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# Executive Summary

Mapping and Valuing Ecosystem Services in Mondulkiri:  
Outcomes and Recommendations for Sustainable and  
Inclusive Land Use Planning in Cambodia

**Lead authors:** Karina Watkins; Chansopheaktra Sovann; Luke Brander; and Baromey Neth.

**Lead editors:** Nirmal Bhagabati; Emily McKenzie; Lucy Emerton; Maelle Pelisson; Coline Ganz; and Kimheak Chhay.

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# 1. EXECUTIVE SUMMARY AND POLICY RECOMMENDATIONS

Cambodia is a country rich in natural resources that sustain the wellbeing of the nation's population and contribute to the country's economy. It has the largest areas of contiguous and intact forests in mainland Southeast Asia. Millions of people in Cambodia, many rural and poor, depend directly on the natural environment for their daily basic food, water, energy needs and income generation. All Cambodians depend on the country's forests to: regulate the water and soil cycles; provide protection against floods; storm protection; recreational benefits and tourism revenues. All of these benefits are known as ecosystem services which are the goods and services nature provides us for free and are essential for life support processes (Millennium Ecosystem Assessment 2005). These services however are threatened by continued deforestation driven by large-scale infrastructure projects, timber production, illegal logging, mining projects, and other development activities.

Economic growth is essential for the country to develop. However, economic growth at the expense of natural resources and ecosystem services is unsustainable, weakening the functioning of the country's ecosystems and increasing vulnerability among the poorest communities. WWF Cambodia therefore recommends an ecosystem approach to land use planning to ensure that development projects take place outside of areas of critical ecological importance thus preventing economic activities from undermining the functioning of ecosystems. With the generous support of the European Union and USAID and in collaboration with the Royal University of Phnom Penh, WWF Cambodia has conducted a study in the densely forested province of Monduliri to highlight the location and value of the province's key ecosystem services with a view to integrate ecosystem services into land use and spatial planning decisions.

The Royal Government of Cambodia's (RGC) National Spatial Planning Policy aims to address land use challenges and ensure that land and natural resources are used and managed in a sustainable, effective and equitable manner to support socio-economic development, food security, national defense and natural balance (RGC 2011). Without effective land management planning and integrated land use plans, it is likely that: encroachment into Protected Areas (PAs); unsustainable exploitation of forests and fisheries; and poor water management, will become exacerbated. The poorest are likely to be most severely affected (Diepart 2008) however, Cambodia's economy too is also likely to be impacted as the country depends on natural resources for economic development and tourism.

As recognized in the National Strategic Development Plan (NSDP) 2014-18 (RGC 2013a), there is a need to better manage Protected Areas and a need for more information on biodiversity and natural resources. The RGC has demonstrated its willingness and commitment to work towards sustainable development, as evidenced in the National Policy and Strategic Plan on Green Growth (2013b), the National Green Growth Roadmap (2013c) and the current efforts to develop an Environmental Code (in development, 2016). Ecosystem-based management and planning can contribute to achieving sustainable development, defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987; Cohn and Lerner 2003).

A set of tools called InVEST (which stands for Integrated Valuation of Ecosystem Services and Tradeoffs) was used to spatially map and economically value different ecosystem services in the Monduliri province as part of a ecosystem services assessment and valuation undertaken from June 2014 to September 2016. The overall objective of the project was to support policymaking and provide information useful for land use and spatial planning decisions. The specific objectives were to:

1. Produce baseline maps demonstrating the areas with the most priority ecosystem services (or 'hotspots' of priority ecosystem services) and areas with the least;
2. Assign an economic value to priority ecosystem services by carrying out an economic valuation of these ecosystem services; and
3. Provide insights on how priority ecosystem services could be affected by different interventions (policies / actions) in the future, by producing maps of these ecosystem services in 2030 according to different future scenarios.

The team produced maps, in pixels and by sub-watershed, of the following ecosystem services: carbon storage; non-timber forest products (NTFPs); habitat quality of wildlife; annual water yield; avoided nutrient pollution (or nutrient retention); and avoided sediment pollution (or sediment retention).

The following ecosystem services were also assigned an economic value: carbon storage, NTFPs and annual water yield. The remaining ecosystem services were either too small to be valued (as in the case of sediment and nutrient retention) or required primary valuation studies that were not available (as in the case of habitat quality).

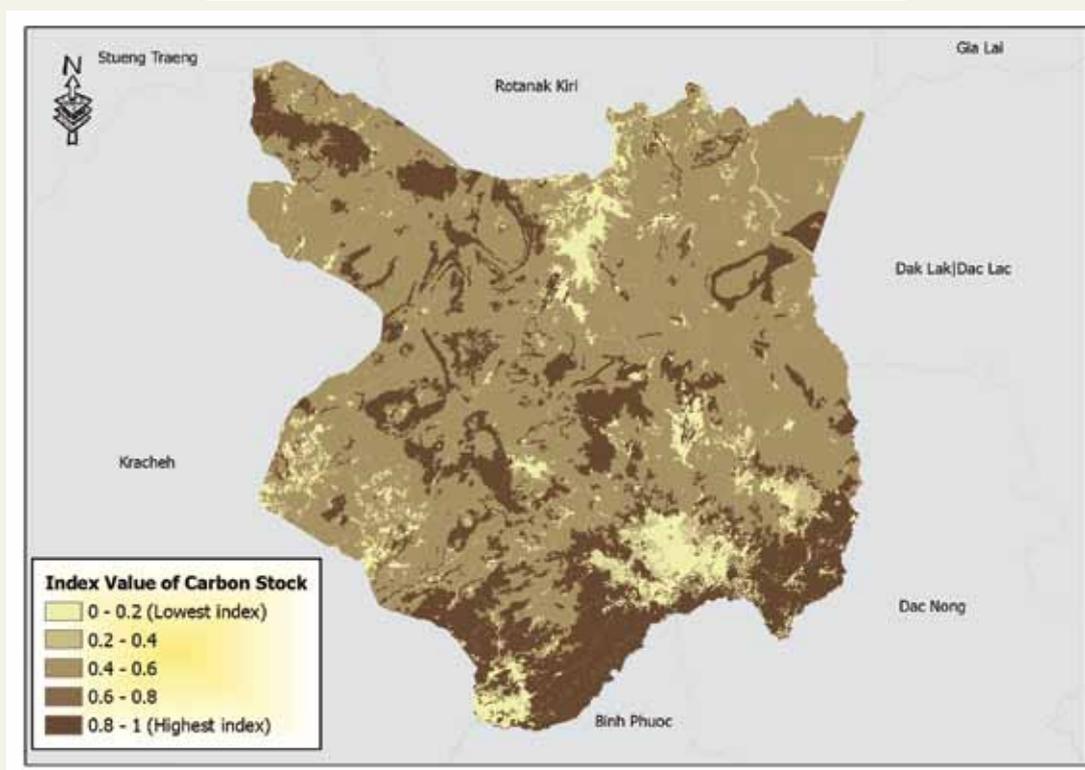
The baseline maps produced to quantify and identify the location of hotspots of ecosystem services used 2010 data on forest cover published by the Forestry Administration, Department of the Ministry of Agriculture, Forestry and Fisheries (MAFF 2011) in order to use the most recent official, Land Use Land Cover maps as a data source. In addition to the mapping and valuing of ecosystem services to produce the baseline maps, ecosystem services were mapped under different future scenarios which showed the changes in Mondulkiri's ecosystem services (in biophysical and economic terms) in 2030 under a: Conservation (or low deforestation) scenario, Green Economy (or moderate deforestation) scenario and Business as Usual (high deforestation) scenario.

## Carbon Storage

Trees' ability to store (or sequester) carbon is an important ecosystem service provided by functioning forest ecosystems. The value of carbon storage is diminished if a forest is converted, e.g. through logging or burning (Aerts and Honnay 2011). As can be seen in the map below, the study assessed the carbon stock (or amount of carbon stored in the forest ecosystem).

Figure i shows the areas with the highest carbon stock in Mondulkiri (in dark brown) and the ones with the lowest carbon stock in Mondulkiri (in pale yellow), the legend shows a relative scale of carbon stock for Mondulkiri province. Even areas that have not been legally zoned can be seen to have a higher stock. The provinces with high carbon stock are serving an important function: regulating the climate, regulating water cycles and providing individuals nationally and globally with the goods and services needed for day to day activities. It is therefore recommended that decision-makers consider sustainable financing mechanisms such as carbon offsets, REDD+ and other options to sustain the functioning of these forest ecosystems.

