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Assessment of bio-physical, social and economic drivers for forest transition in Asia-Pacific region

Jawaid Ashraf^{a,*}, Rajiv Pandey^b, Wil de Jong^c

^a RS & M Division, Forest Research Institute, Dehradun 248006, Uttarakhand, India

^b Biodiversity and Climate Change Division, ICFRE, Dehradun, Uttarakhand, India

^c Center for Integrated Area Studies, Kyoto University, Japan

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ABSTRACT

Forest transition (FT) has taken place in many developing countries in recent decades. Analysis of developing countries FT is mostly based on case studies and exploring a limited set of drivers that result in forest cover change. This paper attempts to identify and explain trends in forest cover change across nine countries of the Asia Pacific based on panel data of a period of over 50 years (1962–2011). We used discriminant analysis to identify relationships between bio-physical variables (forest cover area and land under cultivation) and socioeconomic variables (GDP, assets and infrastructure), and the transition status (transition vs. no transition) of the countries. The results show a net increase in forest cover in China, India (with consistent increase in the area of agricultural land in both), Philippines and Vietnam; and a decrease in Indonesia, Laos, and Malaysia (with a consistent decrease in the area of agricultural land). They also show a decrease of forest cover and area of agricultural land in both Japan and South Korea. The discriminant analysis results suggest that FT is linked to variation in area of agricultural land (Indonesia, Japan, Malaysia, Philippines, Vietnam), livestock population (China, Indonesia, South Korea, Laos, Malaysia), urban population (India, Laos, Philippines, Vietnam), cereal production (Indonesia, Japan, Philippines), and area of arable land (China and Japan). The results concur with FT predictions of forest cover change in relation to bio-physical and socioeconomic dynamics, with heterogeneity in rates of change across the nine countries. The results have implications for existing FT models. We conclude that there is opportunity for a refinement of analyses and explanations of FT by considering the effect of precise bio-physical and socioeconomic drivers.

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1. Introduction

Forest transition (FT) is a possible forest development paths, where direction, magnitude, and speed is influenced by societal factors or drivers (Lambin and Meyfroidt, 2010). FT relates to land use transition, which is a broader change in land use. FT was initially discussed in the early 1990s by Alexander Mather who analyzed recurring patterns of forest cover changes in European countries (Mather, 1990; Mather, 1992; Mather and Fairbairn, 2000). Subsequently, Foster et al. (1998) presented empirical evidence of FT in North America. FT refers to a transition from decreasing (deforestation) to expanding forest cover (reforestation) at a geographical scale (Lambin and Meyfroidt, 2010). FT in a confined geographical region occurs when reforestation begins or increases and exceeds deforestation, which declines or stops (Grainger, 1995). FT also concurs with land use transition, as land used for non-forest purposes becomes designated for forest land use (Barbier et al., 2010). Incorporating land use transition into a FT model implies a

delay between the deforestation decline and forest cover increase (Grainger, 1995). After an initial focus on Europe and North America, FT analysis was extended into low per capita GDP countries such as China, India, Vietnam, and Costa Rica and elsewhere (Meyfroidt and Lambin, 2008, 2011; Rudel et al., 2009; Grau et al., 2003; Mather, 2007; Bae et al., 2012).

Many countries are now recognized to have experienced FT, but the conditions under which transition occurs varies from place to place. FT was noticed in northern Europe between 1850 and 1980, but until 1990, FT was not observed in southern Europe (Mather, 1990; McNeill, 1992). European countries had experienced a reversion of deforested lands to forest during the 14th century when the continent suffered from the pneumonic plague (Herlihy, 1997; Poos, 1991), but the majority of them experienced a second wave of FT during the 19th and 20th century. Scotland and Denmark, for instance, experienced FT in early 20th century. As per FAO statistics on forest cover for the past decades, a turnaround of forest cover has occurred in Bangladesh, China, Costa Rica, Cuba, Denmark, Dominican Republic, France, Gambia, Hungary, Ireland, Peninsular Malaysia, Morocco, New Zealand, Portugal, Puerto Rico, Rwanda, Scotland, South Korea, Switzerland, and the United States (Rudel et al., 2005). China experienced a forest cover

* Corresponding author.

