Raising awareness of local communities on deforestation consequences and providing them with alternative sustainable livelihoods would reduce the incentive to undertake illegal logging. Land rights should be recognized as another preventive tool to address encroachment.

Effective governance requires collaboration from all stakeholders from national to commune level, as well as support from local communities. 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.

Best practice plans are those that are developed with the participation of stakeholders through the process. The process is in some ways more important than the outcomes as it: helps raise awareness of the environmental challenges and laws; can lead to mediation or resolution of disputed land claims; can serve to develop and strengthen PA management plans such that they contribute to the broader human landscape; and can ensure that stakeholders recognize that they are part of a broader landscape and must adhere to the rule of law re environmental use.

Sustainable financing mechanisms

The government should identify sustainable financing mechanisms for the management and protection of Protected Areas, i.e. ecotourism, community enterprises (NTFPs etc.) REDD+, voluntary carbon markets, etc.

The private sector should to be engaged and be made accountable to compensate its impact on Natural Capital through a strong participation in sustainable financing mechanisms, such a payment for ecosystem services, trust funds, conservation offsets, etc.

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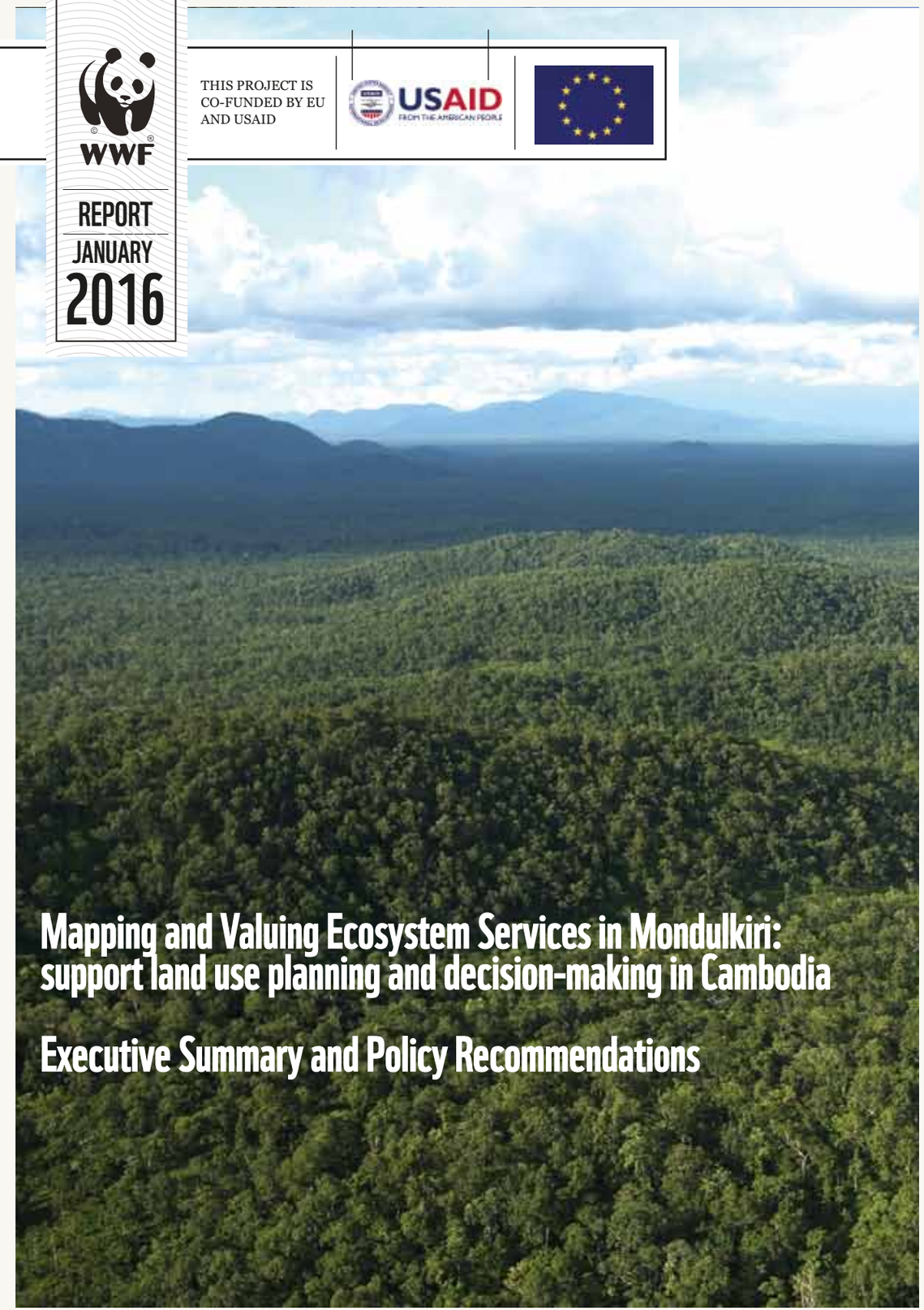

Mapping and Valuing Ecosystem Services in Mondulkiri: support land use planning and decision-making in Cambodia

Executive Summary and Policy Recommendations

INTRODUCTION

In Cambodia, the National Spatial Planning Policy (2011) 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 (Royal Government of Cambodia (RGC) 2011). Without effective land management planning and integrated land use plans, many problems may result including encroachment into Protected Areas (PAs), illegal logging, jurisdictional confusion, land grabbing and in general unsustainable exploitation of forests and fisheries and uneconomical uses of water, which affects the livelihoods of the poor, as well as tourism and the growth of cities (Diepart 2008). As stated in the National Strategic Development Plan (NSDP) 2014-18, there is currently a lack of a means to manage natural PAs and a lack of information on biodiversity and natural resources. Ecosystem-based management and planning can support with addressing these as it is designed to facilitate environmental restoration, as well as the protection and conservation of wildlife habitat and other natural resources (Cohn and Lerner 2003).