**Figure i: Baseline map of carbon stock (in pixels)**

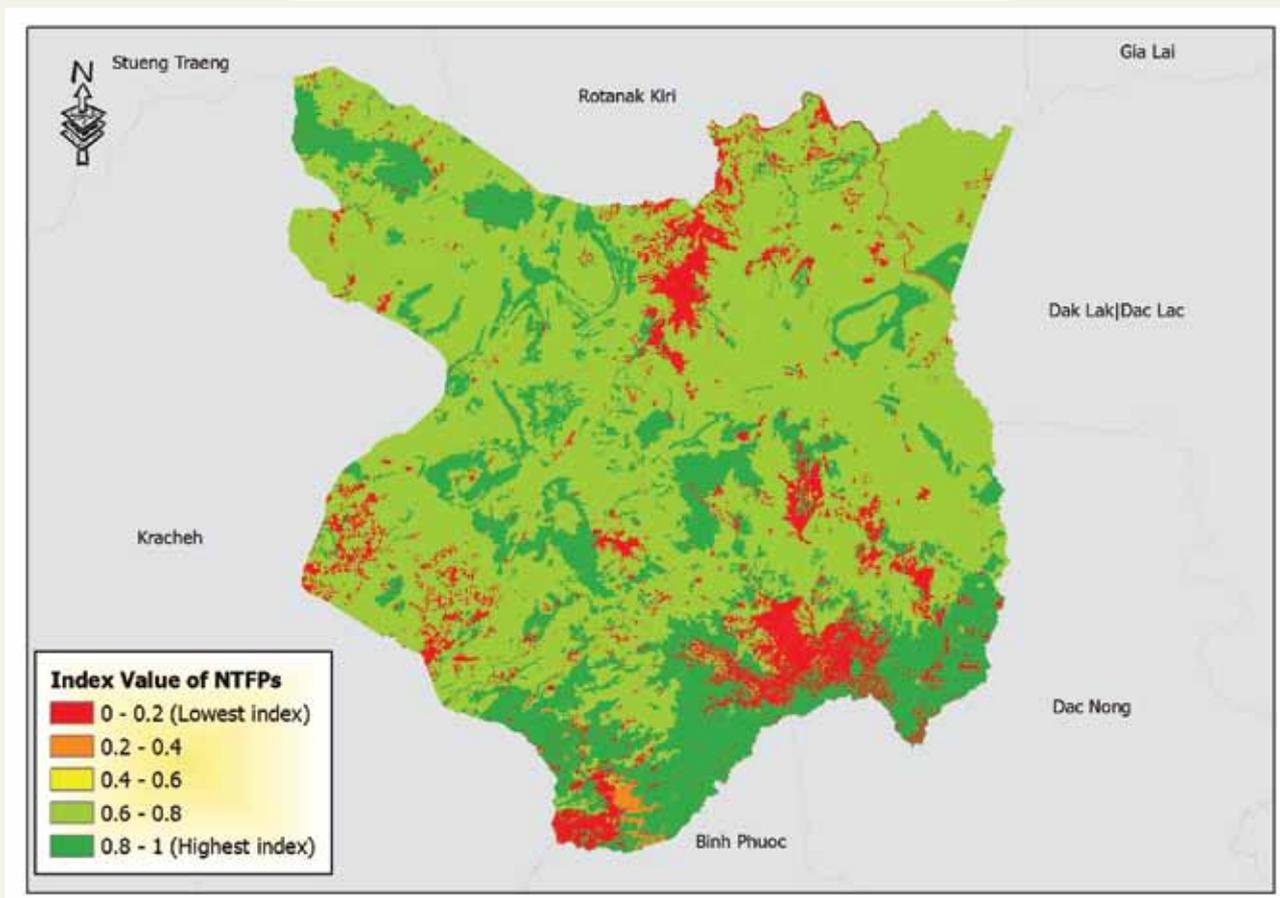


## Non Timber Forest Products (NTFPs)

NTFPs provide: basic subsistence in the form of food; medicines; materials for constructing homes and furniture; cultural benefits; and a source of income (e.g. from selling honey or rattan products). NTFPs are important in the livelihoods of local people. The NTFPs that were taken into consideration in this mapping and valuation study include: liquid resin, solid resin, bamboo and wild honey. The communes with the highest quantities of NTFPs are: Bu Chri, Roya, Chong Phlah, Krong Teh and Dak Dam. By looking after the forests in these communes to ensure the well-functioning of the forest ecosystem, the commercial and livelihood opportunities of NTFPs would be enhanced. Local communities would consequently benefit from these sustained sources of income, on which households greatly depend.

The conservation and protection of the areas that produce the highest quantities of NTFPs (the darker green areas in Figure ii), can occur through planning economic development activities outside of these areas and strengthening law enforcement operations in these forests which would significantly reduce deforestation in these areas. The forest would then be able to continue to provide this vital ecosystem service, so highly valued by local communities. Supporting the birth and growth of NTFP enterprises e.g. promoting systems of sustainable bamboo harvest and production, is a way of supporting the local economy. This could also help reduce incentives for more unsustainable practices such as illegal logging.

**Figure ii: Baseline map of NTFPs (in pixels)**



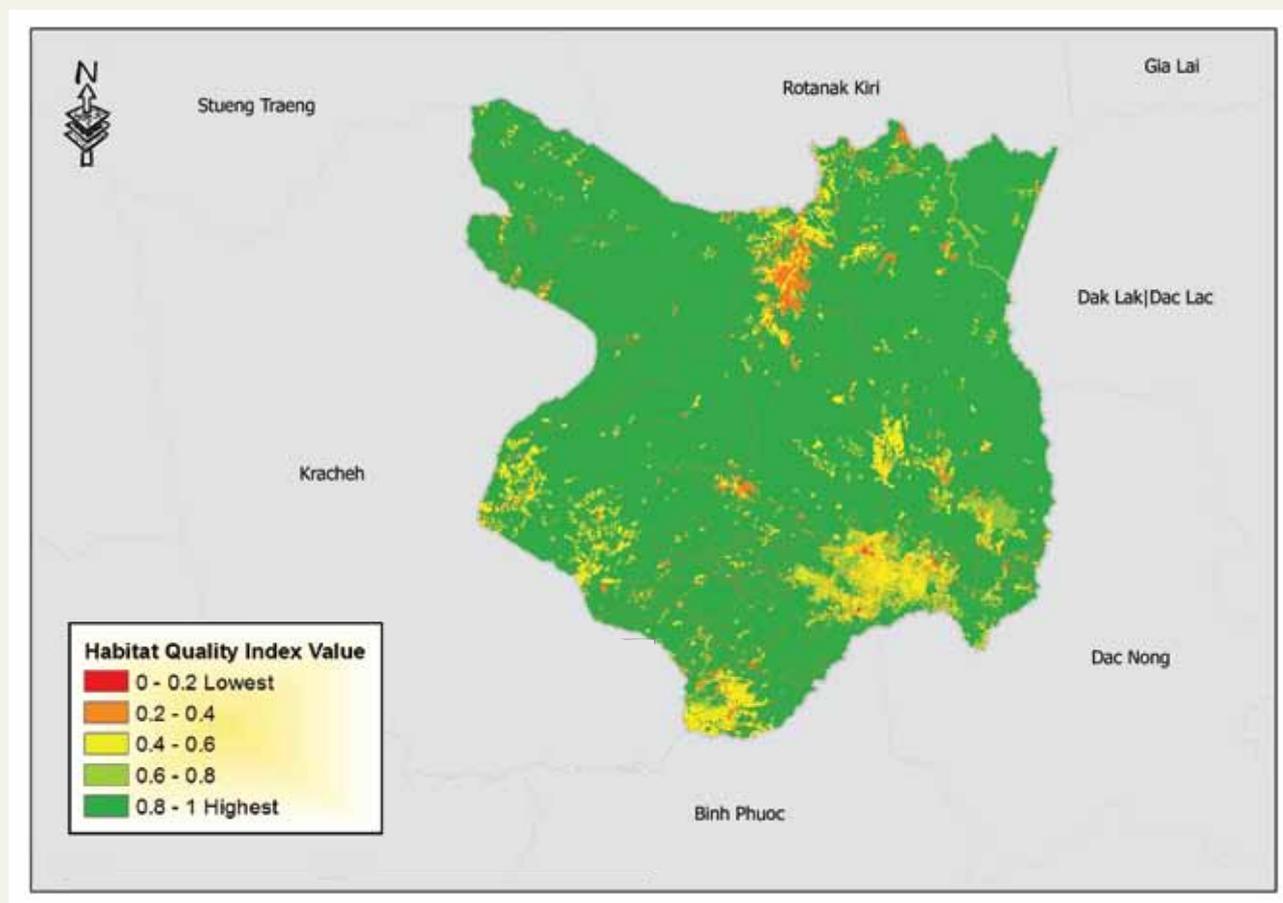
## Habitat Quality

Habitat quality<sup>1</sup> is defined in this study as habitats that are suitable for the following wildlife species: Asian elephants, white rumped vultures and tigers, the latter of which are considered functionally extinct in Cambodia but which the country is trying to bring back into the wild by creating more enabling conditions such as enhancing the quality of potential habitats. These wildlife species attract tourism and provide recreational benefits as well as serve to contribute to the food chain on which we all depend. The areas of land that would be considered as suitable habitats for these three wildlife species are located in Phnom Prich Wildlife Sanctuary (PPWS),

<sup>1</sup>These 3 species were selected amongst 8 endangered and critically endangered species (IUCN list) to ensure that different types of habitats were represented. Mondulokiri has been recognized as one of the most suitable areas for recovery of tiger population density.

Mondulkiri Protected Forest (MPF) and some parts of Seima Protected Forest (SPF). Habitat quality is therefore highest in areas with dense forest. Ecotourism could be an additional way of making substantial economic returns from investing in wildlife conservation. WWF-Cambodia believes that ecotourism can help to create additional opportunities to sustain community livelihoods in the landscape, to raise awareness among community members about the value of forests and wildlife, and to co-finance the management of Protected Areas.

