

Land use transitions: Socio-ecological feedback *versus* socio-economic change

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ABSTRACT

The concept of land use transition highlights that land use change is non-linear and is associated with other societal and biophysical system changes. A transition in land use is not a fixed pattern, nor is it deterministic. Land use transitions can be caused by negative socio-ecological feedbacks that arise from a depletion of key resources or from socio-economic change and innovation that take place rather independently from the ecological system. Here, we explore whether the sources of land use transitions are mostly endogenous socio-ecological forces or exogenous socio-economic factors. We first review a few generic pathways of forest transition as identified in national case studies, and evaluate the varying ecological quality of expanding forests associated with these pathways. We then discuss possible explanatory frameworks of land use transitions. We use the case of the recent forest transition in Vietnam as an illustration. Socio-ecological feedbacks seem to better explain a slowing down of deforestation and stabilization of forest cover, while exogenous socio-economic factors better account for reforestation. We conclude by discussing the prospects of accelerating land use transitions in tropical forest countries.

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Introduction

Human societies constantly coevolve with their environment through change, instability, and mutual adaptation. As a result, land use change is non-linear and is associated with other societal and biophysical changes through a series of transitions. The concept of forest transition refers to a change at a national or regional scale from decreasing to expanding national forest areas – i.e., from net deforestation to net reforestation – that has taken place in several European countries, in North America and, more recently, in China, India, Vietnam, Costa Rica, Puerto Rico among others (Mather and Needle, 1998; Mather et al., 1999). This particular form of land use transition has been well studied empirically. While the initial focus of forest transition studies was the historical experiences of industrial countries in Europe (Mather, 1992; Walker, 1993; Mather et al., 1999) and North America (Foster et al., 1998), several recent studies have demonstrated that a similar pattern of forest-cover change is taking place in some tropical countries with developing economies (Rudel et al., 2002a; Grau et al., 2003; Klooster, 2003; Hecht et al., 2006; Mather, 2007; Nagendra, 2007; Meyfroidt and Lambin, 2008a,b). This similarity in pattern does not imply that the causes of the forest transition are the same. A predominantly national focus in forest transition studies has been increasingly complemented by

subnational-scale studies (e.g., Baptista and Rudel, 2006; Sloan, 2008).

It is important to better understand under what conditions land use transitions do take place. The causal mechanisms behind land use transitions can invoke two forces of a different nature. On one hand, land use transitions could be associated with negative feedbacks that arise from a depletion of key resources or a decline in the provision of important ecosystem goods and services. Such explanations transpose to socio-ecological systems the dynamics that are typical of ecological systems—i.e., growth under resource constraints. In this context, by “socio-ecological feedback”, we mean changes in land use decisions that result from a severe degradation in ecosystem services that was caused by past land use practices, the important point being that this process is endogenous to the coupled socio-ecological system. On the other hand, land use transitions could be caused by socio-economic change and innovation that take place rather independently from the ecological system and follow their own dynamics. These changes are exogenous: they can be driven by urbanization, economic development or globalization and yet have an impact on land management and thus lead to a land use transition. These two lines of explanation of land use transitions raise the following questions: Are the sources of land use transitions mostly ecological or socio-economic; endogenous or exogenous; local or global? It was once claimed that humanity did not move out of the Stone Age due a lack of stones. Similarly, do societies profoundly modify their land use practices in response to a depletion of natural resources or ecosystem services that follow from their previous land use? Or, rather, are land use

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transitions an unintended side effect of innovations in other sectors of societies—technological innovations, economic modernization, changes in social organization and preferences?

The objective of this paper is to advance our theoretical understanding of the causes of land use transitions by reviewing possible generic causal mechanisms associated with such transitions. We start with a definition of what is meant by land use transition. As most of the empirical studies on this issue have focused so far on forests, we then review a few generic pathways of forest transition. Next, we attempt to expand this understanding to land use in general by discussing possible explanatory frameworks of land use transitions. Our focus is on land use transitions that relieve pressure on natural ecosystems and maintain or even restore the provision of ecosystem services. We then apply these explanatory frameworks to the case of Vietnam to test whether they help to bring clarity to the multiple forces that act synergistically to bring a land use transition in a particular place. We conclude by discussing the prospects of accelerating land use transitions in tropical forest countries.

Background

A transition can be defined as a process of system change in which the structural character of the system transforms (Martens and Rotmans, 2002). The concept of land use transition refers to any change in land use systems from one state to another one—e.g., from a system dominated by annual crops for local consumption to a system with large tree plantations in response to market demand or new institutions. Whereas a system-wide perspective on land use tends to focus on the slow and gradual processes of change at the scale of large entities (DeFries et al., 2004), a perspective centred on local communities or agents emphasizes people's own foreseeable futures at the individual level and abrupt transitions that result from the adoption of new land use practices in response to critical events (Lambin et al., 2003; Lambin, 2005).

While a land use transition is defined as a change in land use system, a forest transition is often viewed more narrowly as a change in land cover trend. Some authors represent the forest transition as the turning point between two specific land use transitions, the first from a land use system with high forest cover to one with low forest cover, and the second from low to high forest cover (Grainger, 1995; Barbier et al., 2010). These two transitions can be separated by a time lag with a stable and low forest cover. This implicit state-and-transition model could be replaced by a more dynamic view that represents the forest transition as a land use transition from two land use systems in dynamic equilibrium: one characterized by exploitative use of forests and thus associated with declining forest cover and the other characterized by a sustainable use of forests and thus associated with recovering forest cover.

Transitions in land use must be viewed as multiple and reversible dynamics. A transition is not a fixed pattern, nor is it deterministic. It is highly contingent and there is large variability in specific trajectories. There is thus a strong notion of instability and indeterminacy in land use transitions. Transitions should be viewed as “possible development paths where the direction, size, and speed can be influenced through policy and specific circumstances” (Martens and Rotmans, 2002). The actual ecological and social significance of a land use transition depends on the existing land cover prior to and after the transition (Farley, 2007). Land use transitions are associated with changes in the provision of ecosystem good and services on which human societies depend. There is a great diversity in geographic and historical contexts associated with land use transitions and numerous complexities in both the ecological and social systems (Perz, 2007).

