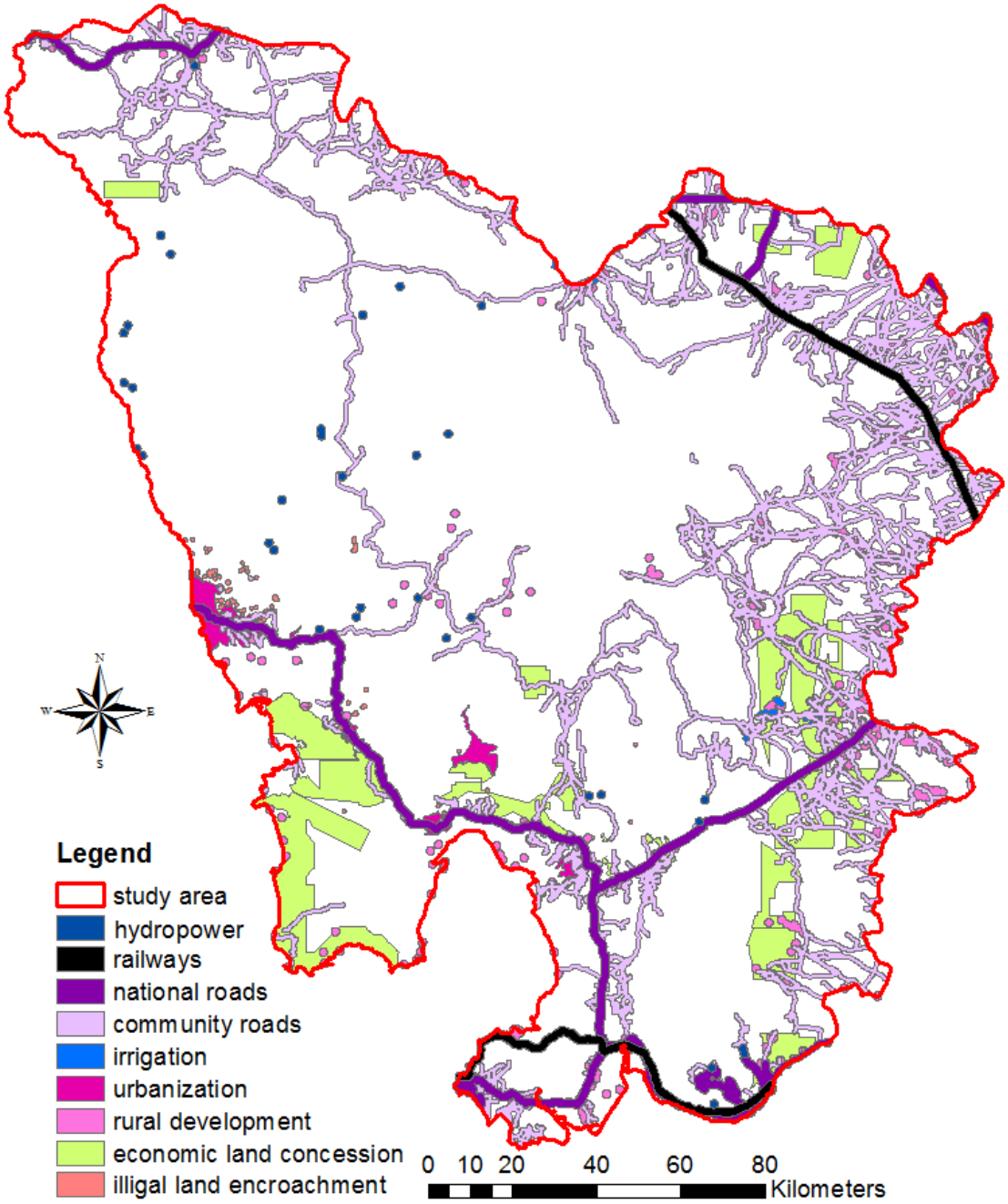
Three social land concessions have been planned in Koh Kong province of the Cardamom landscape. The allocation will be based on the Sub-decree on Social Land Concession (RGC, 2003b). The RGC has decided that the Cardamom landscape is the only opened space for resettlement of demobilized soldiers and other poor families. However, environmental impacts will occur as a result of resettlement. Thousands of hectares of forest clearing will be conducted in the planned areas and more pressure on using surrounding forests for livelihood of newcomers will affect the elephant corridor and biodiversity. To minimize the effect from social land concession development, the Wildlife Alliance is in the process of lobbying the RGC to allocate these land concessions in strategic locations so less forest will be destroyed and resettled people will have closer access to water, health clinics, markets, and public transportation. This NGO will also make sure that the development will be consistent with the BCI project that supported by the ADB and the provincial authority.

1.4.5- Hydropower Development

The Cardamom landscape has large potential areas for hydropower development. Sixteen hydropower projects have been studied in the landscape with an estimated installed capacity of 1,731 MW, of which 9 are currently operational, under construction or planned (operational: Kirirom I and Kamchay, under construction: Kirirom III, Stung Russey Chrum, Stung Tatay, or planned: Stung Battambang, Stung Pursat, Stung Metoek,

Stung Chhay Areng) (Figure 4). This potential is expected to supply up to 50 percent of the country's energy needs. This is because of the heavy rainfall and river network that flow through the landscape.

Figure 4: Development profile of the Cardamom landscape



However, all of these hydropower facilities would mostly be managed as a concession under a build, operate, and transfer model agreements, where investors assume responsibility to design the facility, obtain financing, oversee their construction and operate them to recover the investment and to make a profit. At the end of the concession period, which in Cambodia is generally 30 years, the facility is returned to the state. This is the multimillion dollar investment and the energy sources are intended to supply power to neighboring towns and communities. However, hydropower also creates large environmental impacts. The first impact is the forest destruction caused by these projects due to forest clearing in the reservoir and power line areas. Furthermore, sub-contract the reservoir forest clearing projects to logging companieshas led to the whole forest area destruction due to bad governance and corruption of government institutions. The second impact is the change of ecosystem that is caused by the different water regime between the upstream and downstream areas. In the Cardamom case, upstream area face community floods, for example, the Chhay Areng hydropower now needs to move three communities away from the project area (International Rivers, n.d.). The downstream area suffers from reduced water flow, which causes water shortages for agriculture and community uses. Biodiversity is also affected due to the change of ecosystem, especially fish and aquatic species that can’t migrate through the dam construction between upstream and downstream.

Other effects of this development include immigration, settlement, and pollution that are caused by each project. Immigration happens as a result of the project's employment and usually creates settlement around the project areas. Pollution is one of the biggest issues. There is a concern that foreign companies have little incentive to reduce environmental impacts. If settlement occurs in the areas, more forest destruction happens because of a higher demand for wood for house construction and firewood for energy.

1.4.6- Irrigation Development

Recognizing the importance of water management for promoting the country's rice production, the Royal Government of Cambodia and donors are making efforts to expand the irrigated area in Cambodia. The expectation is that irrigation will make farmers less reliant on rainfall, allowing them to cultivate more crops with more certainty and predictability, resulting in higher productivity and better livelihood outcomes. Based on this policy, the MOWRAM has been assigned to be responsible for irrigation development in the country. Many construction projects have been planned and completed in the Cardamom landscape, especially in eastern parts to provide irrigation water for agriculture. Even though this development appears to improve rural community economy, it also has negative landscape impacts because it expands the road network, which opens the area to illegal land clearing for agricultural expansion, immigration, fuel wood gathering, timber harvest and poaching.

1.4.7- Infrastructure Development

Infrastructure development has been targeted as one of the RGC's policies to strengthen the national economy and eliminate rural poverty. The Fourth Legislature of the RGC was elected to continue the rehabilitation and development of transport infrastructure, including further construction and maintenance of roads, expansion of port capacity, restoration and development of railroads, expansion of airport services, and strengthening of flight safety and traffic safety. In the Cardamom landscape, there are three national roads (National Road 4, 5, and 48), two railways (the southern railway is connecting from Phnom Penh to Kampot and Preah Sihanouk and the northern railway connecting from Phnom Penh to Battambang and Poipet), and other many secondary and community roads. The construction of the new National Road 48 created remarkable pressure on natural resource management of the landscape. It created significant forest destruction, brought in new immigrants, and encouraged other development activities along the road. Illegal logging and hunting in the area have also significantly increased.

The rehabilitation of the two railway lines to handle higher volumes of cargo traffic and be part of the Asian Railway Network through linkage with the railway network in Thailand and Vietnam will create the same experience. According to a Loan Agreement (Greater Mekong Subregion (GMS) Rehabilitation of the Railway in Cambodia) between the Kingdom of Cambodia and ADB, the ongoing project's objective is to facilitate sub-regional trade and economic growth in Cambodia by providing a cost-effective and efficient transport railway. The railway link through Cambodia is also an integral part of the GMS southern economic corridor, which is one of 11 flagship programs under the GMS sub-regional economic cooperation. However, the donor and the RGC have to take into account the indirect impacts on the Cardamom landscape that might result from this development.

1.4.8- Urbanization

There are two types of urbanization in the Cardamom landscape. The first type often undertaken by the government enlarges district and provincial towns. The second is implemented through leasing ELCs for 99 years to foreign companies to develop tourism projects. For example, the development a 36,000 ha site within the Botum Sakor National Park by the Chinese Union Development Group (Hance, 2012) is creating a huge and fancy master plan for this area's development with several highways, a modern sea port, an international class airport, a luxury residential area, and a high class resort.

However, either type of urbanization converts natural forests into modern cities and increase human density in the area, create more pressure on natural resources uses, and attract other development activities. In the case of Chinese development, it might not benefit much to the Cambodian people since the concession rental fee is extremely cheap (maximum USD 10 per hectare per year) (Ministry of Agriculture Forestry and Fisheries [MAFF], 2012). To balance the development and conservation of the Cardamom landscape, the RGC must take into account proper management of the area including the elimination of deforestation drivers, such as stopping ELC permission, improving the tax

system, fighting corruption and nepotism, and supporting local communities through appropriate environmentally compatible development projects.

1.4.9- Community Development

Based on the RGC's governance reform plan, decentralization and deconcentration are encouraged to happen at the commune level. Many projects are supported by government and donors directly to the commune councils of each province of the landscape. Each commune council requested to develop its own commune annual development project proposal to submit to the government and donors for support. Based on my own review, many of those projects are illegal and environmentally incompatible. Those include projects to improve community livelihood through infrastructure and agriculture expansion inside conservation area systems, which again creates more pressure for sustainable forest management in the areas. There is a lack of understanding of environmental and ecosystem issues in each commune council, which might lead to the implementation of incompatible projects that decrease natural resources and affect their livelihood in the long term.

Chapter 2: Land Management Planning in the Cardamom Landscape: Implications for Biodiversity Conservation and Economic Development

2.1- Introduction

The management of land resources is the basis of the livelihoods of most of Cambodia's population and is a dominant part of the national economy. Although other sectors are growing rapidly, agriculture accounted for nearly 1/3 of Cambodia's GDP and directly employed over 50% of the workforce (Hill & Menon, 2013), whilst nearly 80% of the population still live in rural areas (Löhr, 2011). Other natural resource-based sectors such as forestry and fisheries are also important and the multiplier effects of agriculture and related sectors in areas such as trade and processing increase their significance in the national economy. Despite recent economic progress, Cambodia remains poor, ranking 138th in the world in terms of the UNDP's Human Development Index (United Nations Development Programme [UNDP], 2013). The recent global economic downturn and rising food prices have together shown the potential vulnerability of emerging growth sectors to external conditions and the management of land resources remains the foundation of livelihoods and food security for the majority of Cambodia's population.

The increasing recognition of the importance of ecosystem goods and services to economic growth and poverty reduction comes at the same time as evidence that human pressure on ecosystems is negatively impacting the provision of these services. Land degradation pressures such as deforestation and soil erosion have emerged as important issues in the development debate in Cambodia, directly affecting the productivity of agriculture as well as impacting water resource availability, the availability of fish and forest products and other key ecosystems services.

There are also concerns over the integrity of important ecosystems including ecosystems in the Cardamom landscape – ecosystems that contain biodiversity resources of global significance and provide a wide range of other vital services to people living both in the immediate vicinity and further afield. This study represents the first attempt at a comprehensive evaluation of a number of important ecosystems services in the Cardamom landscape. Three landscape management scenarios representing different

views of how the Cardamom landscape should be managed are evaluated in terms of their effect on four ecosystem services. .

2.2- Methods

2.2.1- Formal statement of the problem

Three stakeholder groups have different opinions and strategies to manage the Cardamom landscape. The private sector, along with several government agencies responsible for economic development, such as the CDC, the MEF, the MoC, the MIME, the MRD, the MPWT are in favor of developing the Cardamom landscape into cities, industrial agriculture, hydropower dams and power lines, mining concessions, highways, sea ports and other forms of development. In contrast, donor communities and NGOs state that the Cardamom landscape is the largest landscape remaining in Southeast Asia and should be protected for biodiversity conservation and ecosystem services. The Cambodian government with assistance from other line ministries such as the MoE and the MAFF is trying to balance the two different interests. This chapter develops three scenarios that are broadly reflective of these three views on how to manage the Cardamom landscape. To wisely manage this important landscape, it is important to integrate environmental and economic principles. Each landscape scenario is evaluated and compared on how well it delivers on various environmental and economic objectives.

