

FACTORS INFLUENCING LAND-USE AND LAND-COVER CHANGE

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Keywords: land-use change, land-cover change, determinants of land-use and land-cover change

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Summary

Since time immemorial, humans use land to meet their material, social, and cultural needs. In this process, they are modifying land resources in various ways, often with detrimental impacts on the environment and human well-being. Land cover may change under the influence of biophysical conditions only but, most frequently; it results from human-induced land-use change.

Land-use and land-cover change is influenced by a variety of biophysical and societal factors operating on several spatial and temporal levels, and acting in intricate webs of place- and time-specific relationships. At the level of the individual land unit, relevant biophysical factors include local climate and weather, topography, bedrock and soil type, surface water, and groundwater. The choice of land use and decisions to change it are influenced by the size of the household, age, gender, education, employment, attitudes, values, and personal traits of household members, site-specific conditions—accessibility, *landesque* capital, regional land-use structure—as well as by transportation cost, profits, parcel size, competition, costs of production, product prices, public and private financial support, land-management practices, land tenure, and

ownership.

At higher spatial levels, pivotal biophysical influences on land-use and land-cover change include regional climate, landform, geology, soils, hydrology, vegetation, and fauna. Societal factors relating to population structure and dynamics, income and affluence, technology, socio-economic organization, culture, institutions, and political systems shape demand for land, land-use patterns and their change. Future land-use and cover change will depend, on the one hand, on the dynamic relationships among these factors and the resulting land-use patterns, from the individual to higher spatial levels and, on the other, on national and international direct and indirect policies instituted to mitigate the adverse environmental and socio-economic impacts of land-use and land-cover change.

1. Introduction

Land holds a central position in human existence and development. Since their appearance on earth, humans have used land and its resources to meet their material, social, cultural, and spiritual needs. They have used land for the provision of food, clothing, shelter, and heat; for producing a large variety of goods and services for their own use or market exchange; for moving around and transporting goods; for recreation and leisure; for aesthetic pleasure; for attaining social status and prestige; for spiritual satisfaction; and for claiming territorial sovereignty.

In this process, they have modified and are modifying land in various ways and intensities. Natural forests and grasslands are converted into agricultural and grazing areas for crop and livestock production, to urban and industrial land, and to infrastructure (roads, dams, etc.). Wetlands are drained and converted into agricultural, residential, recreational and industrial uses. Land is mined to obtain ores, minerals, and stones. Cropland undergoes intensification, extensification, marginalization, abandonment, or conversion to urban and recreational (tourist) uses. Abandoned land may be reforested or it may be degraded further. Settlements may experience urbanization, suburbanization, or de-urbanization. Residential areas can be converted into commercial areas and vice versa, high-income neighborhoods may turn into slums, and so on. Land degradation is an extreme form of land-cover change that results from uses of land that overexploit its resources.

Changes in Earth's natural land cover have been taking place since time immemorial, and have been associated with both natural phenomena and human interference. Since 1700, however, land-cover changes have been reported as being human-induced changes, and these have caused diverse, mostly adverse, impacts on both society and the environment. Several ancient writers have documented the destruction of natural areas from salinization, overgrazing, fire, and other human activities. In his 1864 seminal essay "Man and Nature; or, the Earth as Modified by Human Action," Marsh has described how people used and modified land to serve various purposes, altering, thus, the environment. After the 1960s and 1970s, numerous studies documented the detrimental impacts of human activities that began to cause worldwide concern and action. In 1987, the Brundtland report introduced the notion of *sustainable development* in the political arena; the quest for sustainable use of land resources became an

important policy and planning goal. This was translated into a search for a policy and planning approach to direct land-use change towards sustainable pathways.

The recognition of the importance of land-use and land-cover change in the context of global environmental change and sustainable development is perhaps best reflected in the launching, in 1993, of the Land-Use and Land-Cover Change (LUCC) Core Project/Research Program, under the authority of the International Geosphere-Biosphere Program (IGBP) and the International Human Dimensions Program (IHDP).

