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Deforestation Dynamics: A Review and Evaluation of Theoretical Approaches and Evidence from Greece

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1. Introduction

Amongst others, forest land use changes occur for multiple reasons and from interacting processes and mechanisms. Human-driven changes, at an array of scales, are affecting forest ecosystems accelerating changes such as global warming with adverse consequences on human well being. Research has demonstrated that, in the long term, there is to not a single factor or set of factors that can explain the emerging patterns of land uses and their associated changes (Chomitz and Gray 1996; Lambin, Turner et al. 2001; Aspinall 2004). Yet, the importance of forests on global environmental issues such as biodiversity loss and global warming is apparent.

Deforestation processes have different characteristics across space and time (Verburg, Schulp et al. 2006). A particular combination of factors that may explain deforestation pattern somewhere, might not be applicable for justifying change in any other location or time period (Mahapatra and Kant 2005). Therefore, there is a need for conducting empirical investigations in order to analyse and understand the geographical and historical context of land use changes. In addition, forest fragmentation, conversion and modification have significant economic, social and environmental implications (Elands and Wiersum 2001; Walker 2001; Platt 2004; Verburg, Overmars et al. 2006) such as disruption in continuity of the natural landscape, forest and open-land constriction between agricultural and urban land uses, deterioration of vital habitats that sustain valuable biodiversity as well as broader issues such as air pollution.

In this paper, we concentrate on reviewing and evaluating deforestation-related theoretical schemata. We introduce a representative collection of theories dealing, directly or indirectly with deforestation processes in order to provide guidance to an appreciation of the past and the future land use patterns. In addition, we give evidence of recent deforestation dynamics in Greece.

2. Framework of review and evaluation

Theories are presented in a timeline context. There is also a set of criteria used for the evaluation. The criteria are presented in table 1.

EVALUATION AXES	SPECIAL CRITERIA OF EVALUATION
A. SCALE	A.1 Human decision level A.2 Spatial Level A.3 Temporal Level (time step)
B. FOCUS OF THE THEORY	B.1 Raking of the phenomenon B.2 Descriptive B.3 Causal B.4 Predictive
C. MAIN MECHANISM OF LAND USE CHANGE	C.1 Economic Mechanisms C.2 Social Mechanisms C.3 Administrative-Political Mechanisms C.4 Natural Resources
D. INTERDISCIPLINARY	D.1 Transectoral focus D.2 Sectoral focus
E. NATURE OF THEORY	E.1 Descriptive E.2 Geometrical E.3 Mathematical
F. LEVEL OF DEVELOPMENT	F.1 Developed countries F.2 Developing countries

Table 1. Framework for evaluating of deforestation-related theoretical schemata.

a. The scale in which the theory can be applied for describing and interpreting land use changes.

The significance of scale is critical and concerns:

- The human decision-making process (single person, household etc).
- The *geographical unit of analysis* (spatial analysis) in which the theory can be effectively applied (city, region, country).
- The *time unit of analysis,* (temporal analysis) which is connected with the ability of the theory approaching short-term, medium-term or long-term changes.

b. The central aim of the theory.

Theories, mainly attempt to classify, describe, explain or even forecast spatial tranformation phenomena. Classification is a way of categorizing observed land use changes, so that any likely differences or similarities in the way that spatial phenomena transform space, are better understood. Descriptive theoretical approaches, in addition to classifying observed complex geographical formations, also attempt to determine concrete functional relationships and processes that, in turn, reveal likely associations between different uses of land. Explanatory theoretical perspectives concentrate on the determination of factors and dynamics that produce, wear out or eliminate certain land uses. Finally, predictive theoretical perspectives focus on the projection of spatial phenomena into the future aiming at forecasting any future composition of land use system.

c. Main mechanism of land use change.

The comprehension of underlying causes associated with land use change processes as well as The understanding of the major mechanisms of land use allocation is a critical matter. The existing theoretical pool in the field of land use change includes diverse approaches that either focus on economic processes and factors or on social and administrative processes, or support that the spatial distribution of different land uses is determined by the existing

distribution of natural resources. Therefore, it is extremely significant to understand the particular mechanism or set of mechanisms that each theoretical perspective puts forward in order to approach successfully complex spatial phenomena.

d. Sectoral or multi-sectoral approach.

The choice of how to approach a particular land use change process is of critical importance. Some theoretical perspectives follow a sectoral approach whereas some others employ an inter-sectoral logic. In the first case the theory focuses in only one category or subcategories of land use (rural use, urban use, forest use, or residence, industry, tourism, etc.). In the second case, the focus is shifted towards interpretation of intersectoral phenomena connected with observed land use transformations (e.g. urban sprawl etc).

e. Nature of theory.

The way that each theory has been stated or presented, relates to the level of formalism and scientific severity. Generally speaking, most theories adopt a verbal, geometrical, or mathematic approach or a combination of them, as a basic platform in putting forward their key statements.

f. Level of development

Remarkable differences in the levels of economic growth between countries have caused the emergence of at least two general categories of theories. There are theories suitable for satisfactorily interpreting spatial phenomena in developed societies, and also theories that mainly apply best in the case of less developed countries.

Below, an attempt is made to critically review some of the most important theoretical approaches that directly or indirectly refer to processes in forest land use change.

3. Review of theoretical approaches

This section provides a brief review and evaluation of theoretical approaches on the phenomenon of forest land use change. The purpose of the review is to locate the major proximate and underlying causes of deforestation proposed by the literature. Recent attempts to theorise forest land use changes have yielded some noticeable contributions on the field of deforestation.