Ecosystem services are the goods and services nature provides us for free such as clean water, food and climate regulation, and are essential for humans' well-being and life support processes, both in the form of direct benefits (food supply, medicine, clothing, recreation opportunities) and indirect benefits (pollination, seed dispersal, water purification, nutrient cycling etc.) (Millennium Ecosystem Assessment, 2005; Wall, 2004). In spite of their importance, the values of many ecosystem services are not reflected in existing market prices and are therefore currently hugely undervalued and in many cases undergoing rapid degradation and depletion.

In the North-East of the country, Mondulkiri is a densely forested province with 90% forest cover (Forest Administration Department, Ministry of Agriculture, Forestry and Fisheries 2010) and numerous critically endangered species such as Siamese crocodiles and giant ibis. Other wildlife species include Asian elephants, leopards, banteng, wild water buffalo, jackals and wild dogs. Its forest cover is under threat as a result of an increasing amount of Economic Land Concessions (ELCs).

To support the Royal Government of Cambodia to achieve effective land use management and sustainable natural resources management that balances conservation and development, WWF worked in cooperation with the Royal University of Phnom Penh (RUPP) and provincial level government officials in Mondulkiri Province to map and value some of the most important ecosystem services in Mondulkiri.

Doing so, a set of tools called InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) were used, to quantify, map and value different ecosystem services. The overall objective was to support decision / policymaking and provide information useful for land use / spatial planning. The more specific objectives are to:

- Identify where ecosystem services are provided in Mondulkiri Province by mapping them;
- Value these ecosystem services with monetary metrics; and
- Provide insights on how these ecosystem services may be affected by different policy interventions by developing and comparing the different ecosystem service outcomes of different future scenario maps.

The team produced maps that showed the sum of carbon storage and sequestration, non-forest timber products (NTFPs), habitat quality, avoided nutrient pollution (or nutrient retention) and avoided sediment export (or sediment retention) by sub-watershed. The team also assessed and mapped annual water yield by sub-watershed, as well as the combination of all ecosystem services by sub-watershed, using pixels and, as far as possible, by commune. Each ecosystem service studied was mapped and valued under different future scenarios which showed Mondulkiri in 2030 under a: Conservation (or low deforestation) scenario, Green Economy (or moderate deforestation) scenario and Business as Usual (high deforestation) scenario.

What are the richest Ecosystem Services Areas of Mondulkiri Province?

Carbon Storage

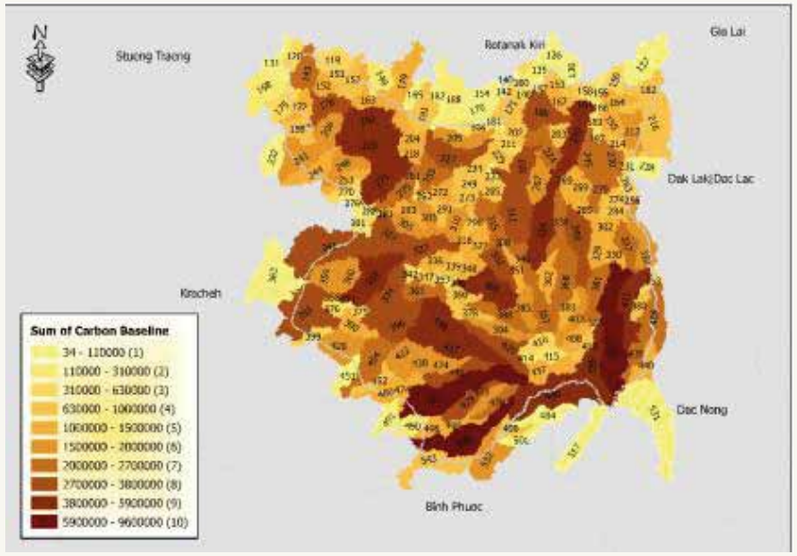

Figure i: Baseline map of carbon stock by sub-watershed

Carbon storage value is lost if a forest is converted through logging or burning. Carbon sequestration is one of the most important ecosystem services provided by functioning forest ecosystems. As you can see in the two maps below, the study assessed the carbon stock of each of the Mondulkiri communes as well as per sub-watersheds. Bu Chri and Roya cover large land areas and have a high carbon stock. The densely forested Phnom Prich Wildlife Sanctuary (PPWS) is located mostly in Bu Chri as well as neighboring communes. The communes Chong Phlah and Srea Preah have also high carbon stock and are located in PPWS and Seima Protected Forest respectively.

Figure i shows the communes with the highest carbon stock in dark brown and the ones with the lowest in pale yellow. Even Protected Areas that have not been officially zoned prove to have a higher carbon stock and therefore worth continuing to protect and manage carefully. This province is particularly rich in carbon stock, opportunities for financing mechanisms such as REDD+ and carbon offsets should be considered.

Non Timber Forest Products (NTFPs)

NTFPs are crucial ecosystem services for local livelihoods. They provide basic subsistence with food, medicines and construction materials for shelter, cultural and ritual values as well as cash income for many local communities. The economic value of NTFPs currently represents 58% of average household income in Mondulkiri. NTFP products taken into consideration in this study are liquid resin, solid resin, bamboo, wild-honey bees and strychnine trees. Bu Chri, Roya, Chong Phlah, Krong Teh and Dak Dam are the five communes with the most abundant NTFP resources. Bu Chri, Roya, Krong Teh, Srae Preah, Srae Sangkom and Chong Phlah communes have a very high potential for enhancing NTFP commercial and livelihood opportunities now and in the future.

Greater protection of the forests in PAs and Protected Forests is a necessary measure to ensure that the forest continues to provide these products that are a key resource for 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 as well as reducing incentives for illegal deforestation for livelihood purposes among local populations.

