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Tea plantations as a driving force of long-term land use and population changes in the Eastern Himalayan piedmont

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ABSTRACT

Reconstructing the long-term impacts of tea plantations on land use and cover (LULC) change over time is important for making policy decisions on management and conservation. This can be very effectively done by integrating historical and remote sensing data; however, such approach has rarely been used to date. The present study analysed the role of the large tea plantation system in the forest cover change in 2105.9 km^2 of the Himalayan piedmont in India's West Bengal state, from the first settled agriculture in the mid-19th century to present day. The impact of domestic and international markets together with local factors such as floods on tea plantation development were also investigated to identify potential scenarios of LULC change in the next few decades. Analysis of historical and remote sensing data as well as census reports revealed that between 1874 and 2010, forest area decreased by 69.5% and land under tea cultivation increased to 30.7%. Population density grew as much as 5122.2% to 470 people km^{-2} between 1872 and 2011. Piedmont development was not uniform and denoted two periods: new land use structure formation (1874–1930) and its further stabilization (1930–2010). The first period showed rapid deforestation at an annual rate of 16–30 km^2, with an increase of tea production areas up to 16 km^2 per year. The second period saw slower deforestation rates (2–4 km^2 annually) and steady growth of tea production areas (2 km^2 annually). Population growth changed from workforce immigration to settled families. Limited space for settlement expansion favoured population concentration and initiated urbanization processes. Despite the initiation of deforestation and migration through the location of tea gardens, the close relationship between deforestation and population density has not been found in piedmont. At the early stages of plantation development, the greatest deforestation occurred at the lowest population density in the piedmont history. Later, a significant decline in the deforestation rate was accompanied by a demographic explosion. At the same time, reserved forest played the very important role in preserving the remnants of forest cover. Features of the natural environment and land use policy led to tea cultivation approaching maximum expansion in the studied area.

1. Introduction

Plantations function as a near-industrial form of production that exploits land and labour has environmental, economic, and social consequences. Numerous studies identified large plantation expansion as an important driver of deforestation (Angelsen and Kaimowitz, 2001; McMorrow and Talip, 2001; Lambin et al., 2003; Miyamoto, 2006; Rudel et al., 2009a; Shearman et al., 2009; Ajonina et al., 2014; Jadin et al., 2016). The replacement of natural forests by monocrops, together with introduced exotic crops such as oil palm and rubber trees (originated from Africa and South America respectively) to Southeast Asia and tea (originated from China) to India where a semi-wild tea variety was already growing (Byerlee, 2014), led to a loss of biodiversity and decline of soil fertility (Dang, 2005; Hartemink, 2005, Xiao et al., 2006; Koh and Wilcove, 2008). The dominance of plantations on export commodities also facilitated their expansion to meet a growing global market demand (Gibbs et al., 2010). Therefore term "plantation" is usually referred to a distinct type of agricultural system associated with colonial expansion in tropical and subtropical regions several hundreds years ago (Courtenay, 1980). Large plantations are typically monocropped, with production that generally requires initial crop processing and an export market as well as a specialized management team in charge of a workforce (Tiffen and Mortimore, 1990; Stephens et al., 1998). Although tea is one of many plantation crops, studies emphasize some of the specific features of a large tea plantation system, such as relatively long commercial lifespan of tea bushes, a large workforce requirements and creation off-farm employment (Bhowmik et al., 1996; Kadavil, 2005; Dutta et al., 2010).

Relationships between deforestation and population, however, are complex for plantations, similar to other agricultural systems. Initial plantation development usually results in increased migration, often at the expense of indigenous people living in the natural forest (Lambin et al., 2001; Byerlee, 2014). Further, population growth as a cause of deforestation has been extensively debated because the impact of

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population might depend on other factors such as infrastructure, agricultural trade, nonagricultural work opportunities, poverty rate, or urbanization (Geist and Lambin, 2002; Ningal et al., 2008; DeFries et al., 2010; Miyamoto et al., 2014).

The studies mentioned above show that short-term land use and population changes in areas occupied by plantations are relatively well recognized since satellite remote sensing datasets are available. In contrast, the long-term and comprehensive assessments of plantations role in the tropics tend to treat historical land use and population dynamic usually as a background for presenting changes in selected elements of environment (Sawyer, 1993; Hartemink, 2003) or economic development (Tiffen and Mortimore, 1990). A literature review indicates a gap in quantification the long-term impact of plantations on LULC and population dynamics, essential to interpret the causes of any subsequent LULC changes as well as making policy decisions on management and conservation.

Between many cultivated plants, tea is a major plantation crop in a number of tropical and subtropical countries including India. The introduction of tea plantations into India in the early 19th century was associated with uncertainties of trade with China (the main tea producer at that time), growing demands for tea in Europe, and gaining knowledge of tea cultivating techniques (Roshan, 2012). The large (> 100 ha) plantation model implementation was deemed best to produce tea to commercial standards. Today, the tea industry is considered as one of the largest agro-based organized manufacturing industries in India. As one of the world's main producers of tea, India contributes to around 30% of global tea production (Chang, 2015). About 87% of tea produced is consumed domestically; however, per capita consumption is low, at about 0.80 kg per year (Tea Board of India, 2011–12). The tea plantations provide direct employment to more than a million workers. Large tea plantations contribute to 69% of total tea production. The remaining tea is produced by small tea growers (< 10 ha) that emerged in southern and northern India in the 1960s and 1980s, respectively (Biswas, 2016).