2.2.2- Threat mapping

Literature reviews and field investigations indicate nine main threats in the Cardamom landscape. Urban development (URD) is one of the main threats and is usually driven by population growth, national economic development, globalization, privatization, and private sector investment policies. Direct impacts of this threat consist of habitat degradation and biodiversity loss, forest clearing, illegal logging, and hunting. Similarly, village development (VID), especially in the form of social land concessions, which clears additional forest land for displaced people, reduces forest cover. Railway (RAW) and national road (NAR) construction threaten the landscape by increasing access

to the area and encouraging immigration that caused deforestation and biodiversity loss. There are many commune council proposals to develop community roads (COR) and irrigation system development (IRD) which again attracts immigration and causes deforestation and biodiversity loss just at a smaller scale. Hydropower development (HYD) that is permitted by the government is not only destroying forests in the construction areas, but also encouraging more illegal logging. ELCs in the landscape are the most destructive threat to biodiversity because this development replaces natural forest cover by plantations. There are also many cases of illegal land encroachment (ILE) in the landscape that are caused by lack of clear land tenure, weak law enforcement, and lack of good governance (Figure 5).

Figure 5: Divers and direct impacts of threats to the Cardamom Landscape

2.2.3- Defining Land Use Land Cover Scenarios

I used the Cambodian national land cover map produced by the MPWT in association with the Japanese International Cooperation Agency (JICA) (JICA, 2003) to generate the baseline land use land cover (LULC) change map for the Cardamom landscape. I also developed three landscape management scenarios of LULC change for

the 2002–2052 time periods. The three landscape management scenarios are: 1) strong conservation (SCO), 2) mixed conservation and development (MCD), and 3) strong development (SDE). I compared Thematic Mapper satellite imagery between 2002 and 2006 to estimate the extent of change over 50 years using current rates of change. This was done in three reference landscapes. One located in a conservation zone (within a protected area), a second outside of a protected area, but not in an area of intensive development, and a third in a high development zone. I then visited each of these reference areas to verify changes and buffer distances.

The strong conservation scenario is a future land management option that land is put into conservation by minimizing all development activities, improving law enforcement, limiting the number of ELCs, and increasing CA as much as possible in the landscape. This scenario LULC map is predicted based on conservation initiatives of donors and NGO community's arguments for conserving the Cardamom landscape. These arguments include the recommendation on the establishment of conservation areas and pressure for cancellation of inappropriate development projects as well as the reduction of illegal logging, hunting and land encroachment around settlement and along infrastructure. Criteria and buffer distances for defining this scenario was provided in Table 4.

The mixed conservation and development scenario is the current government land management option that balances conservation and development. This scenario LULC map is based on the RGC's sustainable natural resource management policies with all impacts and threats that are occurring on the landscape today. Based on previous year satellite imageries of land use changes and my direct field investigation, many threats must be buffered to include all existing impacts in this scenario. Criteria and buffer distances for defining this scenario was shown in Table 4

The strong development scenario is a future land management option where all planned development activities are allowed to occur, such as permitting all ELCs that planned by the private sectors even though they are located in the current CAs. The LULC map of this scenario is predicted based on development pressure caused by the

RGC's investment policy and private sector's investment projects. This development pressure includes both ongoing and planned development activities that already occurred and will happen during the study period of the landscape. Criteria and buffer distances for defining this scenario was provided in Table 4

Table 4: Criteria for Creating Landscape management Scenarios

Threat	SCO	MCD	SDE
Urban development	Includes all areas	Includes all areas	Buffers 2000m
Rural development	Buffers 500m	Buffers 1000m	Buffers 2000m
Development along railways	Buffers 500m	Buffers 1000m	Buffers 2000m
Development along national roads	Buffers 500m	Buffers 1000m	Buffers 2000m
Development along community roads	Buffers 250m	Buffers 500m	Buffers 1000m
Hydropower development	Buffers 500m	Buffers1000m	Buffers 2000m
Irrigation development	Includes all areas	Includes all areas	Buffers 2000m
Economic Land concession	16 ELCs	23 ELCs	36 ELCs
Illegal land encroachment	Will be enforced	500m	1000m

2.2.4- Description of InVEST model

InVEST is a suite of software models used to evaluate ecosystem goods and services provided by a landscape. To date, the InVEST tool set includes 14 ecosystem service models and can be run as an extension to GIS or as a standalone program (Tallis et al., 2013). For my study; I used five models of InVEST: carbon sequestration, habitat quality and degradation, water yield, water scarcity, and valuation of hydropower value. I also used an agriculture production model. These models were used to compare the outcomes of different scenario to show which scenario provides the greatest economic return and landscape sustainability.

2.2.5- Modeling Ecosystem Services

2.2.5.1- Carbon sequestration

The carbon storage model applied to the Cardamom landscape includes the sizes of three carbon pools: aboveground biomass, belowground biomass, and dead organic matter. Aboveground biomass is comprised of all living plant material above the soil (e.g., bark, trunks, branches, leaves). Belowground biomass encompasses the living root systems of aboveground biomass. Dead organic matter includes litter as well as lying and standing dead wood. Due to data deficiency, soil carbon pool was not included in this analysis.

The InVEST carbon storage and sequestration model aggregates the amount of carbon stored in these pools according to the LULC map of each scenario. Using maps of LULC types and the amount of carbon stored in carbon pools, this model estimates: the net amount of carbon stored in a land parcel over time and the market and social values of the carbon sequestered in remaining stock.

The model runs on a gridded map of cells called raster format in either GIS or as a standalone model. Each cell in the raster is assigned a LULC type such as forest, orchard, or water reservoir. For each LULC type, the model requires an estimate of the amount of carbon in the three pools described above. I estimated the aboveground carbon pool based on Sasaki (2006), Kapos et al. (2010), Top et al. (2006), and van Beukering et al. (2009). I then calculated the belowground carbon pool by using Cairns et al. (1997)'s regression $\boldsymbol{C_{below} = EXP(-1.0587 + 0.8336 * Ln(C_{above}))}$ and dead organic pool based on Harmon and Sexton (1996), which is assumed to be equal to 15% of aboveground pool. All these carbon pools were calculated in metric tons per hectare (tC/ha) as provided in Appendix 5.

I used the MCD LULC map as the current LULC and SDE and SCO LULC maps as the future LULC to calculate the net change in carbon storage over a 50 year time period to estimate the carbon sequestration/loss and its social value and compare the differences between the current MCD and alternate future landscapes of SDE and SCO. For this analysis, I assumed the time path of carbon sequestration is a linear transition

over 50 years and used an estimate of the social cost of carbon of USD 43 per metric ton (Nelson et al., 2009). I also applied a 4% market discount rate (Sasaki, 2010; van Beukering, Cesar, & Janssen, 2003), and 0% carbon discount for this analysis. I reported outputs of the model expressed in Mg of carbon per grid cell and the value of sequestration in dollars per grid cell.

Valuation is applied to sequestration, not storage, because current policies relate to carbon sequestration. The social value of a sequestered ton of carbon is the social damage avoided by not releasing the ton of carbon into the atmosphere. There are two discount rates that determine how the social value of carbon sequestration changes over time. The first discount rate is the standard economic discount rate that reflects the fact that people typically value immediate benefits more than future benefits. The second discount rate adjusts the social value of carbon sequestration over time. This value will change with the impact of carbon emissions on expected climate change-related damages changes. If we expect carbon sequestered today to have a greater impact on climate change damages than carbon sequestered in the future, this second discount rate should be negative. On the other hand, if we expect carbon sequestered today to have less of an impact on climate change mitigation than carbon sequestered in the future, this second discount rate should be positive.

2.2.5.2- Biodiversity

I first defined habitat as "the resources and conditions present in an area that produce occupancy – including survival and reproduction – by a given organism" (Hall, Krausman, & Morrison, 1997). High quality habitat for a species has the structure and function within the range of historic variability of habitat used by that species. Habitat quality usually declines in proximity to anthropogenic disturbances and the intensity of these disturbances. In the Cardamom landscape application, I used the Asian Elephant as the target conservation object for this model because it is an umbrella species and its population density is stable and high. Elephants are also important for ecotourism.

Maps of the LULC are transformed into maps of habitat quality for elephants. Habitat quality in a grid cell is a function of the LULC in the grid cell, the LULC in

surrounding grid cells, and the sensitivity of the habitat in the grid cell to the threats posed by the surrounding LULC. Each LULC type is given a habitat suitability or quality score of 0 to 1. For example, lowland dry evergreen forests suitable for elephants (habitat suitability=1), but settlement areas are not suitable for elephants (habitat suitability=0). Appendix 6 shows how a particular LULC type is considered as an elephant habitat and its specific sensitivity to each threat.

Besides a map of LULC and data that relates LULC to habitat suitability, the model also requires data on habitat threat density and its effects on habitat quality. In general, I consider human modified LULC types that cause habitat fragmentation, edge, and degradation in neighboring habitat threats. The conversion of a habitat LULC to non-habitat LULC reduces the size and contiguity of neighboring habitat patches which impose "edge effects" on habitat parcels and can have negative impacts within habitat parcels by, for example, facilitating entry of predators, competitors, invasive species, or toxic chemicals and other pollutants. Further, in the Cardamom landscape, road construction is a threat to forest habitat quality because of roads provide access to timber and NTFP harvesters. This impact of threats on habitat in a grid cell is a factor of the degradation source's weight, the distance between habitat and threat source, the level of legal/institutional/social/physical protection from disturbance in each cell, and the relative sensitivity of each habitat type to each threat on the landscape as described above. Appendix 7 shows all threats in the landscape, scores of the degradation source's weight, and the maximum distance between habitat and threat source across space.

Then, I analyzed habitat quality for the three landscape scenarios with a set of threat layers for each modeled scenario and assume that the relative weights of threats and sensitivity of habitat to threats do not change over time. I used the threat data table as shown in Appendix 7 and the habitat sensitivity data table as shown in Appendix 6 to generate a habitat quality and degradation score for each scenario. These habitat quality scores should be interpreted as relative scores with higher scores indicating landscapes more favorable for the elephant and other related species conservation. The landscape habitat quality score cannot be interpreted as a prediction of species persistence on the

landscape or other direct measure of species conservation in the same way that the output of the carbon model is an estimate of the actual carbon stored on the landscape. The InVEST habitat model does not convert habitat quality measures into monetary values.

To convert this habitat quality into monetary value, I model changes in habitat quality, elephant population, and ecotourism revenue in the landscape. The model is based on the following principle:

To examine the above relationships, two linear equations were used. The first equation is between ecotourism revenue as the dependent variable and elephant population as the independent valuable at each site. This relationship defined as follows:

$$Y_i = a + b\,E_i + \varepsilon_i \quad (1)$$

where, Y_i is the return from ecotourism for site *i*, E_i is elephant population at site *i*, ε_i is the error at site *i*, *a* is the intercept, and *b* is the slope of this regression.

The second relationship is between elephant population as the dependent variable and the sum of habitat quality as the independent variable. The equation for this relationship can be written as follows:

$$E_i = c + d\,HQ_i + \alpha_i \quad (2)$$

where HQ_i is the sum of habitat quality for site *i*, α_i is the error at site *i*, *c* is the y intercept, and *d* is the slope of this regression.

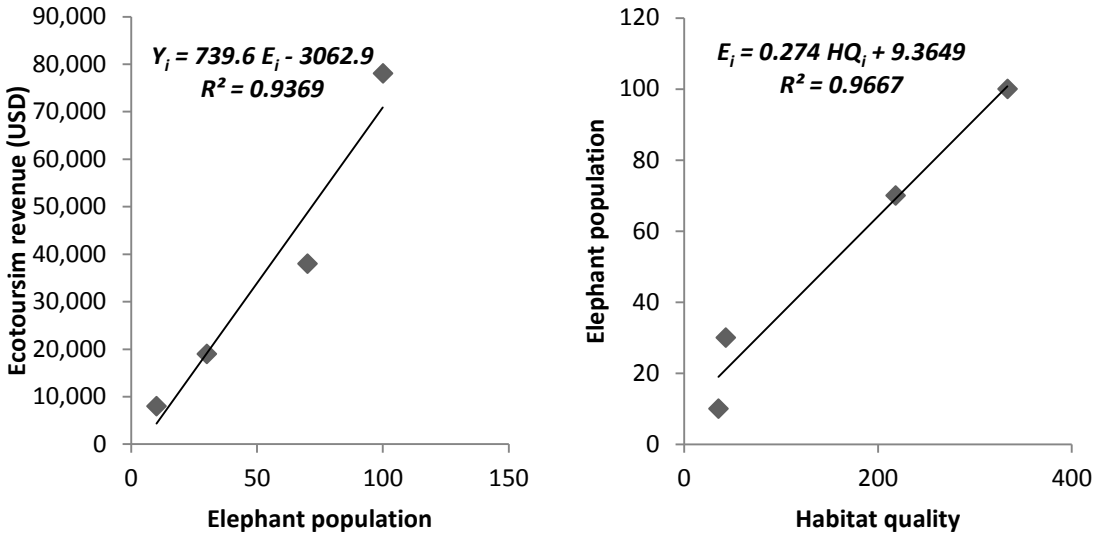
Then, I predict the ecotourism revenue depends on habitat quality by combining the two equations as follows:

$$Y_i = a + bc + bd\, HQ_i + \delta_i \quad (3)$$

where, Y_i, HQ_i, a, b, c, and d are as defined above and δ_i is the error at site i of this equation.

I used four existing community-based ecotourism projects in Chi Phat, Trapeang Rung, Chambak, and Tatay communes and excel scatter plot to define these regressions. The annual ecotourism revenue of each ecotourism project was obtained from reports (Pichdara, 2012; Reimer & Walter, 2013) and the elephant population at each ecotourism site was estimated based on previous surveys (Wildlife Alliance, 2011, 2012) and my field investigations. Finally, the sum of habitat quality for each ecotourism site is calculated from InVEST's biodiversity model. The results of using simple linear regression analysis are shown in Figure 6.