**Figure iii: Baseline map of Habitat Quality (in pixels)**



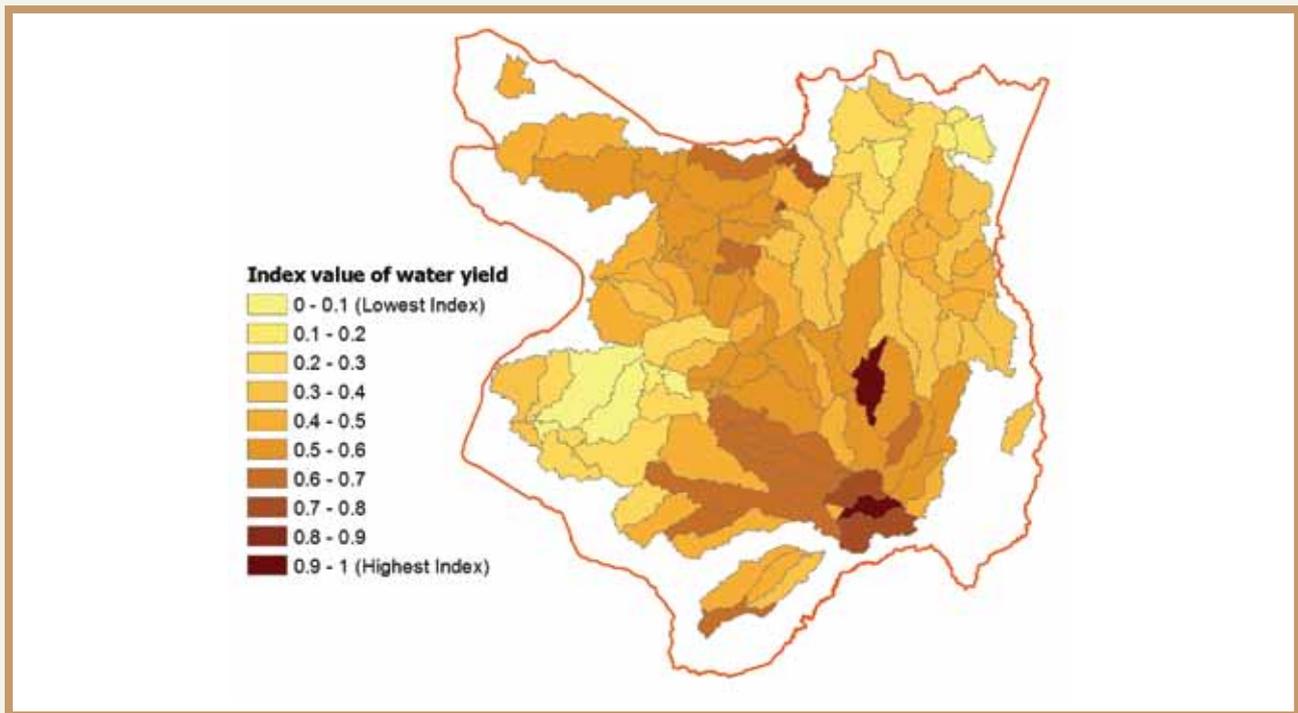
## Annual Water Yield

The annual average water yield on a landscape is defined here as the annual average quantity of water produced by a watershed. Natural forests regulate the water cycle by absorbing and storing water in tree roots during the rainy season and releasing them back into the streams in the dry season. Without trees there are more extremes in water availability: in the short term there is likely to be more water entering the streams as a result of fewer trees, which could increase the likelihood of flash floods and of pollutants entering the water supply. In the longer term, things could change due to other factors, e.g. rainfall patterns change due to extensive deforestation, or loss of tree roots results in the soil losing water retention capacity, which could lead to flash flooding in rainy seasons followed by water shortages in dry season as the water is no longer held in the soil over time and released gradually over the year, but all released shortly after it falls as rain. This flow pattern cannot be captured by the model, however, as it currently only takes into consideration annual averages for water. However the InVEST seasonal water model, which does take the seasonal variability of water yield into account, is currently being developed and trialed.

As shown in Figure iv, the areas with the highest water yield (depicted in dark brown on the map) are the areas with the most precipitation and least amount of natural forest available to absorb this excess surface water. High water yield arises when annual estimations of evapotranspiration are low. Water yield is low where estimated evapotranspiration on a yearly basis is high. Evapotranspiration<sup>2</sup> is higher in a dense forest than on grassland.

<sup>2</sup> Evapotranspiration is a term for all processes through which water, in liquid or solid form, becomes atmospheric water vapor. It includes evaporation from soil, lakes and rivers and vegetative surfaces. It also includes transpiration, which represents evaporation from within the leaves of plants. Evapotranspiration is the primary link in the hydrological cycle between the land and the atmosphere therefore it plays a vital role in stabilising water availability (FAO no date; Allen et al. 1998).

**Figure iv:** Baseline map of Annual Water Yield by sub-watershed



Payments for Watershed Services (PWS) can help manage and maintain water. PWS are defined as contractual and voluntary transactions where a ‘buyer’ agrees to provide some kind of compensation or payment to a ‘seller’ conditional on delivery of a hydrological ecosystem service, or implementation of a land use or management practice likely to secure that service (Wunder 2005). PWS is a way of regulating the water supply, water quality, and erosion control, to the benefit of all.

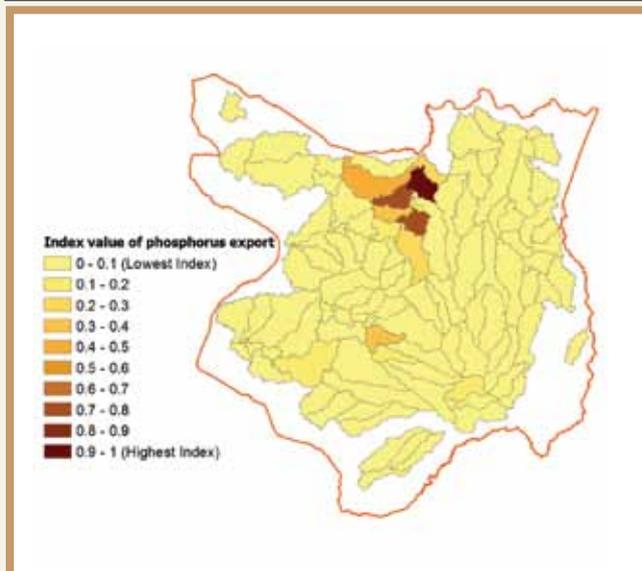
## Nutrient Retention

Nutrients are required for plants to grow. Nitrogen, phosphorus and potassium in particular are the most important contributors to the growth of plants including crops for food. Soil is a major source of nutrients however farmers also add nutrients to the soil when applying fertilizers (which tend to be made up of mostly nitrogen and phosphorus) to enhance agricultural productivity (Lines-Kelly 2004). Forests maintain the levels of nutrients in the soil by retaining nutrients in networks of tree roots thus limiting the runoff of fertilizers into nearby rivers and streams. Deforestation, and the consequent loss of these root networks, can result in a reduction in nutrient retention (the function trees perform to retain nutrients in the soil) and an increase in the flow of nutrients into water systems (Lines-Kelly 2004; An et al. 2008). This can lead to water contamination, affecting human health. Flooding, which can also increase if there are fewer tree root networks to absorb excess surface water, is likely to increase fertilizer runoff and affect water quality in rivers (Bhagabati et al. 2012).

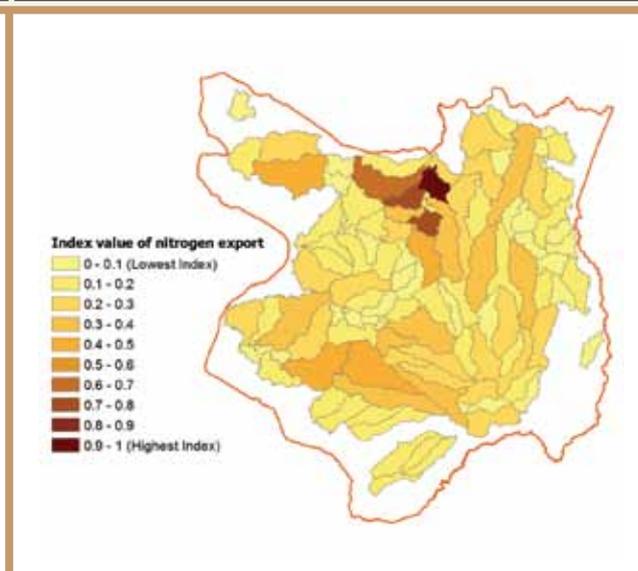
This study estimated the relative importance of nutrient retention, per sub-watershed, as an annual average, using a ‘water purification: nutrient retention’ model to simulate nitrogen and phosphorus loading into streams and water bodies. The model used can map the amount of nitrogen and phosphorus nutrients (the most common nutrients in fertilizers) that go unabsorbed by the trees.

Figures v and vi map the sub-watersheds with the highest phosphorus and nitrogen exports (the areas in dark brown have the largest quantities of nutrients). Areas with large quantities of nutrients (or nitrogen and phosphorus export) tend to be in agricultural areas where fertilizers, herbicides or pesticides are likely to be used. Areas low in nutrients tend to be areas of dense forest.

