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Impact of land-use zoning for forest protection and production on forest cover changes in Bhutan

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ABSTRACT

Bhutan is characterized by a landscape dominated by forests. A substantial share of these forests is dedicated to nature conservation, with an extensive protected area network connected by biological corridors. Forestlands are also partly allocated to timber production, including forest management units subjected to strict regulations. We assessed the effectiveness of these various land-use zoning units to protect forest cover. We used a matching procedure to control for covariates and obtain robust estimates of the impact of each type of unit on forest cover changes during the 2000s. We also investigated subsets of the protected area network to test for effectiveness heterogeneities within this network. Our results showed that protected areas prevented 63% of the forest loss expected in forestlands under this protection status. These units also curtailed forest gain. Long-established protected areas were more effective at avoiding forest loss than recent ones, while the levels of stringency and operationality of protected areas had no differentiable impact on forest loss. We detected more forest loss in forests surrounding protected areas compared to more distant forestlands, showing a leakage effect. Biological corridors had no impact on forest loss and gain. Forest management units decreased forest loss by half. After accounting for the selection bias, this study demonstrated the effectiveness of land use zoning for forest conservation in Bhutan.

1. Introduction

According to the latest FAO Forest Resources Assessment, worldwide annual rates of net forest loss have more than halved between the 1990s and the 2010–2015 period (Keenan et al., 2015). Tropical deforestation also slowed, mostly due to decreasing deforestation rates in Brazil (Keenan et al., 2015). However, this reduction is contested by direct remote sensing observations, which measured a 62% increase in net humid tropical deforestation between the 1990s and the 2000s (Kim, Sexton, & Townshend, 2015). The tropics concentrated 32% of global forest loss in 2000–2012 (Heino et al., 2015). The fate of tropical forests thus remains of major concern, particularly in poor, tropical countries (Sloan & Sayer, 2015).

Although nonstate, market-driven governance regimes are yielding promising conservation outcomes (Heilmayr & Lambin, 2016), biodiversity conservation still largely depends on public interventions, including land use zoning (Lambin et al., 2014). Zoning consists of segmenting the landscape into units where human access and uses are legally restrained and limited to specific activities or agents according to their assignment, such as protection or production activities. The designation of natural areas under a protection status – i.e., protected areas – is a particular type of land-use zoning, commonly used for biodiversity protection (Andam, Ferraro, & Hanauer, 2013; Cuenca, Arriagada, & Echeverría, 2016; Geldmann et al., 2013; Hanauer & Canavire-Bacarreza, 2015; Joppa & Pfaff, 2010; Mascia et al., 2014; Miteva, Pattanayak, & Ferraro, 2012).

Globally, the share of the terrestrial realm designated as a protected area increased exponentially since the late 1950s and was estimated at 14.4% in 2014 (Ferraro & Pressey, 2015; Watson, Dudley, Segan, & Hockings, 2014). Areas under protection include 16.3% of the world forests and up to 26.6% of tropical forests (Morales-Hidalgo, Oswalt, & Somanathan, 2015), with great variability between countries and ecoregions (Schmitt et al., 2009; Watson et al., 2014). Downsizing, downgrading, or even degazettement of areas under protection is also

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Table 1
Protected areas and biological corridors of Bhutan.

Name	Type	Year of creation	Operational year (NSB, 2011)	IUCN category	Area (km^2)	Households (Wangchuk, 2007)	Settlement/km^2
Jigme Dorji	National Park	1974	1995	II	4324	1000	0.31
Bumdeling	Wildlife Sanctuary	1995	1998	IV	1537	136	0.15
Thrumshingla	National Park	1998	2000	II	908	1626	0.19
Toorsa[a]	Strict Nature Reserve	1993	/	Ia	611	na	0.03
Sakteng	Wildlife Sanctuary	1993	2003	IV	743	616	0.69
Jigme Singye Wangchuck	National Park	1995	1995	II	1727	950	0.65
Royal Manas	National Park	1966	1966	II	1024	650	0.57
Khaling[b]	Wildlife Sanctuary	1974	/	IV	338	na	0.42
Phipsoo	Wildlife Sanctuary	1993	/	IV	270	na	0.79
Wangchuck Centennial	National Park	2008	/	II	4922	na	0.13
North corridor[c]	Biological corridor	1999	/	VI	934	na	1.01
TSNR-JDNP[d]					149		0.33
JDNP-JSWNP[d]					275		1.00
TNP-BWS[d]					79		2.39
TNP-JSWNP-RMNP[d]					501		0.10
KWS-SWS[d]					160		0.01
JSWNP-RMNP-PWS[d]					376		0.85
RMNP-KWS[d]					212		0.99