Habitat quality

Habitat quality focuses on three main species tigers, white-rumped vulture and elephant[1]. Wildlife plays an important role in ecosystem services and stabilizes the food web for all fauna, flora and human populations. The areas that have the highest sum value of habitat quality are within in the territory of PPWS, Mondulkiri Protected Forest (MPF) and some part of SPF. The study highlights that the communes of Bu Chri, Roya, Chong Phlah, Krong Teh and Srae Sangkom are the most suitable areas for habitat of endangered wildlife, with the most amount of evergreen trees.

Ecotourism is 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 forest and wildlife, and to co-finance PAs.

[1] *These 3 species were selected amongst 8 endangered and critically endangered species (IUNC list) to ensure that different types of habitats were represented. Mondulkiri has been recognized as one of the most suitable areas for recovery of tiger population density.*

Annual Water Yield

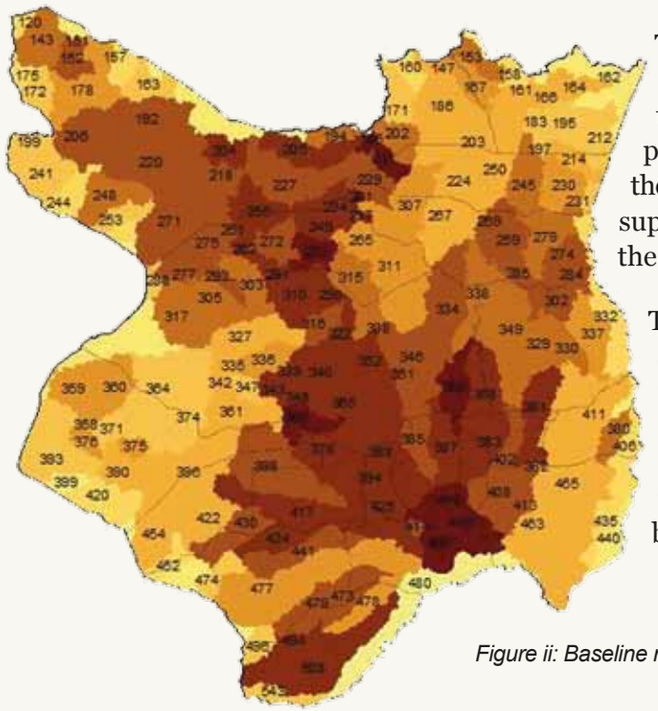

Figure ii: Baseline map of Water Yield by sub-watershed

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. Without trees the process is disrupted and water is less easily absorbed. Increases in water yield therefore increase the likelihood of flash floods and of pollutants entering the water supply. As shown in figure ii, the areas with the highest water yield (dark brown on the map) are the areas with the least amount of natural forest.

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Nutrient Retention

The study estimated the relative importance among all sub-watersheds of nutrient retention using a 'water purification: nutrient retention' model to simulate nitrogen and phosphorus loading into streams and water bodies. These nutrients, often generated as a result of fertilizer application and other human activities, are leading causes of water pollution. It is important to note that when a forest is dense with trees these nutrients are retained in the soil via complex root networks; but when the trees are lost there is no means of retaining the nutrients and so they are leached out of the soil as runoff into the nearby water systems.

The results of this model are reported as the total nitrogen and total phosphorus loads exported from each sub-watershed as an annual average (Bhagabati et al. 2012). The Figures iii and iv below highlights the sub-watersheds with the highest phosphorus and nitrogen exports (high in dark brown).

Figure iii: Baseline map of the sum of nutrient retention for phosphorus export by sub-watershed

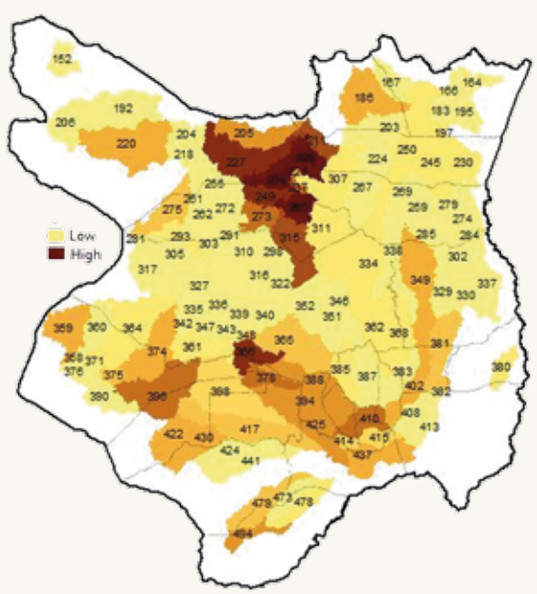
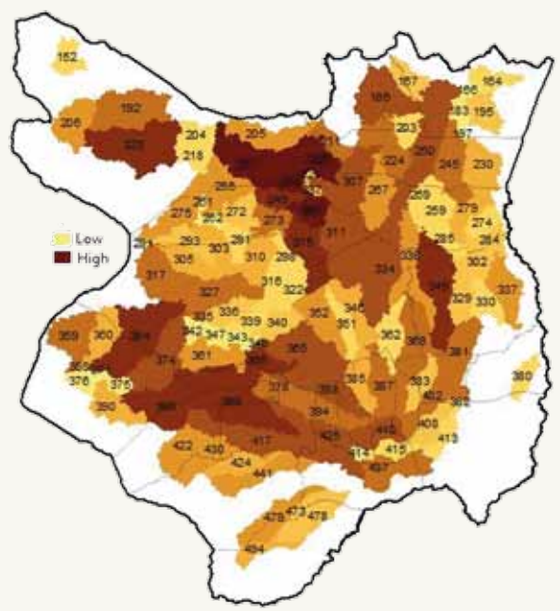


Figure iv: Baseline map of the sum of nutrient retention for nitrogen export by sub-watershed



This shows that deforestation can greatly affect water quality as losses in trees upstream can increase the amount of nutrients that enter the water downstream (fewer trees are absorbing these nutrients).