Figure 6: Relationships between ecotourism revenue, elephant population, and habitat quality



The relationship between elephant population and habitat quality was predicted with the R^2 is 0.9667 and the standard error of estimate is 9 elephants. The relationship between ecotourism revenue and the elephant population was predicted with the R^2 is 0.9369 and the standard error of estimate is USD9,473.

To get the whole landscape ecotourism value, I applied equation (3) to the InVEST habitat quality map of each scenario. Similar to other services, I applied a 4% annual discount rate to calculate the total value over the 50 year time.

2.2.5.3- Water Yield

The water yield is the first step of the InVEST reservoir hydropower model. It determines the amount of water running off each pixel, which is calculated as the difference between precipitation and evapotranspiration. This model is based on the Budyko curve and annual average precipitation. The annual water yield Y(x) for each pixel on the landscape x as follows:

$$Y(x) = \left(1 - \frac{AET(x)}{P(x)}\right).P(x)$$

where, *AET(x)* is the annual actual evapotranspiration for pixel *x*, and *P(x)* is the annual precipitation on pixel *x*.

For vegetated LULC, the evapotranspiration partition of the water balance, $\frac{AET(x)}{P(x)}$ is an approximation of the Budyko curve developed by Zhang et al. (2001):

$$\frac{AET(x)}{P(x)} = \frac{1 + w(x)R(x)}{1 + w(x)R(x) + \frac{1}{R(x)}}$$

where, *R(x)* is the dimensionless Budyko dryness index on pixel *x*, defined as the ratio of potential evapotranspiration to precipitation (Budyko, 1974) and *ω(x)* is a modified dimensionless ratio of plant accessible water storage to expected precipitation during the

year. As defined by Zhang et al. (2001), *ω(x)* is a non-physical parameter to characterize the natural climatic-soil properties. The non-physical parameter is defined as follows:

$$w(x) = Z\frac{AWC(x)}{P(x)}$$

where, *AWC(x)* is the volumetric plant available water content. The soil texture and effective rooting depth define *AWC(x*), which establishes the amount of water that can be held and released in the soil for use by a plant, estimated as the product of the difference between field capacity and wilting point and the minimum root restricting layer depth and vegetation rooting depth. Root restricting layer depth is the soil depth at which root penetration is strongly inhibited because of physical or chemical characteristics. Vegetation rooting depth is often given as the depth at which 95% of a vegetation type's root biomass occurs. This root depth value was given in the table of Appendix 8. *Z* is a seasonality factor that represents the seasonal rainfall distribution and rainfall depths. Rainfall in the Cardamom landscape is high (9 months per year), so I used 8 as the Z value for this analysis.

Finally, I define the Budyko dryness index, where *R(x)* values that are greater than one denote pixels that are potentially arid (Budyko, 1974), as follows:

$$R(x) = \frac{Kc(lx).ETo(x)}{P(x)}$$

where, *ETo(x)* is the reference evapotranspiration from pixel *x* and *Kc(lx)* is the plant (vegetation) evapotranspiration coefficient associated with the LULC l*x* on pixel *x*. *ETo(x)* reflects local climatic conditions, based on the evapotranspiration of a reference vegetation such as grass of alfalfa grown at that location. *Kc(lx)* is largely determined by the vegetative characteristics of the LULC found on that pixel (Allen, Pereira, Raes, & Smith, 1998). *Kc* adjusts the *ETo* values based on the crop or vegetation type in each pixel of the LULC map, and is then used to estimate actual *ET (AET)* for the watershed, one of the model outputs.

For other LULCs (open water, urban, wetland), actual evapotranspiration is directly computed from the reference evapotranspiration ETo:

$$AET(x) = Kc(lx).ETo(x)$$

where *ETo(x)* is the reference evapotranspiration, and *Kc(lx)* is the evaporation factor for each LULC. The estimated *Kc* value is provided in Appendix 8.

2.2.5.4- Water Scarcity

Water Scarcity is the second step of the InVEST reservoir hydropower model. It calculates the water scarcity value based on water yield and water consumptive use in the watershed(s) of interest. Appendix 9 shows how much water is consumed by each LULC type that is calculated based on Bhagabati et al. (2012). These land use-based values only relate to the consumptive portion of demand; some water use is non-consumptive such as water used for cooling or other industrial processes that return water to the stream after use. For simplicity, each pixel in the watershed is either a "contributing" pixel, which contributes to hydropower production, or a "use" pixel, which uses water for other consumptive uses. This assumption implies that land use associated with consumptive uses will not contribute any yield for downstream use. The amount of water that actually reaches the reservoir for dam d is defined as the difference between total water yield and total consumptive use in the watershed. This water consumption is calculated as follows:

$$V_{in} = Y - u_d$$

where u_d is the total volume of water consumed in the watershed upstream of dam d and Y is the total water yield from the watershed upstream of dam d.

If the user has observed data available on actual annual inflow rates to the reservoir for dam d, they can be compared to V_{in}. This is done by dividing the observed values by the estimated values to derive a calibration constant. This can then be entered

in to the hydropower calibration table and used to make actual power and value estimates rather than relative.

2.2.5.5- Valuation of Hydropower Value

In the third step, the reservoir hydropower model estimates for each scenario, the amount of energy produced, the value of that energy, and the present value dollar estimate for the entire remaining lifetime of the reservoir. The net present value can be calculated using current hydropower production cost data. The energy produced and revenue are then redistributed over the landscape based on the proportional contribution of each sub-watershed to energy production. Final output maps show how much the energy production and hydropower values can be attributed to each sub-watershed's water yield over the lifetime of the reservoir.

So, at dam d, power is calculated using the following equation:

$$p_d = \rho \,.\, q_d \,.\, g \,.\, h_d$$

where p_d is power in watts, ρ is the water density (1000 Kg/m^3), q_d is the flow rate (m^3/s), g is the gravity constant (9.81 m/s^2), and h_d is the water height behind the dam at the turbine (m) (Appendix 10). In this model, we assume that the total annual inflow water volume is released equally and continuously over the course of each year.

The power production equation is connected to the water yield model by converting the annual inflow volume adjusted for consumption (V_{in}) to a cubic meters per second flow rate. Since electric energy is normally measured in kilowatt-hours, the power p_d is multiplied by the number of hours in a year. All hydropower reservoirs are built to produce a maximum amount of electricity. This is called the energy production rating, and represents how much energy could be produced if the turbines are 100% efficient and all water that enters the reservoir is used for power production. However, in the real world, turbines have inefficiencies and water in the reservoir may be extracted for other uses like irrigation, retained in the reservoir for other uses like recreation, or released from the reservoir for non-power production uses like maintaining flows downstream. To

account for these inefficiencies, the flow rate, and power unit adjustments, annual average energy production ε_d at dam d is calculated as follows:

$$\varepsilon_d = 0.00272 \,.\beta\,.\, y_d \,.\, h_d \,.\, V_{in}$$

where ε_d is hydropower energy production (KWH), β is the turbine efficiency coefficient (%), y_d is the percent of inflow water volume to the reservoir at dam d that will be used to generate energy.

To convert ε_d, the annual energy generated by dam *d*, into a net present value (NPV) of energy produced (point of use value), we use the following,

$$NPVH_d = (p_e \varepsilon_d - TC_d) \,.\sum_{t=0}^{T-1} \frac{1}{(1+r)^t}$$

where TC_d is the total annual operating costs for dam *d*, and p_e is the market value of electricity (per unit of energy consumed) provided by the hydropower plant at dam *d*. T_d indicates the number of years present landscape conditions are expected to persist or the expected remaining lifetime of the station at dam *d* (set *T* to the smallest value if the two time values differ), and *r* is the market discount rate. The form of the equation above assumes that TC_d, p_e, and ε_d, are constant over time.

Energy production over the lifetime of dam *d* is attributed to each sub-watershed as follows:

$$\varepsilon_x = (T_d \varepsilon_d).(\frac{c_x}{c_{tot}})$$

where the first term in parentheses represents electricity production over the lifetime of dam *d*. The second term represents the proportion of water volume used for hydropower production that comes from sub-watershed *x* relative to the total water volume for the

whole watershed. The value of each sub-watershed for hydropower production over the lifetime of dam *d* is calculated similarly:

$$NPVH_x = NPVH_d \,.\, (\frac{C_x}{C_{tot}})$$

The hydropower energy and value grids are the most relevant model outputs for prioritizing the landscape for investments that wish to maintain water yield for hydropower production. The hydropower value grid contains the most information for this purpose as it represents the revenue attributable to each sub-watershed over the 50 year lifetime of the hydropower stations. In my case, the energy values do not vary much across the landscape, so the hydropower energy outputs are very useful in planning and prioritization. Comparing any of these grids between LULC scenarios allows me to understand how the role of the landscape may change under different management plans. Appendix 10 contains all data needed and simply feed into InVEST to run.

2.2.5.6- Agriculture

The net present value of agricultural crop production in the landscape depends on cultivated areas, crop type and cycle, yield, crop prices and production costs. LULCs that are considered to be cultivated areas include orchards, paddy fields, dryland crops, swidden agriculture, forest plantations, rubber plantations, receding and floating rice fields, and parts of development areas inside settlement and along roads (JICA, 2003).

I obtained crop cultivated areas from the three scenario LULC maps. I determined each crop type, cycle, and yield based on MAFF statistics data (MAFF, 2013). The production price for each crop was taken from the Cambodian agriculture market information website (MAFF, 2014).

For this analysis, I assumed that 20% of the settlement area is cultivated by villagers for family consumption and sale. This included mostly vegetable and other fruit trees (village crops). I also assumed that 20% of land cover along roads were crops such as maize, sweet potatoes, soybean, cassava, and others (road crops) that are cultivated by

villagers and agricultural enterprises. Large scale agricultural included all ELCs that generally cultivate agro-industrial crops such as cassava, sugarcane, oil palm, cashew nut, rubber, acacia and eucalyptus (industrial crops). I aggregated the yield and prices of all crops cultivated in each agriculture land type (i.e. village, road, and industrial). The crop production period is also included in this analysis. For example, rice and other vegetable productions can be produced up to 3 times per year depending on the variety and irrigation conditions. So, the production yield for these crops is calculated as annual bases. Then, I estimated the agriculture value as follows:

$$NPVAG = CA(x).PY(x).CP(x).(1 - PTC).\sum_{t=0}^{T-1}\frac{1}{(1+r)^t}$$

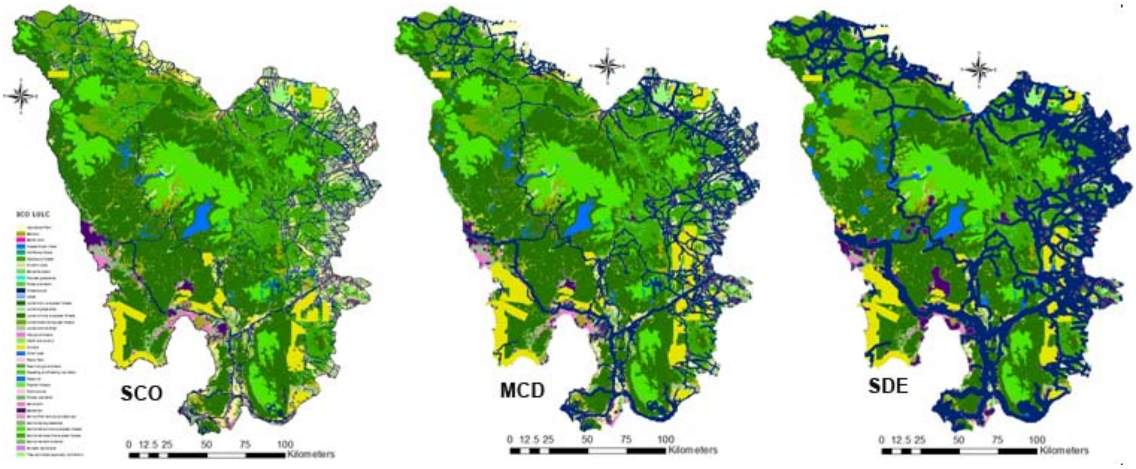
where *CA(x)* is the cultivated area for crop *x* calculated in ha, *PY(x)* is the production yield for crop *x* calculated in matrix ton per ha per year, *CP(x)* is the price of crop *x* calculated in USD per ton, *PTC* is the fraction of production and transportation cost, *T* is the 50 year timeframe, and *r* is the 4% market discount rate. Due to limitation of data on production cost, I calculate the *PTC* based on Dararath et al. (2011) and (MAFF, 2013), which is 25.65% for tree plantations and 44.63% if they are cash crops and others.

2.3- Results

2.3.1- LULC maps

LULC maps of the three scenarios are shown in Figure 7. Green color indicates nature habitat and blue color indicates disturbances caused by development activities. Yellow color shows ELCs granted by the RGC in the landscape. Based on the above criteria, the future conservation LULC map (SCO), the current LULC map (MCD), and the future development LULC map (SDE) consisted of about 16%, 26%, and 40% of disturbance, respectively. SDE converts natural habitats to other LULCs two and a half times as much as the SCO. These habitat conversions mostly occurred at the edge areas around the landscape.