Forest transition pathways

In a widely cited study, Rudel et al. (2005) identified two main forest transition pathways based on a cross-national study for the 1990s: a forest scarcity path and economic development path. Recent case studies identified a broader range of processes associated with forest transitions. Below, we briefly summarize the two forest transition pathways identified by Rudel et al. (2005). They are each followed by a description of their more contemporary version. We also identify a fifth pathway that takes place at a finer geographical scale. We then qualify these pathways by discussing their varying ecological quality.

Forest scarcity pathway

In some countries, a scarcity of forest products and/or a decline in the flow of services provided to societies by forest ecosystems prompted governments and land managers to establish effective afforestation programs. In this first pathway proposed by Rudel et al. (2005), political and economic changes affecting the forest sector arise as a response to the adverse impacts of deforestation. For example, following landslides on deforested slopes, floods in downstream watersheds, rising prices for forest products, public demands for parks, and pressure from civil society for wildlife conservation, private initiatives or policy interventions lead to programs to afforest marginal lands and create reserves to protect old-growth forests. In China, national reforestation policies were not only inspired by a scarcity of forest products (20% of China's territory was still covered by forests at that time) but by concerns about flooding and soil erosion that can result from deforestation. The alleged linkage between the clearing of forests on slopes of watersheds and the increasing frequency of severe flood events has been a key argument to promote reforestation in 19th century Europe, mostly in the Alps, and to ban logging in Thailand, China and the Philippines (Mather and Fairbairn, 2000; Durst et al., 2001; Mather, 2007), even though this linkage is still controversial (FAO-CIFOR, 2005; Bradshaw et al., 2007).

State forest policy pathway

In some cases, changes in national forest policies play a central role in stirring the forest transition. These new land use policies may be in part triggered by elements of the above forest scarcity pathway but their underlying motivations are often factors outside the forestry sector: a willingness to modernize the economy and land use, integrate marginal social groups such as ethnic minorities living in forests, or promote tourism or foreign investments by “greening” the image of the country; or a geopolitical interest in asserting control over remote territories via the creation of natural reserves or managed state forests. In these cases, this pathway is distinct from the forest scarcity pathway. It does not inevitably result from economic development policies if these have a focus on industrialization and/or a decentralized implementation. In several Asian countries, an increase in forest cover has been strongly promoted by the state since the 1990s (Mather, 2007).

The Himalayan Kingdom of Bhutan offers a good example of a policy intervention in the forestry sector that is not motivated by forest scarcity. Forest cover increased in Bhutan from 64.6% of the country area in 1990 to 68% in 2005 (FAO, 2006). This increase took place despite an average population growth rate of 3%, with only 21% of the total population living in urban areas in 2003, and an agricultural sector still representing 33% of GDP. Fuelwood accounts for over three-quarters of total energy consumption and nearly all non-commercial energy consumption (Uddin et al., 2007). The forest legislation of Bhutan imposes that a minimum

forest cover of 60% is maintained permanently at a national scale. The Forest Policy of Bhutan (1991) and the Bhutan Forest and Nature Conservancy Act (1995) have translated in the legislation the principles of sustainable management of forests, biodiversity conservation, and social forestry (Uddin et al., 2007). More than 27% of the country's area was managed as protected areas in 2005. The new forest policies give a role for traditional forest users in managing forest activities on publicly owned land, including community lands. Most forests are under this category of land ownership rights. Tree planting and forest management is also encouraged on privately owned land. Underlying these forest policies is, in no way, a depletion of forests but rather the unique philosophy of development in Bhutan outlined by King Wangchuck in the late 1980s. The promotion of the happiness of the people is viewed as being more important than economic prosperity. As part of this policy, preservation and sustainable use of the environment is one of the key objectives pursued by Bhutan. It is inspired by the Buddhist culture of harmony and compassion, and its representation of the place of human beings within the complex web of interdependent relationships between all forms of existence. The path of forest transition in Bhutan is therefore motivated by an ecocentric development model, and associated with central government policies and a forest ownership regime of mostly publicly owned forestland.

Economic development pathway

In other countries, economic development has created enough non-farm jobs to pull farmers off of the land, thereby inducing the conversion of fields into forests. This second pathway proposed by Rudel et al. (2005) therefore occurs when, after a period of deforestation, large areas of land marginally suitable for agriculture are abandoned and left to forest regeneration. Because of economic expansion, labour force is driven from agriculture to other economic sectors and from rural to urban areas. Investments in the industrial sector raises urban wages and create rural labour shortages. Thus labour scarcity rather than a scarcity of forest products drives the reforestation. Due to market development, agricultural intensification is concentrated in the most suitable regions. As farmers adopt more productive agricultural technologies, crop production increases in the core agricultural regions, with a consequent decline in crop prices. Agriculture becomes unprofitable in marginal fields.

Globalization pathway

A more modern version of the economic development pathway occurs when a national economy becomes increasingly integrated into global markets for commodities, labour, capital, tourism and ideas (Rudel, 2002). Compared to historical forest transitions in Europe and North America, developing economies in today's world are strongly affected by globalization. Kull et al. (2007) identify four processes associated with globalization and that impact forest cover: neo-liberal economic reforms, labour out-migration, local manifestations of international conservation ideologies, and growing tourism and land acquisition by expatriates. These processes alter qualitatively and quantitatively the way economic modernization affects forest covers. The range of migrations is expanding from the nearby city to remote, economically advanced countries. Rural regions increasingly export forest and agricultural products to global markets and offer aesthetic services for a growing number of foreign tourists that import their views on how a beautiful landscape should look like. As a result of private investments, land privatization and the expansion of global tourism, forest conservation activities increasingly take place on private lands. In parallel, the rural poors seek employment outside their region or country

and send back remittances to marginal rural regions, which can relieve pressure from the land (Hecht et al., 2006). International environmental NGOs, multilateral environmental conventions and aid agencies globalize sustainable development objectives and related forest management practices. Economic globalization also facilitates the displacement of deforestation from countries that undergo a forest transition to forest-rich regions, via the international timber trade (Meyfroidt and Lambin, 2009).