One such contribution referred to as "*forest transition theory*" has been put forward by Mather, Grainger and Needle since the early '90 (Grainger 1995; Reid, Tomich et al. 2006). According to this theoretical perspective, an overview of forest land use changes in the long run, provides firm evidence that while initially forest land areas retreat at a high speed, at same point, depletion starts slowing down. There is even a critical point over which the process of depletion reverses and forest land recovers by expanding into new areas. *Prosperity level* seems to have a key role in the whole process. The main land use change mechanism suggested by this theory is of economic nature and also has some common places with Kuznets' Environmental Curve (Koop and Tole 1999; Ehrhardt-Martinez, Crenshaw et al. 2002) that links national or regional environmental quality with the state of economic development. The spatial level of analysis that the theory best applies is to nationwide or higher.

Based on the aforementioned perspective, Mather (2006) and Grainger (1995) state that most of the developed countries have been in a state of forest transition as forest land has been expanding for several decades. Explanations concerning forest transition processes are sought both in *development theory* and *modernization theory*. These theoretical perspectives focus on the importance of economic and social changes that spring from the adjustment of

the economic, social and political structure to technological advances. In this respect, during the course of development increased pressure is put on forest land due to higher demand for land and forest related products. As a spatial unit moves to higher stages of development, pressure on forest land retreats because technological innovations allow for increased productivity in the primary sector, limiting the needs for expansion on forest land. At the same time, the increased rates of urbanization drive large waves of population away from the countryside into cities and towns lowering the pressure on forests by human activity in exurban remote areas.

A sizable body of empirical research on forest transition theory has generated considerable evidence in favour of some of the theory's reasoning (Koop and Tole 1999; Ehrhardt-Martinez, Crenshaw et al. 2002; Geist, McConnell et al. 2006; Reid, Tomich et al. 2006). Empirical evidence systematically suggests a negative relationship between the rate of deforestation and the rate of urbanization or the level of new technology adoption in the primary sector (Perz 2007).

In a recent attempt of improving the context of the theory, Angelsen (2001) suggests that the stages of forest transition theory (low deforestation, intense deforestation, containment of deforestation, afforestation) can be better understood by focusing on the fundamental characteristics of the long-term relationship between *agricultural land rent and forest land rent*. Mathematically, this means that forest land use changes $[DU]_{fr}$ are a function of agricultural land rent $[LR]_{agr}$ and forest land rent $[LR]_{frs}$ of the type

$$DU_{fst} = f\left(\frac{LR_{agr}}{LR_{frs}}\right).$$

In this case, the most important part of the analysis is to identify the way and magnitude of the influence of applied policies on agricultural and forest land rent. However, Angelsen points out that diagnosis and measurement of the actual influence of policies on land rent is, at least difficult to achieve, since on top of the obvious and direct impacts, economic phenomena are usually involved in numerous feedbacks and interactions that produce new waves of influences on land rent. For instance, the adoption of a new technology in agriculture may initially make agricultural activities more profitable fueling the expansion of agricultural land on forest land. In the long run, however, balancing effect will emerge due to changes both in agricultural goods prices and wages in agriculture leading to the containment of the expansion or even a reverse process of forest advancement.

The aforementioned analysis by Angelsen focuses on tropical regions, where one of the most important proximate causes of deforestation is believed to be agricultural activity. However, in cases where urban land uses control the process of deforestation, the relationship between forest and urban land uses in terms of land rent might constantly fuel urban expansion. An additional consideration regarding the Agelesen's land rent approach rests on the property regime of forest resources. In several parts of the world, the great share of forest land belongs to the state and not to private owners. In those cases, where the state cannot assure its one rights on land there is more scope for forest land encroachment and exploitation through logging and cultivation. In these cases, forest land use change processes maybe better understood on the basis of Hardin's theory of *the tragedy of the common* (1968). Individuals when act independently might have no motives for considering the need for a sustainable use of shared natural resources (Herschel 1997). The negative external

economies by the depletion of forest resources are spread to society whereas the economic profits from wood exploitation and agricultural production in formerly wooded land are capitalized on by the intruders.

Approaches for unsustainable forest resource exploitation are not scarce. Several researchers (Roberts and Greimes 2002; Shandra, London et al. 2003), drawing from the "*theory of dependence*" by Baran, Frank and Amin as well as from "*world systems theory*" by Wallerstein, claim that the developed regions have establish a particular system of economic exchange that imposes certain land use patterns to the less developed regions. This particular economic exchange process between the developed and the less developed peripheries takes place on unequal terms resulting in the unsustainable use of natural resources in the less developed areas. Power, wealth and prosperity are, therefore, related to the depletion of forest resources in the developing regions and to the sustainable use and possible expansion in prosperous regions.

Both the importance and the adaptive nature of strategies employed by agents in order to maintain their prosperity level were firmly established in the context of "*multi-phasic response theory*" proposed by Davis in 1963. It is now believed that applied more broadly, *multi-phasic response theory* can help to understand how agents decisions impact land use changes (Lambin, Geist et al. 2006).

A similar body of approaches attempts to apply concepts from "*game theory*" in order to capture agents' behaviour in forest land use change process. (Fredj, Martvn-Herrɑn et al. 2004). According to some of these perspectives, the major decisive force of the way forest resources are utilized is state policies. State policies are far from static paying particular importance to economic growth during periods of economic difficulties where environmental concerns are ranked low in social agenda. Therefore, regardless of the level of economic development, the changing conditions of economy over a period of time could result in the adoption of a sustainable or a less sustainable behaviour towards forest resource. However, in some cases the unsustainable behaviour adopted by agents may not lay on the difficulties brought about by unfavourable economic conditions. It might be, in fact, an act of land speculation based on either high tolerance shown by the political system or insufficient administrative and environmental monitoring mechanisms. Yet, in the context of game theory it is proposed that it is possible to arrive to sufficient and sustainable solutions to the issue of deforestation through cooperation and coordination of the involved parties and individuals (Fredj, Martvn-Herrɑn et al. 2004; Stern 2006).