Water downstream is then polluted as a result. A way to resolve this problem is to maintain the trees on top of hills and slopes (upstream) to reduce the risk of runoff and pollution of water downstream. Sustainable farming practices such as terraced farming is another way of preventing runoff.

Sediment retention

Sediment is a key factor in the deterioration of water quality. Soil particles transported by water are often deposited in streams, lakes, and wetlands. Land disturbing activities such as road construction and maintenance, timber harvesting, mining, agriculture, residential and commercial development, all contribute to this problem.

For a Province with local populations so dependent on clean water for drinking and for use in agricultural processes, soil erosion and sedimentation due to the clearing of forests is highly likely to have detrimental impacts on families' wellbeing and household incomes, especially in the Southeast of the Province where volumes of sediment export are highest. Therefore prevention is much more favorable to trying to address the poor water quality at a later stage, which is likely to be extremely costly. Watershed management, PWS and sustainable farming would also go some way to addressing this problem.

Combined Ecosystem Services

The study analyzed the sum values of the five ecosystem services assessed, by commune and by sub-watershed. Unsurprisingly the researchers found that the larger the forest cover in a commune, the higher the amount of ecosystem services. As highlighted in Figure ix, for example, Bu Chri commune has the largest area of forest cover in the landscape; while, Monourom Commune has the least amount of forest area with a high population density.

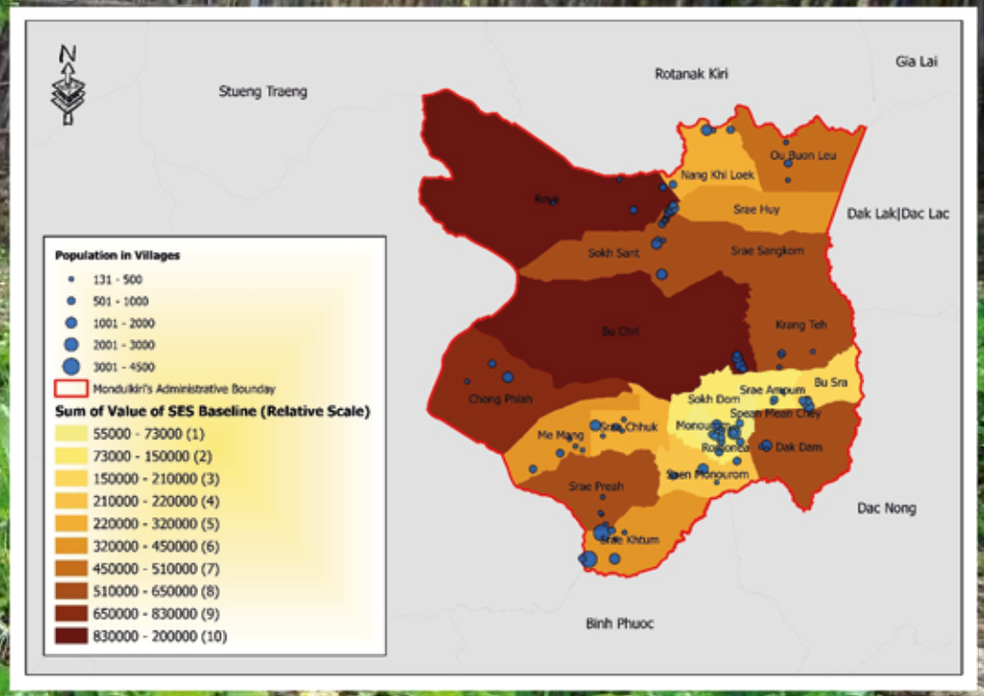


Figure v: Baseline map of the sum of combined ecosystem services by commune

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

Economic valuation can be a useful way of 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 / land use planning decisions, the costs and benefits are not adequately represented, which results in an undervaluation in ecosystem services.

As part of the assessment of ecosystem services in Mondulkiri Province, the project team provided economic value of ecosystem services by placing a monetary value on the welfare changes resulting from land use changes under alternative future development scenarios. The team valued changes in NTFP availability, the regulation of water yield, and carbon storage and sequestration under different scenarios.

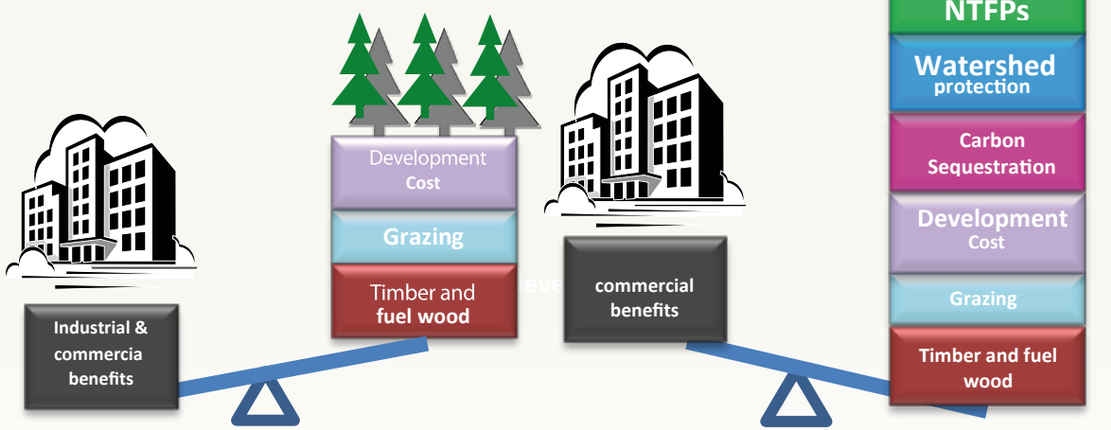


Figure vi: Illustration to demonstrate how ecosystem service valuation provides a more complete accounting of costs and benefits (The Natural Capital Project 2015)

How would Ecosystem Service be affected by Different Future Development Scenario?

