An Overview of Theoretical and Empirical Studies on Deforestation

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Abstract

Deforestation is one of the critical issues in our global climate change era. It leads to two important environmental challenges, loss of biodiversity and increasing of greenhouse gas emission. Many efforts have been introduced, developed and implemented. However, a declining forest cover still presents. Since deforestation is a complex and intertwined issue, understanding its complexity and context on which it is debated is crucial. This paper aims at discussing some grand theories of deforestation, especially from economics perspective. The discussion covers the proximate-underlying causes of deforestation, the Environmental Kuznets Curve for deforestation theory, the forest transition theory and the land rent theory. For each, this paper elaborates their original notion, basic idea, empirical studies and policy derivation. Finally, comparable similarities and dissimilarities and their future extend are reviewed.

Key words:
Deforestation, proximate and underlying causes, Environmental Kuznets Curve for deforestation, forest transition, land rent.

1. Background

Global society has experienced the damaging impacts of forest cover loss for a long time (Allen & Barnes, 1985). Currently, global forest cover continues to decline (Köthke et al., 2013). FAO (2010) predicts that the current annual global forest loss is about 13 million hectares accounting for approximately 17 percent of the total annual greenhouse gas emissions (IPCC, 2007). In the coming future, increasing global demand for food, biofuels and natural resources gives more pressure on forests (Carlson et al., 2012).

Deforestation has been attributed to various damaging impacts resulting in increasing global costs (Uusivuori et al., 2002). In micro level, deforestation is associated with fires, soil erosion, watershed deterioration and microclimate change. Globally, deforestation may cause negative global consequences: timber supply, hydrologic unbalance, biodiversity, global cycles of substantial elements and massive carbon emissions.

Deforestation is not just an environmental concern but also a multi-socio-economic-demographic one. Even now, it has been put in the global political agenda (Köthke et al., 2013). In academic fields, deforestation initiates an ever growing multidiscipline researches and studies (Damette & Delacote, 2012), either at the global, regional, national, sub national or site level. Deforestation is no longer a forest sector per se, but a multi-sectoral problem. Discussion and policy derivation on deforestation is ranging in a very wide spectrum. Hence, in order to help us in understanding its complexity and in what context a certain debate of deforestation is examined, this paper aims at overviewing some theoretical understanding of deforestation. Comprehending its theory is

substantial, not only for explaining the existing circumstances but also for predicting results and future condition of deforestation (Rudel et al., 2005). As one of the major global environmental issues, theories of deforestation are relatively infant starting from 1990s. Furthermore, deforestation is mostly in tropical developing countries where society is so dynamics that theorizing deforestation will be quite challenging.

This paper begins the discussion by presenting some basic understanding on how forest and deforestation are defined by several well-known institutions. Knowing those basic definitions is very important for researchers in putting the context of a certain study. For policy makers, basic knowledge on these understanding is crucial when legal policy and strategy will be exercised further. The third section discusses factors, and how they are categorized, that influence forest cover change. It also elaborates possible relationships among explanatory factors of deforestation. The fourth part is about some theories on how deforestation is explained, especially from economics perspective. The discussion goes through the proximate and underlying theory, the Environmental Kuznets Curve for deforestation theory, the forest transition theory, and the land rent or land use change theory. Finally, review across those theories are discussed in the last section of this paper.

2. How are forest and deforestation defined?

Forest and deforestation seems to be general terms that are commonly understood in everyday life. However, for the sake of science and policy, those terminologies must be clearly defined; and, definition must be measurable. Even though forest and deforestation are of our global major issues, there is no single definition agreed. The discussion in this section is mainly based on Schoene et al., (2007) with some updated information.

FAO is a long established institution from which their data and definition on forestry sector are widely referred and utilized. FAO (2006) defines forest as a land spanning more than 0.5 hectares with trees higher than 5 meters and canopy cover of more than 10 percent, or trees are potentially able to reach these thresholds in situ. In this definition, land that is predominantly under non-forest uses is excluded. Another definition is developed by the United Nations Environmental Program/the Convention on Biological Diversity or UNEP/CBD (2001) who considers the same minimum quantitative criteria (minimum 0.5 hectares, crown over 10 percent and height of trees 5 meters) but excludes temporary un-stocked areas. The United Nations Framework Convention on Climate Change or UNFCCC (2006) also develops a little bit different measures by using range values (minimum area 0.05-1.0 hectares, tree cover 10-30 percent and height of tree 2-5 meters). However, to cope with smallholder project, they suggest using the lowest values (UNFCCC/SBSTA, 2004). Detail comparison is shown in Table 1.

Table 1. Definitions of forest

Parameters	FAO	UNEP/CBD	UNFCCC
Young stands	Considered	Considered	Considered
Temporarily un-stocked areas	Considered	–	Considered
Forestry land use	Considered	Considered	–
Minimum area (ha)	0.5	0.5	0.05–1
Minimum height (m)	5	5	2-5
Crown cover (%)	10	10	10-30
Strip width (m)	20	–	–

Source: adopted from Schoene et al. (2007).

In sum, common criteria of defining forest are minimum area, minimum height of trees, minimum canopy cover, and land uses. The latter criterion is referred to non-forest uses, such as agriculture or urban areas. Land converted from forest to non-forest uses is excluded from the forest.