On the other hand, there is a quite different view concerning the current social behaviour and state intervention towards forest resources. It is widely believed that current afforestation policies are not merely an opportunistic reaction to the undisputed acute depletion of forest resources and its associated impacts. Instead, they also revile a much deeper transformation of social attitudes and ethics towards the environment. Mather et. al (2006) argue that at least in the case of developed countries, a great part of society is driven by the principles of *post-productivism philosophy*. Profit maximisation is not the only as well as the central axis of individual behaviour formation. Economic growth is possible to coexist with protection and restoration of the environment. Several aspects of this new philosophy of *post-productivism* can especially be traced in the countryside (Shucksmith 1993) in the form of certain environmentally sensitive policies that are voluntarily embraced by farmers. Amongst other, afforestation policies, organic farming measures and codes of good agricultural practice aim to establish alternative agricultural land management as well as

sustainable ways of agricultural production. Current agricultural land uses are increasingly characterized by the aforementioned *post-productivist* features (Reid, Tomich et al. 2006) as the demand for environmental services has risen sharply in developed regions during the last decades. Therefore, land use changes in the countryside could possibly be better understood in the light of society's priorities in the context set by *post-productivism*.

In this respect, *Maslow's theory of the hierarchy of needs* maintains considerable potential in explaining certain emerging land use conversions as well as land use qualitative modifications in exurban land use systems. The importance of the new *post-consumption social motives and ethics* stresses Inglehart (1990) pointing out that current economic, technological, and sociopolitical changes have resulted in an apparent transformation of the fundamental cultural characteristics of developed societies. This transformation is ceaseless and has a greater impact on new generations. As new generations replace the older ones in the system of political, social and economic organization, the characteristics of adopted economic development strategies change, as well incorporating more environmental considerations. The implied redirection in priorities, behaviours and ethics is mostly reflected on agricultural policies and thus on rural land uses. Nowadays farmers receive more subsidies and other benefits in order to sustain and improve the quality of soil than to increase agricultural goods production.

Recently, the concept of *post-productivism* has been enriched with a spatial dimension grounded on the observation that some regions have developed stronger *post-ponductivism* structures than others (Agarwal, Green et al. 2002; Reid, Tomich et al. 2006). *Post-ponductivism* is thought of as a spatial phenomenon too, that is strongly connected to the rural patterns of land uses. Amongst others, Marsden (1998), Groot et. al. (2007) and van der Ploeg et. al. (2000) underline the fact that there exist considerable spatial differences within developed countries at the regional level in relation to the intensity one can observe evidence of *post-productivism*. Nevertheless, Mather argues that in spite of the observed spatial differences in the strength of *post-productivism* characteristics amongst developed countries and regions, the phenomenon is present and lies on deep social and cultural transformations in progress in the developed countries. Such transformations are capable of inducing constructive institutional interference which is both a cause and a consequence of new policy planning and application.

The emergence of *post-productivism* concept as a mean of interpreting the observed rural land use changes has received considerable criticism. Among others, Evans believes (2002) that productivism and post-productivism carry a dualistic meaning just like fordism and post-fordism, and therefore, cannot contribute to an in-depth understanding of complex spatial phenomena. Alternatively, more solid theoretical approaches should be considered such as the *regulation theory*. According to this perspective, new economic patterns and social structures are the result of capitalist economic crises as well as efforts to overcome these crises. Accordingly, the observed spatial inequalities and the associated land uses and characteristics of agricultural sector are analogous to the established production relationships, to spatial division of labour and to changing power allocation in the field of governance.

Recently, *ecological modernisation theory* has been proposed as an alternative to *post-productivism* argument in terms of rural land use change theorisation. According to the advocates of this view (Andersen and Massa 2000; Buttel 2000; Marsden 2004), it is possible and therefore it should be pursued, economic growth and social prosperity to be in line with environmental protection. Technological advances are at the core of this perspective as they are thought of

being able of substantially contributing to the effective utilization of natural resource and to the decrease in the volume of both utilized raw material and produced waste.

Another recent view on managing deforestation proposes the concept of *"compensated reduction"* (Santilli, Moutinho et al. 2005). According to this view, countries that are chosen to lower their national level of deforestation should receive post facto compensation if they commit to stabilize or even reduce deforestation in the future. In other words, designing and offering large scale incentives might be a strategy capable of managing high deforestation rates as it occurs in tropical forest regions. This proposal works similarly to the Certified Emissions Reductions (CERs) or the Clean Development Mechanism (CDM). It also relates to the notion of valuation of the "unpriced" services of forests in order to reduce deforestation through economic mechanisms.

In several instances, there exist perspectives linking deforestation directly to the expansion of agricultural activities. Deforestation due to agriculture expansion is threatening several critical aspects of the environment such as biodiversity. Regarding the driving factors, it is thought that technological development and international prices are the basic drivers of crop expansion. Nevertheless, local actors can develop ways to apply sustainable changes in the economic activities and reduce negative impacts managing deforestation rates through conservation policies. It seems, that the powerful position of some actors in the predominant production and distribution chains of agricultural goods is influenced immensely where generated prosperity accumulates (van der Ploeg 2000; Allen, FitzSimmons et al. 2003). In several instances, the greatest share of added value deriving from the ongoing restructuring of agricultural sector is not yielded by local producers and as a result the future course of sustainable agricultural systems appears uncertain (Smith and Marsden 2004). It is suggested that a reasonable response to the aforementioned issue could be the placing of restrictions on the size of food distribution enterprises as well as localising their characteristics (Raynolds 2000; Allen, FitzSimmons et al. 2003; Seyfang 2006; Feagan 2007). However, such arguments are directly opposite to the prevailing process of globalization in food production and distribution. It might be more realistic as well as effective to accent and emphasize the fundamental qualitative differences between globalization and localization approaches.

Globalization of food production and distribution systems abstracts and alienates economic transactions from their social and environmental context (Raynolds 2000; Seyfang 2006). Heterogeneity of rural social and natural forms and processes is neglected. In globalisation era, it is almost impossible for a consumer of a particular agricultural commodity to identify the particular social relations and environmental circumstances under which the commodity was produced (Allen, FitzSimmons et al. 2003). Contrarily, the suggestions of *green economy* favour the identification and designation of the social and environmental framework of production allowing the emergence of *economies of place* (Seyfang 2006).