Smallholder, tree-based land use intensification pathway

In marginal regions dominated by smallholder agriculture, a significant increase in tree cover can be associated with the expansion of fruit orchards, wood lots, agroforestry systems, gardens, hedgerows, and secondary successions on abandoned pastures or fallows that are sometimes enriched with valuable species (Hecht et al., 2006). These wooded landscape mosaics often develop at the forest margins (Wiersum, 2004), creating a continuity between planted and natural forests. They have evolved over millennia under the influence of smallholder land use systems that actively manage the multifunctionality of ecosystems (Michon et al., 2007). The motivation of smallholders may be to decrease their vulnerability to economic or environmental shocks and guarantee their livelihood through ecological and economic diversification—e.g., through the extraction of non-timber forest products. These “domestic forests” (Michon et al., 2007) involve a form of land use intensification as they require high levels of labour inputs and traditional environmental knowledge. It is driven by innovations in farming systems rather than by forest conservation, which makes it distinct from the forest scarcity path. Where these land use patterns have emerged recently, it is often following a reallocation of labour between plots with a different land suitability within a farm—e.g., concentration of labour on irrigated plots in valley bottoms and tree plantations on steep slopes that were previously cultivated extensively (Meyfroidt and Lambin, 2008a) or roadside reforestation with short-cycle shifting cultivation of high-value crops for urban markets (Rudel et al., 2002b). In other locations, rural communities actively restore forests and their ecosystem services on degraded lands (Chazdon, 2008). Contrary to the economic development path, this pathway of forest transition is not associated with a decline in rural population or in agriculture. Rather, it maintains “wildlife-friendly” farming (Green et al., 2005) and reforestation does not signify land abandonment (Rudel et al., 2002b). These tree-based land use systems are more likely to include indigenous species and biological diversity than intensive cultivation. They therefore have conservation value and make substantive contributions to various ecosystem services. Yet they do not have the same composition and structure as primary forests and are associated with a fragmented landscape. These successional, anthropogenic forests form the matrix of natural forest fragments (Hecht et al., 2006). Note that the increase in tree cover associated with this pathway is not always captured in land use statistics and thus may remain hidden.

Ecological quality of forest transitions

Each of the above pathway can be associated with varying impacts on the delivery of ecosystem goods and services and with forests with different ecological qualities. FAO definition of forests, which is widely used, include all land with tree crown cover (or equivalent stocking level) of more than 10% and area of more than 0.5 ha (FAO, 1999). Alien monoculture industrial tree plantations for timber or paper pulp qualify as forest, as all other forms of planted forests. Tree crop plantations – e.g., gum arabic (*Acacia Senegal*) or rubber (*Hevea brasiliensis*) – are also included in the FAO

Table 1
Hypotheses on ecological quality of forest transition pathways in relation to their main driving forces.

	State forest policies	
	Top-down government intervention through land use planning; mostly government-owned land	Government intervention through market-based mechanisms; importance of private and communal land ownership
Integration of forestry sector in world economy		
Strong	Large monoculture plantations (e.g., China). Low ecological quality.	Tree plantations mixed with intensive agriculture and secondary forests (e.g., Ecuador's Andes, Chile). Low to medium ecological quality.
Weak	Natural forest regeneration; forests managed for ecosystem services (e.g., Bhutan). High ecological quality.	Natural forest regeneration and diverse agroforestry systems on smallholders' land (e.g., El Salvador). High ecological quality.

definition of forest. Thus, a country that would have depleted its primary forests and would then replace them by tree crop plantations could appear to undergo a forest transition. This is an artefact of the definition of forest as used by FAO for global accounting purpose. This definition does not take into account the quality and "naturalness" of forests. Intuitively, such forms of reforestation or afforestation should not qualify as a forest transition. Yet, if the focus of a study would be exclusively on carbon cycle accounting or provision of timber for example, this could indeed be considered as a forest transition for that narrow purpose.

Certain forest transition pathways are more likely to lead to forest transitions with a high ecological quality than others (Table 1). Forest transitions caused by national-scale policies of land use planning implemented by strong states, with a wood sector strongly integrated in regional to global markets, are often associated with large monoculture industrial tree plantations with a low ecological quality. The reforestation in China illustrates this situation (Zhang et al., 2000). By contrast, forest transitions caused by land use decisions by a large number of land managers, with small to medium size land holdings, and in a country with few exports of roundwood or wood products are more likely to be associated with either natural forest regeneration or successional, anthropogenic forests and agroforestry systems that are intrinsically more diverse. El Salvador is a good example of this case (Kleinn et al., 2002, Hecht et al., 2006). In other countries, reforestation is promoted by the government via various market-based incentives for private and public rural landholders and a strong support for wood exports. This is generally associated with plantations of fast-growing species that are mixed in the landscape with intensive agriculture and secondary forests, as in the Andes region of Ecuador (Farley, 2007; Vanacker et al., 2003) and in Chile (Clapp, 2001). Finally, forest transitions driven by land use planning by the state in economies rather isolated from regional to global markets and dominated by smallholders tend to lead to an expansion of natural forests that provide multiple ecosys-

tem goods and services, as illustrated by Bhutan. Some countries such as Vietnam (see below) fall across some of these categories.

Explanatory frameworks

Underlying these multiple forest transition pathways lie two fundamental forces that influence land use decisions in general: (i) negative socio-ecological feedbacks that arise once the flow of goods and services provided by natural ecosystems has severely declined; they force a slow down or even reversal of land conversion; and (ii) socio-economic dynamics that are not a direct result of land cover change but that nevertheless lead to a shift from an expansion of land use to natural ecosystem recovery at the national scale. In the first case, driving forces are mostly endogenous and local while, in the second case, they are mostly exogenous and originate from a higher organization level, from neighbouring regions or from local innovations. This distinction requires defining the boundaries of the coupled socio-ecological systems that are directly involved in land use transitions: the territory being affected and its local population. Any boundary is arbitrary and setting one around a place does not imply a lack of integration of this place in its regional context.