Accordingly, definition of deforestation is strongly based on how forest is defined and measured. Deforestation is basically the change of forest. FAO (2001) defines deforestation as the long-term reduction of the tree canopy cover below the minimum 10 percent threshold. As noted above, land-use changing from forest to non-forest uses is counted as deforestation. However, temporary tree cutting where the forest is expected to regenerate is not considered as deforestation. UNFCCC (2006), as outlined in their forest definition, has a different threshold, in which deforestation is defined as a measurable sustained decreased in crown cover from greater than 10-30 percent to less than 10-30 percent. They also put emphasis on the direct human-induced conversion of forested land to non-forested land. Table 2 presents the comparison of those definitions.

In academic and policy fields, the availability and reliability of data are still raised many concerns. In various studies, measurement of deforestation is wide-ranging, such as absolute forest cover loss, rate of forest cover loss, agricultural expansion,

Table 2. Definitions of deforestation

Parameters	FAO	UNFCCC
Transition from forest to non-forest	Considered	Considered
Land use change	Considered	–
Crown cover change	<10%	<10-30%
Only directly human-induced	–	Considered
Temporarily non stocked condition does not constitute deforestation	Considered	Considered

Source: adopted from Schoene et al. (2007).

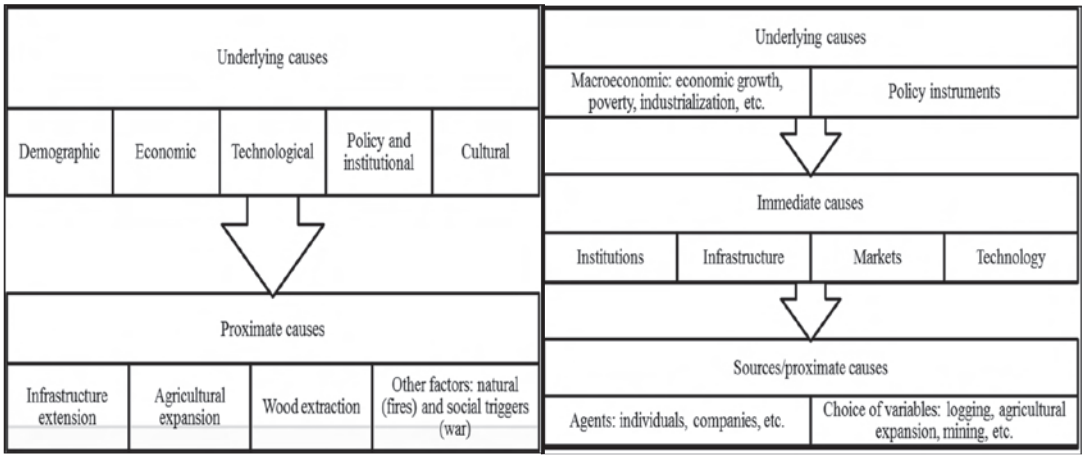
wood production and percentage of forest cover over by land area (Mahapatra & Kant, 2005). Even more, a meta-analysis study by Choumert et al. (2013) finds that there are nearly 15 measures of deforestation, including roads and built-up areas, have been used by scholars. These various measurements make study on deforestation more complex (Shafik, 1994). Recently, an interesting study on the consequences of different measurement of deforestation is done by Romijn et al. (2013) in the case of Indonesia. Lastly, the main message of this complexity discussed in this section is that discourse and study of deforestation should be positioned in a specific context and scale, especially when it is closely related to other terms such as forest degradation (Contreras-Hermosilla, 2000).

3. What factors affect deforestation?

Deforestation involves various factors covering not only environmental aspect but also socio, economic, demographic, and political aspects. They are intertwined one and another in such complex non linear interaction. Scholars have tried to understand that complexity by developing such classification of variables attributed to deforestation, which is commonly grouped into two: the proximate/direct causes and the underlying/indirect causes.

Initially discussed in the context of global environmental change induced by human activities (Turner II et al., 1990), the classification of driving forces of deforestation under this theory becomes well-established. However, the terminology of underlying, which was termed as the driving force, was introduced in 1992 in an article by Meyer & Turner II (1992) published in *Annual Review of Ecology and Systematics*. The authors broadly covered global land-use and land cover change; and forest cover change or deforestation is one of global land cover changes. They classified factors driving global land-use/cover change into the proximate and the underlying sources. In the case of tree cover change, they indicate some direct sources, such as land clearing, ranching, timber extraction, and fuelwood extraction, whereas the underlying factors could be population growth, economic development, socio-cultural or technological change. Implicitly, this approach was applied to analyze the case of deforestation in Philippine/Southeast Asia (Kummer & Turner II, 1994). Currently, this framework, then, has been developed further by forest scholars (Angelsen & Kaimowitz, 1999; Contreras-Hermosilla, 2000; Geist & Lambin, 2001, 2002; Kaimowitz & Angelsen, 1998).

Briefly, the proximate cause is defined as human activities that directly change the physical environment reflected in land cover, which is formed by underlying driving force, the indirect factor. The proximate factor is the near-final or the final human



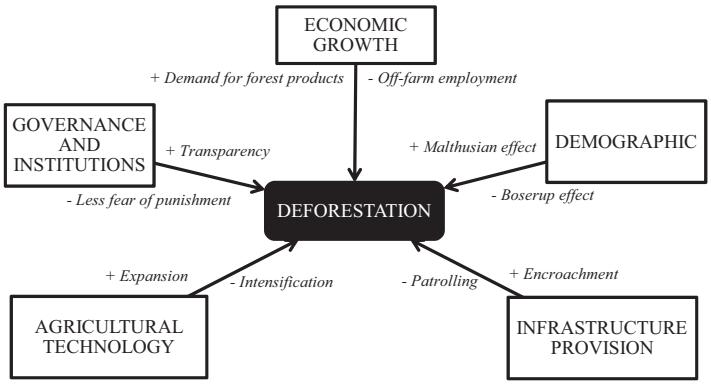
a) Proximate-underlying b) Proximate-intermediate-underlying

Sources: a) Geist & Lambin (2002); b) Angelsen & Kaimowitz (1999), Basu & Nayak (2011).

