Effectiveness of Community Forestry for Forest Conservation in Cambodia

Introduction

Community forestry (CF) is a natural resource management system which is maintained by local community members at the village and community level. It is considered a successful means for achieving positive social-ecological outcomes, reconciling biodiversity and carbon conservation, local knowledge and livelihood needs (Bowler et al. 2012). Further, CF is reportedly more effective than protected area management for forest conservation (Ellis and Porter-Bolland 2008; Porter-Bolland et al. 2012). As a form of self-governed decentralised forest management, CF is a complex, nested, social-ecological system. Even so, it has been claimed that participatory forest monitoring under CF is cheaper than under private and state management because it is more expensive to hire forest officials from the city to monitor isolated forests (Ostrom 2007).

With 77 percent of Cambodia's total population of 16.25 million living in rural areas, forests play an important role in rural household livelihoods and are of special cultural and spiritual significance to many, especially in traditional communities. Forest cover has decreased substantially over the past five decades, from 13,227,100 ha or 73.04 percent of the total land area in 1965 to 8,742,401 ha or 48.14 percent in 2016 (FA 2011; MOE 2018). To keep large tracts of forest intact and improve local livelihoods, the Cambodian government has laid down several policies and strategies. The 2002 Forest Law sets out the framework for the management, use, development and conservation of forests, which are managed by the Forestry Administration (FA) under the auspices of the Ministry of Forestry, Agriculture and Fisheries. CF is one of the six major programs of National Forestry Program 2010–29, and has been implemented since the 1990s with the cooperation of local non-government organisations (NGOs), international organisations and development partners. By 2017, there were 580 CF sites in 21 provinces with a combined forest area of 470,970 ha (FA 2017). The FA plans to increase the number of CF sites to 1,000 by 2029, quadrupling the land area under CF to 2 million ha (FA 2015).

So far there have been studies on CF in Cambodia (Persson and Prowse 2017), but there have been no county-scale studies on the effectiveness of CF. Moreover, these studies, as well as many similar works on CF in other developing countries, have inevitably relied on small datasets derived from a few case studies, the results of which are not strong enough to help decision makers plan better policies for natural resource management (Nagendra 2007). This research will contribute to filling that knowledge gap. This article draws on the author's PhD thesis (Lonn 2018), which used a country-scale dataset on 197 community forests, established between 1994 and 2005, to compare and measure change in forest cover between 2005 and 2016.

Methods

CF site selection and characteristics

Due to incomplete or missing data, only 197 (out of 580) CF sites, covering a total of 121,701.51 ha across 19 provinces, were selected for study (Figure 1). These CF sites are located mainly to the north and south of the Tonle Sap Lake. Elevations range from 0 metres to 589 metres above sea level and slope gradients range from 0 percent to 50 percent. Annual rainfall in these areas is 1000 mm to 2600 mm (NIS 2012). The main forest types are semi-evergreen, evergreen and deciduous, and the condition of the forests in CF sites is generally degraded but being restored and regenerated. The major tree species are Beng (*Afzelia xylocarpa (Kurz) Craib*), Thnong (*Pterocarpus pedatus* Pierre), Kokoh (*Sindora cochinchinensis H. Baill*), Phcheuk (*Shorea obtusa* Wallich ex Blume), Sokram (*Xylia dolabriformis* Benth) and Tbaeng (*Dipterocarpus obtusifolius* Teyjsm ex Miq.). The common wildlife found in community forests includes wild boar, rabbits, deer, wild chickens, snakes, peacocks and monkeys (FA 2010).