E-mail addresses: jawaid.ashraf@gmail.com (J. Ashraf), rajivfri@yahoo.com (R. Pandey), dejongwil@gmail.com (W. de Jong).

turnaround in the second half of the 20th century and other countries much more recently. The majority of countries experienced FT with very low remaining forest cover, however, New Zealand, South Korea, and the United States are exceptions, as these countries had comparatively large areas still under forest when turnarounds occurred. If viewed at a regional scale, forest cover has been expanding in counties in Europe, North America, countries in the Caribbean, East Asia, and Western–Central Asia. Forest cover is still declining in most of Central America, South America, South and Southeast Asia and regions in Africa. Between 1990 and 2015, tropical countries such as India, Bhutan, Laos, Philippines, Vietnam did experience FT and converted net forest loss to net forest expansion (Keenan et al., 2015).

The drivers responsible for FT in developed countries are mostly related to land use transition. The latter, in turn, is causally linked to the increase of production costs and enhanced agricultural technology (Foster, 1992; Andre, 1998; Mather et al., 1999). During the early phases of land use transition, demand for agricultural land and timber along with timber products caused forest clearing and deforestation (Culas, 2012). When economic development progresses, agricultural production costs increase, and agro-technology improves. These two processes result in the abandoning of agricultural lands which then reforest. In addition, demand for forest products may also contribute to reforestation on marginal agricultural land. The two processes have been identified as the economic development and forest scarcity FT pathways (Rudel et al., 2005).

Recent studies recognized the need to draw upon additional reforestation drivers to explain FT in several of the developing countries where FT has been observed (Castaneda, 2009; Perz and Skole, 2003; Mather, 2007; Xu et al., 2007; Sloan, 2015). These include agriculture sector development (Perz and Skole, 2003; Rudel et al., 2005), rural–urban migration, use of new energy sources (DeFries and Pandey, 2010; Tiwari and Bhattarai, 2011), and legislation and policies (Foster and Rosenzweig, 2003). FT in many developing countries can be linked to socioeconomic development, such as rural exodus, agricultural intensification, the establishment of extensive tree plantations, economic industrialization, enhanced education and technical knowledge, and the strengthening of socio-political institutions (Yackulic et al., 2011; Nagendra and Southworth, 2010; Farley, 2010; Rudel, 2009).

In developing countries the drivers themselves are unique, or they may have typical characteristics. For instance, people migrate from rural to urban areas but continue to support the relatives who stay behind through remittances (Rudel et al., 2009). Modest intensification of smallholder agricultural production assures the provision of food crops at relatively low prices, but also may lead to shifts in the overall land use pattern. Lambin and Meyfroidt (2010) and Meyfroidt and Lambin (2011) recognized this and that, therefore, explanations of FT in European countries may not be valid for developing countries. Policies that give higher priority to forests over other land use may be triggered by forest scarcity, but also be inspired by land use modernization efforts, the integration of marginal social groups into mainstream society, or the promotion of culture or ecotourism (Lambin and Meyfroidt, 2010).

Recognizing of at least some unique features of FT in tropical countries has led to the proposal of three additional FT pathways: state forest policy; globalization; and smallholder, tree based land use intensification FT pathways. The state forest policy pathway is defined as FT resulting from policies designed specifically to that end. These policies may also be motivated to achieve objectives other than increasing the provision of forest goods and services (Lambin and Meyfroidt, 2010). The globalization pathway is a modern version of the economic development pathways, which is influenced by the integration of the national economy with global markets and trade, but also economic priorities of multinational players, or development cooperation actors. Developing countries are strongly affected by globalization and neo-liberal economic reforms, labor out-migration, international conservation priorities, and international tourism. This may positively affect national forest

