Applied Geography 60 (2015) 10–19

Contents lists available at ScienceDirect

Applied Geography

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

Modelling spatial distribution of critically endangered Asian elephant and Hoolock gibbon in Bangladesh forest ecosystems under a changing climate

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ARTICLE INFO

Article history:
Available online

Keywords:
Wildlife
Climate change
Distribution
Conservation
Modeling
MaxEnt

ABSTRACT

The Asian elephant (*Elephas maximus*) and Hoolock gibbon (*Hoolock hoolock*) are two globally endangered wildlife species limited to only tropical Asian forests. In Bangladesh both species are critically endangered and distributed mainly in the northeast and southeast hilly regions bordering neighboring India and Myanmar. Using existing distribution data, land-use/land cover, elevation and bio-climatic variables, we modeled the likely distribution of Asian elephant and Hoolock gibbon in Bangladesh for 2050 and 2070. We used the IPCC's Representative Concentration Pathways (RCPs) – RCP6.0 and RCP8.5 and Maximum Entropy algorithm for our modelling. Our study indicated that the Asian elephant will be more resilient to climate change compared with the Hoolock gibbon. Habitat loss for the Asian elephant is also expected to remain constant (i.e. 38%) throughout the period, whilst Hoolock gibbon habitat will be more sensitive to climatic variations, with the species predicted to be extirpated from the country by 2070. Being highly exposed to climate change with ever increasing land use pressures, we believe our study in Bangladesh can be used to enhance our understanding of future vulnerabilities of wildlife in a rapidly changing climate. A trans-boundary conservation program with greater attention to the species that are less resilient to climate change is also essential.

Introduction

Rapid biodiversity loss and species extinction are amongst the major environmental issues affecting the structure and functions of ecosystems and human well-being (Alamgir, Pert, & Turton, 2014; Kaeslin, Redmond, & Dudley, 2012; Sachs et al., 2009; Sohel, Mukul, & Burkhard, 2014). According to the latest edition of the Living Planet Report, wildlife populations have declined globally by 52% since 1970 (McLellan, Iyengar, Jeffries, & Oerlemans, 2014). Apart from land-use/land cover (LULC) change, dramatic changes in local and regional climate are responsible for this rapid loss in biodiversity (Faleiro, Machado, & Loyola, 2013; Feeley, Malhi, Zelazowski, & Silman, 2012; Ordonez, Martinuzzi, Radelo, & Williams, 2014; Stanton, Shoemaker, Pearson, & Resitakcakaya, 2014; Thomas et al., 2004). In the tropics, species will lose suitable habitats faster than other regions due to climate change and will therefore be affected more adversely (Loarie et al., 2009; Thuiller, 2007; Wright, Muller-Landau, & Schipper, 2009). With climate change and related extreme events likely to increase over the coming decades, biodiversity and ecosystems are likely to suffer additional stresses in tropical regions, creating a need for integrated assessments and planning for effective conservation (IPCC., 2014; Ordonez et al., 2014; Stanton et al., 2014; Feeley et al., 2012; Kaeslin et al., 2012).

The Asian elephant (*Elephas maximus*) and Western Hoolock gibbon (*Hoolock hoolock*) are two species of global conservation importance that are limited to only tropical Asian forests (Fig. 1; IUCN., 2014). The elephant is the largest living land animal in Asia

