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# Comparative study of the forest transition pathways of nine Asia-Pacific countries

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ABSTRACT

Forest transition (FT) over the last three decades has attracted much academic attention. In this paper we present a comparative study of FT to assess regional variety in nine countries in Asia: China, Japan, the Republic of Korea, India, Indonesia, Malaysia, the Philippines, Laos and Vietnam, using data covering the years 1960–2010. This study's examination of changes in forest area demonstrates that Korea and Japan achieved FT before the 1980s, and that China, Vietnam, India and the Philippines achieved FT more recently, while Indonesia, Malaysia and Laos still experience forest cover decline. Economic development pathway and state forest policy pathway are most common in these nine countries. The globalization pathway is also found to contribute to FT, primarily in countries that are net importers of forest products. The land use intensification pathway is not identified in any of the nine countries. This study also observed that four countries (China, Vietnam, India and the Philippines) tend to achieve FT at relatively low income levels, which may point to the significance of state intervention in the region's countries via forest protection laws, national forest planning and afforestation programs.


## 1. Introduction

Forest transition (FT) is the change from decreasing to increasing forest area (Mather, 1992). The process is now recognized to be common to many countries in temperate and tropical regions (Geist and Lambin, 2002; Lambin and Meyfroidt, 2010; Rudel et al., 2005). Complex factors influence forest degradation and deforestation, and understanding these requires a historical geographic perspective; local, regional and global economic, political and environmental events and processes can have significant impacts on the change in forest cover at national levels (Mather et al., 1999; Barbier et al., 2010; Clement and Amezaga, 2008; Meyfroidt and Lambin, 2009; Klooster, 2003), and the same holds true for FT (Lambin et al., 2003; Mather, 1992).

Rudel et al. (2005) presented two economic models commonly used to predict future forest conditions, identified as: the economic development pathway and the forest scarcity pathway. In the first case, the process of economic development results in more intensive agricultural production and, concurrently, more economically attractive opportunities are created in cities and towns, which promotes rural-urban migration, leading to abandonment of agricultural land that reverts to forest. In the second case, rises in the price of forest products caused by scarcity of forests boost tree planting and thus contributed to forest recovery and rehabilitation. Based on Rudel's work, Meyfroidt and Lambin (2011) argue that FT also occurs along three additional pathways, all of which are dependent upon local socioeconomic and ecological conditions. Countries or regions may experience different pathways to FT given different development trajectories, and forest transition may follow several pathways at the same time in a specific country or region. The pathways include: 1) forest scarcity pathway, 2) economic development pathway, 3) state forest policy pathway, 4) globalization pathway, 5) smallholder, tree-based land use intensification pathway.

This paper takes Meyfroidt and Lambin's (2011) distinction of five FT pathways as a basis and pursues a comparative analysis of FT pathways in nine selected countries in the Asia-Pacific region, including China, Japan, the Republic of Korea, India, Indonesia, Malaysia, the Philippines, Laos and Vietnam. The paper assesses each country's pathway to FT while identifying and comparing basic drivers of forest cover change. The Asia-Pacific region is rich in forest resources, containing an estimated 600 million ha of forest, equal to approximately 17% of global forest area. Moreover, this region had the largest increase of forest cover in the period of 2001–2010, compared to other global regions (FAO, 2012). The majority of Asia's forests are located in China followed by Indonesia, India, Japan, Malaysia, and Laos.

Forest cover dynamics vary greatly in the Asia-Pacific region. China, India, and Vietnam have the highest rates of plantation establishment in the world and such rapid increases in forest cover have contributed significantly to reducing the global decline in forest cover (FAO, 2012). FTs in China and Vietnam are considered to be following the forest scarcity pathway (Mather, 2007) or the economic development pathway (Zhang et al., 2006). The Republic of Korea, on the other hand, is claimed to follow a state forest policy and globalization forest transition pathway (Lambin and Meyfroidt, 2010). These arguments are supported by de Jong (2010), who holds that reforestation efforts have been a major policy priority in these countries since the 1980s. Both China and the Republic of Korea have adopted and implemented settlement

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**Table 1**
Sources and time span of variables.

