Carbon, biodiversity & ecosystem services:
exploring co-benefits

-benefits

Cambodia

UNEP WCMC

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Introduction

Land-use change, primarily through tropical forest loss and degradation, is estimated to contribute between 6–17% of all anthropogenic greenhouse gas emissions (van der Werf *et al.* 2009). The maintenance and enhancement of natural carbon stocks are therefore considered key climate change mitigation measures, especially through the developing mechanism on Reducing Emissions from Deforestation and forest Degradation, forest conservation, sustainable management of forests and enhancement of forest carbon stocks (REDD+).

Well-planned and carefully implemented REDD+ actions can have positive outcomes that are additional to emissions reductions. Such 'co-benefits' include biodiversity conservation and maintenance of ecosystem services, as well as direct improvements to livelihoods and the rights and well-being of local people.

Spatial analyses relating to co-benefits can provide key information to support planning and decision-making on REDD+ at national and sub-national scales. To do so, they should be based on data developed at an appropriate scale and should address those benefits and challenges deemed most important by key stakeholders and practitioners.

This report presents results from an initial effort to produce such analyses for Cambodia. It includes new data on the distribution of terrestrial carbon stocks in Cambodia and analyses of its relation to areas of importance for biodiversity, Protected Areas and other land management units, and pressures (such as forest cover loss). It is expected that the study will be developed further in collaboration with other institutes and stakeholders.

Cambodia

The Kingdom of Cambodia is located in Southeast Asia and spans 181 035 km^2 (Kingdom of Cambodia 2010). It is home to over 13 million people (National Institute of Statistics Cambodia 2009). Cambodia is bordered by Thailand, Vietnam, and Laos (Map 1). The climate of Cambodia is tropical, dominated by the annual monsoon cycle, which is accompanied by alternating wet and dry seasons. Cambodia is considered a high forest cover country: in 2006, 59% of the country was covered by forest (Technical Working Group on Forestry & Environment 2007). The country also contains the largest freshwater lake in Southeast Asia, the Tonle Sap Lake.

REDD+ and its potential co-benefits are widely relevant in Cambodia, where deforestation rates in recent years have been among the highest in the world (FAO 2007), and where many people directly depend on forest resources. In 2008, 85% of the country's population was dependent on fuelwood (CBD National Focal Point Cambodia 2009).

Map 1: Location of the Kingdom of Cambodia

The Government has made considerable efforts to address the issue of deforestation in recent years. Under Cambodia's Millennium Development Goal 7, the country aims to attain forest cover of at least 60% of the country by 2015 (Kingdom of Cambodia 2003).

Developing a carbon map

Generating a map of Cambodia's carbon stocks required combining information from several sources. The result is a new map showing the spatial distribution of carbon stocks in Cambodia's terrestrial ecosystems: in above- and below-ground biomass and soil organic carbon to 1 metre depth.

A map of forest cover in 2005/2006 was provided by the Forestry Administration (FA) of Cambodia (Kingdom of Cambodia 2007). This map is considered the most recent and accurate for forest extent in the country. For areas classified in the FA dataset as non-forest or as 'other forest', an earlier land cover map (JICA 2002) was used to provide more detailed information on vegetation type.[1]

Carbon stock values were assigned to the different land cover classes based on published estimates of biomass or carbon stocks in different vegetation types in Cambodia (Table 1, for more detail see Leng *et al.* in prep.). Where no estimates from Cambodia existed, estimates from similar vegetation types of neighbouring countries were used. Where there were several published biomass or carbon values for a given vegetation type, we averaged the available estimates and applied the result. Most published biomass or carbon values provided information on above-ground biomass only; to determine below-ground biomass for a given land cover class, we used ecosystem-specific conversion factors (IPCC 2006), which provided ratios of below–ground biomass to above-ground biomass for different FAO ecological zones (FAO 2001). Bare soils and rocks, urban and built-up areas, as well as water features, were deemed to hold no above- or below-ground biomass carbon, and so were assigned 0 biomass carbon values. These classes cover about 3% of the country's total area.