The relative importance of endogenous versus exogenous forces has a major importance on the way land use transitions can be understood, modelled and accelerated by policy intervention. If the system dynamics is dominated by negative socio-ecological feedbacks, then a modelling that is built on an analogy with ecological systems may be appropriate. Much of the research on socio-ecological systems is built on the premise that there is a fundamental similarity between the behavior of ecological and social systems. This is a simplification however, as work on risks and environmental stress (Kasperson, 1969; O'Riordan, 1971) and in behavioral geography (Downs and Meyers, 1978) have shown that an environmental signal must be perceived and evaluated

Table 2
Main relationships between forest transition pathways and explanatory frameworks of land use transitions.

Explanatory frameworks	Forest transition pathways				
	Forest scarcity	State policy	Economic development	Globalization	Smallholder intensification
Socio-ecological feedbacks					
Resource-limited growth	X				
Land scarcity, intensification	X				X
Land use adjustment		X	X		X
Socio-economic changes					
Economic modernization			X	X	
Market access		X	X	X	X
Land ownership		X		X	X
Global trade				X	
Diffusion of conservation ideas		X		X	

in order to generate a reaction, and may be socially amplified or attenuated (Kasperson and Kasperson, 1996). By contrast, if socio-economic dynamics are the dominant forces leading to land use transitions, then explanatory models that capture the specificity of social systems need to be deployed. Below, we review some of the explanatory frameworks that can account for these two forces of land use transition, in view of making more explicit possible causal mechanisms (Table 2). They are not mutually exclusive categories. Most of these models or theories represent the interactive spatial dynamics of agriculture and forestry. They thus explain land use transitions in general rather than just forest-cover dynamics.

Socio-ecological feedback regulating land use change

Resource-limited growth and adaptive cycle

In ecology, the stabilization in the growth of a population in a resource-limited environment is generally modelled with the logistic function (Verhulst, 1845). The same function also models the cumulative diffusion of demographic properties across a geographic landscape. Land use change can be viewed as a growth process, with the rate of natural ecosystem conversion being regulated by the density of remaining natural ecosystems. Agricultural expansion can also be conceived as a spatial diffusion process driven by a set of decisions by agents to migrate into frontier areas and to clear land for crop production. In both cases, these models account for the stabilization of the area of natural ecosystems once a threshold has been reached, and thus represent a land use transition. This threshold corresponds to the minimum flow of natural ecosystem services that is required by the local population. To broaden this framework, one could conceptualize land use dynamics based on Holling's adaptive cycle (Holling, 1986), by analogy with the dynamics of natural ecological systems. A recovery of natural ecosystems and land use intensification would then be part of the backloop of this cycle (reorganization and renewal), following a phase of agricultural expansion and capital accumulation.

Land scarcity and agricultural intensification

In a classic view, agricultural expansion “fills up” the land at a fixed technological level, usually, the most extensive one. Once it is constrained by land scarcity and a depletion of soil nutrients, agricultural intensification takes place by substituting labour or capital inputs for land (Boserup, 1965). Through the adoption of land-saving and yield-enhancing technologies and the shortening of the fallow cycle, agricultural intensification is expected to decrease the demand for land and thus allow for a decline in the rate of conversion of natural ecosystems. This could lead to a land use transition with a stabilization or even an increase in tree cover and natural habitats. Out-migration, fertility reduction or changes in tenure arrangements can also relieve pressure on land without agricultural intensification. Agricultural intensification may also result from an increase in market demand and state intervention, independent of land scarcity (Lambin et al., 2003). In that case, improving agricultural technology could encourage more land conversion rather than relieving pressure from nature, depending on how the new technologies affect the labour market and migration, whether the crops are sold locally or globally, how profitable farming is, as well as on the capital and labour intensity of the new technologies (Angelsen and Kaimowitz, 2001). In sum, this explanatory framework of land use transitions encapsulates a widely held view, yet one with a weak empirical support (Rudel et al., forthcoming).

Adjustment of land use

Mather and Needle (1998) suggested that forest transitions could be explained by an increasing adjustment of agricultural

activities to land quality. As farmers learn about the agro-climatic potential of different regions or “terroirs” for specific agricultural land uses, agricultural production gets concentrated in smaller areas with prime agricultural conditions (the core agricultural region) while agriculture is abandoned in the larger regions with a lower productivity, due to intrinsic ecological constraints or following land degradation (the periphery). These marginal regions are then reforested through natural forest regeneration or tree planting. With a better spatial fit between agriculture and agricultural land capability, agricultural production can be maintained or even increased from a decreasing land area under use. This process requires population movements, market integration and dense transport networks. It takes place when regions have a comparative advantage for specific land-based productions. In this mechanism, there is an ecological feedback on agricultural productivity but social learning, mobility and communication also play an important role. There is good historical evidence at a national scale for this theory of land use transition.

Exogenous socio-economic dynamics

Economic modernization

The environmental Kuznets curve shows an increase in the environmental impact of a society in the early stages of economic development, followed by a lessening of this impact once per capita income has exceeded a certain threshold (Stern, 2004). The environmental Kuznets curve predicts that economies in transition should have the highest rates of natural ecosystem conversion and, as they become richer, these rates should decline and ecosystem restoration should take place. Causal factors are assumed to be a change in energy sources, technological progress in agriculture and forestry, greater awareness of the value of natural ecosystems, a growing ability to pay for nature-friendly land use practices, the action of pressure groups for environmental protection, and the ability of governments to draft strict environmental legislation and enforce compliance with it. Cross-country analyses show that the recovery of natural ecosystems with development is not a spontaneous effect of economic growth but rather the consequence of vigorous environmental policies that have aggressively promoted ecosystem restoration and the adoption of more sustainable land use practices (Bhattarai and Hammig, 2001; Mather, 2007). Reduced land degradation in one place is also to some extent the result of a displacement of food production and wood extraction to other places through trade. Empirical evidences to support the existence of an environmental Kuznets curve for forest cover are ambiguous as the factors associated with deforestation and reforestation differ across regions, between countries and through time within a single country (Ehrhardt-Martinez et al., 2002; Ewers, 2006). The environmental Kuznets curve is a highly idealized and abstract pattern linking development with environmental impacts. It encompasses many of the processes linking natural ecosystem recovery with economic development, modernization, industrialization, and urbanization (Perz, 2007).