Figure 7: Land Use Land Cover maps of the three landscape scenarios



2.3.2- Carbon Sequestration

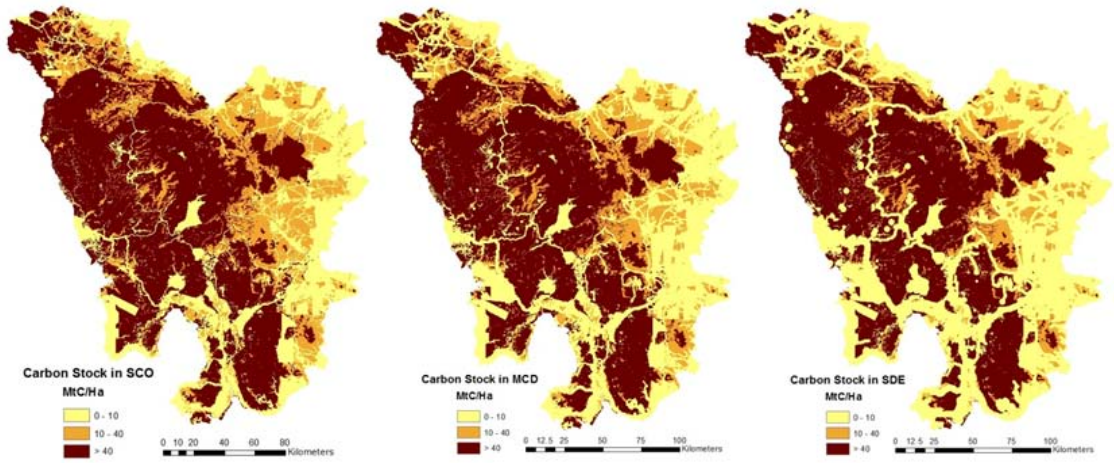
The InVEST carbon model provided both carbon stock and sequestration amounts and values in monetary terms for each grid cell of the landscape. Carbon stock and sequestrated amounts were in MtC per hectares and sequestrated values in USD. The calculation was based on USD 43 per metric ton of carbon per year, at 4% market discount rate, and 0% of the annual rate of change in carbon prices.

2.3.1.1- Carbon Stock

As shown in Figure 8, the SCO had the highest levels of carbon stock in many locations of the study area. The lowest carbon stock was on the edge area around the landscape due to forest degradation. It was estimated that a total of 577,168,536 MtC, 533,631,188 MtC, and 470,247,720 MtC were stored under the SCO, MCD, and SDE scenarios, respectively.

About 60% of each scenario's carbon stock is located inside the CA system and 40% located in forest areas outside. All highest stock areas were located inside the Central Cardamom Protected Forest, Samkos and Aural Wildlife Sanctuaries, Bokor National park, and Samlut Multiple Used Area.

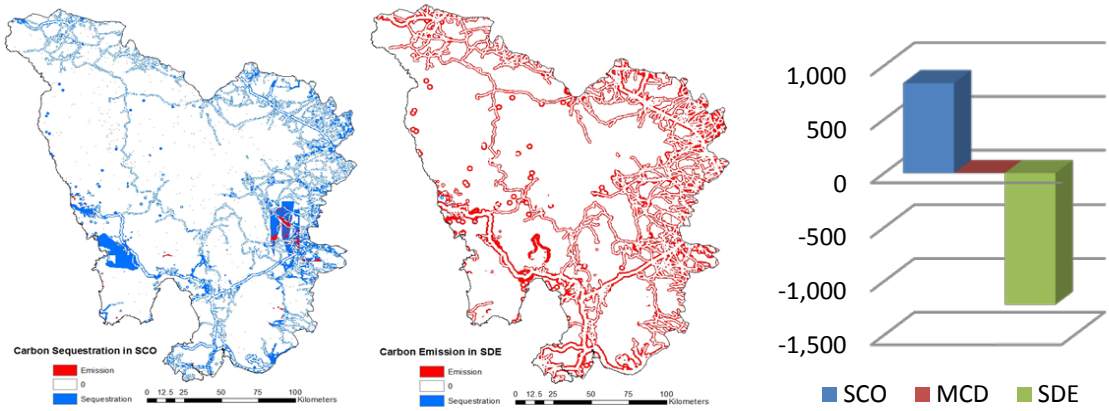
Figure 8: Distribution of Carbon Stock of the three landscape scenarios



2.3.1.2- Carbon Sequestration and Emission

Carbon sequestrations and emissions are presented in Figure 9. Relative to the current management activities (MCD), over the 50 year time horizon the SCO would sequester 43,537,336 MtC, which is monetary terms is equal to USD 836,511,553. Conversely, under the SDE the landscape would release 63,383,817 MtC of carbon to the atmosphere, resulted in a loss of about USD 1,217,835,30 over 50 years relative to today under the SDE. Moreover, the landscape would release 106,921,153 MtC of carbon that equaled USD 2,054,346,854 over 50 years if development is implemented instead of conservation of the area. It is clear that the SCO provides the highest economic return and at the same time significantly sustains biodiversity.

Figure 9: Carbon Sequestration of SCO and SDE (million USD) over 50 years



2.3.2- Biodiversity

The InVEST biodiversity model provided habitat degradation and quality for each grid cell of the landscape. The habitat degradation map is shown in Figure 10 and the habitat quality map is presented in Figure 11. The blue color in Figure 10 indicates the highest habitat degradation score and the green color indicates the lowest. Conversely, the green color in Figure 11 indicates the highest habitat quality score and the red color represents the lowest.

Figure 10: Habitat Degradation between the three Scenarios provided by InVEST

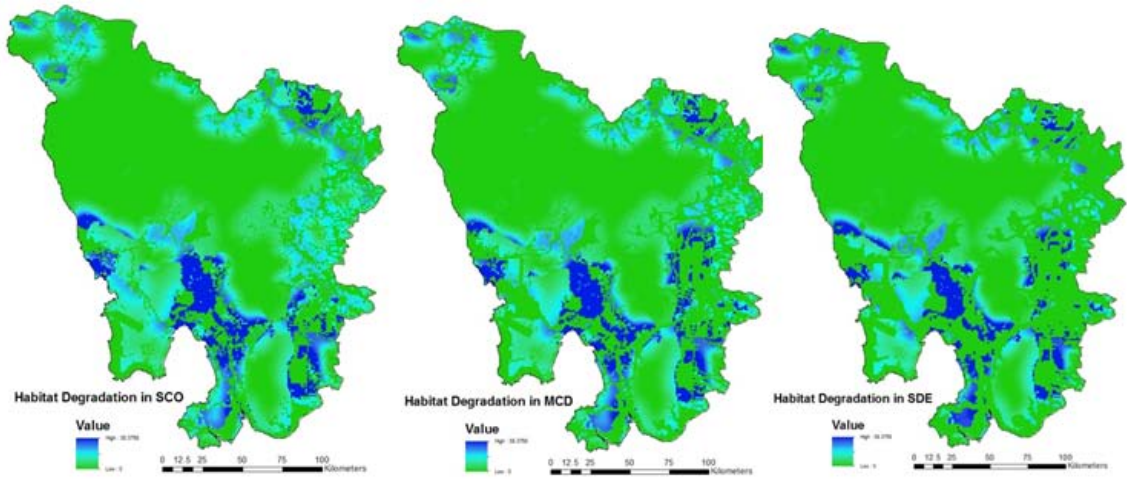
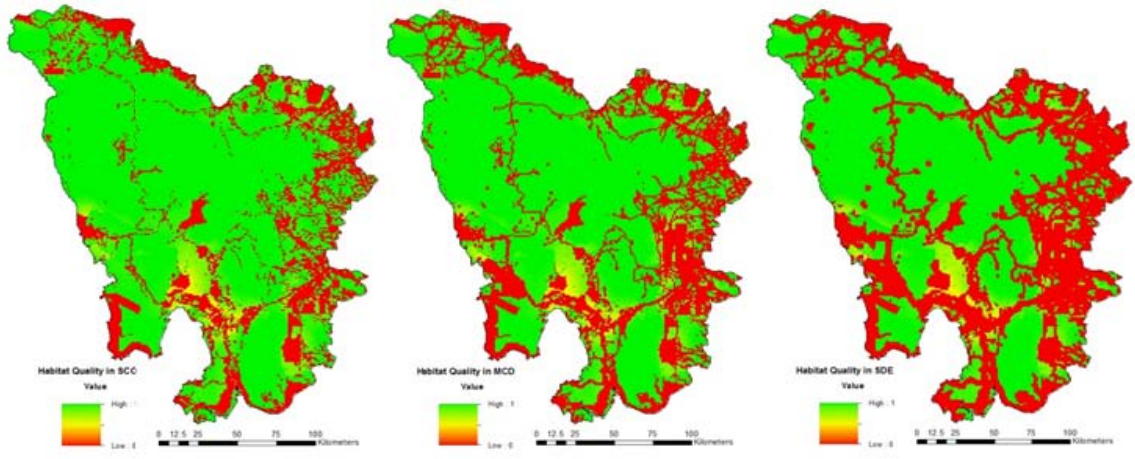


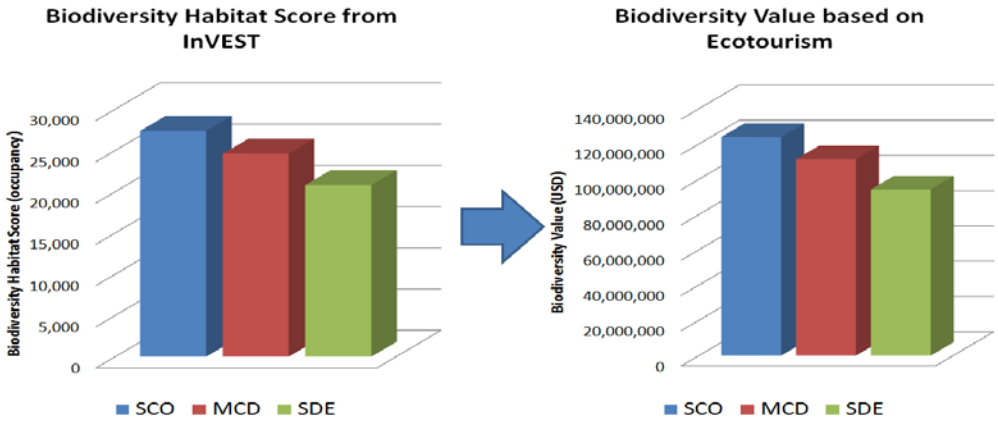
Figure 11: Habitat quality between the three Scenarios provided by InVEST



Based on ecotourism revenue modeling, the biodiversity habitat quality was converted into a monetary value. It was estimated that the Cardamom landscape managed under the future conservation (SCO), the current management activities (MCD), and the future development (SDE) potentially gained a total of USD 123,986,104, USD 111,395,104, and USD 94,234,942 over the 50 year time, respectively (Figure 12). This also means that USD 12,591,000 would be gained under the SCO and conversely, the entire landscape would lose USD 17,160,162 over 50 years relative to today under the SDE. This monetary value estimation was calculated only based on ecotourism revenue and strongly depend on ecotourism facility development in the area. Better management of each ecotourism site might also increase the revenue.

Based on this analysis, the ecotourism value is USD 1-1.69 per ha. However, the current value of biodiversity should also include the existence value of biodiversity, which can be estimated as the expenditure of approximately USD $5/ha/yr in the Cardamoms by conservation NGOs. Furthermore there two reasons that the biodiversity value should be increased. Given current predictions of rates of species extinction and increased human demand for ecotourism opportunities in an increasingly urbanized global landscape, the value of ecotourism should increase and in fact, the demand green space is already increasing (Lo & Jim, 2012). Also local use of biodiversity in the form of an array of non-term forest products used by local people is not incorporated into our model.

Figure 12: Comparing biodiversity value of the three scenarios over 50 years



2.3.3- Hydropower

The InVEST hydropower model provided water yield, water consumption, and hydropower production and values for each scenario. These results are shown in Table 5.

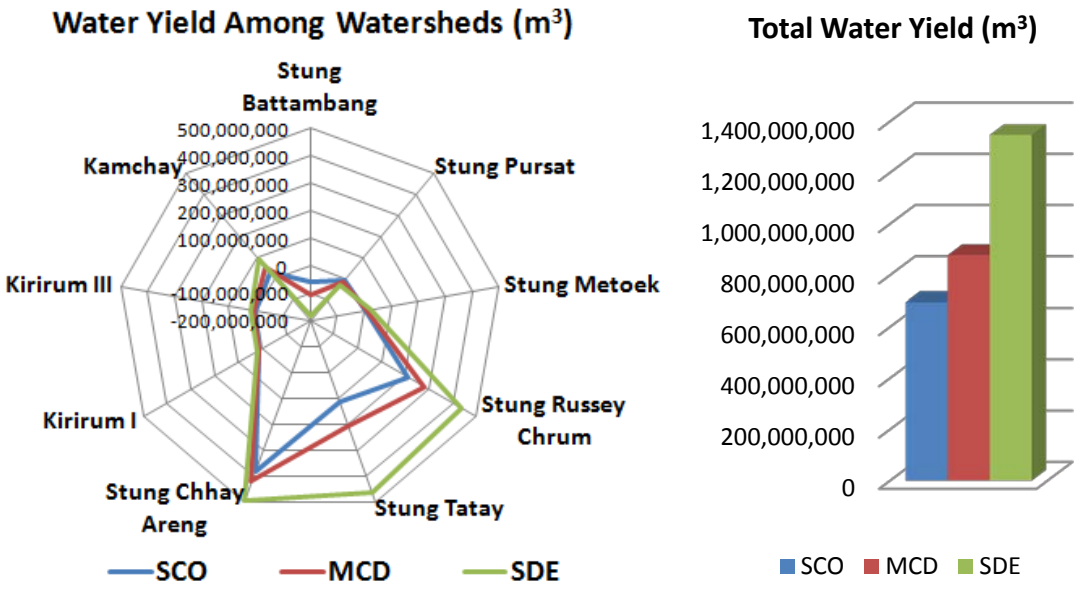
Table 5: Water yield, water consumption, hydropower energy, and hydropower value over 50 years of each watershed among the three scenarios