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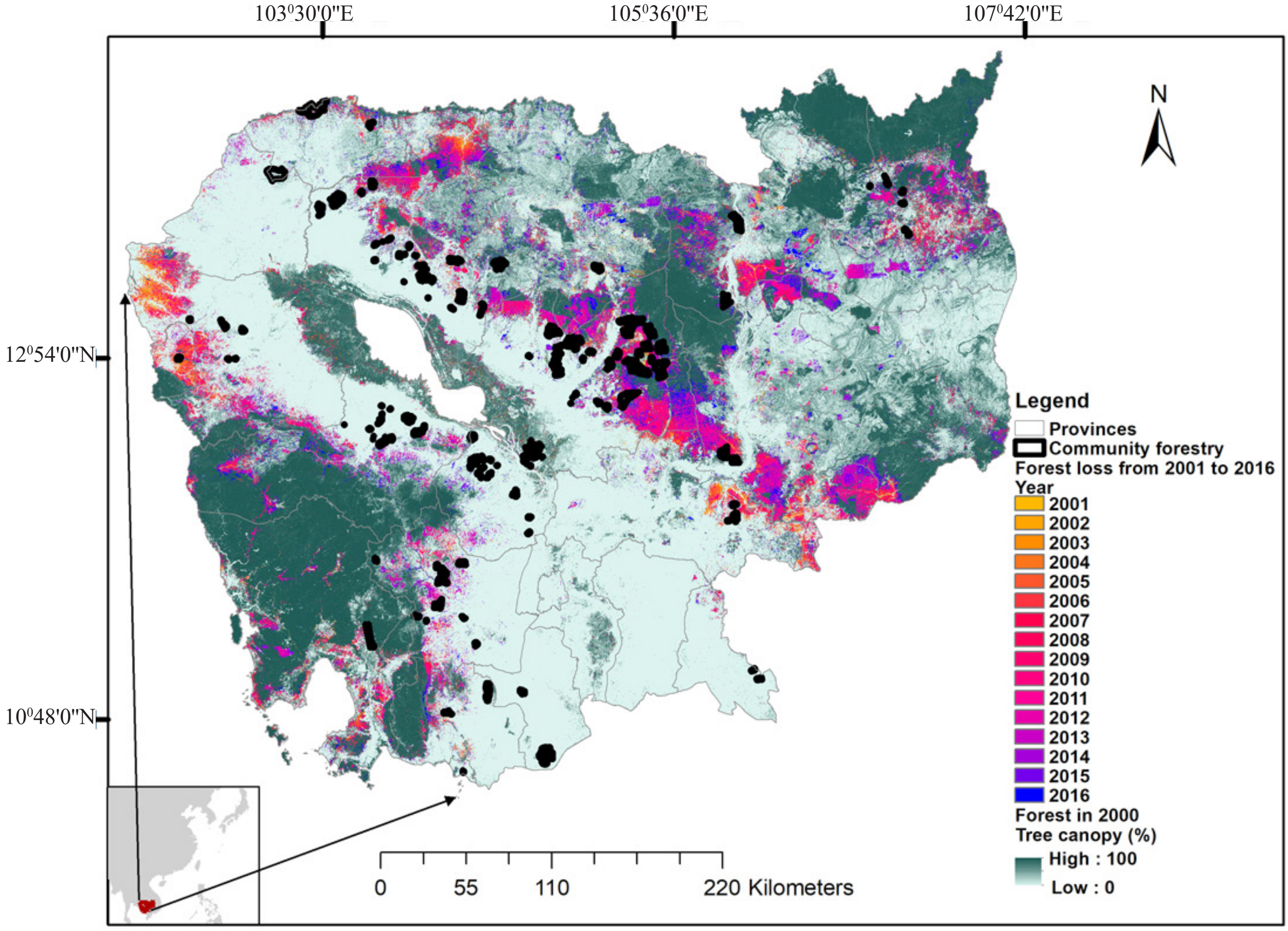
Figure 1: Location of the 197 selected CF sites showing tree canopy in 2000 and forest loss from 2001 to 2016