Land rent and market access

Land use change can be motivated by the desire to capture new economic opportunities as much as by the need to respond to factor scarcities and ecological constraints. The land rent theory of von Thünen and that of Ricardo predict that any parcel of land, given its attributes and location, will be used in the way that earns the highest rent. Land use changes – including the conversion of natural ecosystems – are therefore driven by choices by land managers among alternate rents. In any location, the outcome might be land conversion or nature restoration depending on the relative rent between potential uses of nature and cleared land. A land

use transition that would preserve or restore nature thus depends on changes in the opportunity cost of natural ecosystem maintenance (Walker, 1993). If the value of the natural ecosystem goods and services are higher than the value of agricultural production or other uses of that same plot of land, than nature conservation or restoration will take place—provided that a market exists for these ecosystem services to direct payments toward the land managers. These values are influenced by market access, policy interventions, land tenure, and economic opportunities associated with land use. For example, a decrease in commodity prices on the global market has led to agricultural contraction in some marginal regions and thus to a land use transition. In Costa Rica, the creation of new markets for ecosystem services (carbon sequestration, quality water provision, scenic beauty, biodiversity conservation) are aimed at increasing the land rent of standing forest compared to other land uses, to promote reforestation. Land use transitions are thus controlled by the influence of markets for different land-based products or services on the competition between different land uses (Barbier et al., 2010).

Land ownership regime

In many countries affected by a land use transition, the official land ownership regime has been transformed from open access or informal communal regimes to more formal government-owned and private land. Yet, many government-owned lands are effectively governed by local communities, as common-property resources, or by private enterprises that were allocated concessions (Agrawal et al., 2008). Moreover, there has been a rapid increase worldwide in the land area under various protection status (national park, wildlife reserves, conservation areas), with restrictions on human use. Attempts to formulate generalizations on the tenure regime that is best at nature conservation or restoration are doomed to failure given the diversity of social and ecological contexts, and the large number of factors that determine the effectiveness of ecosystem governance. However, any tenure regime other than open access offers a much greater capability to exclude other land users and to regulate resource extraction by authorized users. Several studies have shown that forest management by local communities can be as effective for conservation as strict government protection (Nagendra, 2007). Forest transitions in Europe involved privatization of forestland while several cases in Asia were associated with the devolving of land management decisions to villages or communities, even though the state sometimes retained formal ownership of the land. In Latin America, various agrarian reforms have allowed for collective decisions about land management, a concentration of technical assistance and funds on cooperatives, and an economic diversification that has relieved pressure on natural ecosystems (Hecht et al., 2006). In Costa Rica, the removal of restrictions on land acquisition by foreigners led to foreign property investment and forest conservation on these private lands (Kull et al., 2007). Changes in land ownership regimes and in effective governance are also a major driver of land use transition in rangelands (Sneath, 1998).

Global trade

Thanks to the development of cheap intercontinental transport that goes hand-in-hand with globalization, the trade in food and timber has greatly developed over the last century. Imports of food, roundwood and processed wood in a region relieves pressure on natural ecosystems in this region but displaces it to the exporting regions. For example, international timber trade does affect significantly spatial patterns of wood harvest: in 2000, international timber trade comprised 19% of the value of primary forest products (Kauppi et al., 2006). Reforestation in one country is facilitated by importing wood from (or exporting deforestation to) another coun-

try. North America is the largest producer and exporter of industrial wood, which mostly originates from re-planted forests that are broadly similar to native forests. Malaysia and Indonesia export to China, Japan, the U.S. and Europe large volumes of tropical timber extracted from their primary forests. Other wood-exporting countries such as Chile extract a large fraction of their timber from plantations based on exotic species (Clapp, 2001). All other things being equal, the development of international timber trade could in theory decrease the global forest area harvested by concentrating production in the high-yielding regions (Kauppi et al., 2006). Forest transitions in lower yielding countries may thus have been facilitated by economic globalization. Note however that exploitation of natural forests in the tropics is also constrained by physical and institutional accessibility of forest stocks. Global timber trade data do hide the actual ecological impacts of wood extraction as the wood that is traded may originate from primary forests or plantations and, in the latter case, from native or exotic species. The international trade in crop and livestock products explain in a similar way land use transitions in general: land use intensification in some places and cropland abandonment in others accelerate with food exchanges.

Global diffusion of environmental conservation ideas

Since the Brundtland report and Rio's Earth Summit, sustainable development has been high on the agenda of aid agencies, the scientific community, and various NGOs. Ministries of Environment and Natural Resources have gained traction and multilateral environmental conventions have been signed. The ideology of nature conservation has been globalized and influenced national policies in various sectors. In some cases, adoption of sustainable development policies was an opportunistic decision to gain access to international and private funds for environmental projects—e.g., in debt-for-nature swaps, or as part of the Global Environment Facility (GEF). Most resource management institutions have adopted nature conservation principles. This led to the creation of protected areas, land management laws, and public services responsible for research and education on natural resource management. A variety of new schemes have been developed: forest certifications, fair trade initiatives, payment for ecosystem services. . . Whether a particular country was facing a natural resource crisis or not, the global spread of environmental conservation ideas has affected resource management institutions at global to local levels through a greening of national policies (Hecht et al., 2006). The global diffusion of new knowledge systems, values, environmental attitudes, and institutions explain a transition toward more sustainable land use in many world regions (Raquez and Lambin, 2006).