The resulting biomass carbon map was then combined with data on the spatial distribution of soil carbon, which were extracted from the Global Map of Terrestrial Soil Carbon Stocks (Scharlemann *et al*. in prep.) because no suitable national data were available.

Table 1: Total carbon (C) stock (Gt) and total carbon density (t/ha) for different land cover classes in Cambodia

Land cover	Area [km^2] (%)	Total C Stock [Mt] (%)	Biomass Carbon Density (t/ha)	Sources used for estimate
Evergreen forest	37228 (20)	1022 (34)	191-211	National
Deciduous forest	47070 (26)	880 (30)	114-126	National
Semi-deciduous forest	13617 (7)	324 (11)	161-178	National
Bamboo & secondary /regrowth forests	2998 (2)	36 (1)	25-92	National
Bamboo	357 (<1)	4 (<1)	49	Regional (China)
Grasslands	10774 (6)	99 (3)	10	Regional (Vietnam)
Shrubland & flooded shrubland	14851 (8)	134 (5)	11-13	National
Flooded forest	143 (<1)	3 (<1)	129	National
Evergreen wood- & shrubland	960 (1)	8 (<1)	14	Regional (Vietnam)
Mangrove forest	334 (<1)	8 (<1)	142	Regional
Mixed forest	169 (<1)	4 (<1)	161-178	National
Riparian forest	144 (<1)	4 (<1)	191-211	National
Dry wood- & shrubland	371 (<1)	3 (<1)	11	Regional (Vietnam)
Degraded mangrove forests	176 (<1)	3 (<1)	85	Regional
Dry deciduous (open) forest	3 (<1)	<1 (<1)	78	National
Plantation (rubber)	854 (<1)	15 (1)	102	Regional
Agricultural lands	46001 (25)	399 (13)	5	IPCC global average

[1] Non-forest areas in the FA dataset that had been classed as forest in the JICA dataset were assigned to the same land cover class as the nearest non-forest area in the JICA data.

The new map of terrestrial carbon stocks was used for all subsequent analyses and statistical summaries, but because the coarseness of the soil carbon data visually obscures the detail of the biomass carbon data, the biomass carbon map is used for display throughout. It shows the distribution of biomass carbon in five carbon density classes, each of which contains approximately 20% of the total carbon stock in the country (Map 2).

According to this analysis, a total of 2.97 Gt of carbon is stored in the biomass and soils of Cambodia's terrestrial ecosystems. About one third of this carbon is stored in the country's evergreen forest (see Table 1). The largest areas of very high carbon density are found in the wet evergreen forests of the Cardamom Mountains Rainforests Ecoregion in the southwest of the country. With over 100 mammal species and more than 450 bird species, this area holds some of the greatest species richness and intact natural habitats in the region (Wikramanayake *et al.* 2001).

The highest carbon density class, which holds 20% of the country's carbon, covers 12% of the country's land area (Figure 1). Approximately 40% of Cambodia's carbon stock is held in less than a quarter (23%) of its area.