Source: Forest loss and tree canopy data is from Hansen et al. 2013

Data

Following Davis et al. (2015), tree canopy of 30 percent and above is considered forest. Forest loss between 2005 and 2016 was calculated based on tree cover data for the year 2000 from a global forest change study using medium (30 m by 30 m) spatial resolution satellite images (Hansen et al. 2013). Spatial resolution is measured in pixel size: 1 pixel equals 30 metres. A 30 m by 30 m resolution represents an area of 900 m^2 and is therefore accurate enough for assessing tree cover in Cambodia's CF sites. Statistics on CF and information on the boundaries of CF sites come from the FA (2015). Information on country, district and village boundaries is from census and map layer data 2008 (NIS 2010), and on road networks (main roads and subroads) from the Ministry of Public Works and Transport and Japan International Cooperation Agency (2003). Terrain data on elevation and slope is from the ASTER Global Digital Elevation Model.[1]

Estimation of forest cover change

The study used a covariate-matching method to estimate forest cover outcomes within the CF sites (treatment) and their buffer zones (control), defined as a 10 km perimeter around the CF boundaries. In our study, we focus on two sets of factors: biophysical – slope and elevation of the CF sites; and socioeconomic – distances from the CF sites to the nearest roads and markets (i.e. district centres), CF villages and CF boundaries. These characteristics can influence the likelihood of deforestation. We therefore reduce bias by matching the distributions of confounding covariates inside and outside the CF sites.

[1] ASTER stands for Advanced Spaceborne Thermal Emission and Reflection Radiometer.

Table 1: Estimated deforestation in and around CF sites

Location	Total area (ha)	Total forest area in 2005 (ha)	Total forest area in 2016 (ha)	Deforestation between 2005 and 2016	
				(ha)	(%)
Inside CF	121,701.51	78,697.35	60,359.40	18,337.95	23.30
Outside CF	1,302,064.74	517,194.99	325,527.39	191,667.6	37.06

Table 2: Average treatment effect on treated (ATT) for deforestation

	Deforestation
Estimate	-0.115 ***
Standard error	0.002
Rosenbaum test	1.75

Note: *** statistically significant at the 1 percent level ($p < 0.01$).

Covariate matching is a five-step process. First, we calculate the average treatment effect on the treated (ATT), which is the difference in average deforestation outcomes between the treated areas (i.e. the CF sites) and control areas (the CF buffer zones). In so doing we randomly select 10 percent of all pixels classified as forest in 2005, giving sample sizes of 77,955 pixels inside CF sites and 1,005,088 pixels outside CF sites. We then use nearest-neighbour matching, based on the Mahalanobis distance classification. Matching was performed in R version 3.4.3 (R Core Team 2017). Finally, we check the robustness of the ATT estimates to hidden bias using the Rosenbaum bounds approach, which indicates the required level of unobserved heterogeneity needed to make a statistically significant ATT non-significant (Rosenbaum 2002). We set the significance level at 5 percent (p=<0.05).

Results

The CF sites and their buffer zones have similar socioeconomic characteristics, particularly the distances to CF villages and the nearest markets, but different biophysical characteristics. The mean elevation of areas in the CF buffer zones is higher than that of areas within the CF sites (Appendix Tables A1 and A2).