The land use transition in Vietnam

In this section, we take Vietnam as a case study to illustrate that real life cases merge many of the rather theoretical categories reviewed in the previous sections. Rather than following a historical timeline (see Meyfroidt and Lambin, 2008a,b), we analyse the different contributing processes in the agricultural and forestry sectors. First, we show that the above-described pathways are not independent and interact in several ways, and then we assess the role played by socio-ecological feedbacks *versus* broader socio-economic dynamics in the land use transition in Vietnam.

Forest transition pathway

In any particular country, one can detect the overlapping influence of several pathways. The case of Vietnam suggests the existence of a forest transition path associated with agricultural intensification by smallholders in marginal regions. It was caused

by a combination of “push and pull” factors. Through several policies (Resolution 10 in 1988 and the Land Law of 1993), economic liberalization, paddy land allocation, and market integration increased the profitability of cultivation in lowlands. The rapid deforestation in mountainous regions combined with a high population density led to a reduction in fallows, soil erosion on hillsides and a shortage of suitable land for shifting cultivation. The relative profitability of slash-and-burn cultivation in the uplands declined compared to the cultivation in valleys. Farmers therefore intensified paddy rice cultivation by shifting labour to the plots with the highest agro-ecological potential. Absent any mechanization, little labour force was left for slash-and-burn agriculture or paddy lands expansion. The upland plots were thus either abandoned or planted with trees. Forestland allocation after 1993 and zoning policies mainly after 1991 reinforced land scarcity and prohibited newcomers to claim degraded land abandoned by farmers. These changes contributed significantly to the increase in natural forest area in mountainous regions of Vietnam (Fig. 1). The effectiveness of forestland allocation policies was also influenced by economic and agricultural changes: where paddy lands were abundant and paddy rice cultivation intensive, farmers had an alternative to shifting cultivation. The policy was therefore more easily accepted. Where paddy lands were scarce, policy restrictions on shifting cultivation in forestlands were less strongly enforced. Forestland allocation by itself was not sufficient to stimulate forestry activities and forest planting. Market outlets and capital investments were also necessary. Following the forest transition in Vietnam, the (often illegal) import of timber from neighbouring countries accelerated and fuelled the growth of the wood sector (Meyfroidt and Lambin, 2009). Clearly, when dealing with a particular case of land use transition, the elegant simplicity of a few clear-cut pathways gives way to rather messy interactions between elements of all the above pathways. In the case of the forest transition in Vietnam, we find land scarcity induced by natural resource degradation and state policies, which leads smallholders to intensify agriculture and to integrate in the market.

Socio-ecological feedback

A decline in the provision of ecosystem services clearly contributed to initiate the forest transition. Several signals of forest degradation and resource overexploitation had been perceived at the highest political levels. Scattered tree planting during the New Year festival was initiated by Ho Chi Minh in 1959 and demonstrated the importance of trees and forests for livelihoods (Le, 1999; De Jong et al., 2006). The severe impacts on Vietnamese forests of the Second Indochina War gave rise to the term “ecocide” (Weisberg, 1970; Westing, 1983). Although other factors contributed more to deforestation (De Koninck, 1999), forest degradation during the war contributed to the recognition of reforestation as one of the biggest challenges for Vietnam (Vo Quy, 1992; Veilleux, 1994). The increasing scarcity of suitable trees to cut forced several forestry enterprises to cease their activities and threatened the wood processing industry of shortages of raw material (Castren, 1999; Ministry of Agriculture and Rural Development, 2001). In neighbouring Thailand and China, exceptional flood events triggered drastic forest policy changes in the 1990s (Durst et al., 2001). Although no significant floods associated with deforestation took place in Vietnam during the 10 years preceding the forest transition in 1993 (from the EM-DAT database, n.d.), Vietnamese scientists had warned of the growing impact of typhoons and floods attributed to deforestation and the consequent necessity to protect forests (Veilleux, 1994). National political decisions that led to the forest transition were also influenced by a perception of ecological degradation. Rights and responsibility of

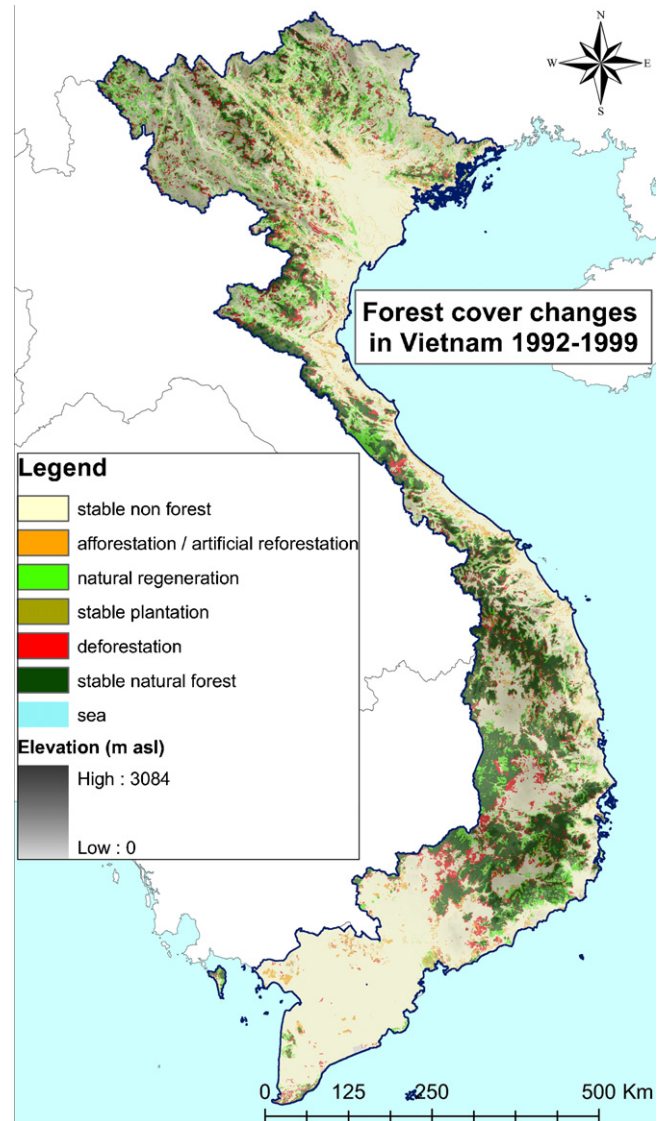


Fig. 1. Forest cover changes in Vietnam, 1992–1999, according to Forest Inventory and Planning Institute (FIPI) data. Tree plantations are concentrated close to the main industrial centres, in the midlands of the northern region and central coast, and in the Mekong plain in the south of the country. Natural reforestation occurred mainly in the mountains of the northern region and central coast, where forests were severely depleted in the early 1990s. Clearing for primary forests was still taking place during the 1990s in the central highlands.

