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Recent trends of forest cover change and ecosystem services in eastern upland region of Bangladesh

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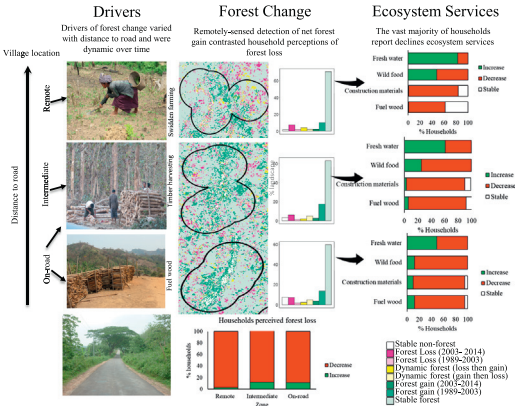
HIGHLIGHTS

- Forest cover changes were assessed by using satellite imagery and local people's perceptions
- Drivers of forest cover changes shift over time and space in the landscape
- Rural households perceived a severe decline in ecosystem services and forest cover
- Households identified small gains in planted tree cover, which had a limited impact on improving ecosystem services

GRAPHICAL ABSTRACT



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ABSTRACT

Forest cover changes have diverse outcomes for the livelihoods of rural people across the developing world. However, these outcomes are poorly characterized across varying landscapes. This study examined forest cover changes, associated drivers, and impacts on ecosystem services supporting livelihoods in three distinct areas (i.e. remote, intermediate and on-road) in the Chittagong Hill Tracts region of Bangladesh. The three zones had features of decreasing distance to major roads, decreasing levels of forest cover, and increasing levels of agricultural change. Data was collected from satellite images for 1989–2014, structured household interviews, and group discussions using Participatory Rural Appraisal approaches with local communities to integrate and contrast local people's perceptions of forest cover and ecosystem service change with commonly used methods for mapping forest dynamics. Satellite image analysis showed a net gain of forest areas from 1989 to 2003 followed by a net loss from 2003 to 2014. The gain was slightly higher in intermediate (1.68%) and on-road (1.33%) zones than in the remote (0.5%) zone. By contrast, almost 90% of households perceived severe forest loss and 75% of respondents observed concomitant declines in the availability of fuel wood, construction materials, wild foods, and fresh water. People also reported traveling further from the household to harvest forest products. The main drivers of forest loss identified included increased harvesting of timber and fuel wood over time in the intermediate and on-road zones, whereas swidden farming persisted as the major driver of change over time in the remote zone. The contrast between remotely-sensed forest gains and household-perceived

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forest loss shows community experiences may be a critical addition to satellite imagery analysis by revealing the livelihood outcomes linked to patterns of forest loss and gain. Community experiences may also evoke solutions by characterizing local drivers of forest change. Failing to disaggregate the impacts of forest loss and gains on ecosystems services over time may lead to uninformed management and further negative consequences for human well-being.

1. Introduction

Forest loss and land degradation has increased significantly across tropical countries with consequences for biodiversity (Wright, 2005) and human well-being (Alfonso et al., 2016). Though the global rate of deforestation has decreased in the past decade, the loss of natural forests still continues at an alarming rate in many countries of South America and Africa (FAO, 2015a). Forest cover changes have diverse implications, mainly negative effects on the sustainable supply of ecosystem services from small to large spatial scales (Balthazar et al., 2015; Sunderland et al., 2017; Ellison et al., 2017). In tropical forests in particular, most of the impacts of forest loss are clearly evident at the local scale in the livelihoods of rural people who depend on forests and trees to support their livelihoods (Gray et al., 2015). Ecosystem services are broadly defined as benefits that people obtain from ecosystems following MA (2005), and have been recognised for local livelihoods (Fisher et al., 2013). There are a variety of benefits that ecosystems provide, mainly provisioning, regulating, cultural, and supporting services to human well-being. Changes in ecosystem affect many aspects of human well-being, but in particular, people who often directly depend on services including food, fresh water, fuel wood are the most vulnerable to changes in ecosystems.

Studies led by Sunderland et al. (2017) across a forest transition gradient in six tropical landscapes showed a close association between forest loss and fewer ecosystem services available than in the past. The loss of forest areas corresponds to variations in fuel wood, wild foods, fodder for livestock along different locations of a landscape. On the other hand, forest gain referred to by several studies as increase in intensive management of timber production and conversion of native forests into monoculture plantations may result in trade-offs, especially with water purification and regulation, nutrient cycling, soil maintenance, genetic diversity maintenance, recreation, and possibly cultural values (Pirard et al., 2016; Balthazar et al., 2015; Alfonso et al., 2016; D'Amato et al., 2017).