Scena	Watershed Name	wyield_vol	consum_vol	hp_energy	hp_value
SCO	Stung Battambang	-59,093,806	15,475,200	-3,407,505	-13,322,521
	Stung Pursat	-3,814,572	0	-290,518	-1,135,855
	Stung Metoek	7,038,547	1,264,200	904,678	3,537,072
	Stung Russey Chrum	212,428,547	0	27,503,549	107,532,208
	Stung Tatay	112,894,433	1,113,200	16,540,046	64,667,567
	Stung Chhay Areng	385,328,227	250,400	56,560,231	221,136,793
	Kirirum I	12,638,008	0	880,010	3,440,623
	Kirirum III	1,207,200	0	63,045	246,489
	Kamchay	27,490,644	0	2,931,162	11,460,133
	Total	**696,117,229**	**18,103,000**	**101,684,698**	**397,562,509**
MCD	Stung Battambang	-105,597,822	13,399,000	-5,437,679	-17,819,384
	Stung Pursat	-11,957,638	0	-910,694	-3,560,593
	Stung Metoek	11,463,320	1,263,000	1,598,105	6,248,200
	Stung Russey Chrum	279,058,826	0	36,130,304	141,260,731
	Stung Tatay	210,708,376	3,024,000	30,730,642	120,149,359
	Stung Chhay Areng	422,540,757	564,800	61,979,829	242,326,105
	Kirirum I	13,815,747	0	962,018	3,761,256
	Kirirum III	5,267,511	0	275,091	1,075,536
	Kamchay	53,062,920	0	5,657,781	22,120,550
	Total	**878,361,998**	**18,250,800**	**130,985,396**	**515,561,759**
SDE	Stung Battambang	-180,793,949	12,263,900	-8,821,971	-34,491,771
	Stung Pursat	-28,609,908	0	-2,178,931	-8,519,092
	Stung Metoek	24,395,803	1,263,000	3,624,263	14,169,987
	Stung Russey Chrum	437,195,838	0	56,604,620	221,310,340
	Stung Tatay	467,919,140	10,146,000	67,735,776	264,830,464
	Stung Chhay Areng	497,074,510	1,817,200	72,743,394	284,409,035
	Kirirum I	20,841,959	0	1,451,267	5,674,102
	Kirirum III	16,640,092	0	869,012	3,397,626
	Kamchay	92,803,992	0	9,895,133	38,687,570
	Total	**1,347,467,479**	**25,490,100**	**201,922,563**	**789,468,261**

2.3.3.1- Water Yield

Water yield volume was calculated in m^3 and shown in Table 5 and Figure 13. Among the nine watersheds, the InVEST model clearly showed that only three watersheds: Stung Russey Chrum, Stung Tatay, and Stung Chhay Areng located in the middle of the landscape had significant large water yields to produce energy. Two of the nine watersheds: Stung Battambang and Stung Pursat did not have enough water for energy production. This is because these two watersheds were located in the northern part of the landscape where precipitation is relatively low. Stung Kamchay located in the southern part of the landscape has some water to produce energy.

Figure 13: Comparing water yield among the three scenarios over 50 years

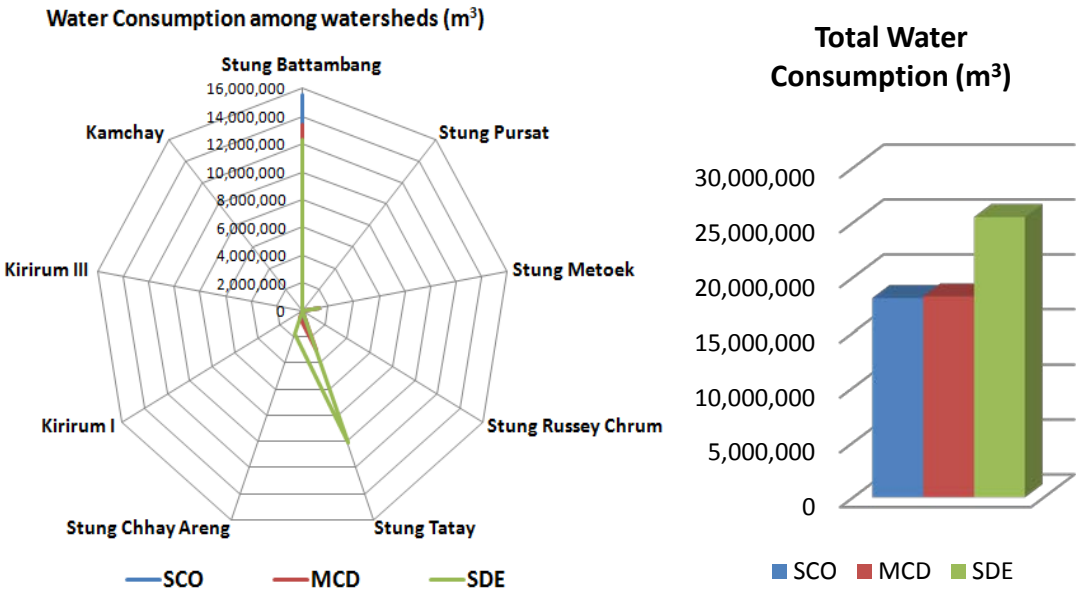


Between the three scenarios, the SDE provided the largest total water yield volume for the nine watersheds in the landscape. It was estimated that 696,117,229 m^3, 878,361,998 m^3, and 1,347,467,479 $m^3$of water yield were provided by the SCO, MDE, and SDE, respectively. The reason that the SDE provided the largest water yield is because this scenario removed vegetation and resulted in lower evapotranspiration compared to the other two scenarios.

2.3.3.2- Water Scarcity

Water consumption volume was also calculated in m^3 and shown in Table 5 and Figure 14. Among the nine watersheds, water consumption only existed on four: Stung Battambang, Stung Metoek, Stung Tatay, and Stung Chhay Areng. The Stung Battambang watershed is the one that consumed the lost water compared to others because this watershed was surrounded by paddy fields and other uses.

Figure 14: Comparing water consumption among the three scenarios over 50 years

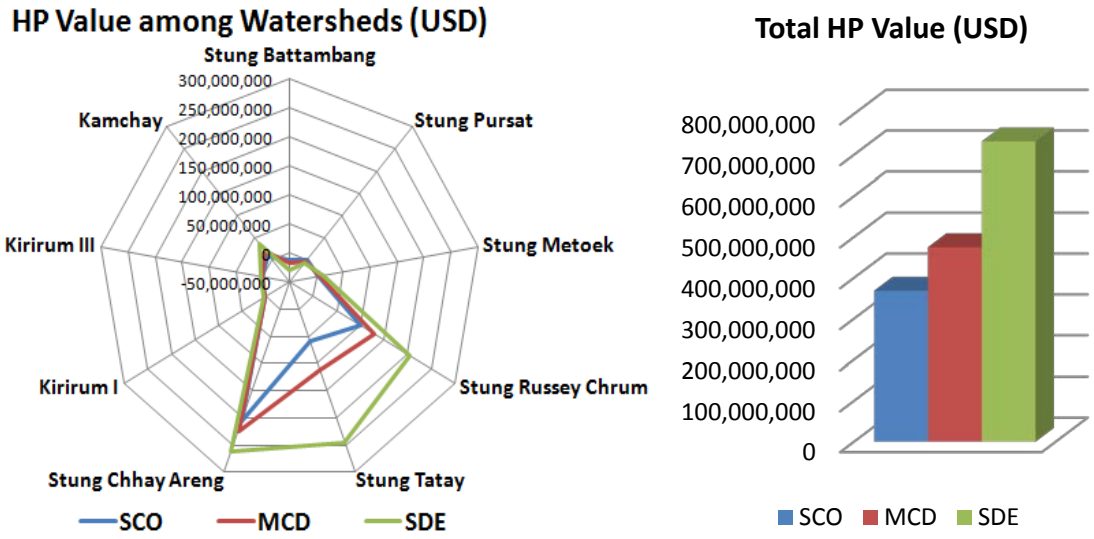


2.3.3.3- Hydropower Production Value

Production value was calculated in USD. Only three hydropower projects, Stung Russey Chrum, Stung Tatay and Stung Chhay Areng, produced large amounts of power (Table 5, Figure 15). It was estimated that USD 397,562,509, USD 515,561,759, and USD 789,468,261 were produced by the SCO, MCD, and SDE over 50 years, respectively. Among the three scenarios, the SDE produced the largest value of energy. Relative to the current management activities (MCD), the SDE would gain USD 277,347,124 over 50

years. Conversely, the entire landscape would lose USD 114,558,627 over 50 years relative to today under the SCO.

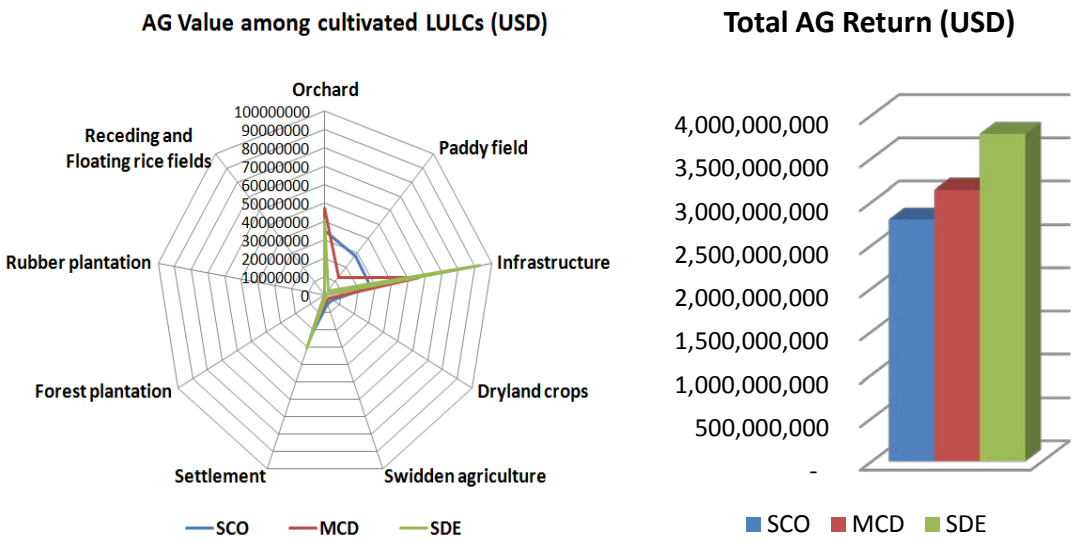
Figure 15: Comparing hydropower value of the three scenarios over 50 years



2.3.3.4- Agriculture

Agriculture is the most valuable service of the landscape. The value of agriculture return of each cultivated land cover for each scenario is provided in Figure 16. It was estimated that USD 2,797,446,155, USD 3,138,332,541, and USD 3,782,229,139 were gained by the SCO, MCD and SDE, respectively. The SDE provided the greatest economic return. Relative to the current management activities (MCD), the SDE would gain USD 643,896,598 over 50 years. Conversely, the entire landscape would lose USD 340,886,386 over 50 years relative to today under the SCO. However, this development might not sustain biodiversity in the landscape due to its replacement of natural habitat with agriculture plantations. Further, improper use of chemical fertilizers and pesticide might seriously pollute the landscape.

Figure 16: Comparing agriculture value among the three scenarios over 50 years

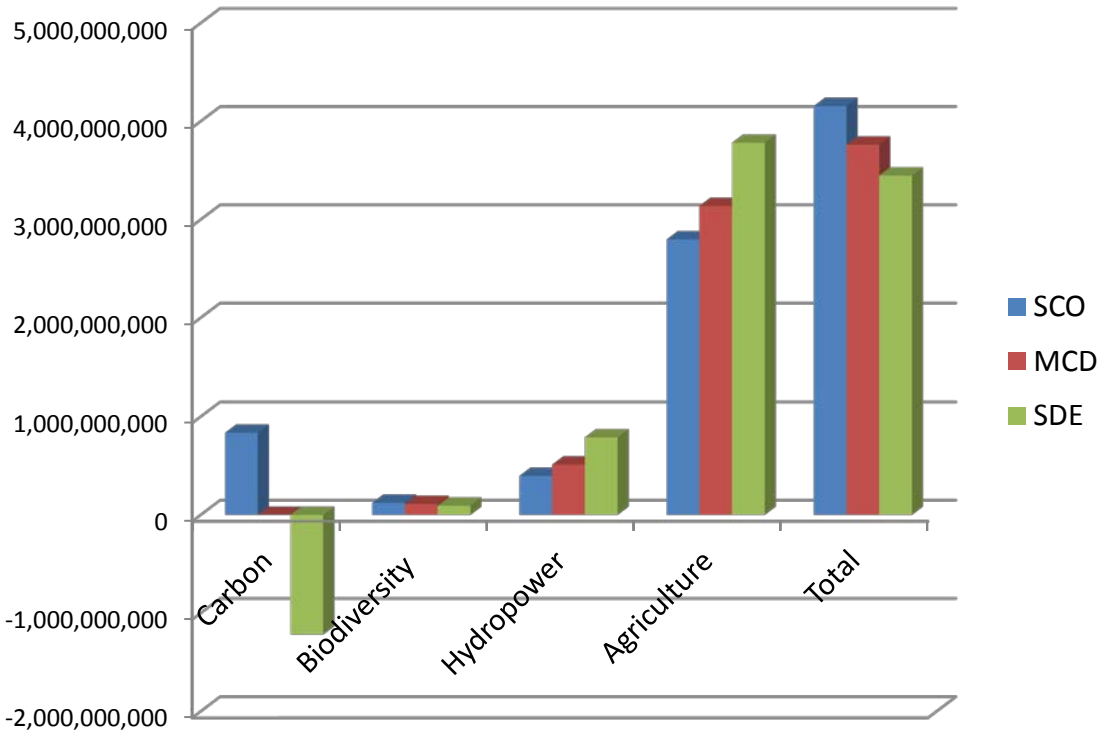


2.3.3.5- Totaling of Ecosystem Services

Figure 17 shows the total value of the four studied ecosystem services. The SCO generated the highest returns for the landscape. Relative to the current management activities (MCD), the SCO would gain USD 398,542,039 over 50 years. Conversely, the entire landscape would lose about USD 346,171,550 over 50 years relative to today under the SDE. In addition, this SCO preserved forests and sustained biodiversity more than the other two. Among the four studied services, agricultural generated the highest returns on the landscape. The ecotourism value was relatively small compared to the other values. The value of biodiversity may be much larger but I did not have the data to calculate other components of biodiversity value. The SDE of the hydropower provided greatest value under compared with other scenarios. There is less evapotranspiration under SDE so there is more water provision to generate the energy. However, this is a 50 year timeframe (long term) that carbon and biodiversity models can accumulate the optimum values under the SCO. If this analysis focuses on short term (less than 10 years), the SDE might be the best choice because of the agriculture model that usually produces the

optimum value at the beginning, especially in Cambodian cases that wood resources on the land are first harvested for concession preparation costs.

