



## Review paper

## Forest reference emission level and carbon sequestration in Cambodia



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## ABSTRACT

Adoption of the Paris Agreement suggests the urgent need for developing countries to establish a forest reference emission level (FREL) if they wish to seek financial support to reduce carbon emissions from deforestation and forest degradation. Analysis of past trends of deforestation is important for establishing a FREL, but so far only a handful of studies exist on such analysis at the commune level. We used the available data of forest cover in 2002 and 2006 and forest inventory data to analyze forest cover and carbon stock changes according to seven forest types at commune level in Cambodia. Carbon stocks were estimated in four carbon pools, namely aboveground, belowground, litter and deadwood pools. This analysis formed the basis for determining the FREL at national and provincial levels in Cambodia. We found that carbon emissions due to deforestation were 82.2 TgCO<sub>2</sub> yr<sup>-1</sup>, but carbon sinks (removals) due to increase of forest cover were 72.3 TgCO<sub>2</sub> yr<sup>-1</sup>, representing the net emission loss of 9.9 TgCO<sub>2</sub> yr<sup>-1</sup> between 2002 and 2006. Taking the trend of deforestation between 2002 and 2006 as a baseline, FREL for a 30-year timeframe was estimated for six time intervals. FRELs at national level were estimated to be 26.8 to 69.2 TgCO<sub>2</sub> yr<sup>-1</sup> or up to 36% of the total greenhouse gas emissions in Cambodia. Our study provides a first look at how to set subnational and national FRELs for Cambodia using a retrospective approach. Such a framework could form a useful basis for Cambodia to adopt the national and subnational FRELs, for which effective policies can be developed to address the drivers of deforestation and forest degradation.

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## 1. Introduction

International efforts have been made to reduce tropical deforestation and forest degradation because of the concern over the threats to livelihoods of forest dependent communities, loss of biodiversity, and climate change and its effects on sustainable development. Accordingly, a number of agreements have been reached. Most notably, the adoption of the REDD+ scheme, which is an initiative referring to Reducing Emissions from Deforestation and Forest Degradation PLUS (+) forest conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries (Christoff, 2008), in the Bali Action Plan at the thirteenth conference of the parties (COP13) to the United Nations Framework Convention on Climate Change (UNFCCC) in 2007, emphasizes that accounting for carbon emissions from deforestation and forest degradation is increasingly important (Margono et al., 2014; Pedroni et al., 2009; Pelletier and Goetz, 2015). In addition, Decision CP.16/1/Add. 1/par. 71 of the UNFCCC requires developing countries to develop four elements if they aim to undertake REDD+ activities for financial compensation (Sandker et al., 2014): (1) a national strategy or action plan; (2) a national forest reference emission level (FREL) and/or forest reference level (FRL); (3) a robust and transparent national forest monitoring system for the monitoring and reporting of the REDD+ activities; and (4) a system for providing information on how the safeguards are addressed or respected. The UNFCCC has defined FREL as the benchmark for carbon emissions against which a country's performance in implementing REDD+ activities can be assessed (Sandker et al., 2014). FREL could be developed using the UNFCCC's guideline provided at the COP17 (Herold et al., 2012). In addition to establishing a national FREL, Decision 12/CP.17 also acknowledges the importance of establishing subnational or provincial FRELs as an interim measure (Herold et al., 2012). The adoption of the Paris Agreement at the COP21 (Brauers and Richter, 2016), along with the submission of the Intended Nationally Determined Contribution (INDC) by parties to the UN convention, especially by developing country parties, suggests the urgent need for the development of FRELs.

In recent years, a number of studies have attempted to estimate carbon emissions from deforestation and forest degradation in the tropics to provide the needed information for establishment of the baseline emissions, against which mitigation measures and performance can be assessed. Based on recent studies, carbon emissions from tropical deforestation are estimated to account for between 8% and 10% (Achard et al., 2014; Baccini et al., 2012; Houghton et al., 2012) to as high as 20%–26% of global carbon emissions (Houghton, 2003; Pan et al., 2011). Despite progress in the study of carbon emissions in the tropics globally, only a handful of studies have attempted to quantify the country-level baseline emissions for the purpose of determining the FRELs. For instance, Romijn et al. (2013) discussed the impacts of different forest definitions on setting up the FRELs in Indonesia. They found that FRELs varied from 484.6 TgCO<sub>2</sub> to 753.3 TgCO<sub>2</sub>. Using national data of forest cover changes and the standard partial equilibrium model, Busch et al. (2009) discussed the impacts of setting up the FRELs on cost per reduction unit under six FREL scenarios for tropical countries. Although previous studies provide useful information on the magnitudes of carbon emissions and the range of possible FRELs in the concerned countries, none of them focused on developing the FRELs for national or subnational level using commune-level data, especially in Cambodia. Such small-scale data are important for understanding forest cover and carbon stock changes and for measuring the implementation performance of the REDD+ activities at small, regional, subnational, and national levels.

Cambodia is a non-Annex I country (i.e., a low-income developing country with no legally binding emission reductions by 2020) to the UNFCCC. Cambodia ratified the UNFCCC in December 1995 and the Kyoto Protocol in August 2002. Cambodia submitted its INDC to the UNFCCC in September 2015, proposing to reduce 3.1 million tCO<sub>2e</sub>, compared to the 2010 emission level, by 2030 (Uy, 2015a). Apart from introducing policies to reduce emissions from energy and transport sectors, Cambodia has actively participated in reducing carbon emissions from deforestation and forest degradation through the REDD+ scheme. Although Cambodia has made remarkable progress in preparation for the full implementation of the REDD+ activities (Chuop, 2015), FRELs are presumably still under development. Thus it is impossible to know what methods and data are being used and how FRELs are decided in Cambodia. Using limited available data, this paper aims to analyze forest cover and carbon stock changes at the commune level and discuss the timely important issue of FREL development. We hope to stimulate discussions on future carbon emissions in various provinces in Cambodia and how FRELs may be determined in the respective provinces. This study uses 2002 and 2006 forest cover data to analyze forest cover change starting from the commune level in Cambodia. Changes in forest cover and carbon stocks in four carbon pools according to seven forest categories are analyzed to provide a basis for estimating carbon emission and removal (carbon sequestration)

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