Forest loss generally results from a combination of direct causes (e.g. agriculture expansion) and underlying forces (e.g. institutional, economic) (Kanninen et al., 2007). Agricultural expansion is by far the most prevalent land-use change associated with forest cover loss, along with infrastructure development and wood extraction (Geist and Lambin, 2002). Typically, smallholder subsistence agriculture is viewed as a less significant driver of forest loss than industrial agriculture, road development, or national policies favouring in-migration and incentives to encroachment in forests (Heinimann et al., 2017; Van Vliet et al., 2012). Further, secure land tenure reduces forest cover loss across a range of ownership regimes and drivers (Robinson et al., 2014). However such widely-acknowledged causes and underlying forces interact in multiple and complex ways, making our understanding of drivers of forest loss at local levels incomplete (Brown and Schreckenberg, 1998). There are place specificities, multiple sectors (e.g. forest, agriculture, mining and infrastructure), cross-scale aspects (local, sub-national and national), and tenure conditions associated with forest cover changes at the local level (Bong et al., 2016). Therefore understanding the diversity of possible causes and underlying forces of forest change requires not only broader regional and historical perspectives (Lambin et al., 2003), but also local perspectives, which provide context and a frame of reference from within a landscape (Shriar, 2014).

Global patterns of tree cover reflect large scale changes from deforestation to reforestation across a range of natural processes and human interventions including planted forests (Rudel et al., 2016; Sloan and Sayer, 2015). However, the loss of forests followed by regrowth of tree covers or monoculture plantations can have low-level outcomes for livelihoods and ecosystem services in the landscapes depending on who gains the benefits and who bears the costs (Lindström et al., 2012; Barbier et al., 2010). Declining forest area associated with an expansion of commercial agricultural area as well as economic development can lead to the irreversible impacts on the delivery of ecosystem services and thus impoverishment of local people. As such, a recovery in forest cover due to plantation forestry implies environmental degradation has raised growing debate in the context of sustainable forest management and human well-being (Alfonso et al., 2016; Ferraz et al., 2014).

Until recently, studies of forest cover change provided a partial understanding of the changes without addressing the impacts on ecosystem services. Based on spatial analysis and community perception, studies showed the dynamic trend in recent forest area change (Twongyirwe et al., 2015; Twongyirwe et al., 2017) or partly drivers (Rudel et al., 2016; Hosonuma et al., 2012). But these have not addressed associated impacts of forest cover change on ecosystem services supporting local livelihoods. A few studies highlighting local communities' experience of forest cover change have shown livelihood impacts in terms of changing accessibility and availability of ecosystem services (Ehara et al., 2016; Thanichanon et al., 2013). But these also lack explaining the roles of forest cover dynamics for both gain and loss in the livelihoods of local people. Such lack of an integrated assessment of remotely-sensed deforestation measurements in combination with perceptions and livelihood impacts has undermined a proper understanding of how forest changes reflect local experiences and livelihoods over time and space. Perceptions about the forest changes reflect community views towards the benefits available in the past and the roles of existing management in sustaining ecosystem services (Alfonso et al., 2016). Integrating community experiences ultimately provides options for overcoming trade-offs and enhancing synergies between forest management and improvement of rural livelihoods (Fisher and Hirsch, 2008) and well-being (Yang et al., 2015).

Within the context of limited integration of remote sensing data and local perspectives for understanding forest change and drivers, the objective of this study was to analyse forest cover change, associated drivers and assess the subsequent impacts on the ecosystem services supporting livelihoods of rural people in the eastern Chittagong Hill Tracts (CHT) region of Bangladesh. Forests and trees historically contributed to the livelihoods of indigenous people in CHT region due to demand for a range of provisioning services (wild food, fuel wood, medicine and water) as well as the source of national revenue through harvesting of raw materials for wood processing, paper and pulp industries. Though forest uses have an important role in the livelihoods of people living in the region (Miah et al., 2012), over-exploitation and degradation that commenced during the last century (Rasul, 2007) and continue to the present have implications for sustaining the benefits (Rasul, 2009). Deforestation may have effects on the ecosystem services provided by forests such as decline of direct benefits of wild food, fuel wood, construction materials, and biodiversity while it has indirect contributions to the loss of soil fertility, degradation of fresh