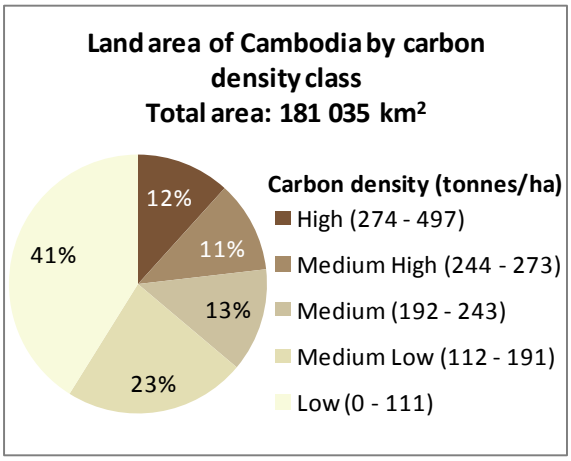
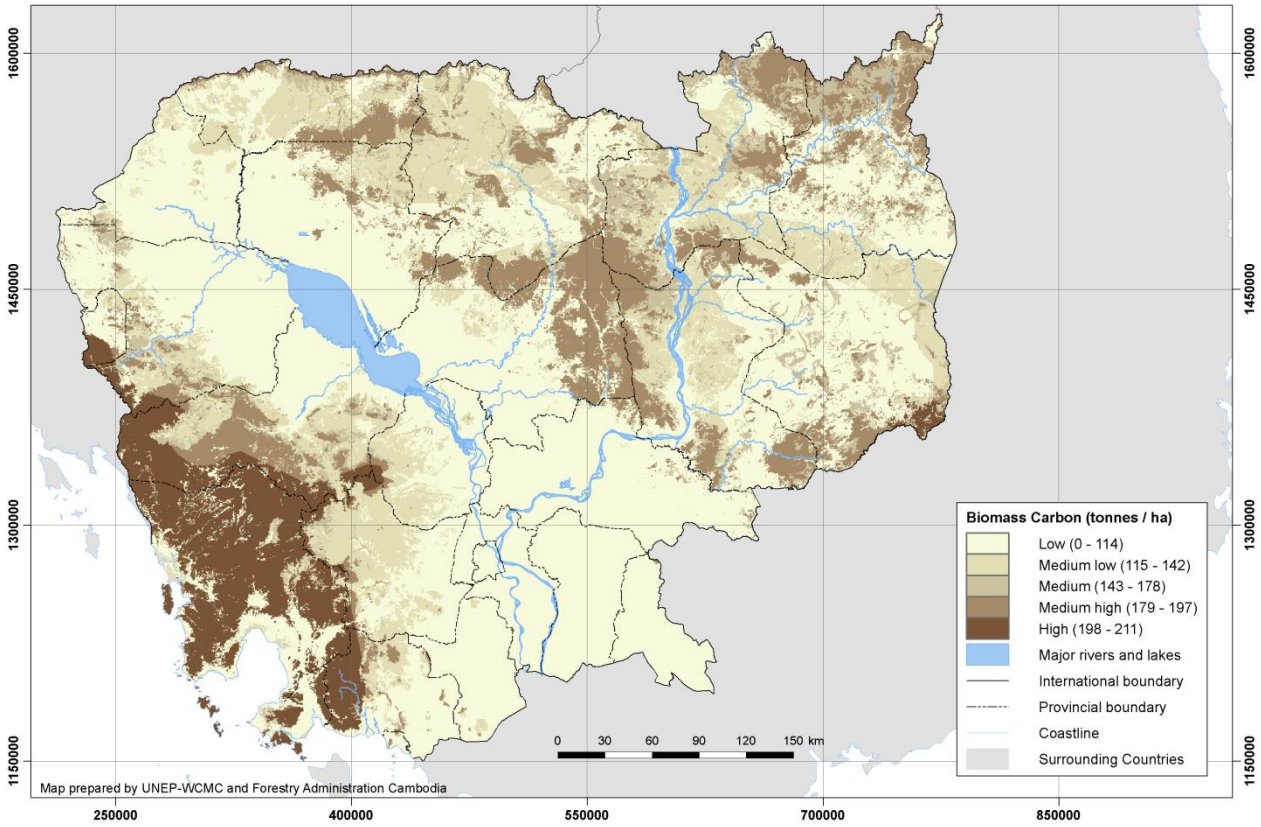


Figure 1: Distribution of land area in Cambodia according to carbon density classes



Map 2: Distribution of biomass carbon in Cambodia (underlying data from Kingdom of Cambodia 2007, JICA 2002)

Carbon and biodiversity

Cambodia is rich in biodiversity, and forms part of the Indo-Burma biodiversity hotspot (Myers *et al.* 2000). It is home to more than 2 000 known plant species, 500 birds, 100 mammals and 800 fish (Table 2).

Table 2: Number of known and threatened species by taxon (CBD National Focal Point Cambodia 2009; IUCN 2010, modified by Wildlife Conservation Society Cambodia)

Taxon	Known species	Threatened species
Vascular plants	2 308	31
Mammals	123	37
Birds	545	24
Amphibians	63	3
Reptiles	88	13
Fish	874	28

The relationship between carbon distribution and areas of importance for biodiversity in Cambodia was investigated using datasets for Important Bird Areas (IBAs, BirdLife International 2010b). IBAs are identified nationally as areas of importance for bird species based on criteria relating to the conservation status of the bird species present and the importance of the site for their persistence (BirdLife International 2010a). Worldwide, there were almost 11 000 sites in 200 countries that had IBA status in 2009 (BirdLife International 2010a). There is evidence from several countries that IBAs encompass many of the areas that are important for taxa other than birds (BirdLife International 2010c). IBAs are not formally Protected Areas; however, some or all of an IBA may fall under other formal national and/or international protection regimes.