Figure 1. Proximate and underlying causes of deforestation

activities altering tree cover or the direct sources of deforestation at the site level. Contreras-Hermosilla (2000) classifies the direct causes into two main subcategories: human activity and natural causes, while Geist & Lambin (2002) more prefers to put natural causes as other factors. The underlying causes working in macro-level seems to be fundamental forces that promote the proximate causes through socio-economic processes. Angelsen & Kaimowitz (1999), then, proposed an additional layer in between, which is the immediate causes or termed as the intermediate causes by (Basu & Nayak, 2011). Figure 1 depicts the classification.

Deforestation is, however, multifaceted process (Mahapatra & Kant, 2005; Robinson et al., 2014) covering various socioeconomic, demographic and environmental variables. Particularly for the underlying causes, causative relationship and links among them are neither one-way nor single nor linear (Angelsen & Kaimowitz, 1999). In this context, the association between explanatory variables and deforestation can be in the form of dual effects, positive and/or negative signs (Mahapatra & Kant, 2005). A brief of dual effect hypothesis of deforestation is summarized in Figure 2.



Source: Mahapatra & Kant (2005).

Figure 2. Dual effect hypothesis of proximate and underlying causes of deforestation

Economic growth, for instance, affects deforestation into two possibilities, both positive and negative effects. Positive impact of increasing economic growth is hypothesized under *the frontier theory*. Increasing capital invested in forest frontier areas brings more pressure to forests. Companies, loggers, and small farmers work together - growth coalition - to expand their encroachment into forest areas (Molotch, 1976 *in* Rudel & Roper, 1997). Rural peasant and poor farmers are also organized by under bigger networks in exploiting their forest resources (Rudel & Roper, 1997; Walker & Smith, 1993). Additionally, rising economic growth increases demand for forest products, turning into more pressure for forests. On the other side, economic development could prevent deforestation through the process of off-farm employment creation. Wealthier level enables society to develop better forest management and build environmental awareness for forest conservation. Moreover, another useful theory in relation to income is *the immiserization theory*. This theory postulates that the poor tend to extract more their natural resources to meet their needs, resulting in expanding deforestation (Myers, 1993; Walker, 1993). Furthermore, Angelsen (2007) divides this explanation into two drivers, local villagers and outsiders.

Scholars and decision makers have concerned about demographic factor. Since global warming is believed as the anthropogenic problem, more attention is paid to this aspect. A well-known hypothesis is *the Malthusian perspective* seeing that increasing population will cause more pressure on forests (Palo, 1994). In economic point of view, more population means higher demand for agricultural products. Those effects will incentivize people to expand agricultural activities into forest areas. However, adverse impact of population growth is expected under *the Boserup effect* arguing that more population mean more creativity, ideas, and technology leading to less pressure on forests (Bilsborrow & Geores, 1994). It is possible also, that increasing population in rural areas may be followed by rural-to-urban migration leaving more land to be forested.

The Boserup hypothesis can also explain a negative effect of agricultural technology on deforestation. A new technology that encourages labor-intensive agricultural activities will obviously result in a less deforestation (Bilsborrow & Geores, 1994) and make possible for agriculture to utilize marginal land rather than forest (Mahapatra & Kant, 2005). However, the development of agricultural technology may also give a strong incentive for farmers to expand their agricultural land into forest areas.

Infrastructure can be the proximate and/or the underlying factors. The direct effect is through the process of forest conversion for the land itself and the construction process, while its indirect cause is due to better accessibility leading to non-forest land uses, transportation cost reduction, and land prices (Schneider, 1995). Those factors may cause more deforestation. On the other hand,

better infrastructure facilitates better forest management and monitoring activities, including patrolling.

Political-institutional aspect is another important variable affecting deforestation. It is widely accepted that better governance and democratic country is associated with lower deforestation. Public scrutiny, checks and balances mechanism, and law enforcement are attributed to this negative relationship. However, a positive association is also possible where "(t)here is less fear of getting punishment due to prolonged judicial procedures" in a democratic society (Mahapatra & Kant, 2005).

As discussed above, the proximate factors exist at micro or site level, while the underlying causes are at macro level. Between them, there are the intermediate causes of deforestation. Finally, interpretation of a certain study should be carefully conducted. Some suggestions should be noted: i) the underlying causes are so dynamics and causal relationship may vary across circumstances (Meyer & Turner II, 1992), ii) micro or macro analysis should carefully employ appropriate factors differently to avoid misinterpretation of study results (Angelsen & Kaimowitz, 1999).