**Figure v:** Baseline map of the sum (or total amount) of phosphorus export by sub-watershed.



**Figure vi:** Baseline map of the sum of nitrogen export by sub-watershed.



## Sediment retention

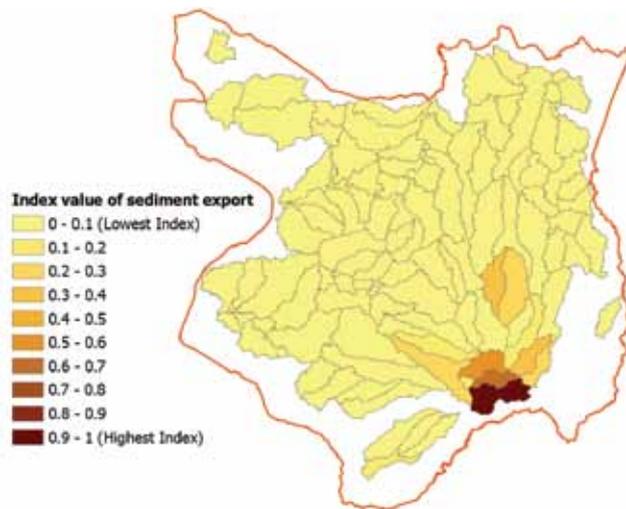
Soil erosion is a significant problem in environments with high rainfall intensity. Forest soils are normally protected by the canopy and stabilized by tree roots and leaf litter. A good root system reinforces the soil and holds it in place reducing the erosive effects of wind, rain, gravity and flowing water (Walker et al. 1996). Land disturbing activities such as logging, tree burning, poor agricultural practices, cause the surface of the soil to form a compacted crust, preventing infiltration (or water on the ground entering the soil) and increasing surface runoff and soil erosion (Van Paddenburg et al. 2012).

River sedimentation occurs when erosion upstream leads to higher sediment loads (or sediment export) in rivers and deposition of sediment downstream. The process occurs naturally and river deltas are formed by sediment deposition, but changes in land use activities upstream may lead to significant increases in the amount of sediment entering a river system (Van Paddenburg et al. 2012). Excessive amounts of sediment can lead to: the deterioration of water quality, as a result of pollutants and harmful bacteria that may be attached to soil particles; algal blooms which block out light that other plants need to grow and reduce the amount of oxygen in the water available for fish; change and often destroy fish habitats and spawning beds; and clog fish gills, impairing their functioning (Walker et al 1996). A build-up of sediment can also lead to a shallower body of water resulting in increased risk of flooding and a reduction in the navigability of water channels, making it more difficult for fishing boats to travel (Fondriest Environmental, Inc. 2014).

Because of the importance of the role of natural forests in retaining sediment, otherwise known as sediment retention or erosion control, this ecosystem service has been assessed in this study by measuring and mapping quantities of sediment export to show the current spread of sediment export and how the amount and spread of sediment is likely to change in 2030 under each future scenario.

In a province with local populations so dependent on fish for food and livelihoods and water for irrigation, cleaning and drinking, sedimentation is likely to have highly detrimental impacts on the wellbeing of local families and household incomes. As Figure vii shows, these impacts are likely to be most keenly felt in the southeastern parts of the province where volumes of sediment export (depicted in dark brown in Figure vii) are highest. Therefore putting in place measures to prevent or limit sedimentation is a more favorable and less costly approach than addressing the problems once the damage has been done. Examples of these measures include: confining deforestation to areas of flat land or small inclines outside of Protected Areas / Protected Forests to limit runoff; promoting sustainable agricultural practices among private sector stakeholders and local smallholders; and implementing watershed management and/or PWS.

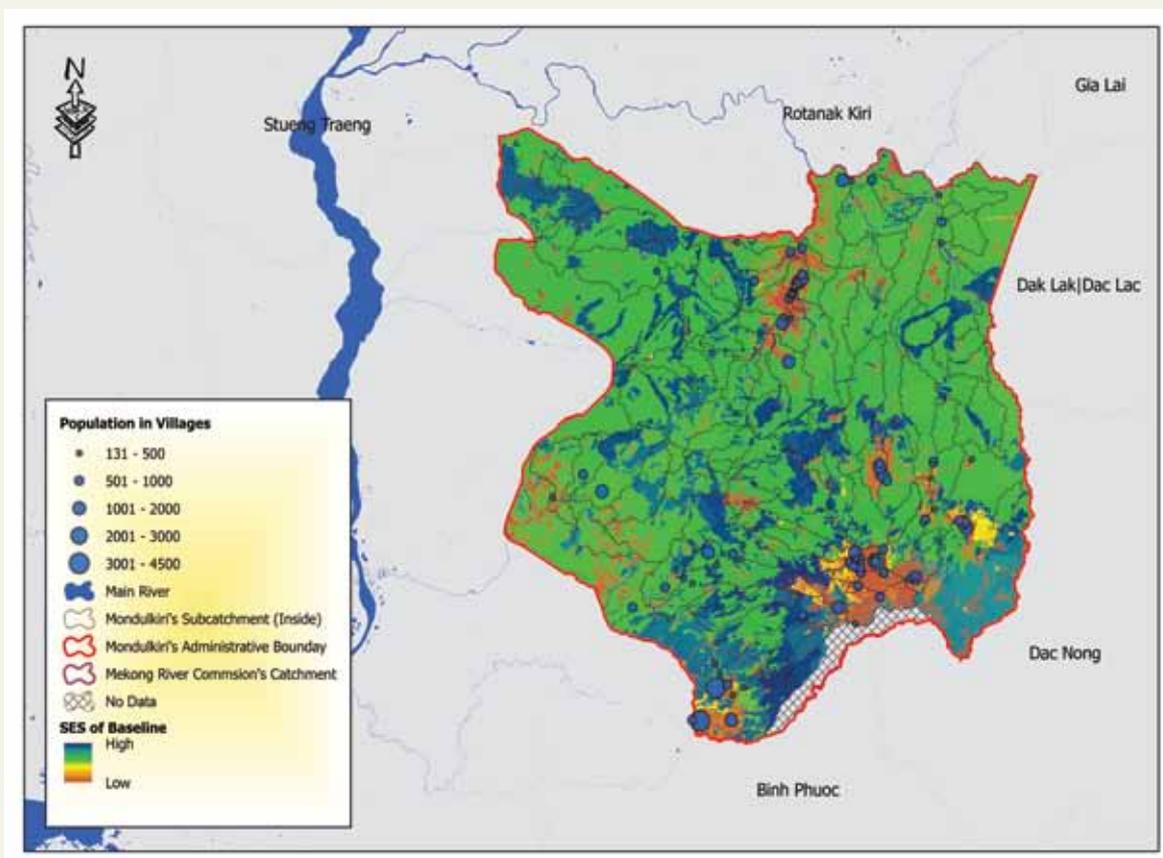
**Figure vii:** Baseline map of sediment export by sub-watershed



## Combined Ecosystem Services

The total amount of all six ecosystem services that this study assessed were aggregated and given the label combined ecosystem services, enabling us to observe the geographical spread of the key ecosystem services that were the focus of this assessment. The map in Figure viii shows the areas with the most amount of combined ecosystem services and the areas with the least. Researchers found that the larger the forest cover in a commune, the higher the amount of combined ecosystem services. As highlighted in Figure viii, the areas in blue and green have a high volume of combined ecosystem services, notably in the Protected Areas, while the areas in yellow and red have fewer forest patches and some have a high population density. The areas depicted in blue and green in the map on Figure viii are important sources of ecosystem services on which local populations depend.