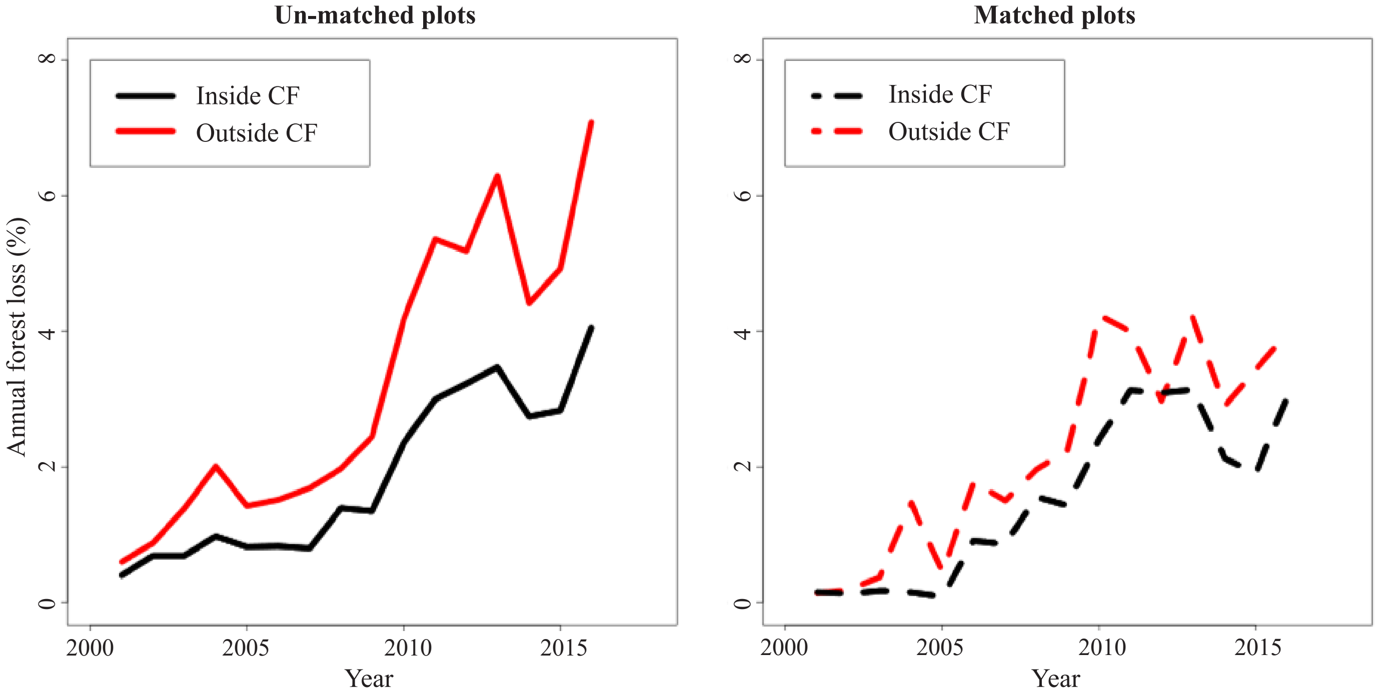
Table 1 presents estimated forest areas in 2005 and 2016. The data indicates that total forest loss in the selected CF sites amounted to 18,337.95 ha or 23.30 percent of total forest cover, compared to 191,667.6 ha or 37.06 percent in the CF buffer zones. The covariate matching results in Table 2 indicate that the deforestation rate in the CF sites from 2005 to 2016 was 11 percent lower than that in the CF buffer zones.

Analysis of matched and nonmatched data indicates that mean annual forest loss in the CF sites is lower than in the CF buffer zones (Figure 2). Importantly, the rate of deforestation seems to have shot up since 2010, implying continuous and increasing deforestation both in and around the CF sites. The matching result is statistically significant at the 1 percent (p=0.01) level. Rosenbaum bounds sensitivity analysis to check for hidden bias shows that our matching results for deforestation are robust up to a factor of 1.75 (Table 2). In other words, the results would remain significant at the 5 percent level even if the covariate of unobserved bias caused the odds ratio of deforestation to differ between areas inside and outside the CF areas by factors as large as 1.75. These values are similar to those obtained in other studies on forest change using similar methods (e.g. Rasolofoson et al. 2015; Miranda et al. 2016).

Discussion

This study builds on a growing body of research to find out on whether or not CF is an effective means of forest conservation, especially in developing countries. As such, it is the first country-scale

Figure 2: Annual forest loss inside and outside CF sites with and without matching



study of CF in Cambodia. An important finding is that CF is effective in reducing deforestation: over the 11 years from 2005 to 2016, the annual mean deforestation rate in CF areas was 11 percent lower than in non-CF areas. This reflects the results of a similar study in the Peruvian Amazon, which found that protected areas reduced deforestation by 8 percent between 2000 and 2005 (Miranda et al. 2016). Conversely, a national-scale study over 11 years (2000–2010) in Madagascar found no evidence that CF reduces deforestation (Rasolofoson et al. 2015). While we can safely conclude from the current study that CF inhibits deforestation in Cambodia, the rate of deforestation in CF areas across the country is nonetheless increasing.