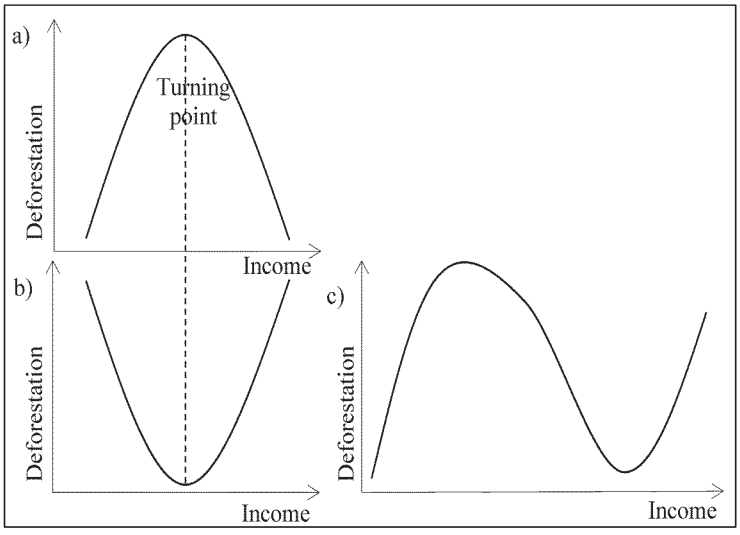
4. Overviewing theories of deforestation

Deforestation is a multi-sectoral issue, stimulating ever-growing researches. Empirical studies have been explored and examined to explain how deforestation has occurred, what factors affecting it and what policy can be suggested to address this issue. Deforestation has also thought-provoking theoretical studies, focusing on how complexity of deforestation can be explained and to what extent deforestation will be. Understanding theory is a fundamental and substantial in figuring out an issue. This section will discuss over some grand theories of deforestation. For each, the discussion will cover their original conception, basic notion/idea and policy derivation, including empirical studies utilizing or framed with those theories.

4.1. Environmental Kuznets Curve (EKC) for deforestation theory: how does income affect forest cover?

Among various proximate and underlying factors of deforestation, as outlined in the previous section, income or economic growth has been paid substantial attention. Originally adopted from economics field proposed by Kuznets (1955) who correlates between income and equality (the Kuznets Curve), environmental economists have developed EKC to investigate income effect on environmental degradation. An initial effort in examining EKC application is done by Grossman & Krueger (1991) who investigates the environmental impacts of trade liberalization (NAFTA).

Afterwards, EKC has been applied in forestry sector, known as the EKC for deforestation, hypothesizing the similar notion of EKC. Theoretically, the concept of the ECK for deforestation was discussed by López (1994). As economic or income growth rising, deforestation will be declined when the stock effects of forest resource on agricultural production are internalized. According to this concept, deforestation is a function of income or economic growth forming an inverted U-shaped curve (Figure 3.a). In the early phase of development when level of income or GDP growth is relatively low, increasing income per capita will accelerate deforestation rate until a certain turning point. During this early stage, deforestation is probably one of negative consequences of development. Then, as income rising, the rate of deforestation will decline. Increasing income would incentivize people to improve their forest resources and environmental quality.



Source: a) Culas (2012); b) Miah et al. (2011).

Figure 3. EKC for deforestation: a) an inverted U-shaped; b) U-shaped; and c) N-shaped

Since EKC for deforestation has been theoretically conceptualized, many empirical studies have been carried out at various levels. Before 1990s, there is one study (Allen & Barnes, 1985) relating to economic growth and deforestation. However, their approach is a linear model by utilizing FAO data 1968-1978 found that GDP per capita is insignificantly correlated with total change of forests. Some empirical studies of EKC for deforestation are well-acknowledged, such as (Antle & Heidebrink, 1995; Bhattarai & Hammig, 2001; Cropper & Griffiths, 1994; Culas, 2007; Munasinghe, 1999; Panayotou, 1993; Shafik, 1994; Stern et al., 1996).

However, the existence of EKC for deforestation is mixed, ranging from no significant correlation (Antle & Heidebrink, 1995; Shafik, 1994; Uusivuori et al., 2002) to significant existence for a specific area - Latin America and Africa (Bhattarai & Hammig, 2001; Cropper & Griffiths, 1994; Culas, 2007). Moreover, in some empirical studies, scholars recognize other forms than an inverted U-shaped curve, such as a U-shaped curve for Asia case (Bhattarai & Hammig, 2001; Culas, 2007) or N-shaped curve (Bhattarai & Hammig, 2001). Possible explanation for the U-shaped curve is the progress of reforestation/afforestation program (see Figure 3).

Recently, EKC for deforestation still motivates many researches. A cross-country study by Ceddia et al. (2013) using FAO data 1970-2006 found the significance of income effect on deforestation. A time-series single country analysis by Esmaeili & Nasrnia (2014) reveals the existence of an inverted U-shaped curve with the turning point USD 24,555/capita for the case of Iran. A criticizing article is discussed by Mills Busa (2013) arguing that the existence of EKC for deforestation should be credited to the developed countries in which their imports drive deforestation in poorer countries. However, the author posits that the curve is still useful to see the progress of the conservation program in the developed countries. Finally, another interesting result from one of empirical studies found that deforestation have taken place at an earlier stage of development than heavy industrialization (Panayotou, 1993). This conclusion is drawn from the fact that the turning point of deforestation is relatively much less than other pollutants.

EKC for deforestation is about the link between development and environment. Based on this theory, there is trade-off between economy and environment during the development stage. In this context, seeking the win-win solution (Munasinghe, 1999) is the main motivation of the EKC study. It is so crucial for developing countries to take lessons learned from developed countries experiencing some environmental damages during their early development phases. Such studies could encourage developing countries in restructuring their development programs towards a more sustainable development path without sacrificing economic goals. In sum, the EKC "… could help the developing countries to avoid higher amount of per capita income for the turning points, and thereby reduce the environmental degradation in the development path …" (Culas, 2007).