**Figure viii:** Baseline map showing combined ecosystem services in Mondul Kiri, from official data source (MAFF 2011)



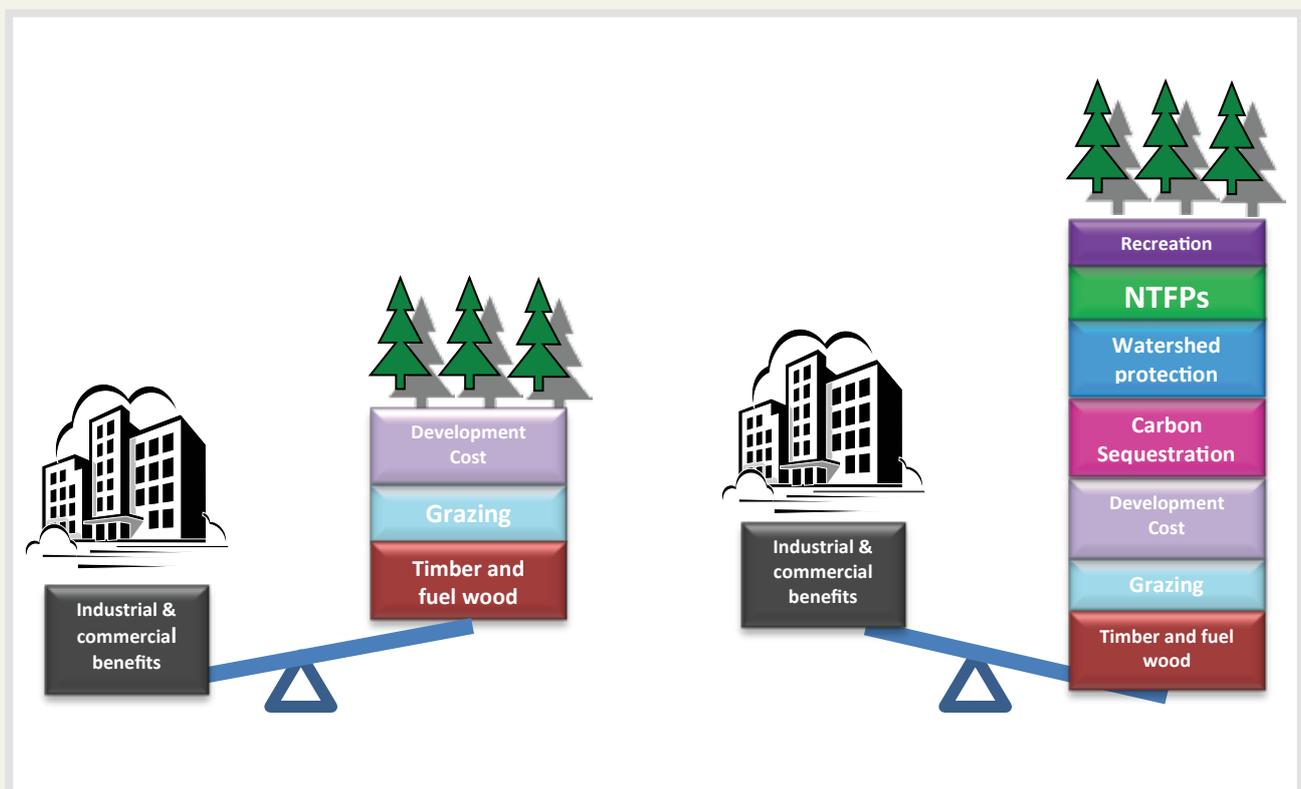
## What is the Economic Value of Ecosystem Services in Mondulkiri Province?

Ecosystem services produce valuable benefits to society and to the local economy for example, the provision of clean water is useful for maintaining the health of fish populations which are important for nourishing humans and enabling local livelihoods. Ecosystems in the Eastern Plains Landscape provide these valuable services for free but these benefits are under threat due to unsustainable land practices that could jeopardize the functioning of these ecosystems thereby reducing the services provided. Economic valuations are a way of assigning a value to these free public services that are under threat to make the economic case for investing in or supporting nature conservation to maintain these vital ecosystem services (Emerton and Aung 2013). Economic valuations can also be useful for justifying and setting priorities for programs, policies or actions that protect or restore ecosystems and their services (Goulder and Kennedy 2011). By neglecting to include ecosystem services in policy or land use planning decisions, the costs and benefits they provide are not adequately represented which results in an undervaluation of ecosystem services. Figure ix provides a visual depiction of the benefits ecosystem services provide that are currently being omitted from these types of decisions.

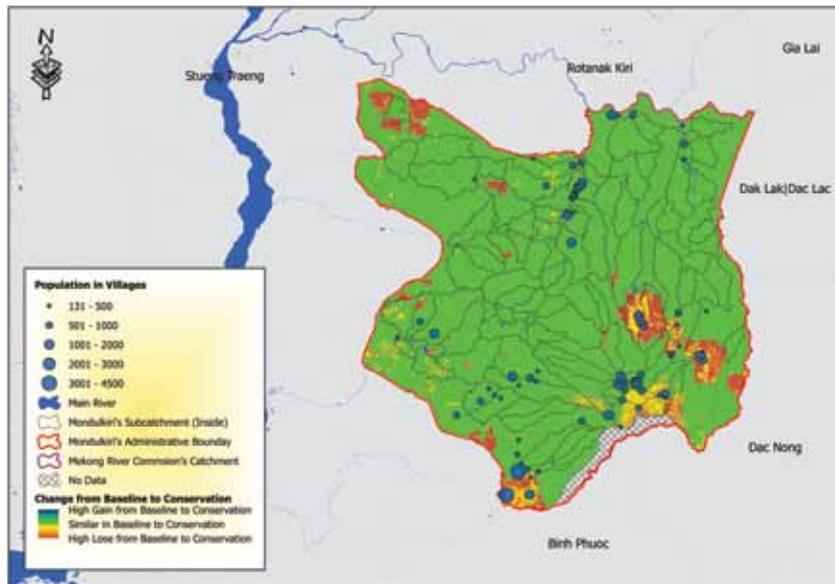
As part of the assessment of ecosystem services in Mondulkiri province, an economic value was assigned to three ecosystem system services (NTFP availability, annual water yield and carbon storage). Three future economic development scenarios were developed and mapped, in collaboration with local stakeholders, each of which envisioned different land use changes between now and 2030, to help inform decisions by understanding how different economic development trajectories will lead to different outcomes. The economic valuation in this study was carried out by assigning a monetary value on the welfare changes that result from the impacts of each scenario on these three ecosystem services in 2030.

Unfortunately not all six ecosystem services could be assigned an economic value. Sediment and nutrient retention as well as habitat quality could not be assigned a value because of data limitations. Although this was not carried out as part of this study, these ecosystem services can be assigned an economic value as part of future research.

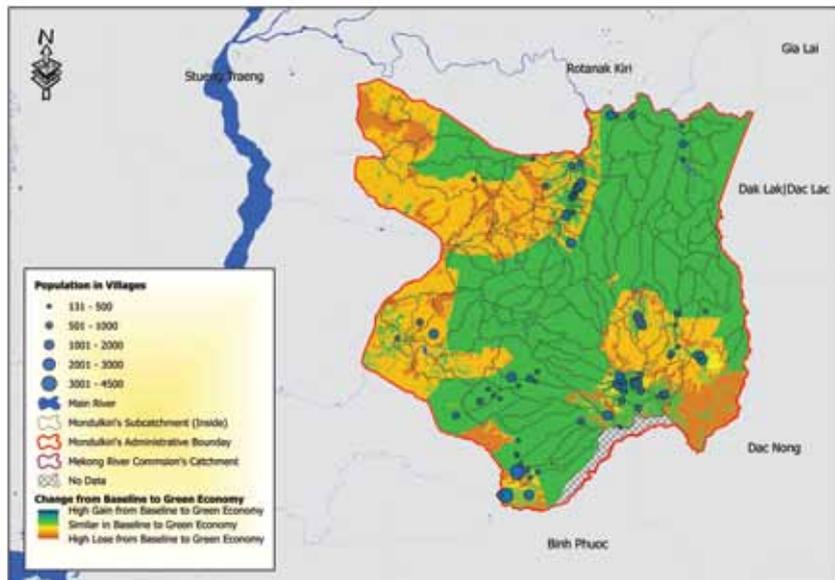
**Figure ix:** Illustration to demonstrate how ecosystem service valuation provides a more complete account of costs and benefits (The Natural Capital Project 2015)



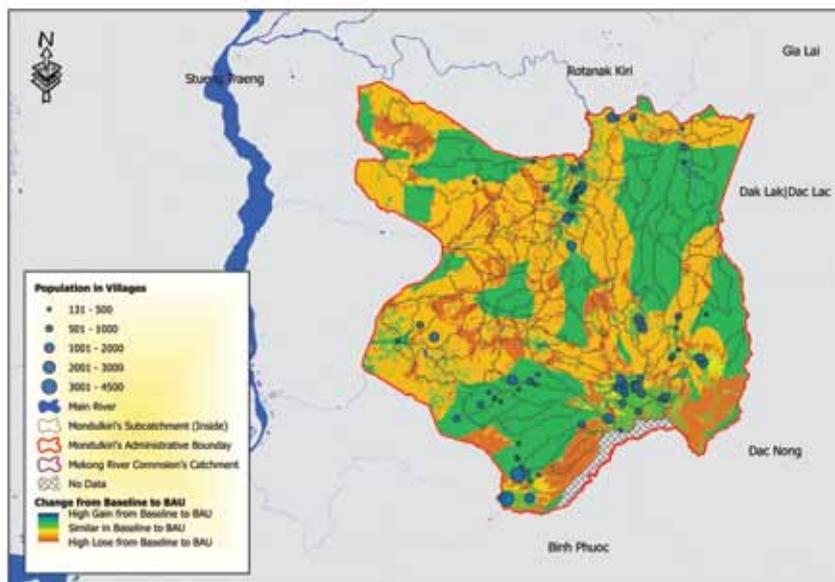
## How would Ecosystem Services be Affected by Different Future Development Scenarios?



**Figure x:** Map showing changes in ecosystem services in Mondulakiri in 2030 under a Conservation Scenario from the from the baseline map (Figure xiii)



**Figure xi:** Map showing changes in ecosystem services in Mondulakiri in 2030 under a Green Economy scenario from the baseline map



**Figure xii:** Map showing changes in ecosystem services in Mondulakiri in 2030 under a Business as Usual scenario from the baseline map

The project team developed maps showing changes in ecosystem services under three different development scenarios for 2030: Business As Usual (BAU), Conservation (CN) and Green Economy (GE). These spatial maps were produced on the basis of 'storylines' (or descriptions on which each different future scenario was imagined, visualised and produced into a map). These were developed by stakeholders, including provincial level government officials from Mondulhiri and civil society representatives, in conjunction with WWF and RUPP. Baseline maps (Figure viii is an example of one) were produced to show the 'current' situation in Mondulhiri. WWF Cambodia and RUPP used official government data sources to produce the Baseline maps therefore 2010 data was used as this is the most recent official government forest cover data for Cambodia.