There are a total of 45 IBAs covering 45 954 km^2 of land across Cambodia (25% of the country's area). They are located mainly in the north-eastern and south-western regions of the country (Map 3). Additionally, there are some clusters of IBAs in the vicinity of the Tonle Sap Lake, and along river courses throughout the country.

Overlaying the IBAs and the carbon data shows that almost one third (0.91 Gt) of Cambodia's terrestrial carbon stock falls within IBAs. Twenty six percent of the 0.91 Gt is in areas of high carbon density, whereas another 35% is in areas of medium or medium-high carbon density (Figure 2).

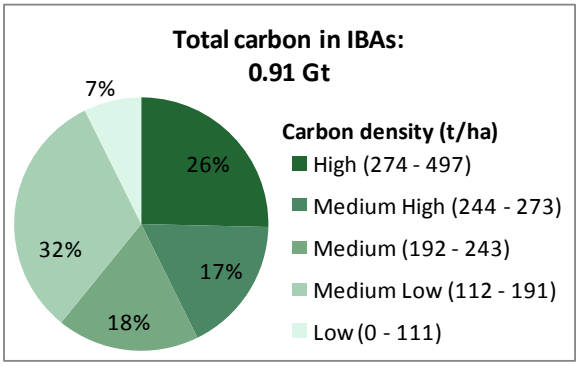
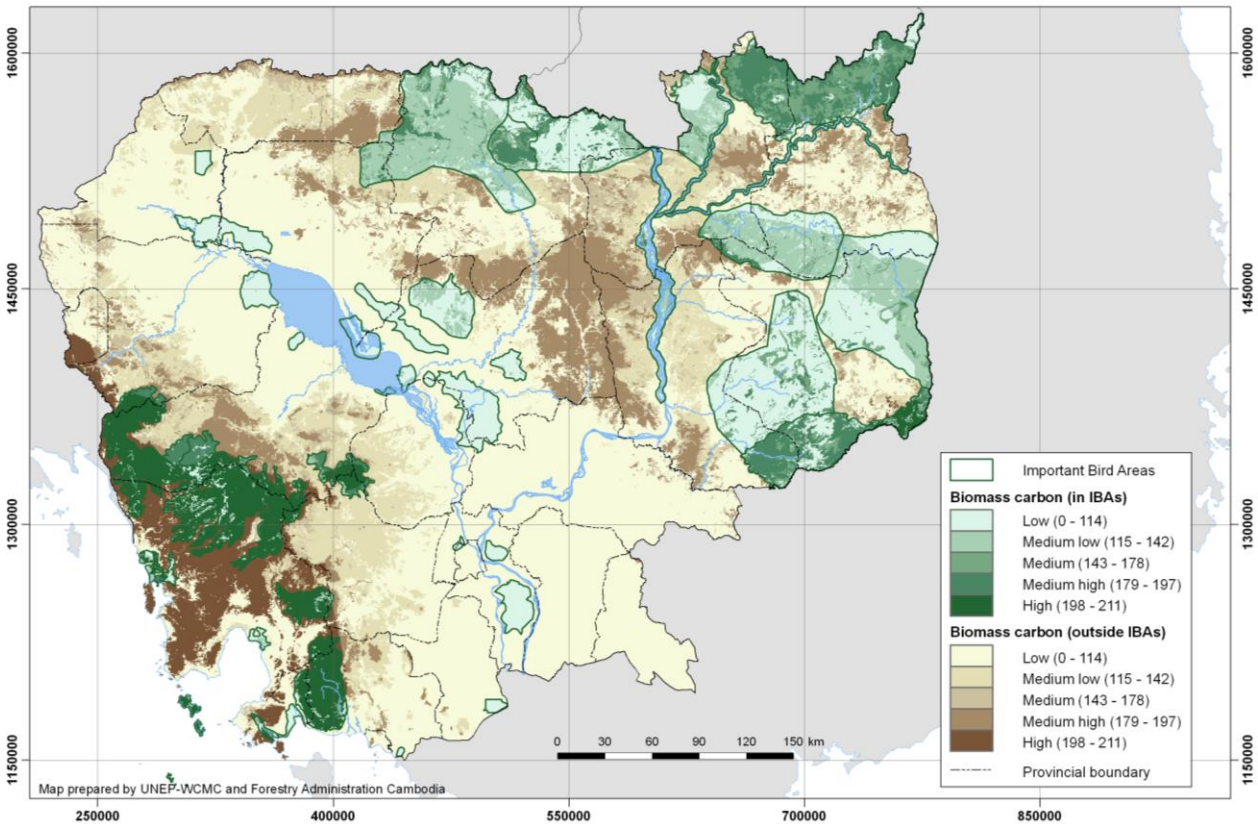