The success of economies of place, however, presupposes reconnecting effectually consumers and producers and establishing trustfulness and reliance amongst all involved actors (Seyfang 2006). Hence, it might be worth focusing on raising *social capital in agriculture* as well as building sufficient stocks of trust, communication and cooperation (Rahman and Yamao 2007). Even though, some critical views (Hinrichs 2003; Winter 2003; Winter 2005) point out that economies of place form a defensive strategy towards the ongoing globalization-driven transformations in agricultural production and distribution.

This strategy is even likely to result in certain spatial disparities in the near future. At the regional and national scale the shift of society towards quality local products may apply

high pressure on the developing regions and nations which primarily rely on exports of agricultural products. Sustainable consumption, therefore, has a worth investigating spatial dimension needing more thorough consideration. In this respect, the notion of *global ecological citizenship* suggests that duties and obligations should be perceived in a wider scale and that consumption of agricultural goods should be guided by global sustainable thinking (Dobson 2003; Smith 2005).

The theoretical schema of desakota by McGee (2007; 2008), is a relatively recent perspective trying to put urban expansion and land use change in the broader context of globalization. The perspective attempts to integrate new economic developments, technological change and other higher level forces with lower level factors such as distance, availability of infrastructure and new business opportunities. Although the model has mostly been tested in Asian regions, it is believed to hold significant potential for western Europe as well (Xie, Batty et al. 2007).

Finally, the theoretical schemata concerning the structure and evolution of urban space include several perspectives based on urban geography and political economy. Among others the theoretical steam of expanding city addresses the importance of current technological progress in the field of information technologies, the massive increase in the volume, flow speed and spatial extent of goods and services exchanged as well as the new social values and ways of living (Munoz 2003; Zhang and Sasaki 2005). According to Ingram (1998), the contemporary city is characterized by a strong tendency of sprawl for both people and employment (Thurston and Yezer 1994).

Despite their diverse origins and spatiotemporal scales of employment, the theoretical perspectives presented share some common features. It seems that both distance and accessibility have a significant influence on deforestation and land use patterns. Moreover, technological changes in transportation play a key role in urban evolution. The new social ethics, behaviours, preferences and ways of living also influence considerably the structure of space. Population and demographics which are traditional forces of change need also be taken into account in the context of regional and urban development.

Summing up the discussion of the above perspectives, it can be argued that the common ground between the aforementioned theoretical schemata lies on the ascertainment that exurban land use conversions and modifications are advancing at a high rate (McCarthy 2005; McCarthy 2008). To some theorists, those changes are circumstantial or adventitious reactions of invested capital on rural areas in order to protect and insure its reproduction (Evans, Morris et al. 2002). Therefore, the current trajectories of rural land use changes could rapidly shift to new directions due to changes in the global economic environment. On the other hand, a growing number of arguments suggest that emerging land use patterns rely on deeper and stable changes in fundamental characteristics of society in terms of the people's attitude towards natural environment (Inglehart 1990; Buttel 2000). However, it is still evident that the rural land use systems is still a matter of concern and an issue for study and evaluation. In the following sections, we attempt to produce empirical evidences on some of the theoretical arguments described above concerning the case of recent forest land use changes in Greece.

4. Synthesis

Following the literature review on deforestation, It is evident that a variety of economic and social forces might work competitively or additively towards the configuration of land use patterns across the regions or the prefectures of a country (Verburg, Soepboer et al. 2002;

Verburg 2006). Following, we make an attempt to connect all the important aspects of deforestation in a coherent conceptual framework. Based on the conceptual framework, an empirical forest land use change model is proposed and the possible effects of all explanatory variables are discussed hypothesizing that the effect of a particular variable may differ between geographical areas.

The underlying causes of forest land use change vary from locality to locality as well as amongst countries (Wood and Skole 1998; Lambin, Turner et al. 2001; GLP 2005). These economic, socio-cultural and political forces are capable of impacting negatively or positively the extent and distribution of forest land. Their influence on forests usually results in quantitative changes as well as qualitative changes. Both conversions and structural habitat modifications are of great importance to policy makers. Reality is even more complex because of the usual linkages and interactions between positive and negative factors of change (Mahapatra and Kant 2005). The likely aggregated outcome of the combination of negative and positive factors is difficult to understand and predict. However, it may be more feasible to identify some dynamic processes through which socioeconomic and political factors operate resulting in distinct patterns of land uses. In this respect we propose urban sprawl, location decisions of economic activities, agricultural expansion and agricultural abandonment as the main factors of forest land use change.

In most cases, quantification of these forces is a difficult task, as is also difficult finding the appropriate methodology capable of giving reliable estimations of the magnitude and importance of the relationships involved. A wide variety of approaches and techniques have emerged for this reason, with the intention to rationalise decision-making about land use change issues (Upadhyay, Solberg et al. 2006). How and to what extent existing methodologies have satisfactorily reached this target is also a matter of research. Among applied methodologies, statistical techniques concerned with land use change dynamics are the most widely used. These models primarily focus on the causes of deforestation rather than its sources. Observed land use patterns are tightly connected to urban and regional development policies and to the enlargement of the regional economy. Their ceaseless transformation is fuelled by the need for serving the rapidly changing economic and social requirements as well as for fulfilling newly arising demands as a result of economic liberalization, privatization and transformation of lifestyle.