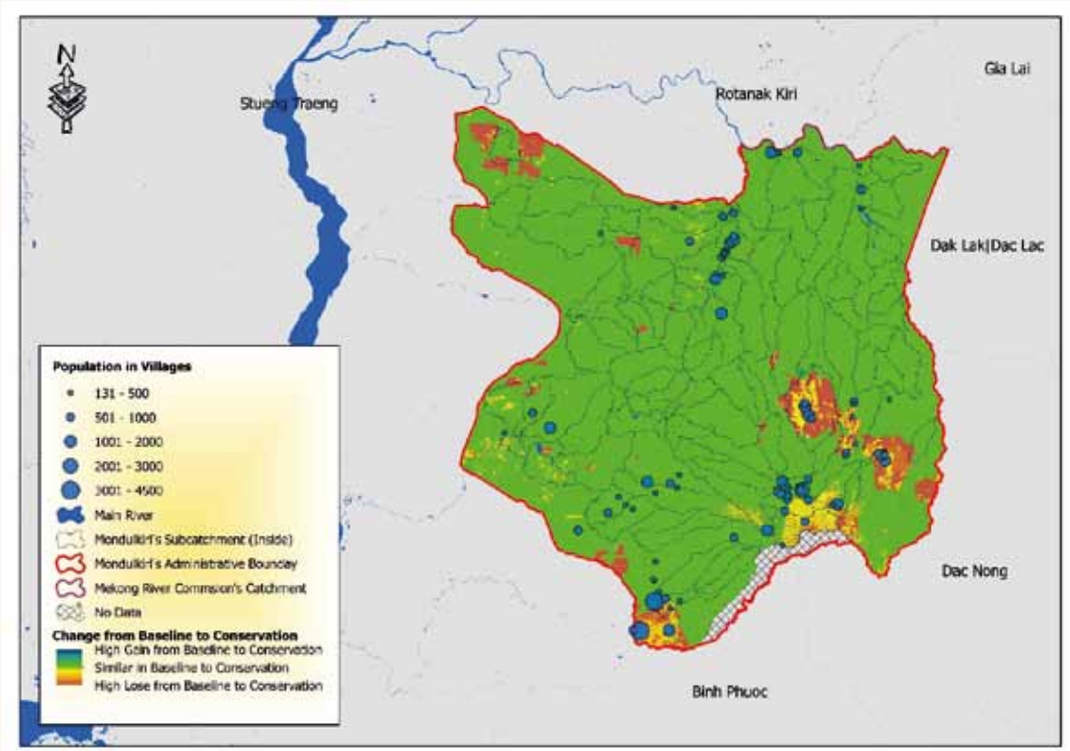


Figure vii: Map showing changes in ecosystem services in Mondulkiri in 2030 under a Conservation Scenario

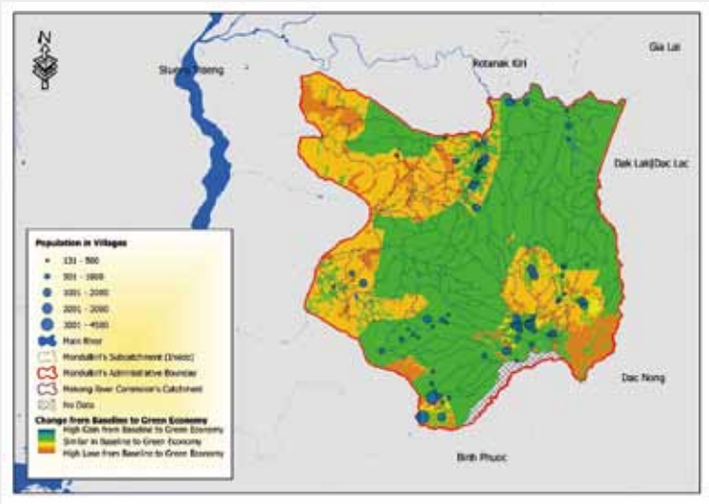


Figure viii: Map showing changes in ecosystem services in Mondulkiri in 2030 under a Green Economy scenario