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http://dx.doi.org/10.1016/j.apgeog.2015.03.001
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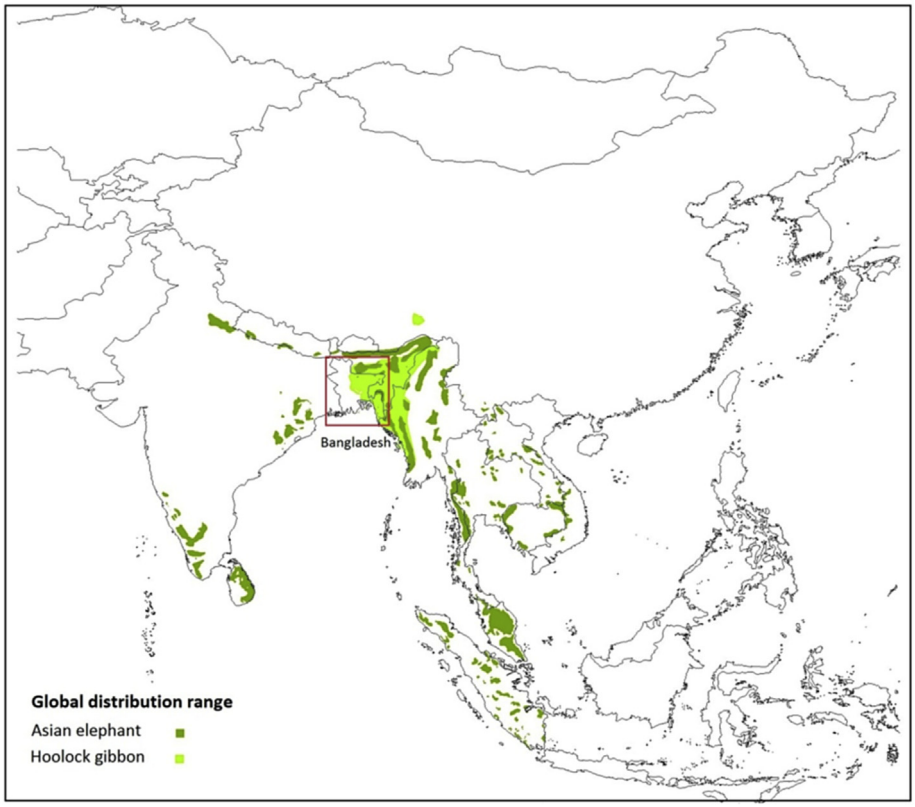

Fig. 1. Global distribution of Asian elephant and Hoolock gibbon.
Source: IUCN.

and has always been an important part of culture and religions here (Mukul, Rashid, & Uddin, 2012; FAO., 2002; Olivier, 1978). Hoolock gibbons, though not as familar as the Asian elephant, are considered to be one of the 25 most endangered primate species in the world (Mittermeier et al., 2009). Populations of both species have declined drastically in recent years due to habitat loss, forest fragmentation, illegal hunting and poaching (Mittermeier et al., 2009; Sukumar, 1989).

Bangladesh is located at 21^0–26^0 north of the equator and has one of the wettest climates in the world (McSweeney, New, & Lizcano, 2010). Due to its geo-climatic location, the country has already experienced substantial changes in local and regional climates and is highly susceptible to any future changes (Alamgir & Turton, 2014; Mukul et al., 2014; MoEF 2008). Both the Asian elephant and Hoolock gibbon were once abundant in most forests in the country, but are now listed locally as critically endangered (Fig. 2; IUCN, 2000). Whilst most wildlife is protected in Bangladesh under the Wildlife Conservation (Amendment) Act of 1974 (Mukul, Uddin, Uddin, Khan, & Marzan, 2008), the population of both species has dropped enormously in recent years (Table 1; Gain, 1998). For instance, the Hoolock gibbon population has declined by more than 50% in the country between 1986 and 2006 (McLellan et al., 2014; Muzaffar et al., 2007).

In recent years, the development and application of species distribution models (SDMs) have benefited the conservation of biodiversity through influencing science, policy and practice (McShea, 2014). SDMs are used as an adaptive management tool to understand the complex landscapes that are undergoing short and long term changes, with models that have evolved to provide future scenarios based on known and projected climatic and environmental parameters (Elith et al., 2011; Elith & Leathwick, 2009). SDM is widely used to determine species distribution patterns at spatial scales (Elith et al., 2011), and produces spatially explicit maps that are useful for identifying areas where conservation efforts should be prioritized (Zhang et al., 2012). Whilst a combination of climate change, deforestation and forest

Fig. 2. Asian elephant roaming around Fashiakhali forests near Chittagong in southeast Bangladesh (left); the endangered Hoolock gibbon in Satchari forests in the northeast Bangladesh (right) (Photo credits: Sayam U. Chowdhury).