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Proximate and underlying causes of forest cover change in Peninsular Malaysia

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ABSTRACT

This study examined the process and causes of forest cover change in Peninsular Malaysia from 1970 to 2010. Time series data on forest cover, land use, timber production, and socio-economic variables of Peninsular Malaysia were analyzed by regression modeling using Akaike Information Criterion (AIC). Peninsular Malaysia experienced extensive deforestation during the 1970s and early 1980s, but since then deforestation has slowed down substantially. Regression results highlighted that poverty alleviation was the principal underlying factor leading to change in forest area. Neither population growth nor economic growth was a major factor affecting forest cover. Oil palm expansion was identified as the main proximate cause of deforestation. Regression results also indicate that oil palm expansion greatly contributed to poverty reduction. Our empirical evidence suggests that in Peninsular Malaysia, agricultural development to reduce poverty, in particular oil palm development, initially led to deforestation. However, substantial decrease in poverty caused decrease in deforestation over the long term. Based on the results of this study, we propose poverty alleviation as a strategy to reduce deforestation. Our findings demonstrate the need to analyze factors that reduce deforestation and to develop effective REDD programs.

1. Introduction

Reducing deforestation has become an issue of global importance, not only for environmental conservation, but also for climate change mitigation. The United Nations' program on Reducing Emissions from Deforestation and Forest Degradation in developing countries (REDD) is being intensively discussed as a key framework in international conventions on climate change. Stern (2006) suggested that if the right policies and institutional structures were in place, preventing further deforestation would be cheaper than other types of mitigation strategies for greenhouse gas emissions. However, the issues surrounding deforestation in developing countries are not easily resolved. The major proximate causes of deforestation, such as commercial agriculture, are difficult to halt because they are important economic activities. It is also difficult to implement the right policies and institutional structures to slow down deforestation in developing countries. To solve the problem of deforestation effectively and sustainably, factors that drive deforestation, as well as those that reduce deforestation, need to be clarified.

Deforestation is caused by various factors, including economic, demographic, political, and institutional drivers (Geist and Lambin, 2002). Deforestation is a complex process that is driven by a combination of proximate and underlying causes, which can vary from region to region (Geist and Lambin, 2001; Lambin et al., 2003; Rudel et al., 2005). Numerous studies identify agricultural expansion as the major proximate cause of tropical deforestation, particularly the production of commercial commodities such as rubber, palm oil, cattle, soybean, coffee, and cocoa (DeFries et al., 2010; Fearnside, 2001; McMorrow and Talip, 2001; Miyamoto, 2006; Motel et al., 2009; Zak et al., 2008). Empirical studies show that the prices of agricultural commodities and deforestation are positively correlated, which could be interpreted as evidence for a causal relationship between these quantities (see Angelsen and Kaimowitz, 1999). In developing countries, commercial export agriculture has expanded to meet the growing global market demand (Lambin et al., 2001; Thongmanivong et al., 2005). The increasing demand for agricultural products on the global market has driven tropical deforestation (Gibbs et al., 2010; Rudel et al., 2009). In addition to agriculture, road construction, unsustainable commercial logging, and fuel-wood collection are proximate causes of deforestation (Cropper et al., 2001; Etter et al., 2006; Geist and Lambin, 2002; Miyamoto, 2007).

The underlying causes of deforestation are not fully understood, and the influence of various factors has been extensively debated. These include population growth (Jha and Bawa, 2006; Mahapatra and Kant, 2005; Zak et al., 2008), poverty (Angelsen and Wunder, 2003; Sunderlin et al., 2008; Wunder, 2001), economic development (Bhattarai and Hammig, 2001; Michinaka and Miyamoto, 2013; Rudel et al., 2005;

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Stern, 2006), insecure land tenure (Börner et al., 2010; Robinson et al., in press), and weak law enforcement (Gaveau et al., 2009), among others. Land-use change is driven by a combination of synergetic factors: pressures on resources, opportunities created by markets, policy intervention, vulnerability, and social organization (Lambin et al., 2003). Lambin et al. (2003) suggested this view as a framework for understanding the complexity of deforestation and other land-use changes.

Recent studies have explored the causes of reduced deforestation and the reversal of net deforestation to net reforestation (so-called forest transition). Thailand has reduced its deforestation rates since the 1980s through logging bans, increased income, and a decline in the use of land for agriculture (Meyfroidt and Lambin, 2011; Wannitikul, 2005). Vietnam experienced forest transition in the 1990s. Reforestation was driven by forest scarcity, economic growth, land privatization, land-use zoning, agricultural intensification, and market liberalization (Meyfroidt and Lambin, 2008a, 2008b). In India, an increase in the demand for forest products associated with economic growth resulted in increased forest cover, while agricultural intensification associated with the green revolution and rising rural wages did not affect forest cover (Foster and Rosenzweig, 2003). Rudel et al. (2005) proposed two pathways of forest transition: (a) "forest scarcity," which prompts governments and landowners to plant trees, leading to afforestation (Asian countries) and (b) "economic development," which creates enough off-farm jobs to draw farmers away from rural and into urban areas (European countries). Lambin and Meyfroidt (2010) suggested globalization, state forest policy, and smallholder tree-based land-use intensification as three additional pathways of forest transition.