Figure 17: Totaling all ecosystem services among the three scenarios



Chapter 3: Discussion and Recommendation

3.1- Discussion

3.1.1- How the landscape is managed?

This study attempted to assess the best land management option for the Cardamom landscape. The Cardamom landscape is currently influenced by three powerful stakeholder groups. The private sector values industrial development, which may help to improve the country's economy and provide jobs and income. Donor communities and NGOs want preservation and have influence on the RGC to preserve the landscape. The donor community has providing billions of dollars per year to run the country. The RCG currently manages the landscape by balancing these two different interests. Fifteen CAs equaled 45.5% of the landscape were set up to protect biodiversity and ecosystems. At the same time, 23 ELCs equaled 17% of the landscape and other development projects were also granted to the private sector to develop the area. The findings of this study largely support the donor communities and NGOs to preserve this important landscape. It means that to have the greatest economic return and at the same time sustain biodiversity in the area, the landscape must be managed under the SCO. The worst scenario of this landscape management is the SDE. These results are also consistent with previous research such as Soussan & Sam (2011) and van Beukering et al., (2009) that found preservation of the Cardamom landscape was critical and should be adopted. One possible explanation is that my evaluation was a 50 year timeframe so it gave enough time for conservation services such as carbon and biodiversity to accumulate in the SCO, surpassing SDE levels. However, long term management of a landscape, for example, the 50 years of this study, might not be in the interest of many governments. This is because most governments are powered by their political parties and they prefer to do something that can produce short term results so people can see and give them votes. In contrast, local communities need long term and sustainable management because they depend on the landscape for generations. In the case of the Cardamom landscape, the management not only targets the short term, but consists of many social and political problems such as corruption and nepotism (Global Withness, 2009). Local people have

been badly treated by not involving them in the decision making, giving them fair benefits from development projects, and even worse, their lands are stolen by the government's ELC agreements with the private sector. It is important for civil society to become more important actors in Cambodian natural resource management. Besides supporting local communities to sustain their livelihoods on the landscape, civil societies also play an important role in reflecting how the RGC implements the donor community benchmarks. To sustain biodiversity and the greatest economic return as shown in this study, the RGC should stop all deforestation activities on the landscape and donor communities have to seriously monitor and put pressure on the RGC if they do not do a better job.

3.1.2- Creation of Land Management Scenarios

Predicting future land management scenarios is not simple. For this study, the creation of land management scenarios was based on the preferences of three stakeholder groups. The strong development scenario resulted in more forest destruction, the strong conservation preserves more forests, and the current landscape management the RGC, is trying to balance development and conservation. This study found that increased development of hydro power and agriculture had positive economic returns, but these came as a substantial cost of lower ecotourism and carbon sequestration payments. Moreover, ELCs granted by the RGC create serious environmental impacts and forest degradation. It usually becomes a hidden mechanism for providing benefits to a few rich and powerful people through corruption and nepotism system and local people are suffering from losing their lands for producing foods. For example, among the 23 ELCs currently permitted in the landscape, only a few of them are actually operating. Others seem to just cut forests for direct benefit or to hold concessions for transferring to other companies to make money. Moreover, while the renting fee of these concessions is extremely low (MAFF, 2012), the under table payments to related decision makers for concession granting and operating is relatively high. Another reason that the SDE converted natural habitats to other LULCs two and a half times as much as the SCO may

be a result of the protected area law adoption in 2008 that allows industrial development inside the protected area system (Kingdom of Cambodia, 2008). Bad governance including corruption and nepotism has also been identified as one of the main drivers of the landscape forest destruction. Even though the LULC maps of the three scenarios were created by applying specific buffered distances and these distances were estimated based on previous year LULC changes and present field investigations, our sample was very small. However, these results do provide important suggestions about the prediction of land management options.

3.1.3- Carbon Model

Carbon value is the most influential component of the models so using the right carbon price is critical. There are two types of carbon price: one is based on social value and another based on current market demand. The social value of a sequestered ton of carbon is equal to the social damage avoided by not releasing the ton of carbon into the atmosphere (Stern, 2006; Tol, 2005). These social cost calculations are complicated and controversial (Nordhaus, 2007; Weitzman, 2007) and sometimes might not be able to convince policy makers to accept them because they usually based on the market price. There is also a considerable range of estimates in the social cost of carbon (Tol 2009). Relative rankings can also be influenced by the geographic or temporal scope of the analysis (Polasky, Nelson, Pennington, & Johnson, 2011). The market price depends on both regulation and voluntary demand. The Kyoto Protocol – the current treaty addressing international climate change – includes a mechanism for establishing projects that sequester carbon to earn credits, which they then can sell to others needing to offset their own CO_2 emissions. As a result of the Kyoto Protocol, the European Union Emissions Trading Scheme emerged to allow the regulated firms of the EU to trade their emissions allowances and the Chicago Climate Exchange (CCX) emerged in the United States. However, the Kyoto Protocol was expired since the end of 2012 and the CCX was not a signatory party of the Kyoto Protocol and went out of business a few years ago. In addition to these centralized markets, there is a few over-the-counter market for voluntary

carbon offsets. The market price of a sequestrated ton of carbon in Cambodia these days ranges between USD 7.00 to USD 9.00 (Voice of America, 2014). These prices do not come close to the profit made possible from felling the forest. Furthermore, local communities whose livelihoods depend on natural resource uses need to be fairly compensated to avoid deforestation. These prices will strongly reflect policies, subsidies, and other factors, and therefore will only indicate the true value of this service to society by chance (Murray, Sohngen, & Ross, 2006). For this reason, I used a low social cost of USD 43 per ton of sequestrated carbon (Nelson et al., 2009). Based on this analysis, USD 27.5 is the breakeaven point for the strong conservation and strong development scenarios. As argued by the U.S.-based Center for Clean Air Policy's 2010 study in the Koh Kong province, carbon credits in Cambodia would have to sell for more than USD 15 per ton to compete with the likely revenue from growing sugarcane on the land instead, even more if it were used to harvest rubber (Dararath et al., 2011; Sasaki, 2010). So, USD 43 per ton seems to provide reasonable compensation to avoid deforestation and sustain biodiversity in the landscape.

3.1.4- Hydropower model

Hydropower development in the Cardamom landscape is critically important for Cambodia, especially since only about 20% of Cambodian households have access to electricity (Sarraf, Rismanchi, Saidur, Ping, & Rahim, 2013). Due to the Cardamom landscape's climate and geography, most of the main waterways have potential for electricity generation (JICA, 2003). Therefore, many hydropower projects have been developed in the area (Ministry of Industrial Mine and Energy, 2005). This study found that the SDE gained the largest return, about USD 790 million, over 50 years. One possible reason is that the SDE, with more forest destruction, gains more returns than the SCO because the water undergoes evapotranspiration in each watershed less than the SCO. This is also because the InVEST model has assumed the precipitation of each watershed remained constant and is not affected by deforestation over time. However, this finding appears to be the best estimate compared to others such as Soussan & Sam

2011 that estimated over USD 75 million a year for the value of the watershed functions of the study area in the Central Cardamom Mountains. The approach of this study should be applied to evaluate other hydropower development projects in Cambodia in order to make a wise decision. For more precision, the horizontal hydrological study of the Cardamom coastal rainforests should be taken into account to detail the hydrological function of this important landscape.

3.1.5- Biodiversity

The Cardamom landscape has been recognized as one of the richest biodiversity hotspots in Asia. Preservation of its natural habitats and ecosystem functions is not only important for sustaining biodiversity in the area, but also for poverty reduction and improving local community livelihoods. By using a combination of InVEST and ecotourism modeling, this study confirmed that the potential ecotourism value of this landscape is invaluable. Even though the value is less than other services, it reflects the biodiversity value based on ecotourism in the area and the method of doing this is new to science. The unit value of this estimate was only USD1-1.69 per ha which is less than the costs that NGOs have paid to protect biodiversity in the area (USD 5/ha/year) and it even much less than the estimation made by previous literature (Bann, 1997; Soussan & Sam, 2011). However, this value is critically important because it is directly shared at the community level among local guides, boat runners, and owners of restaurants, guest houses, and local businesses. Moreover, there are also ways to increase this revenue by adding more projects and improving or investing in more facilities. I recommend the RGC to consider this incredible biodiversity value for any land management issue in this landscape and consider it is one of the strategies to eliminate poverty in the area.

3.1.6- Sustainable Land Management Planning

In order to properly manage the landscape, sustainable land management planning of the Cardamom landscape is needed. There are several land management plans and activities that have been developed separately, inconsistently, geographically, and institutionally based. For example, in the southern part of the landscape, the Wildlife

Alliance is cooperating with the FA and the Koh Kong Provincial Authority to develop the Southern Cardamom Permanent Forest Reserve Management Plan (Forestry Administration, 2011) and implement the Southern Cardamom Biodiversity Corridor Zoning and Demarcation (Koh Kong Governor Office, 2009) under the financial support by the ADB. In the central part, the FFI is working with the MoE to develop and implement community protected area plans for the Samkos and Aural wildlife Sanctuaries and CI is working with the FA on community ranger programs. In the northern part, the Maddox Jolie-Pitt Foundation is working with the MoE to support the management of the Samlaut multiple use area. However, the whole Cardamom landscape management plan is not yet initiated. The plan must identify the roles and responsibilities of stakeholders at all levels to ensure the success of REDD projects as well as the suitable development of local communities (Sasaki, 2010). This planning should focus on a long term approach, integrate all multiple values, and take into account the clear zoning of existing local communities, development, and conservation areas.

3.1.7- Payment for ecosystem services and benefit sharing among stakeholders

Payment for ecosystem services (PES) is the key issue for sustainable development. Individuals, private company managers, and government officials who make decisions that affect ecosystems and their services will pay the prices that reflect these impacts (Daily et al., 2009). Then, this PES has to be fairly shared among stakeholders at the local and global levels. The local level includes the providing of resources for local livelihoods, rich habitat for biodiversity, and regulating the hydrological cycle and climate; the global level includes acting as a vast carbon sink, sequestrating carbon dioxide from the atmosphere and locking it into stores of biomass (Chomitz, 2006). It needs a system that can compensate local people for avoiding deforestation in the area. There are many services that the RGC can promote in the landscape including, carbon sequestration, biodiversity conservation, hydropower development, and watershed protection. Poverty reduction is a laudable goal, but it should not prevent PES schemes from signaling the scarcity of ES. Every payment

system has implications for equity; although these effects may be extremely important they should be addressed separately, not through payments made under the scheme (Kinzig et al., 2011). Payment under table to specific authorities must be stopped because it is a crime under corruption law (Global Withness, 2009). The RGC should develop and adopt this PES policy and implement it as soon as possible.

3.1.8- Future studies

This study did not include all ecosystem services in the landscape. The study just focused on four main ecosystem services in the area: carbon sequestration, biodiversity value, hydropower development, and agriculture return. It would be helpful to include other services in a future study. NTPF is one of the most interesting services that should be precisely studied because it strongly supports local community livelihoods. Horizontal hydrological function of this coastal rainforest should be seriously studied to provide more detail on how important the Cardamom landscape is for supplying water to the country, especially to the agriculture sector that more than 80% of Cambodian people depend on. Other services such as storms, flood and drought prevention, forestry, and fisheries should also be included.

3.2- Recommendations to the RGC

Based on this study, I would like to make recommendations for the Cambodian government to wisely manage the Cardamom landscape in the short and long term as follows:

3.2.1- Short Term–Stop Landscape Deforestation and Degradation

1- Since the SCO is the best option for sustaining biodiversity and economic returns of the landscape, this study recommended that all deforestation activities should be stopped. No more new ELCs should be granted and those that are already permitted must be strictly monitored to ensure that they are compliant with current ELC procedures

and regulations. If there are those that still violate the regulations, cancellations must be made after warnings as stated by the Sub-decree on ELCs.

2- Other illegal activities such as resettlement, land encroachment, logging, and hunting usually follow development projects and are caused by new immigrants. These activities must be closely monitored and laws enforced to prevent illegal resettlement. Local authorities should develop and adopt policies to stop immigrants to the landscape.

3- Alternative livelihoods for local communities should be developed to move them away from slash-and-burn farming practices and other overuse of natural resources. Community-based ecotourism, modern agriculture development on existing cleared land, and value added businesses on sustainable NTFP uses should be encouraged and assisted.