forestlands were transferred to households to encourage their sustainable use and promote reforestation (Sikor, 1998; Mellac, 2000; Clement and Amezcaga, 2009). The ban on exports of raw cut and sawn wood promulgated in 1992 was reportedly a decision of the Prime Minister following a tour in wood processing enterprises that were obviously exceeding their quotas (McElwee, 2004). The government also abandoned the policy of food self-sufficiency of each province, which failed in the mountainous provinces, and emphasized the complementarity and specialization of regions based on their natural advantages (Castella et al., 2006). This new policy orientation is consistent with the theory of adjustment of land use (Mather and Needle, 1998).

Socio-economic dynamics

The policies that contributed to the forest transition in Vietnam were also embedded in broader socio-economic dynamics.

The privatization of land and production means, and liberalization of agricultural markets were part of a general policy reform, called Doi Moi, in response to the economic stagnation and food crisis in the country (Esterline, 1987; Pingali and Xuan, 1992; Kerkvliet and Porter, 1995). Agrarian reforms in China may have acted as an example for the Vietnamese government, in a case of mimetic institutional isomorphism—i.e., organizations facing uncertainty model themselves on other organizations perceived as successful (DiMaggio and Powell, 1983). Yet, bottom-up pressures coming from peasants and *de facto* decollectivization preceding the reforms suggest that internal factors were more important (Cima, 1989; Kerkvliet, 1995). The allocation of forestlands to households was an application of decollectivization to forests (Do, 1994; Sikor, 1998; Mellac, 2000). The stated rationale for the forestland allocation and reforestation programs was to put so-called bare and unused lands – actually fallows – into productive use, and to control shifting cultivation and nomadism, which were seen as backward practices, associated with poverty and causing deforestation (Do, 1994; Sikor, 1995; Jamieson et al., 1998). This view already inspired policies since colonial times (Mellac, 2000). The first large-scale reforestation program – Decree 327 started in 1992 and commonly known as “Regreening the barren hills” – was mainly a project aimed at socio-economic development for which “quick returns on funds were given priority” (Council of Ministers, 1992; Lang, 2002). The subsequent large-scale program – Decree 661 known as the “Five million hectares reforestation program” and started in 1998 – was focused on timber production to support industrial activity (Ministry of Agriculture and Rural Development, 2001; Clement and Amezaga, 2009). These programs had also environmental objectives – claimed to be at the same level as economic objectives – i.e., “to ensure environmental security, reduce natural disasters, increase the capacity of water generation and preserve the source of genes and biological diversity” (Prime Minister of the Government of Vietnam, 1998). However, reforestation programs relied mostly on fast-growing species such as eucalyptus and acacia that have mixed impacts on soil and water regulation and are hardly useful to preserve biodiversity (Cossalter and Pye-Smith, 2003; Clement and Amezaga, 2009). This suggests that policy-makers prioritized economic development and the supply of raw material, and held a simplistic view of the environmental benefits of forests—any tree that puts a green cover on land is equally good (Clement and Amezaga, 2009).

Other political motives also played a role in the policy changes. The State Forest Enterprises (SFE), which were responsible for all aspects of forestry management until the 1990s, are powerful actors in the forestry arena. They are closely linked to the political apparatus and generate significant incomes in some provinces (Lang, 2001; Clement and Amezaga, 2009). In the 1990s, when the large-scale reforestation programs were started, their financial situation was difficult and their status was progressively transformed from governmental to autonomous organizations that were expected to be economically viable (Sikor, 1998; FAO, 2001). Most of the capital from reforestation programs was channelled through the SFE, by giving them responsibility over the technical implementation of reforestation contracts with smallholders and over the funding of protection contracts of large forest areas given a protection status by the state (Clement and Amezaga, 2009). SFE were also allocated most of the forestry land still covered by forests, while smallholders were mainly allocated barren lands. Economic interests of the SFE were therefore, if not a cause of the reforestation programs, at least an important factor in their design. The land use zoning, land allocation and prohibition of shifting cultivation were also aimed at increasing the control of the government

on remote regions and their populations (Lang, 2001; McElwee, 2001; Sowerwine, 2004). The continuation of forest colonization policies in the central highlands (Fig. 1) suggests that territorialization was more important than forest preservation. Finally, the political reforms coincided with the emergence of the sustainable development ideology in the international arena. Promoting the environmental dimension of these reforms and developing ambitious reforestation programs was an effective way to attract capital from foreign donors (McElwee, 2001; Sowerwine, 2004; Zingerli, 2005).

In summary, a perception of ecological degradation probably triggered some of the policy changes that contributed to the forest transition, but the design of these policies, the strong commitment of the government and the emphasis on industrial tree plantations had three socio-economic and ideological motivations: (i) transform “waste” uplands into productive land for the national economy, (ii) implement a liberalization, decentralization and individualization of rights as part of Doi Moi reforms, and (iii) improve the image of the country on the international scene. These elements were backed by the socialist ideology of the Vietnamese leaders, which promotes an anthropocentric and utilitarian interaction with nature and emphasizes economic modernization (Bach Tan Sinh, 2003; Pham and Rambo, 2003).