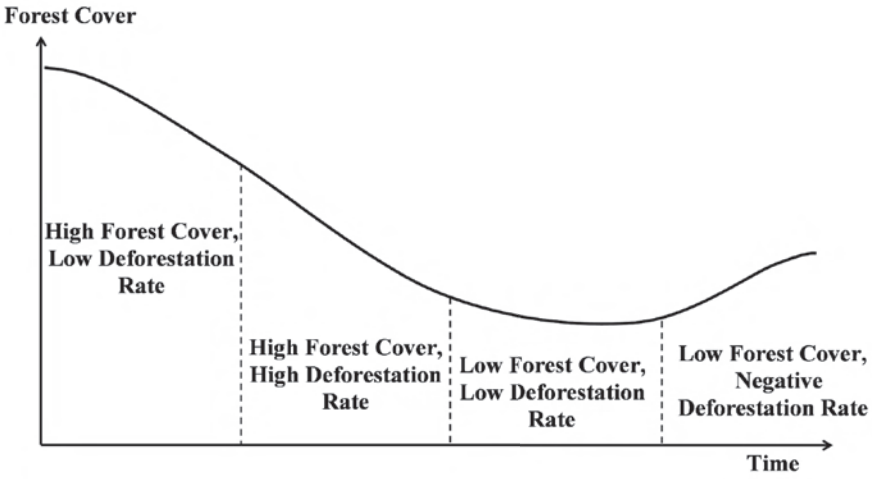
General and basic policy implication developed in this theory is how to flatten and/or how shift the curve so that the turning point can be met at less per capita income and/or at lower level of deforestation, respectively (Motel et al., 2009). Some suggestions are proposed by some scholars, including securing/defining clear property rights (Motel et al., 2009; Panayotou, 1993), improving governance quality and political institutions (Bhattarai & Hammig, 2001; Dasgupta et al., 2006; Motel et al., 2009), and promoting/strengthening environmental regulation and standard (Munasinghe, 1999; Panayotou, 1993). However, some important notes should be kept in mind that: i) income or economic growth is not a panacea for environmental issue; economic policy and environmental policy is not substituted one and another (Arrow et al., 1995), and ii) irreversible impacts of environmental degradation, for example loss of biodiversity because of deforestation, must be fully taken into account; consequently, it is very substantial to recognize a certain critical threshold of the development process (Bhattarai & Hammig, 2001).

4.2. Forest transition theory: how does forest cover change over time?

The dynamics of forest cover is also captured in time dimension, theorized as the forest transition theory. This theory was introduced by A. S. Mather (1992). Originally, he developed this idea based on a basic sequence of natural resource destruction and conservation or the depletion-melioration model proposed by Whitaker (1940) and Friedrich (1904 *in* Whitaker, 1940). This model argues that, at an early stage, natural resource destruction is inevitable to meet the human needs. Rising demand and price of natural resources will incentivize people to conserve and to restore their natural resources.

Then, foresters apply and develop further that idea in the context of deforestation. Forest transition theory focuses more on the temporal changing of forest cover or a change in forest cover trend over time (Lambin & Meyfroidt, 2010). The notion of this theory is to investigate "… the transition point at the time of the lowest forest cover in a given region …" (Mather, 1992). Other simple understanding of this concept are: the change in forest cover from shrinking to expanding forest areas (Mather, 1992) or shifting from deforestation to reforestation (Lambin & Meyfroidt, 2010; Mather & Needle, 1998). Transition happens when declining forest cover trend reverse into increasing forest cover trend. Angelsen (2009) further describes the forest transition in the sequence as provided in Figure 4. After the stage when forest cover is still high and deforestation rate is low, as the development taking place, then forest cover and deforestation rate are low due to scarcity of forest. At the end, an increasing forest rent could

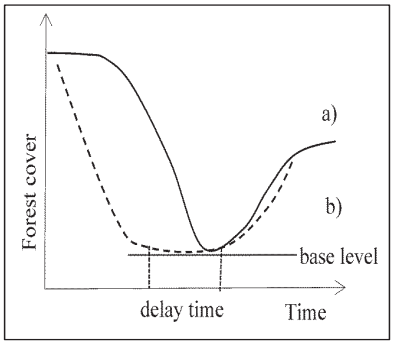
stimulate the transition by incentivizing forest plantation or reforestation/afforestation.



Source: adopted from Angelsen (2009)

Figure 4. Stages of forest transition

Forest transition is generally considered taking place in one cycle of transition, from high forest cover to the lowest point of the forest cover, then increasing of forest cover. So, this U-shaped curve model basically consists of two trends or periods: forest decline and forest recovery (Grainger, 1995), usually in the form of U-shaped or a reverse J-shaped curve (Perz, 2007). For most countries, decreasing forest cover is an inevitable effect of their development processes. At early stage of development, an increasing population and demand of food will bring a significant pressure for forest land because of agricultural land expansion. Then, as countries develop further, an increasing demand for forest products and services will incentivize the process of reforestation.



Source: adapted from: a) Mather (1992) and b) Barbier et al. (2010).

Figure 5. Forest transition theory: a) one phase and b) two phases

By examining the pattern of forest transition from different countries and regions, Barbier et al. (2010) reveal that there is delay time from declining to increasing trend of forest cover (see Figure 5.b). In other word, forest transition may take place in two phases (Figure 5). Aforementioned authors argue that delaying reforestation occurs when people still keep utilizing logged-over forest marginal land for farming, especially in the case of agricultural subsistence. In the context of commercial purposes, tree planting on marginal land may be delayed because of the delay of market signal. Moreover, a recent study finds a more complex pattern in which forest transition may exhibit in multiple transition phases (Yeo & Huang, 2013). This study argues that policy plays an important role in the forest cover transition of Mississippi.