4- The adoption of the protected area law in 2008 that allowed development projects inside the sustainable use zone (Article 11) caused significant deforestation, PA destruction, and effects on biodiversity conservation. This is because of two main reasons: the location of this sustainable use zone is right next to the conservation zone which does not make any sense for sustaining biodiversity and the decision to allocate development projects such ELCs is mostly made without proper biological surveys and is involved with corruption and nepotism. Therefore, this law should be amended to not allow any more development projects in the PA system.

5- Better governance and elimination of corruption and nepotism at all levels are needed from the top policy makers down to ground enforcement teams for Cardamom landscape management. Close monitoring on the implementation of agreements, permissions, and projects must be conducted so illegal and unlawful activities that used to go along with this legal status are prevented. For example, if the permission was made to clear forests in the reservoir to export timbers, other woods from outside must be strictly controlled and enforced. The law on corruption must be applied to all, not only to the poor, but also rich and policy makers, whoever violated the law.

6- The court system must be reformed. Elimination of corruption, nepotism, and impunity in the court system is needed to encourage law enforcement on the ground. As stated by the national constitution, the Cambodian juridical system is an independent body from legislature and government, but it is not up to date. Therefore, making the court system independent and strictly implementing corruption law are extremely important tasks.

3.2.2- Long Term–Adoption and Implement of SLM and PES

1- The landscape has local community livelihoods that strongly depend on natural resource uses; therefore sustainable community-based land resource and forestry management systems should be implemented. Based on previous research, this is recommended within five kilometers of their villages. Working with local communities to stop slash-and-burn farming by assisting them with upland farming systems is critical and must be conducted. This support can be made through existing support by NGOs and the PES system.

2- Up to date, there has not yet been a single credit of carbon traded in Cambodia. Even though some projects that supported by NGOs are ready to sell, there are problems with government institutions that are trying to claim the ownership of it. To have significant returns from carbon credit trading, the RGC should develop clear policies on the benefits from carbon trading, as well as for other PES to be shared. At the same time, the RGC must promote carbon credit sales and put pressure on the UN to issue a clear policy on carbon credit prices.

3- Hydropower development provides great economic benefits and depends on effective watershed conservation to increase water yield and reduce sedimentation. Similarly, these benefits should be reflected through a payment for PES whereby there is a levy on electricity generated that is used to protect the watershed and benefit local communities.

4- The high value biodiversity, watershed maintenance and carbon sequestration ecosystems services are contingent upon the continued maintenance of the

integrity of the large forest ecosystems of the area. The Cardamom Mountains already have a series of conservation measures in place, including several designated protected areas and active work by organizations such as Conservation International. These existing conservation measures should be continued and strengthened, for example to prevent encroachment and combat illegal logging and wildlife trading. This can be paid for through the PES levy described above and through further levies on beneficiaries from these ecosystems services such as tourists to the area and downstream water users.

5- The income from PES schemes has the potential to be the financial basis for a number of the other recommendations for developing SLM options. It means that the development of the area would not be dependent on resources provided from outside, whether from central government or civil society, ensuring the long-term sustainability of these measures

6- The whole Cardamom landscape management planning should be developed by integrating all existing plans such as the Southern Cardamom Permanent Forest Reserve Management Plan, the Cardamom Biodiversity Corridor Zoning and Demarcation, and other CA and PA management plans. This plan should also incorporate the SLM and PES mechanisms and the conversion of all unprotected areas should be CAs for biodiversity and ecosystem conservation.

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Appendices

Appendix 1: List of mammals of international conservation concern of the Cardamom landscape

No.	English Name	Scientific Name	IUCN	CITES	RGC	Reference
1	Sunda Pangolin	Manis javanicus	EN	II	2	Daltry & Momberg, 2000
2	Northern Tree Shrew	Tupaia belangeri	LC	II	3	Daltry & Momberg, 2000
3	Slow Loris	Nycticebus coucang	LC	I	2	Daltry & Momberg, 2000
4	Bengal Slow Loris	Nycticebus bengalensis	VU	I	2	Coudrat et al, 2011; Boonratana, 1999
5	Pig-tailed Maccaque	Macaca menestrina	VU	II	3	Daltry & Momberg, 2000; Coudrat et al, 2011; Boonratana, 1999
6	Long-tailed Macaque	Macaca fascicularis	LC	II	3	Daltry & Momberg, 2000; Coudrat et al, 2011; Boonratana, 1999
7	Stump-tailed Macaque	Macaca arctoides	VU	II	2	Coudrat et al, 2011; Bauld & Sovan, 2004
8	Indochinese Lutung	Trachypithecus germaini	EN	II	3	Starr et al, 2010; Coudrat et al, 2011; Boonratana, 1999
9	Silvery Lutung	Trachypithecus cristatus	NT	II	3	Daltry & Momberg, 2000
10	Pileated Gibbon	Hylobates pileatus	EN	I	2	Daltry & Momberg, 2000; Coudrat et al, 2011; Boonratana, 1999
11	Dhole	Cuon alpinus	EN	II	2	Daltry & Momberg, 2000
12	Asiatic Black Bear	Ursus thibetanus	VU	I	1	Daltry & Momberg, 2000
13	Malayan Sun Bear	Helarctos malayanus	VU	I	2	Daltry & Momberg, 2000
14	Eurasian Otter	Lutra lutra	NT	I	2	Daltry & Momberg, 2000
15	Smooth-coated Otter	Lutrogale perspicillata	VU	II	2	Daltry & Momberg, 2000
16	Oriental Small-clawed Otter	Aonyx cinerea	VU	II	3	Daltry & Momberg, 2000
17	Binturong	Arctictis binturong	VU	III		Daltry & Momberg, 2000
18	Leopard Cat	Prionailurus bengalensis	LC	I	3	Daltry & Momberg, 2000
19	Fishing Cat	Prionailurus viverrinus	EN	II	3	Daltry & Momberg, 2000
20	Marbled Cat	Pardofelis marmorata	VU	I	2	Starr et al, 2010
21	Clouded Leopard	Neofelis nebulosa	VU	I	1	Daltry & Momberg, 2000
22	Leopard	Panthera pardus	NT	I	2	Daltry & Momberg, 2000
23	Indochinese Tiger	Panthera tigris	EN	I	1	Daltry & Momberg, 2000
24	Asian Elephant	Elephas maximus	EN	I	1	Daltry & Momberg, 2000
25	Javan Rhinoceros	Rhinoceros sondaicus	CR	I	1	Daltry & Momberg, 2000
26	Eld's Deer	Panolia eldii	EN		1	ADB, 2005

27	Sambar Deer	Rusa Unicolor	VU		3	Daltry & Momberg, 2000
28	Hod Deer	Axis porcinus	EN	I	1	Daltry & Momberg, 2000
29	Gaur	Bos guarus	VU	I	2	Daltry & Momberg, 2000
30	Banteng	Bos javanicus	EN		2	Daltry & Momberg, 2000
31	Khting Vor	Pseudonovibos spiralis	EN		1	Daltry & Momberg, 2000
32	Serow	Capricornis sumatraensis	VU	I	2	Daltry & Momberg, 2000
33	Black Giant Squirrel	Ratufa bicolor	NT	II	2	Daltry & Momberg, 2000

Appendix 2: List of birds of international conservation concern of the Cardamom landscape

No.	English Name	Scientific Name	IUCN	CITES	RGC	Reference
1	Chestnut-headed Partridge	Arborophila cambodiana	LC		2	Daltry & Momberg, 2000
2	Green Peafowl	Pavo muticus	EN	II	2	Daltry & Momberg, 2000; Royan, 2009; Rhim et al, 2012
3	Crested Argus	Rheinardia ocellata	NT	I		Daltry & Momberg, 2000
4	Oriental pied Hornbill	Anthracoceros malabaricus	LC	II		Daltry & Momberg, 2000, Rhim et al, 2012
5	Wreathed Hornbill	Aceros undulatus	LC	II	2	Daltry & Momberg, 2000; Royan, 2009
6	Great Hornbill	Buceros bicornis	NT	I	2	Daltry & Momberg, 2000; Royan, 2009; Rhim et al, 2012
7	Brown Hornbill	Anorrhinus tickelli	NT	II		Daltry & Momberg, 2000
8	Red-breasted Parakeet	Psittacula alexandri	NT	II		Daltry & Momberg, 2000
9	Blossom-headed Parakeet	Psittacula roseata	NT	II		Daltry & Momberg, 2000
10	Vernal Hanging Parrot	Loriculus vernalis	LC	II		Daltry & Momberg, 2000
11	Grey-headed Parakeet	Psittacula finschii	NT	II		Daltry & Momberg, 2000
12	Alexandrine Parakeet	Psittacula eupatria	NT	II	2	Daltry & Momberg, 2000
13	Oriental Bay Owl	Phodilus badius	LC	II		Daltry & Momberg, 2000
14	Mountain Scops Owl	Otus spilocephalus	LC	II		Daltry & Momberg, 2000
15	Collared Scops Owl	Otus bakkamoena	LC	II		Daltry & Momberg, 2000
16	Buffy Fish Owl	Bubo ketupu	LC	II	2	Daltry & Momberg, 2000
17	Brown Hawk Owl	Ninox scutulata	LC	II		Daltry & Momberg, 2000
18	Brown Wood Owl	Strix leptogrammica	LC	II		Daltry & Momberg, 2000
19	Collared Owlet	Glaucidium brodiei	LC	II		Daltry & Momberg, 2000
20	Asian Barred Owlet	Glaucidium cuculoides	LC	II		Daltry & Momberg, 2000
21	Spotted Owlet	Athene brama	LC	II		Daltry & Momberg, 2000

22	Black Eagle	Ictinaetus malayensis	LC	II		Daltry & Momberg, 2000
23	White-bellied Sea Eagle	Haliaeetus leucogaster	LC	II	2	Daltry & Momberg, 2000; Royan, 2009
24	Changeable Hawk-Eagle	Nisaetus cirrhatus	LC	II		Daltry & Momberg, 2000
25	Grey-headed Fish Eagle	Ichthyophaga ichthyaetus	NT	II		Daltry & Momberg, 2000; Royan, 2009
26	Crested Serpent Eagle	Spilronis cheela	LC	II		Daltry & Momberg, 2000, Rhim et al, 2012
27	Black Baza	Aviceda leuphotes	LC	II		Daltry & Momberg, 2000
28	Jerdon's Baza	Aviceda jerdoni	LC	II	2	Daltry & Momberg, 2000
29	Eastern Marsh Harrier	Circus spilonotus	LC	II		Daltry & Momberg, 2000
30	Pied Harrier	Circus melanoleucos	LC	II		Daltry & Momberg, 2000
31	Crested Goshawk	Accipiter trivirgatus	LC	II		Daltry & Momberg, 2000
32	Northern Goshawk	Accipiter gentilis	LC	II		Daltry & Momberg, 2000
33	Black Kite	Milvus migrans	LC	II	2	Royan, 2009
34	Black-winged Kite	Elanus caeruleus	LC	II		Daltry & Momberg, 2000
35	Brahminy Kite	Haliastur indus	LC	II		Daltry & Momberg, 2000
36	Osprey	Pandion haliaetus	LC	II		Daltry & Momberg, 2000
37	Besra	Accipiter virgatus	LC	II		Daltry & Momberg, 2000
38	Shikra	Accipiter badius	LC	II		Daltry & Momberg, 2000
39	Rufous-winged Buzzard	Butastur liventer	LC	II		Daltry & Momberg, 2000
40	Oriental Honey Buzzard	Pernis ptilorhynchus	LC	II		Daltry & Momberg, 2000
41	Common Buzzard	Buteo buteo	LC	II		Daltry & Momberg, 2000
42	Collared Falconet	Microhierax caerulescens	LC	II		Daltry & Momberg, 2000
43	Oriental Hobby	Falco severus	LC	II		Daltry & Momberg, 2000
44	Hill Myna	Gracula religiosa	LC	II		Royan, 2009
45	Silver Oriole	Oriolus mellianus	EN			Pilgrim & Pierce, 2006;
46	White-winged Duck	Cairina scutulata	EN	III	1	Royan, 2009; Bauld & Sovan, 2004
47	Masked Finfoot	Heliopais personata	EN		2	Mulligan et al, 2009
48	Black-necked Stork	Ephippiorhynchus asiaticus	NT		1	Bauld & Sovan, 2004
49	Milky Stork	Mycteria cinerea	EN	I	2	Royan, 2009
50	Lesser Adjutant	Leptoptilos javanicus	VU		2	Royan, 2009
51	Sarus Crane	Grus antigone	VU	II	2	Bauld & Sovan, 2004
52	Siamese Fireback	Lophura diardi	LC		2	Daltry & Momberg, 2000
53	Cambodian Laughingthrush	Garrulax ferrarius	NT		2	Eames et al, 2002

Appendix 3: List of reptiles of international conservation concern of the Cardamom landscape

No.	English Name	Scientific Name	IUCN	CITES	RGC	Reference
1	Siamese Crocodile	Crocodylus siamensis	CR	I	1	Daltry & Momberg, 2000
2	Royal Turtle	Batagur baska	CR	I	1	Daltry & Momberg, 2000
3	Elongated Tortoise	Indotestudo elongata	EN			Daltry & Momberg, 2000
4	Impressed Tortoise	Manouria impressa	VU			Daltry & Momberg, 2000
5	Asiatic softshell turtle	Amyda cartilaginea	VU	II		Daltry & Momberg, 2000; Bauld & Sovan, 2004
6	Asian giant softshell turtle	Pelochelys cantorii	EN	II		Daltry & Momberg, 2000; Bauld & Sovan, 2004
7	Malayan flat-shelled turtle	Notochelys platynota	VU	II		Daltry & Momberg, 2000
8	Western Black-bridged Leaf Turtle	Cyclemys atripons		II		Grismer & Neang, 2008
9	Giant Asian Pond Turtle	Heosemys grandis	VU	II		Grismer & Neang 2008
10	Mekong Snail-eating Turtle	Malayemys subtrijuga	VU	II		Grismer & Neang 2008
11	Black Marsh Turtle	Siebenrockiella crassicollis	VU	II		Grismer & Neang 2008
12	Asian Box Turtle	Cuora amboinensis		II		Daltry & Momberg, 2000
13	Bengal Monitor	Varanus bengalensis	LC	I		Daltry & Momberg, 2000
14	Water Monitor	Varanus salvator	LC	II		Daltry & Momberg, 2000
15	Clouded Monitor	Varanus nebulosus	LC	I		Grismer & Neang, 2008
16	Reticulated Python	Python reticulatus		II		Daltry & Momberg, 2000
17	King Cobra	Ophiophagus hannah	VU	II	2	Daltry & Momberg, 2000
18	Monocled Cobra	Naja kaouthia	LC	II	2	Grismer & Neang, 2008