Note: na: Not available.
[a] Recently renamed, in honor of the ruling King, as the Jigme Khesar Strict Nature Reserve.
[b] Recently renamed as Jomotshangkha Wildlife Sanctuary.
[c] The north corridor connects the Wangchuck Centennial Park with the four PAs in its surroundings.
[d] Name of BC is the abbreviation of the PAs it connects.

taking place (Mascia et al., 2014). Other forms of zoning, such as for extractive purposes, can also contribute to forest conservation (Bruggeman, Meyfroidt, & Lambin, 2015). Zoning also risks causing leakage by displacing land uses to the periphery of zones with restricted uses (Lambin & Meyfroidt, 2011).

Given variations in stringency and enforcement of land-use zoning policies, there is a need for empirical evidence on their effectiveness to support the design of future ecosystem conservation programs (Ferraro & Pressey, 2015; Gaveau, Linkie, SuyadiLevang, & Leader-Williams, 2009a; Heino et al., 2015; Miteva et al., 2012). Their ability to deliver desirable outcomes is evaluated in terms of both environmental and socio-economic impacts (Cuenca et al., 2016). The impact evaluation literature emphasizes that forest conservation outcomes of protected areas cannot rely on a simple comparison between rates of forest loss in protected and unprotected areas. Actually, selection of areas designated for protection is not random and potentially correlated with probability of forest loss. Protected areas tend to be located where opportunity costs of conversion to other land uses are low, such as areas that are remote, unpopulated, at high elevation, on steep slopes, or with reduced agricultural suitability. This partly explains their imperfect ecological representation (Watson et al., 2014). Accounting for this non-randomness of zoning is critical in assessing the causal impact of protection, i.e., to estimate avoided deforestation compared to deforestation that would have occurred in the absence of protection (Cuenca et al., 2016; Gaveau et al., 2009b).

The Kingdom of Bhutan is located in the Himalaya biodiversity hotspot, with a landscape dominated by forests (Bruggeman, Meyfroidt, & Lambin, 2016). The Bhutanese government has made environmental conservation a pillar of its development philosophy (Brooks, 2010; Jadin, Meyfroidt, & Lambin, 2015; Meyfroidt & Lambin, 2010). The designation of areas for nature protection has been promoted for several decades, with circa 43% of the country area (~38,000 km^2) and 33% of its forests being protected in 2010 (FAO, 2014; NSB, 2011). This extensive protected area network, connected by biological corridors, offers a great opportunity to test the effectiveness of these interventions. Furthermore, the Bhutanese forestry sector has been nationalized and is strictly regulated, with timber extraction confined to specific production units.

The objective of this study is to assess the impact of the zoning of forestlands, including protection and production units, on forest cover changes in Bhutan between 2001 and 02 and 2011. The study period follows the 1995 Forest and Nature Conservation Act, which guides forest management. The impact of zoning could depend on location and characteristics of zoning units, and on causes of forest cover changes (Ferraro & Pressey, 2015). We thus analyzed specific zoning units, areas, and types of forest cover changes. We tested the following hypotheses: (i) Different zoning categories have different impacts on forest cover loss and gain; (ii) protected areas cause leakage to neighboring areas; (iii) protected areas with an operational management plan, with stricter regulations, or that are long-established are more effective at reducing deforestation compared to others; and (iv) protected areas are more effective at deterring forest conversion for agriculture or timber extraction than forest loss due to forest fires and natural hazards.

2. Land-use zoning of forestlands in Bhutan

Managed according to customary laws in the past, forestlands were nationalized in 1969 under the Bhutan Forest Act. Although the first forest management plans were already implemented during the 1960s to limit timber extraction, this Act is the first national policy seeking forest protection, notably through patrolling by forest officers (Penjore & Rapten, 2004, pp. 21–27). It was replaced in 1995 by the Forest and Nature Conservation Act, which defined all forestlands as Government Reserved Forests, except for community forests and private forests that represented around 1% of forestlands in 2005 (FAO, 2014; Jadin et al., 2015; RGoB, 1995). A forest management plan is mandatory for land declared as Government Reserved Forests and no clearing for agriculture, setting fires, or removing forest produce is allowed, except for collecting products for domestic purpose with the proper permit (Penjore & Rapten, 2004, pp. 21–27; Dhital, 2009). Implementation of this legal framework was supported by the Forest and Nature Conservation Rules of 2000, 2003 and 2006 (DoFPS, 2011). These Rules specify land-use regulations, management, and related penalties for each type of forestland zoning units (RGoB, 1995; RGoB, 2006).

The first protected area (PA) of Bhutan, the Manas Game Sanctuary