Figure 2: Distribution of total carbon within IBAs across density classes

Photo: Sarus Crane (© Eleanor Briggs)



Map 3: Distribution of biomass carbon and IBAs (data on IBAs from BirdLife International 2010b)

Carbon, Protected Areas and Protection Forests

Protected Areas are nationally, and in some cases internationally, recognised areas that are managed to achieve long-term conservation of nature, in line with the areas' ecosystem services and cultural values (Dudley 2008). In Cambodia, Protected Areas were established by the 1993 Royal Decree on Creation and Determination of Nature Reserves and the 2001 Royal Decree on the Establishment and Management of the Tonle Sap Biosphere Reserve, and are managed by the Ministry of Environment. More recently, the Royal Government of Cambodia has declared a number of Protection Forests under the 2002 Forestry Law, whose primary function is to protect forests' ecosystems, which serve the public interests. Unlike Protected Areas, however, Protection Forests are managed by the Forestry Administration of the Ministry of Agriculture, Forestry and Fisheries. There are currently 27 Protected Areas and 10 Protection Forests in Cambodia, representing about 24% of the country's total land area.

A new spatially explicit dataset for Protected Areas and Protection Forests was developed by combining current records held in the World Database on Protected Areas (WDPA) (IUCN and UNEP-WCMC 2010) with more recent records from the Forestry Administration and Ministry of Environment. Further updates to the layer were provided through expert input (Tom Clements, pers. comm.). The new layer was then overlaid with the carbon density map to calculate how much carbon is currently stored in Protected Areas and Protection Forests (Map 4, overleaf).

About 21% of Cambodia's total carbon stock (0.62 Gt) is stored in its Protected Areas. An additional 11% (0.33 Gt) is stored within Protection Forests. More than one fifth of the area that is designated as Protected Area is of high carbon density. Within areas designated as Protection Forest, the share of high carbon density area amounts to 25%.

Analysis of the protection status of carbon stocks within IBAs shows that almost 0.6 Gt or 64% of their carbon is in either a Protected Area or a Protection Forest (Figure 3), that is, it has some degree of protection.

Photo: Forest in Cambodia flooded by light (© Edward Pollard / WCS)

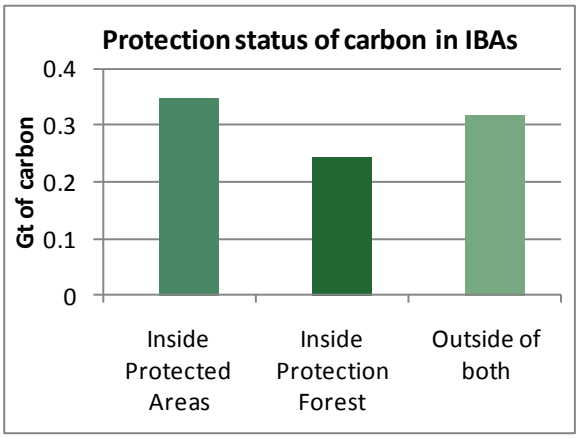


Figure 3: Protection status of carbon stocks within IBAs