In effect of historical development and environmental factors tea cultivation is concentrated in the north-eastern and southern parts of India. The Jalpaiguri District located in the Eastern Himalayan piedmont is one of the most important regions for tea manufacturing and accounts for 15% of tea production area, 13% of tea production, and 13% of tea sector employment in India (Tea Board of India, 2011–12). Despite the long history of tea plantations in the district and their substantial contribution to the Indian economy, no studies have investigated their long-term impact on LULC dynamics and population changes.

The objective of this study was to analyse the role of the tea plantation system in the spatial and temporal pattern of LULC in the piedmont part of the Jalpaiguri District, India, from the first settled agricultural land use to present day. More specifically, the study aimed to (i) investigate long-term LULC dynamic with emphasis on deforestation and population growth initiated by the tea plantations establishment; (ii) explore the role of international and domestic markets in tea plantation development; (iii) examine the influence of local factors specific to the region such as floods on LULC; and (iv) identify potential scenarios of change in land utilization in the next few decades to prepare decision makers for a time when tea plantations (also the principal employer) can reach the maximum legal expansion between the reserved forest boundaries, but the population will probably continue to grow.

2. Materials and methods

2.1. Study area

The study area is located in the piedmont of the Eastern Himalaya in the Jalpaiguri District of India's West Bengal state (Fig. 1A). The Himalayan piedmont, called Duars or Dooars (the gateway to Bhutan), was a part of the Bhutan kingdom when following the British-Bhutan War of 1865, the region was incorporated into the British Indian Empire (Hunter, 1876). The district was named Western Duars; which was changed to the Jalpaiguri District in 1869 (Roy, 2002). The location of the piedmont at the margin of historical kingdoms, the deficit of water infiltrating thick alluvia in winter, the predominance of soils not suitable for the cultivation of staple food crops such as rice, and endemic malaria were the main factors limiting human activity. The region was covered by dense forest and inhabited by small indigenous communities practicing shifting cultivation (Rennell, 1794; O'Donel, 1864–68; Hunter, 1876).

The piedmont area represents a system of alluvial fans decreasing in elevation from 200 to 500 m a.s.l. at the base of the mountain to 100 m a.s.l. over a distance of 15 km. Their surface is dissected by the braided channels of the rivers draining the Himalaya (Starkel et al., 2008). At 15–20 km southward from the Himalayan foothills, the fans coalesce into an extensive Bengal Plain. Thick alluvia with the deep groundwater table (up to 30 m) in the piedmont zone cause a water deficit in winter and necessity of a water supply by piping it down from the margin of the Himalaya or from deep well systems (Ray and Shekhar, 2009).

According to the Koppen classification, the climate is subtropical monsoonal with Cwa type. The mean annual air temperature reaches 23 °C, and fluctuates between 16 °C in winter (January) and 28 °C in summer (August). The mountains' margin and piedmont receive the highest annual rainfall along the whole Himalayan range of about 4000–6000 mm (Soja and Starkel, 2007; Prokop and Walanus, 2017). More than 80% of rainfall occurs during the southwest monsoon between June and September. High rainfalls combined with steep slopes facilitate flood generation that transfer enormous amounts of water and sediment to the Himalayan piedmont (Starkel and Basu, 2000).

A hydrologic and geomorphic approach was employed to delineate 2105.9 km^2 between the Tista River in the west and the Jainti River in the east, and from the base of the Himalaya in the north over a distance of 15 km to the southern fan margin. Piedmont alluvial fans and river channels create here two major landforms – terrace and floodplain – occupying an area of 1721.6 km^2 (81.8%) and 384.3 km^2 (18.2%), respectively. Close relationships occur between landform, soil type, hydrology and LULC in the study area (Bagchi, 2003; Prokop, Płoskonka 2014; Fig. 1B, C). Terraces with deep, permeable and acidic soils are elevated 6–30 m above floodplains. They are occupied by reserved tropical moist deciduous forest with the valuable timber tree Sal (*Shorea robusta*), tea plantations and settlements with domestic gardens. All these LULC types are under various forms of governmental management. Floodplains with shallow, imperfectly drained and neutral soils are occupied mainly by river channels, remnants of riparian forest and rice cultivation (NBSS and LUP, 1991). Due to frequent floods, the floodplain area is treated as a wasteland. About 74% of the almost 1 mln inhabitants of the study area live in the tea estates and villages (Census of India, 2011).

2.2. Historical development of study area and data base construction

With the establishment of British rule, the Bhutan-Duars Act and Waste Land Rules passed in 1869 and 1875, respectively, declared the piedmont as non–regulation district and wasteland tract (Das Gupta, 1994). Such legal status of the Jalpaiguri District facilitated immediate decisions related to low rents of land and long-term leases granted to the tea estates. After the fulfilment of conditions for 5 years of initial lease terms, the second term of lease was extended for 30 years to the tea gardens (Gruning, 1911).

The first tea garden was opened on the left bank of the Tista river in 1874 (Gruning, 1911). In the same year, forests began to be registered as "reserved" by the Forest Department under the provisions of the Forest Act from 1865 (Choudhury, 2015). Subsequent forest legislation in 1878 provided a mechanism for official forest management.

Reconstruction of piedmont deforestation in the years 1874–1930