Peninsular Malaysia has experienced deforestation, mainly due to the expansion of rubber (in the early to mid-20th century) and oil palm (from 1960s onwards) (Abdullah and Nakagoshi, 2008; Henson, 2005). Between 1972 and 1982, the annual deforestation rate of Peninsular Malaysia was estimated by GIS to be 1.7% (Brown et al., 1994). However, the rate of deforestation has declined in recent decades. Henson (2005) showed that the decline of forest area in Peninsular Malaysia was more gradual between 1980 and 2000 than it had been earlier. Abdullah and Nakagoshi (2008) also reported that in the state of Selangor in Peninsular Malaysia, oil palm expansion caused forest loss from 1966 to 1981, but that the rate of loss slowed down between 1981 and 1995.

The present study examined the process and causes of change in forest cover and land use from 1970 to 2010 in Peninsular Malaysia. This analysis was based on time series data on forest cover, land use (for oil palm and rubber), forestry (exports and imports of timber products, log production, sawn timber production, and plywood production), and socio-economic variables [population, gross domestic product (GDP) variables, employment variables, household income, and poverty rate]. To investigate the causes of change in forest cover, we analyzed the factors affecting forest area and poverty rate (identified as the most important variable for describing forest area) by regression modeling using the Akaike Information Criterion (AIC).

2. Methods

2.1. Study site

Malaysia is an upper-middle income country in Southeast Asia, which had a GDP per capita of $15,182 in 2010 (The World Bank, 2013). The annual deforestation rate in Malaysia is relatively low (0.42% for the period 2005–2010) compared with other Southeast Asian countries, such as Cambodia (1.22%), Myanmar (0.95%), and Indonesia (0.71%) (FAO, 2010).

Peninsular Malaysia is the part of Malaysia that lies on the Malay Peninsula. Its area is 131,822 km^2 (Forestry Department Peninsular Malaysia, 2010) and its climate is characterized by abundant rainfall, high humidity, and high temperatures. Forest cover, land use, forestry, and socio-economic data on Peninsular Malaysia for 1970–2010 are shown in Table 1. The forest area in 2010 was 5.8 million ha, representing approximately 44% of land area. The other main land uses are oil palm plantations (2.5 million ha, representing 19% of land area in 2010) and rubber plantations (0.7 million ha, representing 6% of land area). Together, forest, oil palm, and rubber cover 70% of the total land area. Other agricultural land uses from 1970 to 2010 were paddy (2–3%), coconut (1–2%), and orchard (up to 1%) (Department of Agriculture Peninsular Malaysia, unpublished data).

The human population in Peninsular Malaysia was 22,146,000 in 2009, translating into a population density of 168 people per km^2. The population has more than doubled since 1970. The main ethnic groups in Peninsular Malaysia are Malays, Chinese, Indians, and indigenous people. The total GDP grew significantly from 40 billion RM in 1971 to 477 billion RM in 2010. (GDP is adjusted by a deflator at constant 2000 prices.) In 2010, services accounted for 60% of the total GDP, while manufacturing accounted for 29%. The service, manufacturing, and agriculture industries employed 61% (5.2 million), 19% (1.6 million), and 9% (0.7 million) of the total labor force, respectively.

2.2. Data

Statistical analyses were based on forest cover, land use (oil palm and rubber), forestry (exports and imports of timber products, log production, sawn timber production, and plywood production), and socio-economic data (population, GDP variables, employment variables, household income, and poverty rate) of Peninsular Malaysia from 1970 to 2010 (Table 1). The whole of Peninsular Malaysia was used as the unit of analysis. Data were available for some variables for every year from 1970 to 2010, but data were missing for other variables in certain years. As a result, we only used data from the years for which all variables were represented (1976, 1979, 1984, 1987, 1989, 1992, 1995, 1997, 1999, 2002, 2004, 2007, and 2009) in our regression analysis.

Forest cover data were obtained from the Forestry Department Peninsular Malaysia (1979, 1994, 1996, 2001, 2006, 2010, 2011). The forest cover data exclude the area covered by agricultural plantations, such as rubber and oil palm. Forest cover data from 1983 were excluded from the analyses because the data showed extreme change, with a 9% increase in forest area from 1982 to 1983 and a 7% decrease in forest area from 1983 to 1984.

Data on the area of oil palm plantations were obtained from the Malaysian Palm Oil Board (unpublished data). Data on the area devoted to rubber were obtained from the Ministry of Plantation Industries and Commodities (unpublished data).

Data on forest cover and land uses were validated using independent data obtained from the Department of Agriculture Malaysia (unpublished data), which are based on land-use maps obtained from satellite images and other sources for the years 1966, 1984, 1990, 1997, 2000, 2002, 2004, 2006, and 2008. Changes in forest cover and land-use data were analyzed, and the time that the changes occurred was recorded. For example, the land-use map data from Department of Agriculture Malaysia showed a huge reduction in forest area per year for 1966–1984. However, from 1984 to 2008, the reduction in forest area progressed at a much slower pace (Miyamoto et al., 2013). This trend is consistent with the statistical data obtained from the Forestry Department Peninsular Malaysia. The two sets of data are considered independent because the Forestry Department Peninsular Malaysia and other agencies generate statistical data aggregated from local administrative divisions, whereas the Department of Agriculture Malaysia calculates its data from land-use maps from satellite images and other sources. Statistical data from relevant agencies were considered to be reliable to use in the analysis of factors driving forest cover change because they showed similar periodic trends with the land-use map data from the Department of Agriculture Malaysia (Miyamoto et al., 2013).

Forestry-related data, such as exports and imports of timber products and logs, sawn timber, and plywood production, were obtained from the Forestry Department Peninsular Malaysia (1979, 1994, 1996, 2001, 2006, 2010, 2011). Data on population and employment by sectors were obtained from the Ministry of Plantation Industries and Commodities