The Business as Usual scenario envisages continued high deforestation rates between 2010 and 2030. The Conservation scenario prioritises the conservation of natural resources over unsustainable economic development activities and envisages a future with limited deforestation between 2010 and 2030. The Green Economy scenario visualizes a middle path, a moderate deforestation rate in which there is more of a balance between economic development and conservation. These future scenario spatial maps (examples of which are Figures x, xi and xii) were produced collaboratively with policymakers with the aim of helping them visualize how Mondulhiri will look in 2030 if the current trajectory continues and what Mondulhiri would look like in 2030 if alternative paths are taken. It shows the impacts of different economic development paths on ecosystem services and these maps can be used to support spatial planning in Mondulhiri.

## Conservation scenario

As produced and agreed by local stakeholders, the Conservation scenario envisages a future development path of relatively low levels of deforestation, which would mean that in 2030, 85% of Mondulhiri's total land area would remain as forest cover. The Conservation scenario maps show fewer losses of ecosystem services (as shown in the bar chart on Figure xiii and by the relatively few areas in red and orange, which show little forest cover and few ecosystem services on the maps in Figure xiv) with some gains in carbon storage, as a result of the increase in tree cover from rubber plantations grown outside of Protected Forests and Protected Areas. Although some gains in terms of carbon storage can be made, in general monocrop plantations can degrade biodiversity especially if plantations take the place of natural forest as has happened in the Mekong region in the past (He and Martin 2015). In this scenario, the areas with the most ecosystem services (Protected Areas and Protected Forests) see no forest loss between 2010 and 2030.

## Green Economy scenario

The Green Economy trajectory envisioned: increased protection of areas with high biodiversity; adherence to spatial plans; and implementation of sustainable finance mechanisms. This is very much aligned to the NSDP 2014-2018 (RGC 2013a); National Policy and Strategic Plan (RGC 2013b); and the National Green Growth Roadmap (2013c), which promote sustainable land use and natural resources management, and green investment to ensure green development in Cambodia. The GE scenario is also based on the following assumptions, that by 2030:

- Non-forest areas in the province, besides non-forest areas in ELCs, are kept as community use zones, multiple use zones, or sustainable development zones at community scale.
- Existing rice fields in Koh Nhek (in the North of the province) have expanded 10km in the buffer for rice production zones increasing rice production in response to a growing demand for rice.
- The remaining areas in Mondulhiri besides the areas mentioned previously are assumed to be buffer economic zones for rubber plantation (although these are assumed to be sustainable rubber plantations).
- Road projects planned (before 2020) do not go ahead due to the significantly greater contribution this will make to deforestation in the province.

***The GE scenario witnesses a reduction in forest cover from 2010 to 2030 such that by 2030, 53% of Mondulhiri's total land area is forest cover.***

However losses in carbon storage, habitat quality for wildlife and NTFPs are less significant than the losses in the BAU scenario (as shown on the maps in Figure xiv). Risks of sedimentation are also reduced, as forest cover on high slopes are maintained, but the increase in agricultural productivity for rice production may increase nutrient runoff into water channels. These results however do not take into account sustainable agricultural practices, such as terraced rice farming, which can reduce harmful fertilizers entering water channels and affecting water quality. These sustainable agricultural practices are promoted in the National Policy and Strategic Plan on Green Growth (2013b).

Improved governance and management of Protected Areas, as outlined in Cambodia's NSDP 2014-18 (RGC 2013a), are likely to reduce losses in vital ecosystem services. The adoption of the Green Economy scenario, allows for a pragmatic balance between development and conservation.

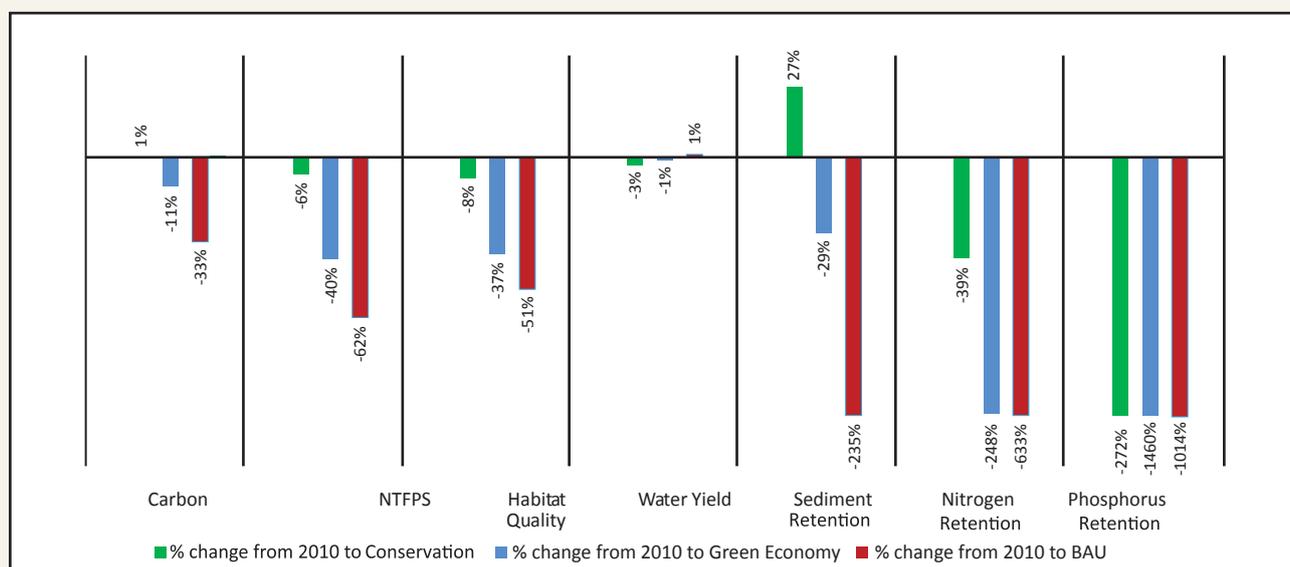
## Business as Usual (BAU) Scenario

The BAU scenario takes into consideration the impact of development activities on ecosystem services that the RGC is currently planning on implementing in Monduliri, for example, ELCs in which rubber plantations are planned; land clearing for other types of monocrop cultivation; road construction; and the development of settlements (or villages). The two main drivers of deforestation between 2010 and 2030 in this scenario are ELCs and the construction of roads, as per the current development plans and as agreed by stakeholders in workshops. Therefore these planned ELCs and roads can be seen in the BAU maps in Figure xiv.

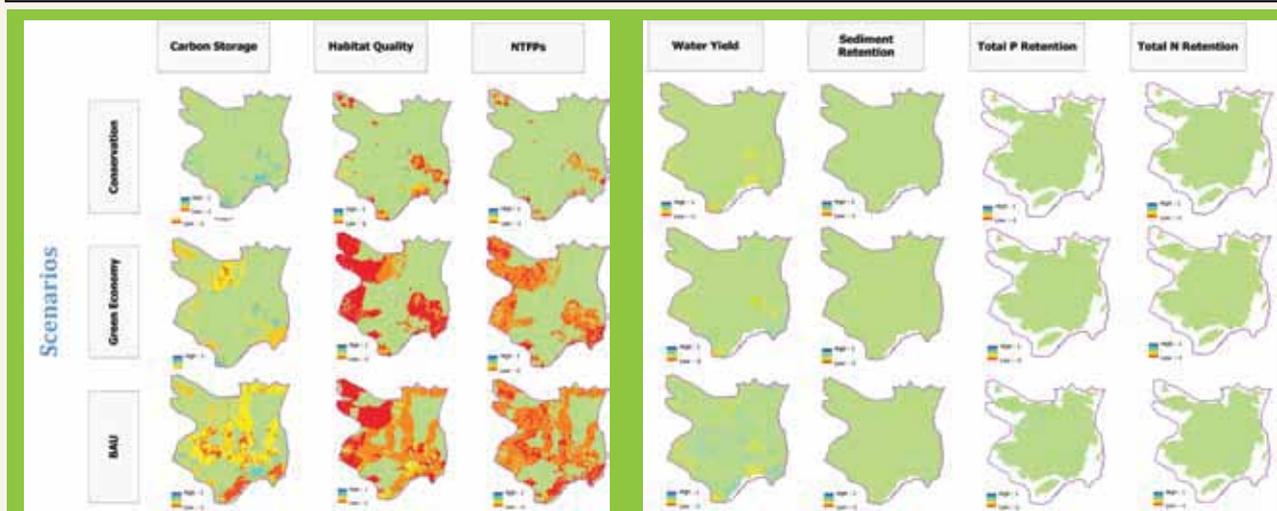
In this scenario, forest cover represents only 34% of the province's total land area in 2030. The high rate of deforestation in this scenario is likely to have detrimental impacts on forest biodiversity, habitat quality of wildlife, soil quality and the amount of carbon stored in the trees, all of which are likely to reduce. Figure xiv shows the losses of all six combined ecosystem services in red, orange and (to a lesser extent) yellow on the BAU maps. The effects are as follows:

- Annual water yield increases as a result of fewer trees to regulate the water, which results in increases in the risk of hazards such as flash floods.
- A 62% loss in the availability of NTFPs (as Figure xiii highlights) results in a reduction of sustainable sources of income for local communities. This can increase their vulnerability and exacerbate poverty in the province, especially if the loss of NTFPs which support households cannot be made up with other sources of income.
- A 33% loss in carbon stored in Monduliri's forests diminishes the ability of Cambodia's forests to regulate the carbon cycle therefore undermining efforts to mitigate climate change impacts and treaties that have been agreed to. Cambodia's target laid out in the country's Intended Nationally Determined Contribution (RGC 2014), to increase forest cover to 60% of Cambodia's land area, is unlikely to be achieved under this future development scenario, given the large forest losses by 2030 in one of the country's most densely forested provinces.
- The most significant losses in sediment and nutrient retention take place in this scenario as a result of the considerable forest loss. Significantly fewer trees upstream absorbing nutrients can increase the amount of nitrogen and phosphorus in water channels downstream. This increase in nutrients entering water supplies and higher rates of sedimentation can lead to diminished water quality. Increased sediment also increases the risk of flooding and can affect the fertility of the top soil on which farmers depend for agriculture. Therefore the security of local livelihoods is at increased risk due to the high forest loss.