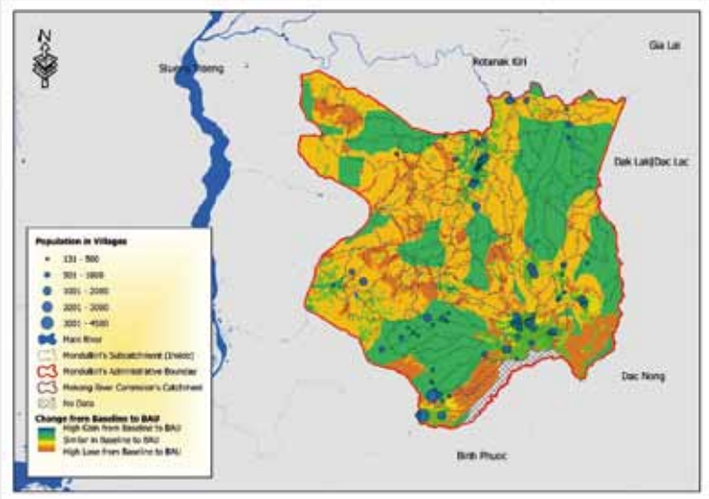
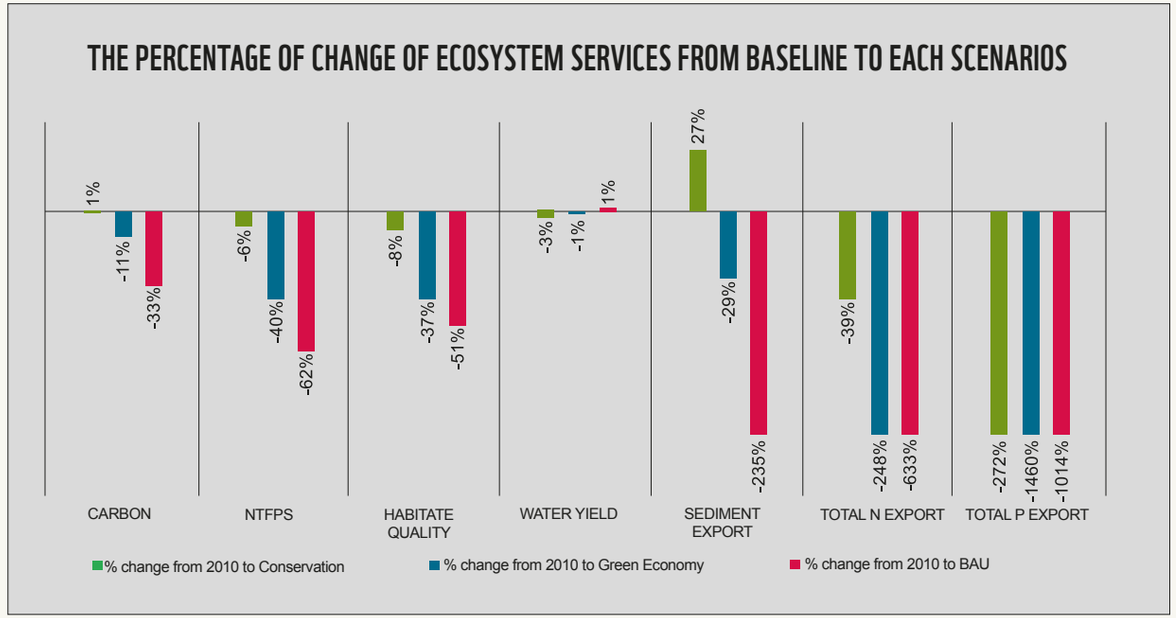


Figure ix: Map showing changes in ecosystem services in Mondulkiri in 2030 under a Business as Usual scenario

WWF and RUPP developed maps showing changes in ecosystem services under three different development scenarios for 2030: Business As Usual (BAU), Conservation and Green Economy. These scenario maps were based on storylines developed with stakeholders including provincial government officials in workshops organized by WWF and RUPP.

The BAU scenario envisages a high deforestation future; the Conservation scenario prioritizes conservation and envisages a low deforestation future while the Green Economy (GE) scenario, the middle path, envisages a moderate deforestation trajectory for Mondulkiri. These scenario maps were designed to enable policymakers to visualize the impacts on ecosystem services of different policy interventions based on the storylines developed by stakeholders at workshops.

Business As Usual (BAU) Scenario



The BAU scenario assesses the impacts of development activities on ecosystem services that the RGC is currently planning to implement e.g. ELCs for rubber plantation, mining exploration, and hydropower construction; road construction; settlement development; timber exploitation; and other crop plantations.

The BAU scenario shows a 66% reduction in forest cover compared with the baseline map (using 2010 forest cover data). This scenario highlights that higher deforestation is likely to have more detrimental consequences on forest biodiversity, soil quality, and amount of carbon stored in trees, leading to economic losses. Figure vii confirms high losses (yellow and orange part of the map) in combined ecosystem services:

- 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: leading to a reduction of local communities' incomes and an increase in poverty and/or an increase in unsustainable and illegal practices (logging, poaching, wildlife trafficking, land clearing).
- A reduction of 33% in carbon storage and sequestration: having negative effects on climate and reducing the available forest cover which can be part of highly profitable international carbon markets.
- Greatest losses in sediment occur under this BAU scenario reducing the fertility of the soil and negatively affecting the livelihoods of the majority of local inhabitants. Significantly fewer trees upstream absorbing nutrients such as phosphorus and nitrogen can increase the amount of nutrients that enter the water downstream and pollute it as a result.

Green Economy Scenario

Green Economy Scenario

Stakeholders in workshops envisioned the Green Economy (GE) trajectory by 2030: 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 2014-18, National Policy on Green Growth (2013c) and the National Strategic Plan on Green Growth 2013-30 (2013b), which promotes sustainable land use and natural resources management, and green investment to ensure green development in Cambodia.

The Green Economy scenario is also based on the following assumptions agreed by stakeholders, 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 are assumed to have expanded over 10km over the buffer for rice production zones to support increased rice productivity, addressing rice consumption demand; and
- The remaining areas in Mondulkiri besides the areas mentioned previously are assumed as buffer economic zones for sustainable agricultural development.
- Road projects planned for do not go ahead due to the significantly greater contribution this will make to deforestation in the province.

The GE scenario shows a 47% reduction in forest cover,

- Losses in carbon storage and sequestration, habitat quality and NTFPs (in orange/red in figure xvi) are less severe than the losses under the BAU scenario.
- Losses in nutrients are significant under the GE scenario, therefore there are also increased risks of polluting the water supply. However under this scenario risks of sedimentation are significantly reduced.

Green Economy Scenario

...contiued from page 12

Implementing green agriculture, as features in the National Strategic Plan on Green Growth (2013b), such as terraced rice farming, will reduce the runoff of harmful fertilizers entering streams and rivers, which pollute water quality and affect soil fertility. Improved governance and management of Protected Areas, as outlined in Cambodia's NSDP 2014-18 (RGC 2013a), are likely to reduce these losses in vital ecosystem services. The adoption of the Green Economy scenario, allows for a more pragmatic balance between development and conservation.

