Landscape and Urban Planning 141 (2015) 1–10

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

Research paper

The changing land cover and fragmenting forest on the Roof of the World: A case study in Nepal's Kailash Sacred Landscape

Kabir Uddin [a], Sunita Chaudhary [a], Nakul Chettri [a,*], Rajan Kotru [a], Manchiraju Murthy [a], Ram Prasad Chaudhary [b], Wu Ning [a], Sahas Man Shrestha [c], Shree Krishna Gautam [d]

[a] International Centre for Integrated Mountain Development (ICIMOD), GPO Box 3226, Kathmandu, Nepal
[b] Research Centre for Applied Science and Technology, Tribhuvan University, Kirtipur, PO Box: 1030, Kathmandu, Nepal
[c] Department of Forests, Babar Mahal, PO Box: 23200, Kathmandu, Nepal
[d] Forest Resources Assessment Nepal, Babar Mahal, PO Box: 23200, Kathmandu, Nepal

HIGHLIGHTS

- Temporal change in land cover and forest fragmentation were analyzed.
- The results showed 9% decrease in forest cover and 12% increase in cropland.
- A further 4% decline in forest cover and 5% increase in cropland were predicted.
- 10% decrease in large core forest and 10.6% decline in core forest was predicted.
- Expansions of cropland coupled with high dependency on forests are the drivers.

ARTICLE INFO

Article history:
Received 3 August 2013
Received in revised form 7 April 2015
Accepted 8 April 2015
Available online 16 May 2015

Keywords:
Forest cover
Fragmentation
Cropland
Biodiversity
Livelihoods
KSL—Nepal

ABSTRACT

Land cover change is one of the most important drivers of forest ecosystem change. The Hindu Kush Himalayan region (HKH) has experienced severe forest degradation but data and documentation are limited. We undertook this study in the Nepalese part of the Kailash Sacred Landscape (KSL), an important transboundary region known for its biodiversity and the scared values. Forest is an important ecosystem within the landscape and provides various goods and services including habitat for many keystone species. However, precise information on forest change and overall land cover change in the area is limited. We analyzed land cover change and forest fragmentation between 1990 and 2009, and the predicted change for 2030. There was a 9% decrease in forest cover and 12% increase in cropland between 1990 and 2009. A further 4% decline in forest cover and 5% increase in cropland was predicted by 2030, together with a slight increase in grassland and barren area. Fragmentation analysis showed a 10% decrease in large core forest between 1990 and 2009, accompanied by an increase in patch forest. A further 10.6% decline in core forest was predicted by 2030, accompanied by an increase in patch, perforated, small-sized core, and mediumsized core areas. The study suggests that expansions of cropland coupled with high dependency on forests are the major drivers of the observed forest change. Recommendations are made based on the results of the study that will help to maintain and restore forest, and support biodiversity conservation and livelihoods.

1. Introduction

Around 75% of the natural forested areas across the world have either been cleared or dominated by human activity since the last ice age (Ellis & Ramankutty, 2008). The global rate of forest loss is currently reported to be 0.6% per year (Hansen, Stehman, & Potapov, 2010). Forest degradation as a result of resources extraction, and conversion of forested areas to cropland, settlement and other land use types is leading to forest fragmentation (Crooks, Burdett, Theobald, Rondinini, & Boitani, 2011), a decrease in productivity (Hijmans, Cameron, Parra, Jones, & Jarvis, 2005), an increase in forest isolation (McGarigal & Cushman, 2002), and changes in community composition (Saunders, Hobbs, & Margules, 1991). Studies have shown that, if not controlled, natural old-growth forests can be critically fragmented to the point at which they can neither maintain viable populations of flora and fauna, nor maintain their

* Corresponding author. Tel.: +977 9841516138.
E-mail address: Nakul.Chettri@icimod.org (N. Chettri).

http://dx.doi.org/10.1016/j.landurbplan.2015.04.003

ecological integrity (Kettunen, Terry, Tucker, & Jones, 2007). Forest fragmentation, in which the forest is reduced to patches, can have a marked detrimental impact on biodiversity. Among others, it can result in homogenization (Lôbo, Leão, Melo, Santos, & Tabarelli, 2011), reduction in habitat quality for forest-interior species, and loss of forest health due to changes in microclimate and increased susceptibility to edge predators, parasites, and invasive species (Thuiller, Albert, Araújo, Berry, & Cabeza, 2008). Rare and patchily distributed species that require a larger range of a specific habitat are particularly affected by fragmentation (Fenoglio, Srivastava, Valladares, Luciano, & Salvo, 2012).