**Figure xiii:** The changes of combined ecosystem services from baseline to each future



**Figure xiv:** Maps of relative changes (gains/losses) in carbon storage, habitat quality, NTFPs, water yield and sediment export for each future scenario



### Economic valuation results

An economic valuation of carbon storage, NTFPs and water yield was carried out, both for each ecosystem services and as a combination of all three. Table i reports the difference in the annual value of forest ecosystem services in 2030 relative to their annual value in 2010.

Once the three ecosystem services were aggregated and assigned an economic value, the results show that their economic value changes between 2010 and 2030 under each different development scenario. By 2030, under the Conservation scenario, there is an increase in the value of the three combined ecosystem services of approximately US \$14.5 million. By 2030, under a Green Economy scenario, the reduction of ecosystem services (as a result of some forest loss) amounts to a loss of US \$370 million to the economy. The most severe loss in ecosystem services comes under the BAU scenario which sees a loss in ecosystem services worth US \$1.1 billion. Losses under a BAU scenario are approximately three times greater than under a GE scenario.

The increase in the value of ecosystem services in 2030 under a Conservation scenario is as a result of an increase in planned rubber plantations which increase the carbon storage in the province by 2030 relative to 2010; but the provision of NTFPs and water have decreased in 2030. GE sees economic losses in all three ecosystem services in 2030 as a result of land use change. The BAU scenario, which has considerably more agriculture and high rates of deforestation than the other scenarios results in the highest economic losses, which is likely to affect the local populations the most. The aggregated annual values of the three categories of ecosystem services are represented in Table i.

**Table i. Changes in economic values of ecosystem services in 2030 relative to 2010 (USD, in 000s)**

	Conservation scenario	Green Economy scenario	Business As Usual scenario
NTFPs	-3,551	-10,685	-21,479
Water yield	-1,303	-6,001	-6,827
Carbon (Social Cost of Carbon) <sup>3</sup>	+19,350	360,250	-1,067,250
Total	+14,496	-376,936	-1,095,556

**Table ii Potential value of marketed carbon credits from avoided carbon emissions, in 2030 relative to 2010 (in million tonnes of CO<sub>2</sub>)**

Value of carbon stored	Conservation scenario	Green Economy scenario	Business As Usual scenario
Saleable volume of carbon credits <sup>4</sup>	74	48	0

<sup>3</sup> The social cost of climate change reflects the damage caused by climate change due to additional carbon dioxide emissions. It is an estimate of the global damage/cost of climate change

<sup>4</sup> Using the assumption that 20% of 'additional' carbon storage can be sold. Additional carbon is assessed relative to the BAU scenario.

Both the Conservation and GE scenarios result in large quantities of additional stored carbon, as Table ii shows. Using a conservative assumption that only 20% of additional stored carbon could be credited and sold in carbon markets, it is estimated that 74 million tonnes of CO<sub>2</sub> could be sold under the Conservation scenario; 48 million tonnes of CO<sub>2</sub> under a Green Economy scenario; but no carbon credits can be sold in 2030 under a BAU scenario, as summarized in Table ii. Therefore, for the period 2010-2030, the corresponding net revenues from crediting and selling stored carbon are \$536 million, under a Conservation scenario, and \$348 million, under a GE scenario. The Conservation scenario results in an increase in stored carbon in 2030 relative to the baseline in 2010. This removal of from the atmosphere has a value of US\$387 million. When the social cost of carbon is taken into consideration, which estimates the global cost of climate change, there are large losses of stored carbon under the GE and BAU scenarios. The damages associated with these large losses are estimated to be US\$7 and US\$21 billion respectively.

The sum of the annual value of NTFPs under the baseline scenario, or the total amount that NTFPs contributed to the Cambodian economy in 2010, is almost US\$26 million and this is predicted to fall to US\$10.6 million in 2030 under the BAU scenario. Under the baseline scenario, NTFPs represent an annual household income of 58% of mean household income. Under the BAU scenario, by 2030, the value of NTFPs reduces to only 24%. If households have no alternative livelihoods to make up that loss, then the reduction in incomes will increase poverty levels and worsen the vulnerability levels of already vulnerable communities.

Forests play a pivotal role in the regulation of water yield. Therefore, the estimated value function for water yield regulation by tropical forests was calculated under each future scenario. For water yield, A meta-analytic value transfer method was used to determine the values. The findings showed that the mean and median value of water yield per hectare of forest is higher under the GE and BAU scenarios, than the Conservation scenario. This is driven by the effect of scarcity on the value of water yield. As the forests decrease, the marginal value (per ha) of remaining forest increases. The loss in total annual value of water yield relative to the baseline is nevertheless much higher under the BAU and GE scenarios, as Table ii shows. Almost \$7 million per year is lost under BAU scenario.

**Table iii: Annual value of water yield in 2030**

	CN	GE	BAU
Mean (US\$/ha)	+88	+115	+123
Median (US\$/ha)	+72	+95	+103
Change in total annual value <sup>5</sup> (US\$; 000s)	-1,303	-6,001	-6,827

Losses in NTFP availability and water yield have a direct impact on local households as they currently represent a large proportion of household income. Under the BAU scenario, the reduction in the availability of NTFPs and water yield are equivalent to losing approximately 50% of household income. The loss of these ecosystem services will result in large reductions in household welfare in Mondulkiri.

## Policy Recommendations for Decision Makers



The overarching policy recommendation resulting from the Mondulkiri ecosystem service assessment and policy analysis is for the RGC to adopt the Green Economy trajectory. Moving towards a Green Economy, which takes into account tradeoffs between conservation and development, involves the protection of geographical areas that are 'hotspots' for ecosystem services and involves enabling economic development activities to take place outside of these 'hotspots'. It will enable the country to be more resilient and sustain the continued benefits ecosystem services provide to local populations, citizens of Cambodia and people around the world. A GE pathway can enhance Cambodia's climate change preparedness, reduce social inequalities and income disparities, and ensure the country maintains its regional competitiveness.

<sup>5</sup> Change in total annual value is computed relative to the baseline level of service provision

A Green Economy approach to development provides a more sustainable growth pattern and is aligned with government policies, notably Cambodia's NSDP 2014-18 (RGC 2013a); National Policy and Strategic Plan on Green Growth (2013b); and the National Green Growth Roadmap (2013c).

A GE approach requires:

- 1) ecosystem-based land use planning and management;
- 2) improved governance; and
- 3) sustainable sources of finance.

## Ecosystem-based land use planning and management

Ecosystem-based land use planning and management is designed to protect and conserve natural resources and facilitate environmental restoration (Cohn and Lerner 2003). The process encourages decision makers and stakeholders to agree on which areas of land should be set aside for conservation and which set aside for economic development activities. This in turn helps to achieve a balance between keeping protected areas intact for conservation and areas designated for development.

This approach can provide an important platform to facilitate a balanced and green development pathway for Mondulkiri. Viewing the province through an ecosystem lens allows decision makers to make informed decisions on how best to sustain ecosystem services, sources of livelihoods, the continued regulation of climate and soil cycles that the country's natural forests provide. It can improve decisions around land use planning and result in a better balance between environmental protection and development in Cambodia. It also provides PA managers with a strong mandate to protect and maintain the valuable ecosystem services within a region and shows how these services are critically linked to the economic performance of small holders and private sector outside the PAs.



## **RECOMMENDATION: GOVERNMENT ADOPTS ECOSYSTEM-BASED MANAGEMENT AND PLANNING AT THE PROVINCIAL LEVEL. THIS WILL BE UNDERPINNED BY ECOSYSTEM SERVICE MAPPING; CAPACITY BUILDING; INCORPORATE FINDINGS OF THE MAPPING INTO SPATIAL PLANNING; AND PRACTICE MONITORING AND LAW ENFORCEMENT.**

Ecosystem services assessments and valuations are ideal for incorporating into spatial and land use planning processes at commune, district and provincial levels. These can support decision-makers to better balance economic growth and human wellbeing.