Conservation scenario

The Conservation scenario (CN) envisages a low deforestation future, with a 15% reduction in forest cover compared with the baseline map. The Conservation scenario maps show fewer losses of ecosystem services (red and orange on the maps in figure xi) with some gains in carbon storage and sequestration, as a result of the increase in tree cover from rubber plantations (which constitute approximately 80% of ELCs in Mondulkiri). This scenario requires no further forest loss in Mondulkiri, including in Protected Areas and Protected Forests, and in terms of the ecosystem services considered in this assessment, it maximizes their overall provision.

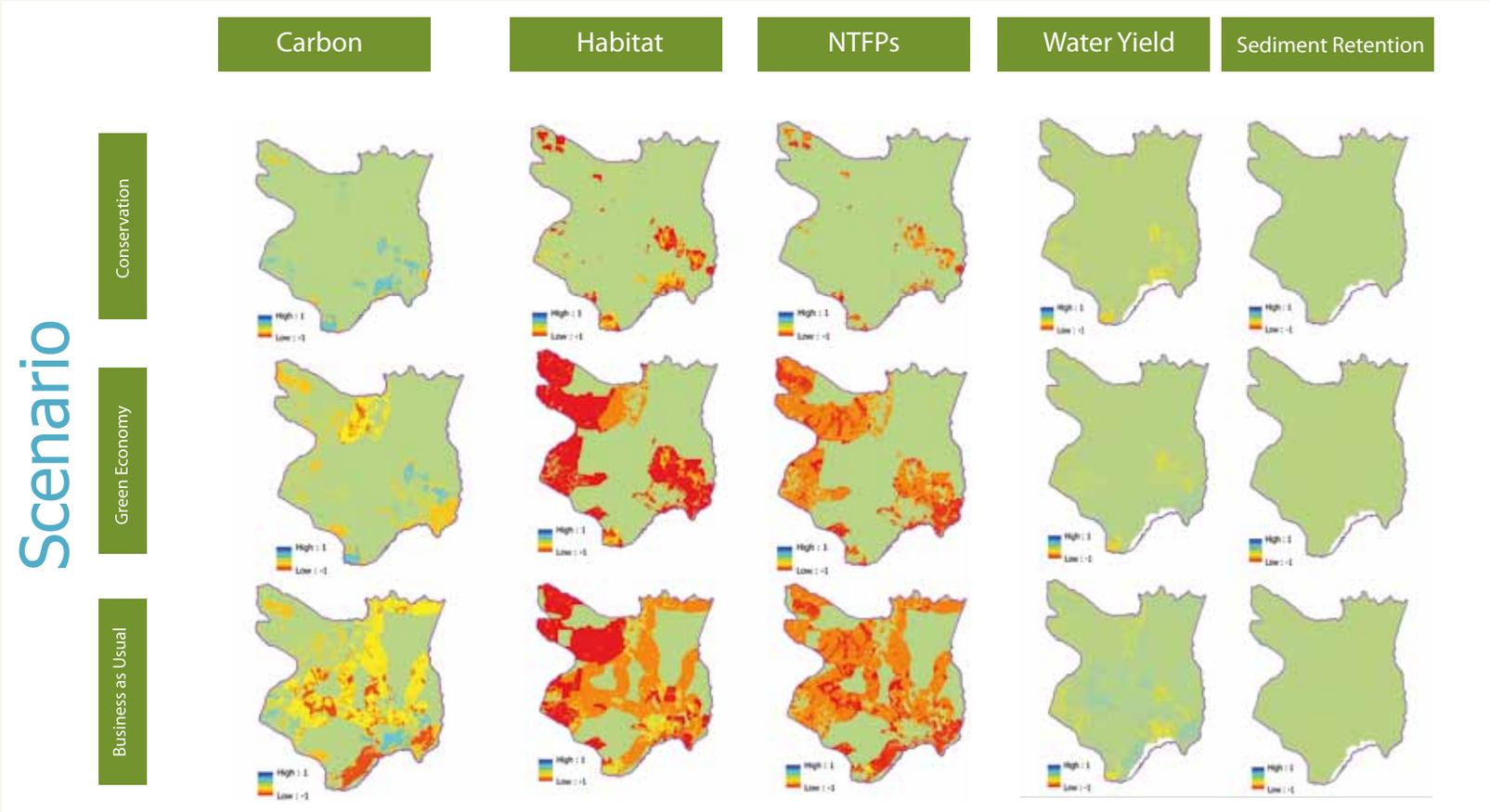


Figure xi: Maps of relative changes (gains/losses) in carbon storage, habitat quality, NTFPs, water yield and sediment export for each future scenario

Economic valuation results

Economic valuations of carbon storage and sequestration, NTFPs and water yield were carried out and table i reports the difference in the annual value of forest ecosystem services in 2030 relative to the annual value in 2010.

The combined economic changes under each scenario are the following: a gain of approximately US$14,500 under a CN scenario, a loss of $37,000 under a GE scenario and a loss of $1.1 million under a BAU scenario. 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 due to increased carbon storage and sequestration in 2030 relative to 2010; whereas the provision of NTFPs and water have decreased in 2030. The aggregated annual values of the three categories of ecosystem services are represented in Table i.

Table i. Changes in ecosystem service annual values in 2030 relative to 2010 (USD; 000's)

	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)	+19,350	-360,250	-1,067,250
Total	**+14,496**	**-376,936**	**-1,095,556**

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_2 could be sold under the Conservation scenario. Under a Green Economy scenario, 48 million tonnes of CO_2 could be sold on carbon markets. 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 CO_2 from the atmosphere has a value of US$387 million. The GE and BAU scenarios result in large losses of stored carbon and the damages associated with this are estimated to be US$7 and US$21 billion, respectively.