Even though CF is a form of decentralised forest management, it is hard to evaluate its effectiveness because of the different types of CF management practices and strategies, ranging from commercial use, forest conservation and protection to timber production (Rasolofoson et al. 2015). Evaluation should therefore be done among the same types of CF (Lund et al. 2009). Some effective CF initiatives receive ongoing support such as through payments for ecosystem services under the Direct Payment for Conservation project (Rasolofoson et al. 2015), whereas less successful CF communities no longer have financial support or incentives from NGOs. However, the current study does not intend to generalise the findings to every CF initiative in Cambodia as some are inevitably more successful than others due to different contexts within a complex social-ecological system (see, for example, Pagdee et al. 2006; Ostrom 2007).

Conclusion

After over two decades of implementing the community forestry program across Cambodia, policymakers need to know whether or not it promotes forest conservation as intended, rather than uncritically expanding the existing program. In this study, we used a country-scale dataset to evaluate the effectiveness of CF as a way to reduce deforestation. The results show that the rate of deforestation in CF areas is 11 percent lower than in nearby non-CF areas. However, deforestation appears to be increasing in CF and non-CF areas alike. These important findings provide high quality information for policymakers to highlight and address the current rate of deforestation in Cambodia. Managing and updating the Forestry Administration's dataset on CF and making it accessible for further research are key for improving CF systems in Cambodia.

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Appendices

Table A1: Summary statistics for the matching analysis of deforestation

Variables	Unit	Inside CF		Outside CF		Mean difference	
		Mean	STD	Mean	STD		
Deforestation	binary (1 or 0)[a]	0.244	0.430	0.337	0.473	0.093	***
Distance to road	metre	4,589.078	3,595.877	5,145.447	3,712.662	556.369	***
Distance to market	metre	19,993.460	10,344.990	20,123.610	10,059.390	130.150	***
Distance to village	metre	4,437.458	3,191.149	4,998.165	3,191.149	560.707	***
Distance to CF boundary	metre	530.050	436.761	7,488.091	3,294.483	6,958.041	***
Slope	degree	4.126	4.426	4.058	4.418	-0.068	***
Elevation	metre	87.123	69.572	115.874	149.352	28.751	***

Notes: *** $p < 0.01$; a variable takes on value of 1 for deforestation and 0 for others; STD = standard deviation.

Table A2: Covariate balance for the matching analysis of deforestation

Variables (Unit)		Mean			Median	Max	Mean
		Inside CF	Outside CF	eQQ diff[a]	eQQ diff[1]	eQQ diff*	eCDF diff**
Distance to road (m)							
	Before Matching	4,589.10	5,137.90	591.41	636.34	1,840.70	0.05
	After Matching	4,589.10	4,537.60	291.32	173.97	3,209.20	0.02
Distance to village (m)							
	Before Matching	19,993.00	20,166.00	915.81	1014.20	5,188.40	0.02
	After Matching	19,993.00	19,782.00	475.25	322.00	2,425.00	0.01
Distance to market (m)							
	Before Matching	4,437.50	4,985.40	720.27	452.19	4,689.10	0.06
	After Matching	4,437.50	4,359.90	147.00	61.53	2,474.90	0.01
Distance to CF boundary (m)							
	Before Matching	530.05	7,455.40	6,925.30	7085.70	14,709.00	0.57
	After Matching	530.05	1,335.70	805.64	707.49	4,498.20	0.34
Slope (degree)							
	Before Matching	87.12	115.88	32.62	5.00	876.00	0.02
	After Matching	87.12	81.56	6.27	3.00	70.00	0.01
Elevation (m)							
	Before Matching	4.13	4.04	0.11	0.00	12.00	0.00
	After Matching	4.13	4.00	0.13	0.00	2.00	0.00

Note: * Mean, Median and Max eQQ diff indicate the mean, median and maximum differences in the empirical quantile-quantile treatment plots (i.e. inside CF sites) and control plots (i.e. outside CF sites); ** Mean eCDF diff indicates the mean difference in the cumulative distribution functions.