Most businesses greatly depend on natural capital, for example, the supply of freshwater is vital for manufacturing, or the flooding control forests provide is important in the protection of facilities from flooding or erosion. The private sector should be encouraged to assess their impacts and dependencies on natural capital and incorporate these considerations into internal decision-making, and as stakeholders in spatial planning. Legal obligations for businesses to undertake these types of assessments would support the strengthening of ecosystems so fundamental for economic prosperity.

The Natural Capital Protocol, is a standardized framework for natural capital assessments that aims to support business managers to inform their decisions by discussing how we interact with nature or more specifically natural capital. It allows businesses to measure, value and integrate natural capital into their existing business processes.<sup>6</sup>

## Strengthened Governance

Transparency, accountability and equity in natural resources governance strengthen the rule of law and empower marginalized communities. Efforts are required to strengthen governance at national and local levels to ensure that laws are effectively implemented which will maintain the natural forests in PAs that provide the benefits humans need to survive. Greater emphasis on law enforcement in Protected Areas is needed to reduce illegal logging and hunting activities in forests. Officials should work across Ministries and across levels of governance to also address the different drivers of deforestation. Strong and effective law enforcement would help in creating an improved governance environment that would promote responsible and sustainable private investments, respecting the interests of the local communities and forests. Effective governance requires collaboration from all stakeholders from national to commune level, as well as support from local communities. Raising the awareness of local communities on the consequences of deforestation and promoting sustainable livelihoods reduces the incentive at the local level to undertake illegal logging. Therefore more accountable and participatory governance will improve land use and sustainable natural resources management.

The cornerstone of successful ecosystem-based planning and management processes is participation from key stakeholders to ensure shared ownership and consensus among diverse interest groups. By having a collaborative approach to land use planning, this can: help raise awareness of the environmental challenges and laws among all stakeholders; lead to the mediation or resolution of disputed land claims; provide a forum to develop and strengthen PA management plans to ensure they take into consideration the needs of local populations residing in the landscape; lead to greater buy-in and increased respect for the plans decided upon; and lead to more effective implementation of plans as all stakeholders have taken part in the planning process.

Economic development activities should be confined to areas outside of PAs. In addition, Environmental Impact Assessments also need to take ecosystem services into consideration in order to improve land use planning and balance economic development and conservation. A key step in the EIA process is to mitigate project impacts on the benefits provided by ecosystems to at least achieve no loss in these benefits by affected stakeholders, and to manage dependencies of the project on priority ecosystem services. There is a need to develop mitigation measures to mitigate loss and enhance gain in ecosystem services benefits. However if these measures are considered insufficient, the following 4-step mitigation hierarchy should be applied to ecosystem services: 1. Avoid an impact altogether by not taking a certain action or parts of an action; 2. Minimize impacts by limiting the degree or magnitude of the action and its implementation; 3. Reduce preservation and maintenance operations on-site during the life of the action; 4. Impacts that can't be addressed by any previous steps, can be addressed by replacing or providing substitute resources or environments that offset the impact on ecosystem services (WRI 2013; Tallis, Wolny and Lozano 2011; McKenzie, no date).

## Sustainable Financing Mechanisms

To support the Royal Government of Cambodia in improving the management of natural forests and sustain the benefits provided by ecosystem services, the government is encouraged to identify and promote sustainable financing mechanisms for the effective management and protection of Protected Areas. Some examples of these include: ecotourism, community-based enterprises dependent on NTFPs, REDD+, voluntary carbon markets, etc. Such opportunities could provide national, subnational and local stakeholders more incentives to protect these important 'hotspots' of ecosystem services sustaining the benefits provided by them.

<sup>6</sup> Interested stakeholders can visit the following website for more information  
<http://www.naturalcapitalcoalition.org/natural-capital-protocol.html>

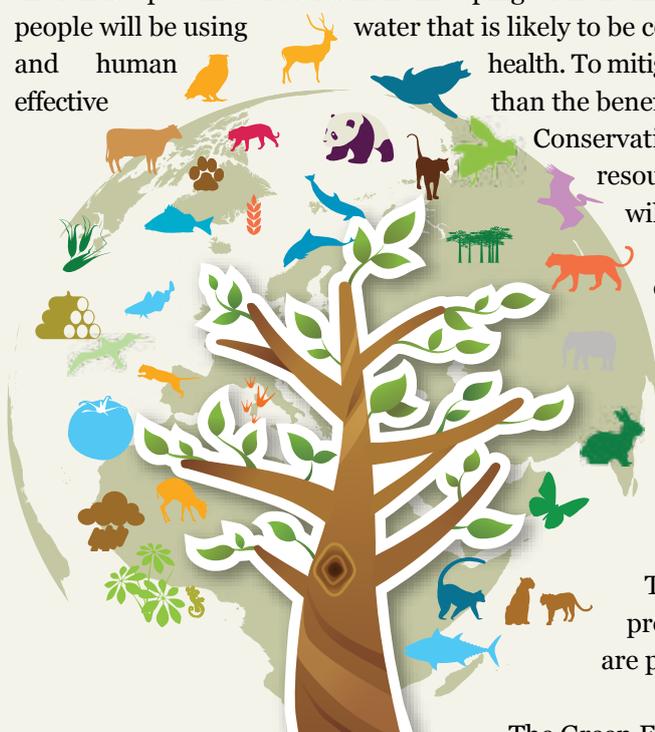
The first carbon credits from a climate change mitigation project in Keo Seima Wildlife Sanctuary, Mondulkiri (WCS 2016), could be the first of many such initiatives that tap into existing voluntary carbon markets in efforts to protect Mondulkiri's forests.

It is recommended that the private sector be held to account if their activities impact negatively on the surrounding area. To ensure that the due compensation is provided to mitigate the impacts of any environmentally harmful activities, companies should be incentivized to participate in sustainable financing mechanisms, such as payment for ecosystem services, trust funds, conservation offsets, etc., through command and control regulation or the creation of market-driven motives.

### Why Green Economy?

WWF Cambodia recommends the integration of the Green Economy scenario in Mondulkiri's land use and spatial planning process as this scenario strikes a balance between conservation – protecting the areas in which there is the largest amount of ecosystem services – and economic development.

Mondulkiri in 2030 under a BAU scenario sees a province with considerably fewer natural forests and consequently fewer ecosystem services that contribute to the wellbeing and livelihoods of local households. Therefore the landscape is drastically changed and, if nothing is done to replace the lost ecosystem services, the landscape will be less resilient in coping with the increased risk of floods and longer droughts; and local people will be using water that is likely to be contaminated and harmful to fish, other aquatic life and human health. To mitigate the negative impacts is likely to be costly and less effective than the beneficial services natural forests provide for free. The



Conservation scenario would result in more tree cover, natural resources, ecosystem services and more suitable areas for wildlife species compared with the other two scenarios (provided these forests are well managed and law enforcement is strengthened). The GE scenario allows for the maintenance of trees in PAs (with strengthened governance, sustainable finance mechanisms etc.) while also enabling economic development outside of PAs to meet economic demands such as an increased demand for rice due to a rising population. Therefore the GE scenario allows for a more strategic and balanced economic development trajectory. Through integrated, evidence-based planning processes, more sustainable approaches to development are possible.

The Green Economy scenario seeks to minimize losses to ecosystems services by conserving protected areas and enabling economic development and food security in the productive parts of the landscape. In addition, the Green Economy scenario ensures structural connectivity of forest habitat, vital for wildlife corridors, without compromising the province's ability to develop and generate jobs. Evidently the PAs form the backbone of ecosystem services across the province. It is imperative therefore to ensure they are supported with best practice management, species protection, law enforcement, and that local and national populations continue to receive the environmental services provided by them. The value of the PAs for their provision of clean water, climate regulation, biodiversity, recreational values, non-timber forest products and services vital for agriculture and development has been made clear in this scientific assessment. Under a GE scenario, natural capital remains a critical enabler of growth, and development takes place but not at the expense of important sources of ecosystem services. This evidence-based scientific assessment and recommendations can inform land use planning and economic development decisions and support the transition to a greener and more sustainable economy, helping Cambodia in achieving its INDC and Sustainable Development Goals.

# WWF - Cambodia & Tigers

1998

WWF began its first conservation programme in Cambodia and established an office to support two protected National Parks.

1,600 - 3,000

The Eastern Plains Landscape is home to the world's largest Banteng population; a globally endangered species and important prey source for tigers.



4

The number of TAI staff based in the WWF-Cambodia office supporting reintroduction efforts.

2022

Cambodia is one of the 13 tiger range countries committed to Tx2 - the global goal to double wild tiger numbers by the year 2022.

120

By 2050, Cambodia could host up to 120 wild tigers - originating from translocated tigers from India.



**Why we are here**

To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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© "WWF" is a WWF Registered Trademark. WWF, Avenue du Mont-Blanc, 1196 Gland, Gland, Switzerland  
Tel: +41 22 364 9111 Fax +41 22 364 0332. For contact details and further information, please visit our international website at [www.panda.org](http://www.panda.org)

**WWF-Cambodia**

#21 Street 322, Boeung Keng Kang 1, Cheamkar Mom, Phnom Penh, Cambodia

Tel: +855 23 218 034

Fax: +855 23 11 909

Email: [wwfcambodia@wwfgreatermekong.org](mailto:wwfcambodia@wwfgreatermekong.org)