Motivations of local land managers

Socio-ecological feedbacks may have played a more direct role in land use decisions by local land managers than was the case for national-scale decision-makers. In Khang, a small village of the Tay ethnic group in the northern mountainous province of Bac Kan, farmers interviewed by the authors justified the abandonment of shifting cultivation based on three reasons: limited availability of land suitable for cultivation due to land degradation (as confirmed by Tachibana et al., 2001; Castella and Quang, 2002); greater awareness of the importance of ecosystem services provided by forests, in particular flood and waterflow protection; and difficulty to continue shifting cultivation due to the forestland allocation policy. However, farmers also acknowledged that their main response to increased flood risk was to adapt – by building bamboo walls and cleaning paddy lands – rather than to restore the forest cover on steep slopes to prevent floods. Many villagers welcomed the forestland allocation policy as it assigns responsibility about forest protection to every household, with collective benefits. The perception of resource degradation and land scarcity may have prepared farmers to accept the new forest policy. The changing policy and economic context – that originated largely outside the forest sector and allowed agricultural intensification in the lowlands – was also necessary to decrease upland cultivation (Sikor, 2001; Castella and Quang, 2002). For the most marginal farmers with no access to paddy lands, contracting cultivated areas was imposed by external forces: forestland allocation, land use zoning and the reinforcement of penalties (Castella et al., 2006; Jakobsen et al., 2007).

Contrary to forest recovery in mountain areas that are dominated by smallholder cultivation, the expansion of timber and fruit tree plantations in more accessible and high potential regions were mainly driven by urban and industrial demand and encouraged by reforestation programs (Fig. 1). These plantations, which account for about half of the reforestation in Vietnam between 1992 and 2005, are therefore driven by economic development forces that are exogenous to the local scale. In sum, while endogenous socio-ecological feedbacks at the local scale have played a role in the forest transition in marginal regions of Vietnam, active reforestation in high potential regions was driven by economic development and urban market demand.

Conclusion and discussion

Several well-supported causal mechanisms exist to explain land use transitions. These relate both to the socio-ecological feedback hypothesis and to the hypothesis of exogenous socio-economic changes affecting land use. In the recent cases of forest transition, socio-ecological feedbacks seem to better explain a slowing down of deforestation and stabilization of forest cover, while exogenous socio-economic factors better account for reforestation. While a perception of resource scarcity or degradation in ecosystem services prepare local agents for the need to adopt new land use practices, it is only once new opportunities arise from external markets, migration, or capital investments that they actually adopt land-saving practices, diversify income sources, and invest in forest restoration. The first dynamic operates largely through people curtailing unsustainable land use practices while the second activity requires an investment and therefore only occurs once there are visible opportunities. State interventions could, however, upset this set of incentives. Grainger (1995) and Klooster (2003) already indicated the utility of disaggregating the forest transition into a land use component—a stabilization of forest cover and agricultural abandonment – and a forest use component – forest recovery thanks to sustainable forest management and protection.

In general, there is little evidence that societies retreat from natural ecosystems because they have been degraded, therefore leading to nature recovery. Rather, institutional or technological innovations are taking place to accommodate the new environmental constraints. Interpreting and modelling the dynamics of socio-ecological systems by analogy with the dynamics of natural ecosystems is useful to a certain point only. While endogenous processes dominate the latter, social systems are more affected by the spread of innovations that originate from outside the boundaries of the local system. Economic, technological or institutional innovations do not necessarily arise in response to resource limitations—as much as a lack of stones was not the driving force of the Bronze Age revolution.

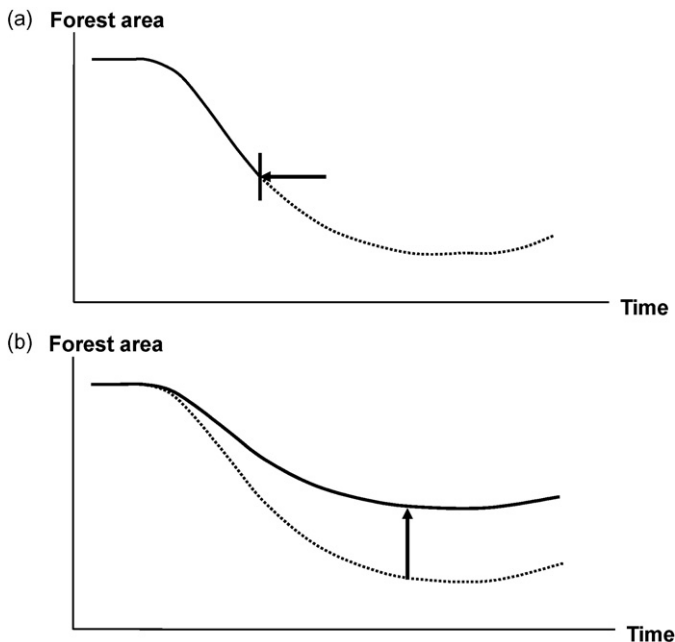


Fig. 2. Schematic representation of two types of forest policy interventions: (a) halting deforestation and (b) accelerating the forest transition.

Globalization in its various forms has contributed to a land use transition in some countries. Currently, much discussion is focused on the design of global institutions to control tropical deforestation. Foremost, this includes the “Reduction of Emissions from Deforestation and Forest Degradation” (REDD) policy proposed under the United Nations Framework Convention on Climate Change (UNFCCC). A widely shared perception of the risks associated with irreversible forest destruction and its contribution to climate change has been the impetus to design institutions addressing the ecological degradation issue where no private actors would intervene spontaneously. Once implemented, a scheme such as REDD would create more economic opportunities for sustainable forest uses under various land development schemes compatible with the preservation of a forest cover, thus increasing the likelihood of forest regeneration. To ensure more permanent social and ecological benefits of such policies, the focus should be shifted from halting deforestation (Fig. 2a) to initiating or accelerating forest transitions (Fig. 2b). This paper suggests that this would require a set of interventions outside the forestry sector, to account for the exogenous factors that historically have contributed to forest transitions. It would also have to include guardrails to avoid a replacement of primary, old-growth forests by monoculture tree plantations.

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