The morphology and evolution of land use patterns have been extensively studied and theorised by scientists of different disciplines (Wood and Skole 1998; Irwin and Geoghegan 2001; Walker 2001; Verburg, Schot et al. 2004; Walker 2004). Thus, a plethora of theoretical and modelling approaches have been developed so far in order to provide possible explanations of land allocation processes. Two general categories of land cover /use changes are described in the literature: conversions and modifications (Baulies and Szejwach 1998; Briassoulis 2000; Lesschen, Verburg et al. 2005). Land cover conversion refers to a change from one cover type to another whereas land cover modification implies structural or functional transitions in cover without loss in initial determinative characteristics. Similarly, land use conversion refers to a complete change from one use type to another whereas land use modification implies structural or functional alterations in use without loss of initial attributive characteristics. Finally, the driving forces (causes) of LUC change can be divided into two categories: Proximate causes and underlying causes. Proximate causes of land use change are associated with coarse anthropogenic operations that directly influence spatial patterns as, for instance, urbanisation, agricultural expansion and forest

exploitation (Geist and Lambin 2001; Lesschen, Verburg et al. 2005). Underlying causes of land use change are associated with generative agents that weave proximate causes, such as economic, socio-demographic and technological factors (Geist and Lambin 2001; Lesschen, Verburg et al. 2005).

Proximate causes	**Land use change forces at the Macroscopic level**	
	Functioning and expansion of urban land forms and activities	Transportation and other kinds of infrastructure
	Functioning and expansion or shrinkage of agricultural activities	Livestock breading systems and forest resources exploitation
Underlying causes	**Economic Factors**	
	Sector arrangement of the regional economy	Sectoral Employment
	Sectoral structure	Investments and business location decisions
	Size and synthesis of imports and exports	Consumption patterns
	Productivity	Diffusion of technology and adoption of innovations
	Competitiveness of the economy	Mean size of businesses
	Technological level of the economy	Scale and agglomeration economies
	Taxation	Investment incentives and development policies
	Income distribution	Added value
	Social factors	
	Population skills level	Housing policy
	Education level	Institutions
	Social infrastructure	Population quality in the public sector
	Social security	Life style
	Demographic factors	
	Population changes	Indirect population potential
	Urban and rural population	Direct population potential
	Age of the population	Population mobility
	Environmental factors	
	Soil fertility	Biodiversity
	Topography	Ecosystem productivity
	Climatic conditions	Water resources
	Stretch of the coastline	Insular or mainland area

Table 2. Proximate and underlying causes of deforestation

Another useful distinction regarding land use change driving forces. could also be taken into account. They can be categorised into "endogenously changed or shifting or metamorphotic forces" that usually change very quickly over time (e.g. employment

patterns of the new economy, location and relocation decisions of certain types of firms, supply and demand of certain products and services) "slow-shifting forces" (e.g. population size and other demographical characteristics) and "conditioning forces" which usually exhibit a temporal stability (e.g. soil types, geomorphology). The last categorisation of driving forces, in a way, implies that a steady state of land use patterns should almost never be expected. This endogenous, ever-changing nature of certain forces has been pointed out by theoretical approaches such as game theory and has also certain modelling implication in land use change studies. As Arthur (2005) states, out-of-equilibrium situations or the emergence of equilibria and the general unfolding of patterns in the economy calls for an algorithmic approach. Land use patterns may represent temporarily fulfilled or unfulfilled complex expectations not necessarily rationally formed as in the case of El Farol Bar problem (Arthur 1994). Table 2 provides a summary of some deforestation driving forces under the aforementioned categorisation framework.

Regarding economic factors, their main effect on land use changes depends mostly on the changes of the sectoral structure of economy. For instance, there might be labour transfer from an economic sector to another as in case of agricultural expansion or large-scale tourism development that may follow a decrease in industrial employment. The aforementioned structural changes are likely to influence decisively the land use system and also result in changes in the allocation of labour and land.

Population movements between regions are also important influential factors of land system. Such movements may have a direction from rural areas to large urban concentrations or there may be a reverse process of rural rebound where people move away from cities towards rural regions. In the first case, there might be intensification of the use of land in peri-urban space. In the second case, land use change happen in the countryside.

Finally, energy policy and taxation in resources such as natural gas and petrol are possible to result in an increase in the use of fuelwood and thus in deforestation or they may result in the development of alternative energy sources such as wind energy, solar energy etc. The likely results on land use system and on forests are complex and difficult to predict. They depend on the applied economic policy and also on the level of environmental awareness of people and authorities.

The impacts of the ongoing economic crisis on forests and on land use system in general, are difficult to forecast as there is no information on the likely duration of economic crisis, and on the particular counties, regions and economic sectors that will be affected most.

5. Evidence from Greece

Land use changes involve several positive and negative impacts on economic, social and environmental aspects. These impacts could have limited territorial scope or wider territorial implications, causing changes in the use of land in a greater geographical scale. (Chhabra, Geist et al. 2006). Impacts can also, have short-term, medium-term or even long-term action, be additive, synergistic, reversible or irreversible. Overall implications depend on recipients' degree of sensitivity, the ability to absorb or cope with pressure, as well as the type, intensity, extent and duration of pressure. Consequently, recognition, estimation and evaluation of likely economic, social and environmental impacts connected to forest land use changes, is a difficult process (Chhabra, Geist et al. 2006). Fig. 1, presents the geographical distribution and magnitude of some key phenomena associated with forest

land use changes in Greece. Based on the information of the Fig. 1, it is possible put forward some comments concerning land use change in Greece:

- High deforestation constitutes a significant process of land use change in several insular as well as mountainous regions of the country (Minetos and Polyzos 2010). A limited number of mainland coastal regions as well as some regions adjacent to large metropolitan areas, present high deforestation rates. Examining the information on the maps, it is obvious that deforestation, very often, coexists with the urban sprawl and illegal housing activity. Beyond the obvious impacts on the biodiversity of these regions, there also emerge several questions concerning erosion processes, flooding and loss of ground via rain water washings. Taking into account that edaphogenic processes follow the geological time scale, such changes should be considered as being irreversible. At the same time, the cost of protecting human activities from flooding events increases, the available fresh water resources lower and microclimate and living conditions at the local level change. In the long term, reduction of biodiversity is expected to affect negatively development opportunities and to also influence the regional level of prosperity (Minetos and Polyzos 2010). Finally, it is worth mentioning that deforestation processes at numerous localities accumulate affecting wider areas at the regional scale and also fuelling global environmental issues such as global warming and climate change.
- Increased conversion and modification of agricultural land present high rates in the case of regions with large urban concentrations, in regions adjacent to the aforementioned ones as well as in several insular regions (Minetos and Polyzos 2009). Processes that contribute to the configuration of this pattern are: (a) Urbanisation of agricultural land and, (b) abandonment of marginal agricultural land. Therefore, in a great number of the aforementioned regions, the loss of agricultural land is connected to pressures deriving from urban sprawl and illegal housing activity (Minetos and Polyzos 2009). In the rest of the regions, loss of agricultural land is connected to the low competitiveness of agricultural sector and the problematic environmental and demographic characteristics within which agricultural activity takes place.
- It is apparent that economic forces such as land-rent, lead to structural changes to the economic base of regional areas in question (Polyzos 2009). However, if we take into consideration the way in which this economic transformation (illegal housing, urban sprawl) is happening, then it is likely that several negative economic, social and environmental impacts will emerge having long lasting action. More specifically, the shrinkage of the economic base of the regional spatial units and, in certain cases, the observed orientation of local economic base to a single activity generates phenomena of "monoculture" (e.g. tourism) in the economy.

Urban sprawl, concerns most regions of the country but it presents particular intensity in the western and southern areas as well as in most of the islands. High sprawl of urban activities in ex-urban location is observed in also relatively remote areas (Polyzos and Minetos 2009). They are also frequent commercial linear developments following the major interregional transportation routes as well as extensive low density areas of urban forms (residential units, tourism infrastructure, etc). A development pattern like this needs to be supported by a large amount of infrastructure (road axes, networks of water supply, networks and installations of waste water treatment) the size of which might be disproportionate to the size of served population.

REGIONS	DEFORESTA-TION	AGRICULTURAL LAND LOSS	URBAN SPRAWL	ILLEGAL HOUSING
Attiki	L	VH	VH	L
Aitoloakarnania	H	H	H	M
Viotia	H	M	M	H
Evia	L	VH	M	H
Evritania	L	VH	VH	L
Fthiotida	M	L	M	L
Fokida	M	H	VH	L
Argolida	L	L	H	H
Arkadia	H	VH	VH	M
Achaia	M	VH	H	M
Ilia	H	H	VH	L
Korinthia	L	VH	M	M
Lakonia	H	VH	VH	M
Messinia	L	VH	VH	VH
Zakinthos	VH	VH	M	L
Kerkyra	VH	M	L	M
Kefallinia	VH	VH	H	L
Lefkada	H	H	H	L
Arta	L	H	M	L
Thesprotia	H	VH	H	M
Ioannina	M	VH	VH	M
Preveza	VH	H	H	L
Karditsa	L	L	M	L
Larisa	VH	L	M	M
Magnisia	L	M	H	H
Trikala	H	M	H	M
Grevena	L	L	M	L
Drama	L	M	L	L
Imathia	M	M	M	VH
Thessaloniki	H	H	L	L
Kavala	M	M	L	H
Kastoria	H	L	M	L
Kilkis	VH	H	L	H
Kozani	H	L	M	L
Pella	M	L	L	M
Pieria	L	L	L	H
Serres	H	VH	L	L
Florina	H	L	L	L
Chalkidiki	L	L	VH	VH
Evros	H	M	L	H
Xanthi	L	L	L	H
Rodopi	M	L	L	H
Dodekanisos	H	H	M	L
Kyklades	H	M	H	M
Lesvos	VH	H	VH	L
Samos	L	VH	VH	L
Chios	VH	VH	L	VH
Irakleio	VH	M	M	L
Lasithi	VH	VH	VH	L
Rethymno	VH	H	H	L
Chania	M	M	M	M

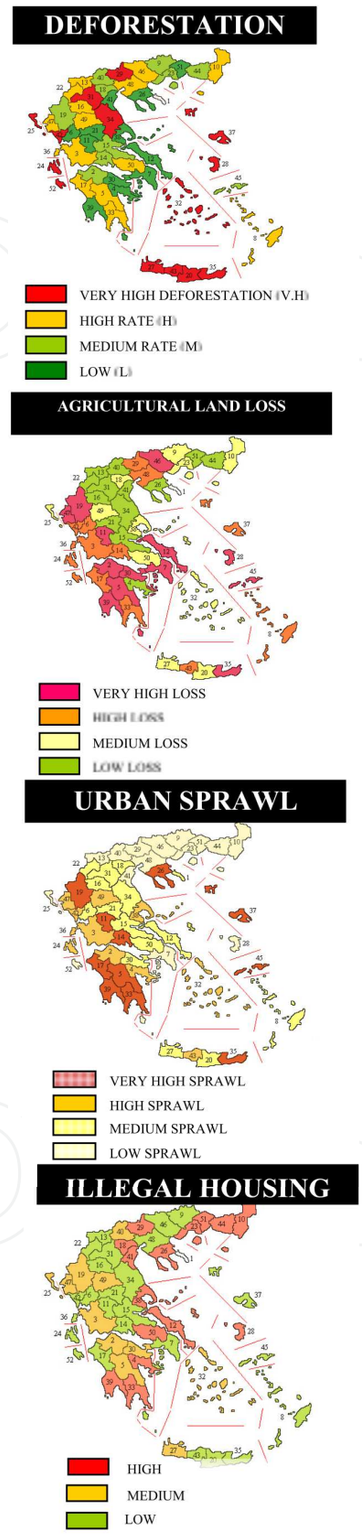


Fig. 1. Matrix of regional spatial units in Greece and the magnitude of significant land use change phenomena (NSSG 1994; NSSG 1995; NSSG 1999; NSSG 2004; NSSG 2004; NSSG 2006).