In the context of forest transition theory, to explain the transition of forest cover, scholars deepen the analysis not only on what factors involve, but also on how those factors form the pattern of transition. Followings items present various paths by which forest transition may occur.

i) *Forest scarcity path*. Under this mechanism, forest transition theory is driven by underlying factors from outside forestry sectors. After forest resources are extracted to meet human needs, scarcer forest will induce higher price of forest products,

including amenity, environmental and aesthetic values of forests. Forest sector will respond to this market incentive through reforestation or afforestation. Still categorized under this path is *the tree-based land use intensification path*, when the driving force, market incentive, motivates people to plant high-yield tree crops, such as fruit, agroforestry, garden and so forth (Rudel et al., 2005).

ii) *Economic development path*. After extracting forest resources for development, generally, economic development generates off-farm opportunity jobs that, in turns, will attract rural people off of their land-based economic activities (Rudel et al., 2005). Rural labor scarcity will induce reforestation or land conversion from agriculture into forestland uses. Furthermore, development could also develop better agricultural technology and agricultural intensification. This circumstance will push agricultural activities limited in the most suitable area; and then reforestation may have more land to take place. Concentration agricultural activities only in marginal land can be possible as the consequences of higher agricultural input prices and/or lower agricultural output prices.

iii) *State forest policy path*. Government plays a crucial role in changing land use cover. Since the government owns most forests, government has a strong political authority and policy to promote and/or de-promote forest cover. Some policies encouraging forest cover could be related to tourism promotion and greening country image. Reforestation and afforestation programs in many countries should be accredited for the government political will as well. Yeo & Huang (2013) recognize a new path, *the forest management policy path*, when the government play an important part in stirring forest transition. However, their idea seems similar with *the state forest policy path*.

iv) *Globalization path*. Global integration of the national economy and markets (commodities, labor, capital, tourism and idea) is another mechanism how forest cover is transformed over time. Four main processes are identified in this pathway: neo-liberal economic reforms, labor out-migration, local manifestation of conservation ideologies, and growing tourism. Globalization makes possible rural areas to export their forest products for global markets. Poor people migrating from rural to urban leave more marginal land to be converted into forest (Mather, 2007). Conversely, from-city-to-rural migration by wealthier people raises demands for aesthetic and environmental services provided by forests in rural areas. Global integration enables international organizations to disseminate environmental efforts and ideas globally.

Several recent studies apply forest transition theory to analyze land use or forest cover changes in different scales. At sub national level, Yeo & Huang (2013) explores a long-term pattern of forest transition in Mississippi and finds the presence of a repeated cycle of forest transition in this area. At national level, this approach is a focus of some studies, including Hostert et al. (2011) and Bae et al. (2012). The former study was conducted for the Soviet context, which experiences two different disturbances - political change and nuclear hazard. The authors find that effects of socio-politic-economic disturbances (political change) are tremendously as significant as the disturbance of technology (nuclear hazard). By analyzing the case of the development of urban forest in South Korea, a high economic growth country, the latter study finds that government policy can play an important role to transform land cover towards a higher forest cover. At regional level, a study by Munteanu et al. (2014) show how the shifts of socio-demographic and institutional factors can drive the pattern of forest transition in Carpathian region (Eastern and Central Europe). In the global level, by exploring across country data during 1990-2010, Köthke et al. (2013) confirm that global forest transition has been taking place at global level, finding a uniform pattern of forest decline.

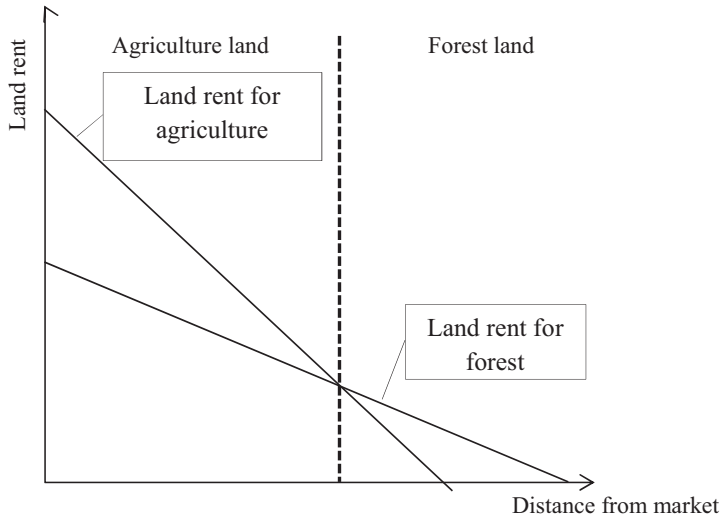
For the sake of academic field, forest transition approach is able to explain the extent of two important issues, forest cover and deforestation, over time. Another prominent position of this theory is that it can be associated with other explanatory variables. Accordingly, policy makers are able to derive some policy alternatives from this theory. Generally, two principal policy directions can be derived, which are policies to halt deforestation and policies to accelerate the transition towards increasing forest cover (Lambin & Meyfroidt, 2010). In doing so, some policies can be exercised which are implicitly embedded in each pathway, as discussed above. Nevertheless, in the field, effective way of promoting forest cover will highly be depend on the competition of values among different land uses (Barbier et al., 2010).