Appendix 4: List of international treaties ratified by the Cambodian government

Title	Type	Date of Signature
Agreement between the European Community and the Kingdom of Cambodia on trade in textile products (*)	Bilateral	19/03/2004
Protocol on the extension of the Cooperation Agreement between the European Community and the member countries of ASEAN to the Kingdom of Cambodia (*)	Bilateral	28/07/2000
Agreement between the European Community and the Kingdom of Cambodia on trade in textile products	Bilateral	4/5/2000
Cooperation Agreement between the European Community and the Kingdom of Cambodia - Joint Declarations - Exchange of letters on maritime transport	Bilateral	29/04/1997
United Nations Convention against Corruption	Multilateral	31/10/2003

WHO Framework Convention on Tobacco Control	Multilateral	21/05/2003
International Treaty on Plant Genetic Resources for Food and Agriculture	Multilateral	6/6/2002
Protocol against the Illicit Manufacturing and Trafficking in Firearms, Their Parts and Components and Ammunition, supplementing the United Nations Convention against Transnational Organized Crime	Multilateral	31/05/2001
Protocol Against the Smuggling of Migrants by Land, Sea and Air, supplementing the United Nations Convention Against Transnational Organized Crime	Multilateral	12/12/2000
Protocol to Prevent, Suppress and Punish Trafficking in Persons, Especially Women and Children, supplementing the United Nations Convention against Transnational Organized Crime	Multilateral	12/12/2000
United Nations Convention Against Transnational Organized Crime	Multilateral	15/11/2000
Cartagena protocol on bio-safety to the convention on biological diversity	Multilateral	24/05/2000
Amendment to the Montreal Protocol on substances that deplete the ozone layer	Multilateral	3/12/1999
Kyoto Protocol to the UN Framework Convention on Climate Change	Multilateral	11/12/1997
International Plant Protection Convention - New revised text approved by Resolution 12/97 of the 29th Session of the FAO Conference in November 1997 - Declaration	Multilateral	7/11/1997
Amendment to the Montreal Protocol on substances that deplete the ozone layer, adopted at the ninth meeting of the Parties	Multilateral	17/09/1997
Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982 (UNCLOS)	Multilateral	28/07/1994
United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa	Multilateral	17/06/1994
Convention on biological diversity	Multilateral	5/6/1992
United Nations Framework Convention on Climate Change	Multilateral	9/5/1992
Basel Convention on the control of transboundary movements of hazardous wastes and their disposal	Multilateral	22/03/1989
United Nations Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances	Multilateral	20/12/1988
Montreal Protocol on substances that deplete the ozone layer	Multilateral	16/09/1987
Vienna Convention for the protection of the ozone layer	Multilateral	22/03/1985
International Convention on the Harmonized Commodity Description and Coding System	Multilateral	14/06/1983
United Nations Convention on the Law of the Sea (UNCLOS)	Multilateral	10/12/1982
Convention on the physical protection of nuclear material	Multilateral	3/3/1980
Treaty of Amity and Cooperation in Southeast Asia	Multilateral	24/02/1976

Customs Convention on the temporary importation of commercial road vehicles (1956)	Multilateral	18/05/1956
Customs Convention on the temporary importation of private road vehicles (1954)	Multilateral	4/6/1954
Constitution of the Food and Agriculture Organization of the United Nations (FAO)	Multilateral	16/10/1945

(*) This treaty has not entered into force yet

Adopted from Treaty Office Database of the European Union External Action

Appendix 5: Carbon Table for Carbon Model

LUCODE	LULC Name	C_above	C_below	C_dead
1	Abandoned field	5	1.33	0.75
3	Flooded grasslands	10	2.36	1.5
4	Flooded shrublands	13	2.94	1.95
5	Forest plantation	95	15.45	14.25
6	Infrastructure	0	0	0
10	Lakes	0	0	0
11	Lowland dry evergreen forests	161	23.98	24.15
12	Lowland grasslands	12	2.75	1.8
13	Lowland moist evergreen forests	191	27.65	28.65
14	Lowland semi-evergreen forests	161	23.98	24.15
15	Lowland shrublands	14	3.13	2.1
16	Mangrove forests	142	21.6	21.3
17	Marsh and swamp	15	3.32	2.25
19	Orchard	7	1.76	1.05
20	Other water	0	0	0
21	Paddy field	3	0.87	0.45
22	Bamboo dominated secondary formations	92	15.04	13.8
23	Rear mangrove forests	120	18.77	18
24	Receding and Floating rice fields	2	0.62	0.3
25	Reservoir	0	0	0
26	Riparian forests	195	28.13	29.25
27	Rock outcrop	3	0.87	0.45
28	Rubber plantation	102	16.39	15.3
29	Sand bank	3	0.87	0.45
30	Settlement	2	0.62	0.3
31	Shrimp/Fish farming and Salt pan	1	0.35	0.15
33	Barren land	3	0.87	0.45

34	Submontane grasslands	20	4.21	3
35	Submontane moist evergreen forests	211	30.04	31.65
36	Submontane semi-evergreen forests	178	26.07	26.7
37	Submontane shrublands	28	5.58	4.2
38	Swidden agriculture	7	1.76	1.05
39	Tree dominated secondary formations	78	13.11	11.7
40	Coastal Open Water	0	0	0
41	Coniferous forest	126	19.55	18.9
42	Deciduous forests	126	19.55	18.9
43	Dryland crops	7	1.76	1.05
44	Estuarine areas	11	2.56	1.65

Appendix 6: Sensitivity Table for Biodiversity Model

NAME	HAB	URD	VID	RAW	NAR	COR	HYD	IRD	ELC	ILE
Abandoned field	0	0	0	0	0	0	0	0	0	0
Flooded grasslands	1	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.5	0.4
Flooded shrublands	1	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.5	0.4
Forest plantation	1	0.4	0.4	0.3	0.3	0.2	0.1	0.1	0.2	0.1
Infrastructure	0	0	0	0	0	0	0	0	0	0
Lakes	0	0	0	0	0	0	0	0	0	0
Lowland dry evergreen forests	1	0.9	0.9	0.8	0.8	0.7	0.6	0.6	0.7	0.6
Lowland grasslands	1	0.6	0.6	0.5	0.5	0.4	0.3	0.3	0.4	0.3
Lowland moist evergreen forests	1	0.9	0.9	0.8	0.8	0.7	0.6	0.6	0.7	0.6
Lowland semi-evergreen forests	1	0.8	0.8	0.7	0.7	0.6	0.5	0.5	0.6	0.5
Lowland shrublands	1	0.7	0.7	0.6	0.6	0.5	0.4	0.4	0.5	0.4
Mangrove forests	1	1	1	0.9	0.9	0.8	0.7	0.7	0.8	0.7
Marsh and swamp	1	0.4	0.4	0.3	0.3	0.2	0.1	0.1	0.2	0.1
Orchard	0	0	0	0	0	0	0	0	0	0
Other water	0	0	0	0	0	0	0	0	0	0
Paddy field	0	0	0	0	0	0	0	0	0	0
Bamboo dominated secondary formations	1	0.4	0.4	0.3	0.3	0.2	0.1	0.1	0.2	0.1
Rear mangrove forests	1	0.9	0.9	0.8	0.8	0.7	0.6	0.6	0.7	0.6
Receding and Floating	0	0	0	0	0	0	0	0	0	0

rice fields										
Reservoir	0	0	0	0	0	0	0	0	0	0
Riparian forests	1	0.5	0.5	0.4	0.4	0.3	0.2	0.2	0.3	0.2
Rock outcrop	0	0	0	0	0	0	0	0	0	0
Rubber plantation	0	0	0	0	0	0	0	0	0	0
Sand bank	0	0	0	0	0	0	0	0	0	0
Settlement	0	0	0	0	0	0	0	0	0	0
Shrimp/Fish farming and Salt pan	0	0	0	0	0	0	0	0	0	0
Barren land	0	0	0	0	0	0	0	0	0	0
Submontane grasslands	1	0.7	0.7	0.6	0.6	0.5	0.4	0.4	0.5	0.4
Submontane moist evergreen forests	1	1	1	0.9	0.9	0.8	0.7	0.7	0.8	0.7
Submontane semi-evergreen forests	1	0.9	0.9	0.8	0.8	0.7	0.6	0.6	0.7	0.6
Submontane shrublands	1	0.8	0.8	0.7	0.7	0.6	0.5	0.5	0.6	0.5
Swidden agriculture	0	0	0	0	0	0	0	0	0	0
Tree dominated secondary formations	1	0.5	0.5	0.4	0.4	0.3	0.2	0.2	0.3	0.2
Coastal Open Water	0	0	0	0	0	0	0	0	0	0
Coniferous forest	1	0.8	0.8	0.7	0.7	0.6	0.5	0.5	0.6	0.5
Deciduous forests	1	0.8	0.8	0.7	0.7	0.6	0.5	0.5	0.6	0.5
Dryland crops	0	0	0	0	0	0	0	0	0	0
Estuarine areas	1	0.9	0.9	0.8	0.8	0.7	0.6	0.6	0.7	0.6

Appendix 7: Threat Table for Biodiversity Model

THREAT	MAX_DIST	WEIGHT
URD – Urban development	10	1
VID – Village development	7	0.9
RAW – Railway construction	5	0.7
NAR – National Road construction	5	0.6
COR – Community Road construction	1	0.4
HYD – Hydropower development	3	0.5
IRD – Irrigation development	1	0.2
ELC – Economic land concession	8	0.8
ILE – Illegal land encroachment	2	0.6

Appendix 8: Biophysical Table for Water Yield Model

lucode	LULC Description	LULC Veg	LULC Category	Kc (1-1500)	Root Depth (mm)
1	Abandoned field	1	veg	300	200
3	Flooded grasslands	1	wetlands	400	1440
4	Flooded shrublands	1	wetlands	600	1310
5	Forest plantation	1	veg	995	1000
6	Infrastructure	0	buit	1	0
10	Lakes	0	water	1	0
11	Lowland dry evergreen forests	1	veg	1000	950
12	Lowland grasslands	1	veg	450	1440
13	Lowland moist evergreen forests	1	veg	1000	910
14	Lowland semi-evergreen forests	1	veg	1000	910
15	Lowland shrublands	1	veg	650	1310
16	Mangrove forests	1	veg	1000	1000
17	Marsh and swamp	1	wetlands	300	200
19	Orchard	1	veg	700	800
20	Other water	0	water	1	0
21	Paddy field	1	veg	650	250
22	Bamboo dominated secondary formations	1	veg	850	1440
23	Rear mangrove forests	1	veg	1000	1000
24	Receding and Floating rice fields	1	wetlands	500	200
25	Reservoir	0	water	1	0
26	Riparian forests	1	veg	1000	910
27	Rock outcrop	1	veg	300	200
28	Rubber plantation	1	veg	995	1000
29	Sand bank	1	veg	300	200
30	Settlement	0	buit	1	0
31	Shrimp/Fish farming and Salt pan	0	water	1	0
33	Barren land	1	veg	1	0
34	Submontane grasslands	1	veg	450	1440
35	Submontane moist evergreen forests	1	veg	1000	910

36	Submontane semi-evergreen forests	1	veg	1000	910
37	Submontane shrublands	1	veg	650	1310
38	Swidden agriculture	1	veg	700	800
39	Tree dominated secondary formations	1	veg	850	1440
40	Coastal Open Water	0	water	1	0
41	Coniferous forest	1	veg	1000	950
42	Deciduous forests	1	veg	1000	1440
43	Dryland crops	1	veg	638	800
44	Estuarine areas	1	wetlands	650	200

Appendix 9: Water Demand Table for Water Sscarcity Model

LULC Name	LULC Code	Water Demand
Settlement	30	400
Paddy field	21	600
Receding and Floating rice fields	24	700
Dryland crops	43	300
Orchard	19	400
Shrimp/Fish farming and Salt pan	31	1000
Forest plantation	5	400
Rubber plantation	28	400

Appendix 10: Evaluation Table for Hydropower Production Model

Station Name	Timeframe	Discount	Efficiency	Fraction	Calib	Cost	Height	Kw_price
Stung Battambang	50	4	0.8	0.7	1	0.06	30	0.175
Stung Pursat	50	4	0.8	0.7	1	0.06	50	0.175
Stung Metoek	50	4	0.8	0.9	1	0.06	80	0.175
Stung Russey Chrum	50	4	0.8	0.85	1	0.06	70	0.175
Stung Tatay	50	4	0.8	0.85	1	0.06	80	0.175
Stung Chhay Areng	50	4	0.8	0.75	1	0.06	90	0.175
Kirirum I	50	4	0.8	0.8	1	0.06	40	0.175
Kirirum III	50	4	0.8	0.8	1	0.06	30	0.175
Kamchay	50	4	0.8	0.7	1	0.06	70	0.175