cover (Kull et al., 2007). The last pathway, generally poorly accounted for in land use statistics, is a significant increase in tree cover on smallholders' farmland, pastures and fallows in the form of orchards, agroforestry, gardens, and secondary successions. Smallholders may reduce vulnerability to economic and environmental shocks, but they may also intensify land use in some parts of their estates and increase tree cover on others (Ashraf et al., 2015; Lambin and Meyfroidt, 2010). With the identification of multiple pathways it also has become evident that various pathways may be followed concurrently or sequentially. The drivers of FT may vary over time, space and location (Kant and Wu, 2013; Rudel et al., 2010) because of wider economic, social and biophysical changes (Rudel et al., 2005; De Jong, 2010).

Research on FT and FT theoretical development has thus (Rudel et al., 2010) shifted from a focus on developed countries (e.g. Denmark, France, Switzerland, the USA, and Scotland and Austria (Houghton and Hackler, 2000; Mather, 2007; Mather et al., 1998; Mather et al., 1999; Krausmann, 2006) to a focus on less wealthy countries, like Puerto Rico, Dominican Republic, El Salvador, Vietnam, China and India (Aide and Grau, 2004; Grau et al., 2003; Hecht et al., 2006; Mather, 2007; Meyfroidt and Lambin, 2009; Rudel et al., 2005). FT, furthermore, can be analyzed at different scales. It is most commonly analyzed at national scale but can also be analyzed at sub-national and multi-national scales (e.g. Meyfroidt and Lambin, 2011). However, cross-national studies which might empirically support the FT theory are less common. Drivers and underlying causes of deforestation have been evaluated for multiple countries (e.g. Angelsen, 1999; Angelsen and Kaimowitz, 1999; Geist and Lambin, 2001; Grainger, 1995; Lambin et al., 2003; Vanclay, 2005; Redo et al., 2012). Studies attempting cross-national analyses of FT include, for instance Rudel et al. (2005), Mather (2007) and Meyfroidt et al. (2010).

The expanded scope of FT research has reconfirmed that elements of social and economic development affect land use and have a subsequent bearing on forest cover (Bhojvaid et al., 2016). Changes in forest cover have major ecological consequences by directly affecting biodiversity, carbon budget, and soil and watershed conservation (MEA, 2005). Understanding patterns and drivers of forest cover change and possible FT trajectories may contribute to achieving broader societal goals of land-use sustainability in the face of rapid global environmental and socioeconomic changes (Redo et al., 2012). FT is increasingly common, but global deforestation still exceeds forest recovery (Damette and Delacote, 2009; Ewers, 2006; Karsenty, 2008). We postulate here that consideration of more factors based on country circumstances, keeping in mind the discrepancies in growth, development and demand and supply of resources, may result in a better explanations of FT (e.g. Mather, 1992; Grainger, 1995; Mather et al., 1999). It may also lead to the proposition of new FT pathways (Lambin and Meyfroidt, 2010).

In summary, prevailing FT explanations may not be sufficient to understand FT in countries where the process is much more recent, especially when it concerns developing countries with their current pace and pattern of development and industrialization, and employment. We concur with Southworth et al. (2011) that there is need for scrutiny of land and forest use in recent FT countries and to expand the explanations of the process. This is an important reason why we implemented a study on FT in nine countries in Asia: China, Indonesia, India, Japan, Laos, South Korea, Malaysia, Philippines and Vietnam, incorporating social and biophysical factors that are expected to cause FT. The number of cases is too low to definitely establish differences in FT, comparing developing and developed countries. However, we aim to reveal the relative importance of various social and bio-physical factors that explain FT in the nine countries and also to note differences between the countries. Our specific objective is to identify the potential drivers or combination of drivers of FT in each of the case countries, and that way contribute to the further development of the FT theory.

In Section 2 of the paper we briefly summarize relevant information on the Asia-Pacific region necessary for understanding the subsequent analysis. In Section 3, we explain the analytical approach, including a

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