4.3. Land rent theory for deforestation: how does land use for forest compete with other land uses?

The land rent approach for deforestation is deeply rooted from the land value framework developed by von Thunen in 1826. The core idea of this spatial economic theory of land use is that a piece of land should be allocated to the use that would generate the highest potential rent (Chomitz & Gray, 1996; von Amsberg, 1994). Spatially, distance or transportation cost has important position in this land use competition. In summary, by assuming profit maximization motivation, competition among land uses will be determined by which land use that yields the highest land rent/value. In Figure 5, for example, among three competing land uses, forest is most suited in Zone C, *ceteris paribus*.

Adopting this theory for the forestry sector, some scholars developed its theoretical explanation (Chomitz & Gray, 1996; Schneider, 1995; Walker, 2004). However, we should note a working paper by von Amsberg (1994) who already considers von

Thunen model for his forestry research. The key to explaining changes in land uses and land cover is changes in land rent of different uses (Angelsen, 2007; Hyde et al., 1996). Particularly, forest could be conserved when land use for forest can generate the maximum value compared to other possible land uses. On the other side, reforestation could be encouraged in a given land if its land use for being reforested can compete with other land uses. In the case of competition between agriculture and forest land uses as described in Figure 6, forest land use will start to take place in the location (dotted line) where land rent of forest is higher than that of agriculture.



Source: simplified from von Amsberg (1994)

Figure 6. Model of land rent for deforestation

Generally, land rent could refer to rents, profits, or utility (Walker, 2004). This value can be seen in a dynamic perspective. Taking an example of the land competition between agricultural and forest land uses, land rents for agricultural use or forest use may change. Shifts of agricultural land rent might be attributed to changes in agricultural output prices, agricultural input price, agro-ecological condition, agricultural technology, labor wages, or transportation cost. While, forest land rent might be altered due to changes in forest product price, forest technology, or economic incentive introduction (Angelsen, 2007). The latter variable, economic compensation mechanism in the forest sector, is the most recent discussion in climate change negotiation that is REDD+ (reducing emissions from deforestation and forest degradation). In this notion, economic compensation can work to change the land rent inducing land use change for a favorable purpose. In the context of reducing deforestation, REDD+ is a proposed economic mechanism to compensate landholder to conserve their forest or to incentivize them to reforest their land. Shortly, it is the opportunity costs of forgone economic benefits from other alternative land uses to avoid deforestation (Ahrends et al., 2010).

The land rent theory provides a basic explanation on how land uses changes spatially (Angelsen, 2007). This theory allows scholars to investigate how the landscape is determined by location. Furthermore, under this theory, to what extent the spatial pattern of forest exploitation will be (Ahrends et al., 2010) can be examined. For decision makers, the main policy implication under this approach is to change the composition of land rent in such a way that forest areas can be protected and/or reforestation can be feasibly promoted.

Currently, the land rent theory has gained interests of several studies. Distance (to Trans-Amazon Highway) plays an important role for smallholders in the Amazon Basin in land allocation decision (Caldas et al., 2007), which is proven by a negative sign of deforestation in the distance. With regard to the relationship between distance to the capital and forest loss, similar finding is found in Tanzania case (Ahrends et al., 2010) and Indonesia case (Busch et al., 2012). In Costa Rica, Robalino & Pfaff (2013) reveal that such payment for environmental service mechanism can potentially avoid deforestation approximately 1 percent per year. Similar mechanism is the interest of Barua et al. (2012) finding that, by combining it with taxation of cash-crop and forestry income, carbon payment can be an effective way to prevent forest clearing in Paraguay. Currently, REDD+ as an economic compensation has also been studied, including studies by (Busch et al., 2012; Gaveau et al., 2009). Not only for developing country context, the land rent concept is also used in the case of deforestation and urbanization in developed countries, such as South Korea (Cho et al., 2014).

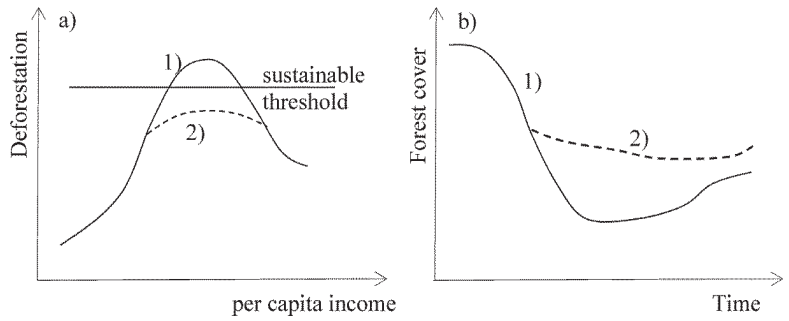
5. Discussion and concluding remarks

5.1. Tunneling through concept

The developing countries, where major tropical forests are located, could learn from the developed country experience in order to avoid such high development level in reducing the environmental degradation, deforestation (Munasinghe, 1999). In policy exercise, win-win policies, policies in such a way that higher economic level can be reached with lower environmental impacts, gain attention. Framed under tunneling through perspective, following discussion will elaborate more about it. This concept has been the interests of, at least, three authors (Culas, 2012; Mills Busa, 2013; Munasinghe, 1999).

An article by Munasinghe (1999) examines tunneling through concept in the perspective of EKC for deforestation theory. Since the first-best policy, which is to achieve a Pareto optimum cannot maximize welfare where an environmental externality presents, the author argues to exercise the second-best policy that is to seek any policy alternative to compromise economic goals and environmental damage.