| Variables | Abbr. | Unit | Time span | Source |
|---|---|---|---|---|
| *Dependent Variables* | | | | |
| Deforestation | DF | 1000 km$^2$ | | World Bank (2014); Liu (2014) |
| China | CHN | | 1962–2011 | |
| Japan | JPN | | 1966–2011 | |
| Republic of Korea | KOR | | 1960–2011 | |
| Vietnam | VNM | | 1960–2011 | |
| Laos | LAO | | 1968–2011 | |
| Philippines | PHL | | 1961–2011 | |
| Indonesia | IDN | | 1968–2011 | |
| India | IND | | 1961–2011 | |
| Malaysia | MYS | | 1966–2011 | |
| *Independent Variables* | | | | |
| GDP per capita | GDPPC | 1000 constant 2005 US$ | 1960–2011 | World Bank (2014) |
| Rural population density | RP | Capita per km$^2$ | 1960–2010 | World Bank (2014) |
| Population growth | PG | % of population | 1961–2010 | World Bank (2014) |
| Agricultural land | AL | 1000 km$^2$ | 1960–2010 | World Bank (2014) |
| Cereal yield per hectare | CY | Ton per ha | 1960–2010 | World Bank (2014) |
| Forest protect laws | FL | 1 if yes and 0 if no | 1960–2012 | Liu (2014) |
| National forest plan or decree | FP | 1 if yes and 0 if no | 1960–2012 | Liu (2014) |
| Forest products and roundwood export Value | EV | Mil. US$ | 1961–2012 | FAO |
| Forest products and roundwood import Value | IV | Mil. US$ | 1961–2012 | FAO |

programs, land classification schemes, decentralized forest management and reforestation programs (Clement and Amezaga, 2008). De Jong (2010) asserts that economic growth, national forest policies, and forest management systems have led to increases in forested area in China since the 1980s and Vietnam since the 1990s. The historical efforts of China and Vietnam to fight illegal logging, to increase investment in large-scale plantations, and to establish vast areas of national nature reserves are regarded as important drivers in the increase of forest area in both countries (De Jong, 2010). In Indonesia and Malaysia, forest resources have continuously declined and deforestation and forest degradation in Laos has become increasingly serious (FAO, 2012), although the latest Global Forest Resources Assessments (FRA) (FAO, 2015) indicates an increase in forest cover in Laos in recent years. The FT literatures, we argue lacks regional comparative approaches and that makes use of new sets of data that have become available in recent years. In this paper we aim to contribute to filling this gap, by comparing FT in the nine countries in the Asia-Pacific region listed above, in order to assess each country's pathway to FT while identifying and comparing basic drivers of forest cover change. We will furthermore explore how the FTs in the countries, compare to the five explanatory pathways proposed by various theoreticians on FT.

## 2. Data and model specification

### 2.1. Data sources

We used two main sources to develop a dataset related to the socio-economic and forest factors across nine countries in the Asia-Pacific region from the 1960s to 2011. Firstly, some data was collected as part of the APFFRI project entitled "Comparative Analyses of Transitions to Sustainable Forest Management and Rehabilitation" (APAFRI, 2013). This project has yielded nine reports, each of which provides an analysis of forest transition in one of nine countries: China, India, Indonesia, Japan, the Republic of Korea, Laos, Malaysia, the Philippines and Vietnam. These nine countries were selected for their diverse array of forest resources and because it was anticipated that their pathways to FT would vary. Secondly, data available from various public sources (i.e. FAO, 2012 and World Bank, 2014) was used. Table 1 provides a detailed description of the data sources of the dependent and independent variables used to assess the importance of drivers of forest transition. The following section describes each variable that we used to correlate forest trends to other factors.

In this study, we consider the following variables: deforestation, GDP per capita, rural population density, population growth, agricultural land, cereal yield per hectare, forest protection laws, national forest plan or decree, forest products and roundwood export value, and forest products and roundwood import value.

The sources and time span of variables are shown in Table 1.

### 2.2. Variables

#### 2.2.1. Deforestation

The dependent variable used to compare FT in the nine countries considered in this study is deforestation (DF) area per year. We calculated DF by trends in forest area (FA). As the first step, we obtained FA data from the 1960s to the 2010s, the former being the earliest period for which reliable nationwide data was available. The FAO database has appropriate data only for the years after 1990, hence data for the period prior to the 1990s was taken from country reports. As the second step, we adjusted FA[1] data into one uniform statistical standard. Data for the years before 1990 came from the countries being studied and these countries used different statistical standards for forest or, within a country, standards were not consistent throughout the time period studied.[2] To compensate for such difference, FA has been adjusted as follows:

$$\text{Average adjusted ratio (ADr)} = [\sum \text{FA (country report, i year between 1990–2010)}/\text{FA (FAO, i year between 1990–2010)}]/n * 100\%. \quad (2-1)$$

Then we obtain FA for each year before 1990 using the same criteria defined by FAO:

$$\text{FA (adjusted, i year before 1990} = \text{FA (country report, i year before 1990)} * \text{ADr}. \quad (2-2)$$

As the third step, we adjusted gaps in the FA data into continuous yearly data. FA is generally collected every several years (e.g. every

[1] Forest area (FA) has been defined by FAO as land under natural or planted stands of trees of at least 5 m high, and with each stand having a minimum crown area cover of 0.5 ha, but excluding tree stands in agricultural fields or trees in urban parks and gardens.

[2] For instance, in 1993, there were some modifications of the criteria to calculate forest area in China. Two modifications were the criterion for forest canopy density changed from >0.3 to >0.2 and the criterion for successfully afforested land changed from a ratio of 85% to 80% of surviving trees per hectare/number of planted trees per hectare.

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