Illegal housing seems to be high in almost all neighbouring regions to large urban concentrations, and also in several costal locations and remote areas (Polyzos and Minetos 2009). While in the past, illegal housing activity as a phenomenon was concentrated in urban and suburban space, resulting in significant negative consequences to the formation and functionality of cities, nowadays it appears that illegal housing phenomenon influences wider spatial units.

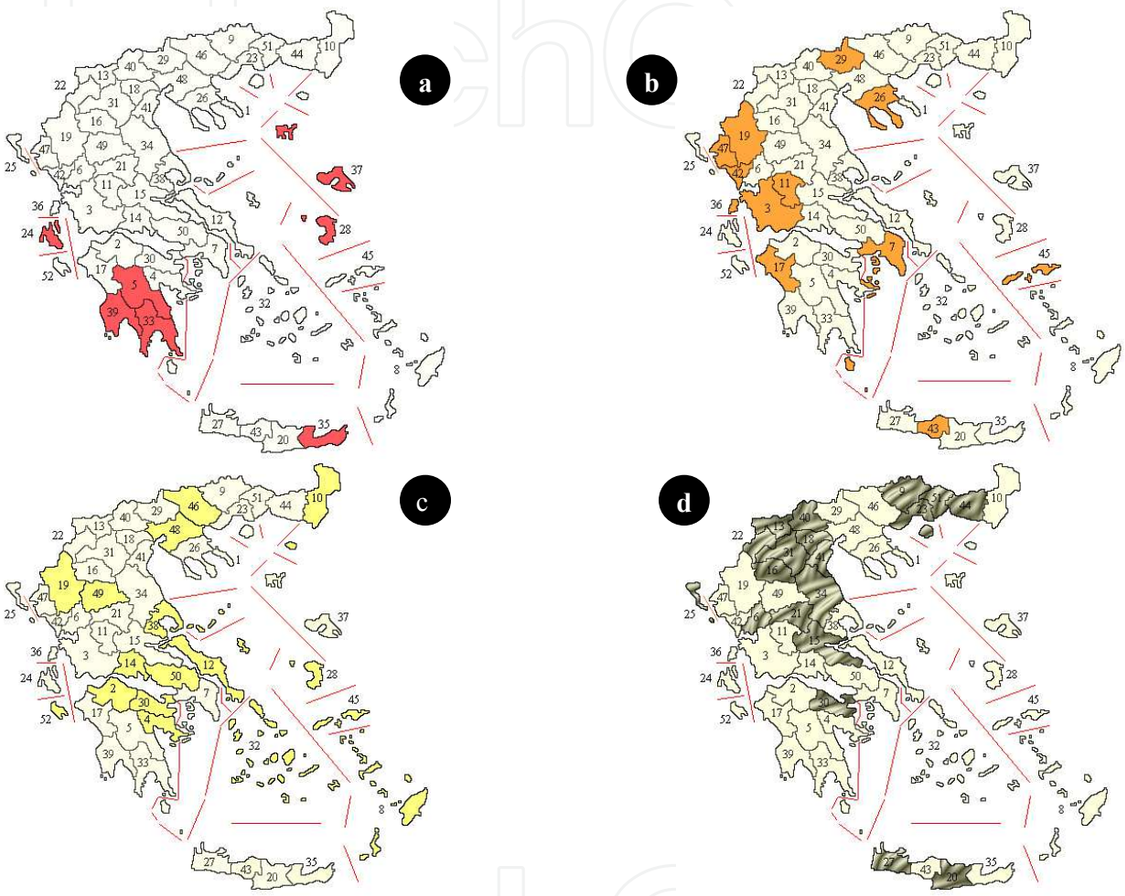


Fig. 2. Hot-spots of land use changes: a) Very significant land use changes b) significant land use changes c) moderate land use changes d) low land use changes

The phenomenon of land use change happens for multiple reasons and also presents important spatial differentiations. In order to acquire an overall understanding of land use transformations and modifications, we attempt to locate "hot-spots" (Reid, Tomich et al. 2006) or "regions of very high activity" across the country (Figures 1 and 2). In the first column of matrix in Fig. 1 we have coloured with red regions that present very high (VH) rates in at least two of the four spatial phenomena that mainly drive land use changes. They also present high (H) activity in at least one of the four aforementioned phenomena. These regions constitute the "hot spots" or "first level areas" of land use change. The spatial "distribution of "hot spots" is presented in the Fig. 2a. In these areas, land use changes are rapid and extensive and they perhaps jeopardize the fundamental regional characteristics as well as economic, social and environmental equilibrium of these areas.

We have also created a second category of hot spots (regions with orange shading in matrix of Fig. 1). These areas include regions with high or very high intensity in three out the four phenomena or regions with very high intensity in two out of four phenomena, excluded the prefectures of first category. These regions constitute constitute "second level hot spots. Their spatial distribution is presented in the Fig. 2b. They are regions in which land use changes are significant in magnitude and their future course may become particularly problematic.
A third category of regions consist of areas with high or very high rate in two out of four phenomena. In these areas, land use changes are of a moderate magnitude either because these regions are in a kind of recession compared to their past size of activity (eg Attica, Thessalonica, Dodekanisa etc), or it is expected that they are going to accelerated in the near future (Trikalas, Ioanninas etc). In most of the rest regions land use change phenomena present low intensity.
Summarising the above discussion, it could be supported that the applied spatial policy in Greece attracts a relatively low interest compared to other sectoral policies. Consequently, objectives regarding regulation of space are not always explicit and compatible while sustainable management of space, protection of environment and relaxation of regional inequalities still remain issues that need to be managed and placed into a proper policy context.