Apart from the impact on biodiversity, fragmentation can also negatively impact ecosystem processes and the flow of ecosystem services (Burkhard, Kroll, Muller, & Windhorst, 2009), which in turn affects the livelihoods of forest dependent communities (Chettri, Sharma, Deb, & Sundariyal, 2002). The fragmentation process may lead to landscape, ecosystem and habitat degradation (Leal, Filgueiras, Gomes, Iannuzzi, & Andersen, 2012; Schleuning, Farwing, Peters, Bergsdorf, & Bleher, 2011), and biodiversity loss (Crooks et al., 2011). Land cover change is becoming so prominent at a global scale that it is significantly affecting the Earth's ecosystems and functions (Lawler et al., 2013). By 2100, the impacts of land cover change on biodiversity at a global scale is likely to be more significant than climate change, nitrogen deposition, species introductions, and changing atmospheric concentrations of carbon dioxide (Sala et al., 2000).

The Hindu Kush Himalayan region (HKH) extends over more than four million square kilometers and includes all of Bhutan and Nepal and parts of six other countries: Afghanistan, Bangladesh, China, India, Myanmar, and Pakistan. It is the source of ten large Asian river systems – the Amu Darya, Indus, Ganges, Brahmaputra (Yarlungtsanpo), Irrawaddy, Salween (Nu), Mekong (Lancang), Yangtse (Jinsha), Yellow River (Huanghe), and Tarim (Dayan), – and provides water, ecosystem services, and the basis for livelihoods to a population of around 210.53 million people in the region. The basins of these rivers provide water to 1.3 billion people, a fifth of the world's population (Schild, 2008). Endowed with a rich variety of gene pools and species, and ecosystems of global importance (Chettri, Shakya, Thapa, & Sharma, 2008), the region hosts parts of four Global Biodiversity Hotspots: Himalaya, Indo-Burma, Mountains of South-West China, and Mountains of Central Asia (Mittermeier et al., 2004). Approximately 39% of the HKH is comprised of grassland, 20% forest, 15% shrub land, and 5% agricultural land. The remaining 21% are barren land, rocky outcrops, built-up areas, snow cover, and water bodies (Chettri et al., 2008). With 20% coverage, forest is one of the most important ecosystems in terms of habitat for flagship species (Chettri, Sharma, & Zomer, 2012; Kandel et al., 2015) and as a source of provisioning, regulatory, cultural and supporting services (Badola et al., 2010; Kubiszewski, Costanza, Dorji, Thoennes, & Tshering, 2013; Pant, Rasul, Chettri, Rai, & Sharma, 2012). However, the region has witnessed significant deforestation in the past (Ives & Messerli, 1989) which is still ongoing in many areas (Pandit, Sodhi, Koh, Bhaskar, & Brook, 2007). Although the HKH has witnessed significant progress in conservation, with 39% of land in protected areas (Chettri et al., 2008), the region is still facing challenges with the effectiveness of protected area management (Oli, Chaudhary, & Sharma, 2013), and protected areas are often isolated as conservation islands (Chettri et al., 2008). The conservation agenda is facing additional challenges with climate change (Singh, Singh, & Skutsch, 2010) and high rates of absolute poverty in some parts (Gerlitz, Hunzai, & Hoermann, 2012). Moreover, the region is poorly researched and the information available on biodiversity, land cover change, and climate change is far less than required. The fourth and fifth reports of the Intergovernmental Panel on Climate Change (IPCC) explicitly pointed to the HKH as a data deficit area (IPCC, 2007, 2014; Solomon