Both a Conservation and GE scenario result in large quantities of additional stored carbon.

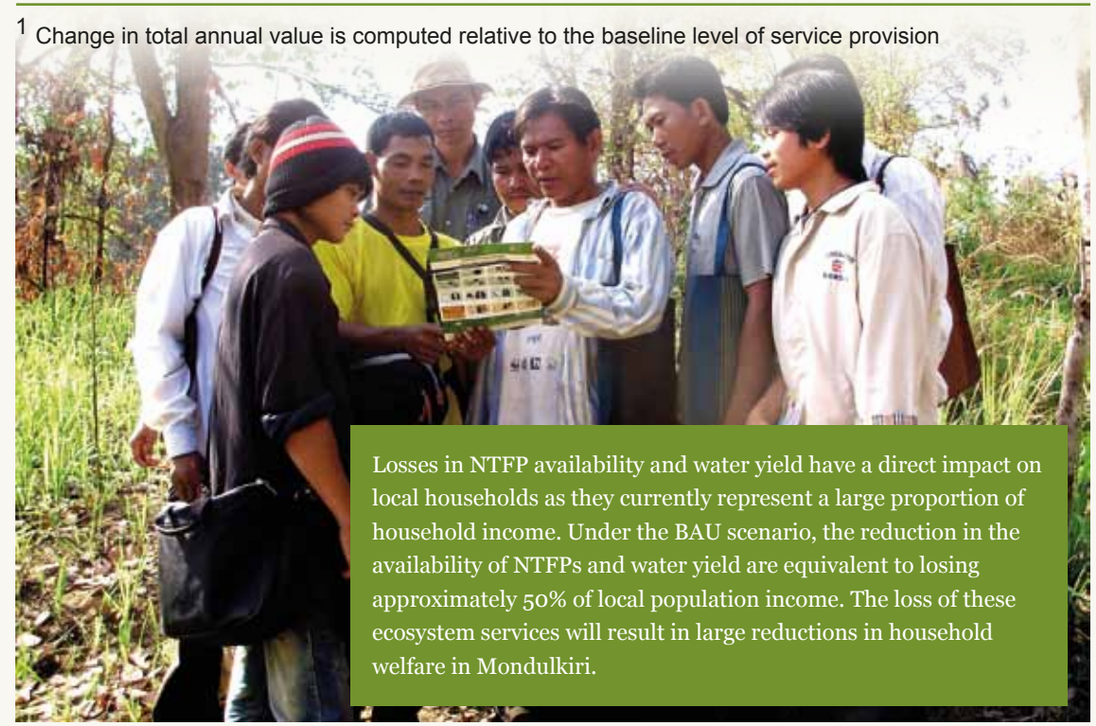
The sum of the annual value of NTFPs in the baseline scenario is almost $26 million and this is predicted to fall to $10.6 million in 2030 under the BAU scenario. Under the baseline scenario, NTFPs represent an annual household income of 58% of mean household income. Under the BAU scenario, by 2030, 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, 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 iii shows. Almost $7 million per year is lost under BAU scenario.

Table ii. Annual value of water yield in 2030 (US$)

	CN	GE	BAU
Mean (US$/ha)	+88	+115	+123
Median (US$/ha)	+72	+95	+103
Change in total annual value1 (US$; 1000's)	-1,303	-6,001	-6,827

[1] Change in total annual value is computed relative to the baseline level of service provision



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 local population income. The loss of these ecosystem services will result in large reductions in household welfare in Mondulkiri.

Policy recommendations for decision makers

Policy recommendations for decision makers

The overarching policy recommendation resulting from the Mondulkiri ecosystem service assessment and policy analysis is for the Royal Government of Cambodia (RGC) to adopt the Green Economy trajectory.

Adopting a national Green Economy (GE) approach is essential for Cambodia to sustain its economic development in the long term. A GE pathway can enhance Cambodia's climate change preparedness, reduce social inequalities and income disparities, and ensure the country maintains its regional competitiveness. Underpinning these critical outcomes, a GE approach ensures enhanced resource governance, nutrient and sediment retention, watershed management, reduced carbon emissions, and maintenance of environmental services. A GE approach therefore offers a better quality of national development and is in line with: Cambodia's National Green Growth Policy (2013); National Strategic Plan on Green Growth (2013); and the National Strategic Development Plan (2014-2018).

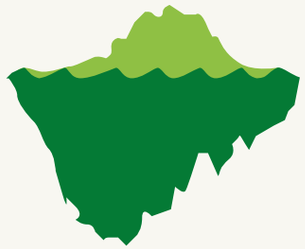
A GE approach requires:

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

Ecosystem-based land use planning and management

Ecosystem-based 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 what land to exploit and what land to conserve, which in turn helps to achieve a balance between keeping protected areas intact for conservation and areas designated for development.

This approach can provide a valuable platform to facilitate a balanced and green development pathway for Mondulkiri. Looking at the province through the broader ecosystem lens allows decision makers to make informed decisions on how to balance environmental protection with development and people's aspirations. It also provides PAs managers with a strong mandate to protect and maintain the environmental values therein, and with the recognition that 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; and best practice monitoring and law enforcement.

Ecosystem service assessments are an ideal tool to incorporate into spatial and land use planning processes at commune, district and provincial levels. They can assist in the incorporation of land use changes, sustainable resource use, environmental flows, and disaster preparedness, and ensure that consideration for these is balanced with development considerations and human wellbeing.

Strengthened governance

Greater emphasis on law enforcement in Protected Areas is needed to reduce illegal logging and hunting activities in forests and should address the different drivers of deforestation. A strong and effective law enforcement would help creating a governance environment that will promote responsible and sustainable private investments, respecting the local communities and forests interests. More accountable and participatory governance is required for improved land use and sustainable natural resources management.