6. Conclusions

This paper has dealt with theoretical perspectives concerning forest land use change in general, as well as the factors of land use changes in Greece. Making informed land policy decisions is central to achieving sustainability at a regional level. Prior to formulating certain sustainable policy objectives and targets, the baseline information needed is the identification kind of the driving forces that influence current forest land use patterns. Generally speaking, these driving forces are closely associated with the economic, social and environmental context within which the regions exist and function. The effects on forest land of the predictor variables that where employed by this study, while significant in most regions are still characterized by many uncertainties. Some theoretically interesting explanatory variables have indicated that the effects of certain processes on land use changes may be important but not always straightforward.
A synthesis and evaluation of the results brings up some important issues relevant to the theoretical framework of the field. In particular, a noticeable argument relates to the course of development of deforestation rate in the long term, when the major competing uses to forests are urban and not agricultural land uses as it is assumed by Angelesen's (2007) model in the case of tropical deforestation. It seems that when the antagonism involves urban and forest land uses and when also the types of forest ecosystems fall into the category of not-productive forests (as it is the case for most Mediterranean forests) then land-rent generated by forest uses is unlikely to compensate for the one coming from urban development of the land. Urban land uses through market mechanisms will tend to outrage forests. As long as the Greek law is strongly opposed to the conversion of forest, it seems that, at least in the sort term, the only way of confronting this market-induced process might be the restructuring of the law enforcement mechanisms.
On the other hand, it seems that in most urban prosperous regions as well as in their vicinity, deforestation has slowed down, although additional data need to be analysed.

Deforestation moves to more remote regions as accessibility improves. There are interactions amongst indirect population potential and illegal housing activity that influence the spatial distribution of deforestation rate. This complex relationship implies a geographical transfer and dispersion of illegal housing phenomenon from urbanized regions to remote, less-urbanized ones. It is likely that urban populations remain the major source of illegal housing activity; however they now tend to exercise this activity in longer distances due to accessibility improvements. If this is the case then deforestation controllers are still in urban areas even though the impacts of their acts are being systematically "exported" to other areas. The geographical transfer of deforestation relieves forests in the places of origin but at the same time, it escalates pressure on the host areas' forests.

An additional issue, relevant to the abovementioned argument, relates to the geographical characteristics of the areas being deforested. In insular prefectures, land surface is a scare resource and areas covered with forests are limited. If such spatial units were involved in a lengthy urban-forest land use antagonism, it would probably be difficult for all stages of forest transition theory to take place. Due to geographical remoteness, small-sized insular regions cannot easily base part of their development on exploiting the land of adjacent regions. Thus, it is difficult for islands to *"export"* deforestation processes. Bearing in mind the scarcity of developable land, high rents associated with urban land uses, the lack of forest cadastral maps and the insufficient forest law enforcement mechanisms, it is more likely for insular forests to move to the direction proposed by the theory of the tragedy of commons rather than the one proposed by forest transition theory. Even if the country as a whole managed to increase its forests, there would probably be winners and losers at the regional scale.

Generally speaking, the spread of urban uses in the countryside has negatively affected forests either directly or indirectly. The improvement of transportation infrastructure, the expansion of urban plans, urban sprawl, illegal housing activity and legal building construction activity create a complex negative background for forest land uses. On the other hand, changes in Gross Domestic Product in agriculture and change in tourism infrastructure either have limited or zero adverse impacts on forests. It seems that the observed improvement in the performance of agricultural sector in the relevant regions has not occurred in the expense of forests through some expansion of cultivated land. In addition, new tourism accommodation infrastructure, possibly due to the mandatory environmental impact assessment introduced in the early '90s, had limited negative effects on forests. However, regions with high growth in their tourism accommodation in ex-urban areas show significant signs of deforestation.

In the context of planning a sustainable forest policy, accessibility issues as well as the spatial patterns generated by urban phenomena such as urban sprawl and illegal housing are of crucial importance. At first glance, the improvement in the regional level of prosperity might be associated with lower deforestation rate. However, it is not certain whether this additional prosperity has been achieved in a sustainable manner. It is likely that improvement in prosperity at some location has been achieved in the expense of forests at some other location. These results could guide further research into improving the understanding of spatial processes such as forest land use changes and into rationalizing forest-related decision making. Strategic project monitoring and appraisal as well as evaluation of project impacts on land uses can help spatial planners and land use decision-makers to introduce specific environmental protection objectives into land development and planning processes.

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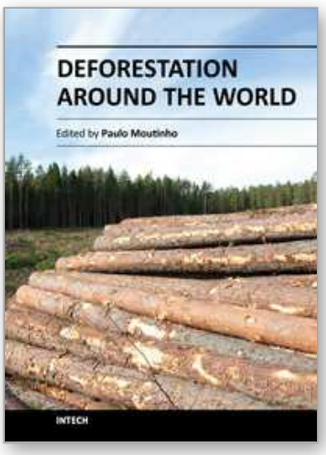
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Deforestation Around the World

Edited by Dr. Paulo Moutinho

ISBN 978-953-51-0417-9
Hard cover, 372 pages
Publisher InTech
Published online 30, March, 2012
Published in print edition March, 2012

Deforestation and forest degradation represent a significant fraction of the annual worldwide human-induced emission of greenhouse gases to the atmosphere, the main source of biodiversity losses and the destruction of millions of people's homes. Despite local/regional causes, its consequences are global. This book provides a general view about deforestation dynamics around the world, incorporating analyses of its causes, impacts and actions to prevent it. Its 17 Chapters, organized in three sections, refer to deforestation impacts on climate, soil, biodiversity and human population, but also describe several initiatives to prevent it. A special emphasis is given to different remote-sensing and mapping techniques that could be used as a source for decision-makers and society to promote forest conservation and control deforestation.

How to reference

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Serafeim Polyzos and Dionysios Minetos (2012). Deforestation Dynamics: A Review and Evaluation of Theoretical Approaches and Evidence from Greece, Deforestation Around the World, Dr. Paulo Moutinho (Ed.), ISBN: 978-953-51-0417-9, InTech, Available from: http://www.intechopen.com/books/deforestation-around-the-world/deforestation-dynamics-a-review-and-evaluation-of-theoretical-approaches

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