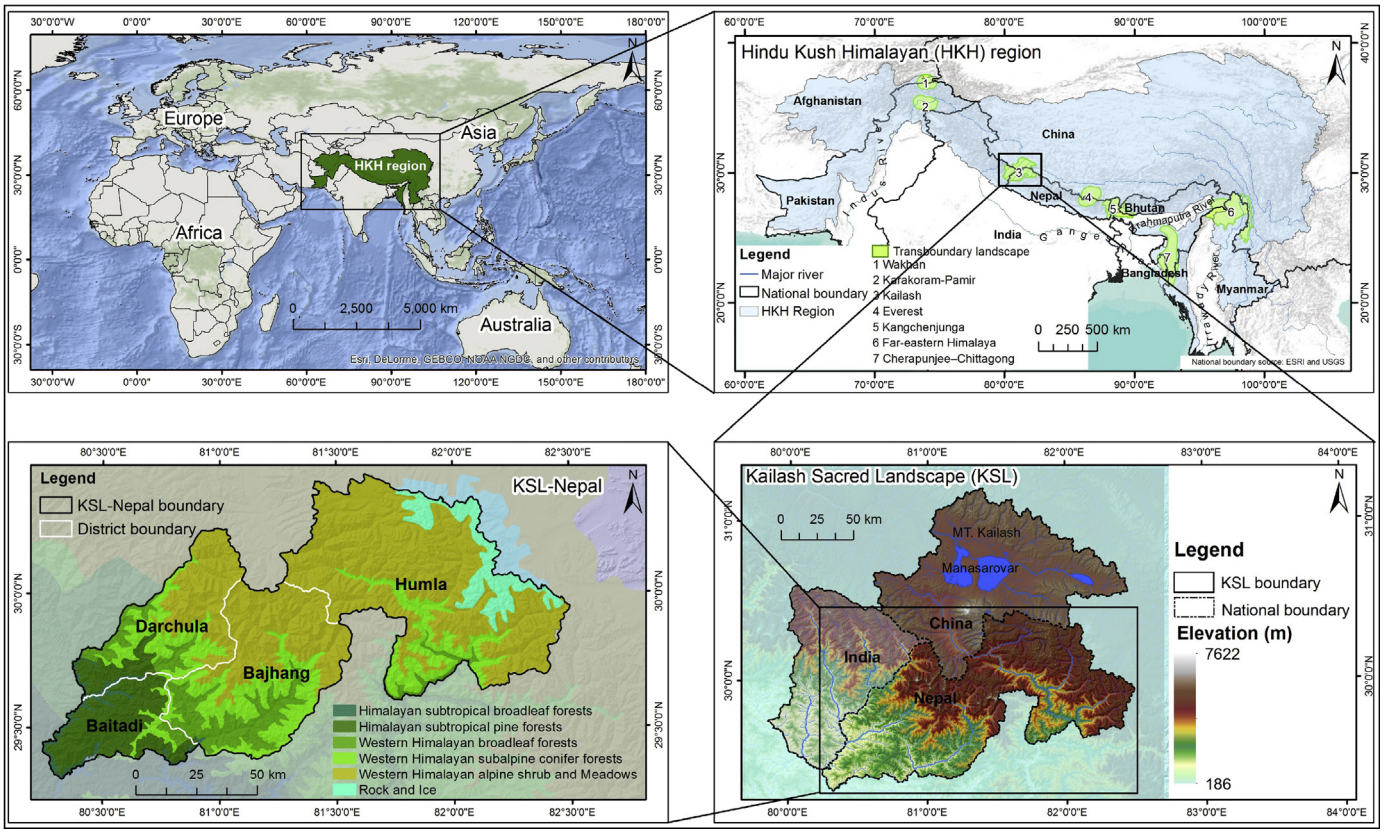

Fig. 1. Map showing the Hindu Kush Himalayas in the global set and Kailash Sacred Landscape and the study area of Nepalse part of the landscape along with its ecoregions.