Depicted in Figure 4, policy makers should focus on how to flatten the curve, which is currently following the existing development path (see line 1 in Figure 7.a) that needs to meet the relatively high level of economic development before deforestation can be reduced. Moreover, this status quo path is obviously not sustainable since it passes through the sustainable threshold (Bhattarai & Hammig, 2001; Panayotou, 1993), such as biodiversity loss that is irreversible. It is essential to shift this existing pathway of development into more sustainable way and to avoid the peak of environmental degradation limit (see line 2 in Figure 7.a). In doing so, the author proposes some major policies, including ex-ante environmental assessment and strengthening the capacity for environmental regulation (Munasinghe, 1999).



Source: simplified from Culas (2012) and Munasinghe (1999)

Figure 7. Tunneling through concept on: a) EKC for deforestation theory and b) forest transition theory

In the context of forest transition theory, different policy examination is discussed by Culas (2012) focusing on the role of economic incentive or the payment for ecosystem services (PES). In the forestry sector, REDD+ scheme now is in the progress to be an attractive economic incentive. Rather than concentrating on sustainable development policy, Culas (2012) suggests that introducing REDD+ could direct the existing development path (line 1 in Figure 7.b) into a path of positive forest cover change (line 2 in Figure 7.b).

The recent idea of tunneling through the concept is put in the context of trade and consumption (Mills Busa, 2013). Based on his analysis, showing that import plays an important mechanism in fulfilling the fuelwood demand in the upper-middle income countries, he comes up with the conclusion that the consumption of wealthier countries is an important driving factor of deforestation in poorer countries. Hence, combined with alleviating poverty in poor countries, tunneling through EKC for deforestation can be accelerated by reducing consumption and/or promoting such an ecological self-sufficiency in developed countries. Furthermore, the author emphasizes that merely alleviating poverty without decreasing demand may intensify deforestation because of increasing new consumers.

In summary, tunneling through perspective deals with such win-win policies, which is to reconcile between achieving economic development goals and avoiding environmental impacts of development. In the forestry sector, it is about how to increase economic development level while simultaneously avoiding deforestation. Such compromising policies seem to be practically implementable and politically acceptable (Culas, 2012).

5.2. Concluding remarks

Deforestation is one of the global environmental issues. However, deforestation is not only an environmental problem, but

also a human-environment interrelated problem. It is not a local or a single national issue, but across country, regional and global issue. Nor it is a forestry issue, but multi-sectoral issue. Moreover, dealing with deforestation has been put into our global politics (Köthke et al., 2013). Deforestation consists of a complex array of various factors (Robinson et al., 2014) with nonlinear relationships. Deforestation gets a strong attention from numerous stakeholders, including scholars and policy makers. To explain that complexity, theory is a substantial basic knowledge to comprehend its issue, as well as to draw its future perspective (Rudel et al., 2005).

The decline in forest cover of deforestation has been recognized as a long-standing issue, which has been concerned globally since the early 1970s (Köthke et al., 2013). Historically, all theories of deforestation, however, have been just initially developed since early 1990s, when global environmental negotiation has found its momentum. It reflects that manifesting a certain theory is a long process passing through history. Complexity of deforestation might also contribute to make this process relatively long.

Reviewing theories of deforestation enables us to draw an essential motivation of all of them, which is to address environmental degradations in forestry sector caused by deforestation, namely biodiversity loss and greenhouse gas emission. By revealing and classifying direct and indirect factors leading to deforestation, policy makers is able to focus more on some strategic variables framed within proximate and underlying theory. EKC for deforestation provides a basic awareness of environmental damages during the development processes. It examines some policy alternatives to deal with environmental impacts. Time dimension is the focus of forest transition theory emphasizing that the unexpected deforestation or forest decline trend should be shifted towards forest recovery or reforestation trend. Land rent for deforestation theory is a spatial economic perspective elucidating how land use for forests competes with other land uses. Those theories offer different basic idea and point of view on deforestation. They offer different framework and approach of deforestation. Those theories, however, bring a similar important message, which is to address forest cover loss.

Going into more detail, most variables affecting and explaining deforestation is human-related factors, such as macroeconomic, demographic, institution, and so forth, with some exceptions such as natural proximate factors (such as forest fire and drought) and the geographical condition and location for instance distance and land productivity (under land rent for deforestation theory). Therefore, all theories develop their debates which lie in a general belief that deforestation is a human-induced issue, as also be indicated by UNFCCC.

Although some parallel features can be drawn, each theory has some differences. First is that each theory develops their discourses in different level and scope. Forest transition is a temporal approach, whereas spatial concern is obviously the interest of land rent for deforestation theory. In the context of economic development stage, proximate and underlying theory might encourage discussion both on macro and micro levels, while EKC for deforestation might be appropriately put in macro level. Secondly, each theory was derived and developed from different school of thoughts. Economics standpoint is the root of EKC for deforestation and land rent theories; while, proximate and underlying approach and forest transition theory are anchored at an ecological perspective.

To what extent of the forestry sector should be put forward into these theoretical debates? Wang (2013) argues that since, in the near future, the forestry sector may be characterized by increasing demand for environmental services and environmental-friendly products from the forests, and then economics-environment debates might be still a challenging dispute. In other word, contrasting with the land use competition model or land rent theory for deforestation, win-win solution seems to be a big future challenge in the real field. Furthermore, scholars give the impression into a conclusion that generalization should be carefully scrutinized. Hence, a careful examination must be thoroughly done when a certain theory will be applied for different context or scope, especially by considering the existence of dual effect hypothesis. Finally, realizing the fact that most of forest areas are owned by public or state forest, the role of the government should be strongly taken into consideration in any theoretical discourses or policy exercises of deforestation.

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