2. Land-Use and Land-Cover Change—Definitions

FAO defines land as “a delineable area of Earth’s terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the near-surface sedimentary layers and associated ground water reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.)”

Turner et al. define land cover “as the biophysical state of Earth’s surface and immediate subsurface.” The term refers to the type of vegetation that covers the land surface, other aspects of the physical environment, such as soils, biodiversity, surfaces, and groundwater, as well as to human structures, such as buildings or pavement. Land use, according to these authors, involves both the manner in which the biophysical attributes of the land are manipulated and the intent underlying that manipulation—the purpose for which land is used. According to FAO, land use concerns the function or purpose for which land is used by the population; it can be defined as “the human activities that are directly related to land, making use of its resources or having an impact on them.” For a given area at a given spatial level, land use is described by specifying the mix and particular pattern of land-use types, the aerial extent and intensity of use associated with each type, the land tenure status, as well as natural and physical characteristics.

Meyer and Turner explain why "land use" and "land cover" are not identical terms. Land cover denotes the physical, chemical, or biological categorization of the terrestrial surface, for example, grassland, forest, or concrete, whereas land use refers to purposes associated with that cover—raising cattle, recreation, or urban living. Land use relates to land cover in various ways and affects it with various implications. A single land use may correspond to a single land cover, for instance, pastoralism to unimproved grassland; a single class of cover may support multiple uses (forest used for combinations of timbering, slash-and-burn agriculture, hunting/gathering, fuel-wood collection, recreation, wildlife preservation, and watershed and soil protection); and, a single system of use may involve the maintenance of several distinct covers (as certain farming systems combine cultivated land, woodlots, improved pasture, and settlements). The distinction between land use and land cover is not so straightforward to make in practice because, frequently, sources of data do not distinguish clearly between cover and use. The terms "land," "land cover," and "land use" are treated in detail in *Land Use and Land Cover, Including their Classification*.

Land-use and land-cover changes refer to (quantitative) changes in the aerial extent (increases or decreases) of a given type of land use or land cover, respectively. However, land-cover changes may result either from land conversion (a change from one cover type to another), or land modification (alterations of structure or function without a wholesale change from one type to another), or even maintenance of land in its current condition against agents of change. Similarly, land-use change may involve either conversion from one type of use to another (i.e., changes in the mix and pattern of land uses in an area), or modification of a certain type of land use (i.e., changes in the intensity of use or alterations of its characteristic qualities/attributes). Land-use and land-cover change are strongly linked; the environmental impacts of land-use change and their contribution to global change occur through physical processes associated with land-cover change.

The detection, measurement, and explanation of land-use and land-cover changes depend on the spatial and the temporal level of analysis. Small changes cannot be detected at high levels of spatial and temporal detail; for example, conversion of a 10-ha wheat field to a tourist complex is not discernible at the national level. Similarly, long-term trends of land-use and land-cover change cannot be discerned within short time horizons and small spatial units; for example, conversion of agricultural land on the urban fringe into suburbs cannot be detected in a one- or two-year period or in an area of a few hundreds of hectares. The specification of the spatial and temporal levels of detail is crucial as it guides the selection of the types of land use/cover and determines the factors influencing the types, processes, and impacts of land-use/cover change within particular spatial or temporal frames.

The analysis of land-use and land-cover change revolves around two central and interrelated questions: What drives or causes land-use and land-cover change? and What are the (environmental and socio-economic) impacts of these changes? The next sections address the first of these questions while chapter titled *Land-Use/Land-Cover Changes and Global Aggregate Impacts* is devoted to the second question.

3. Factors Influencing Land-Use and Land-Cover Change: An Overview

Land-use/cover changes are influenced by a variety of factors operating on more than one spatial and temporal level and acting not in isolation but in intricate webs of place- and time-specific relationships. Several theories, originating in the Natural and the Social Sciences and, most recently, in interdisciplinary research, have been advanced to describe and explain land-use and land-cover change.

Land-use change occurs initially at the level of individual land parcels when land managers decide that a change towards another land-use/land-utilization type is desirable. Aggregately, individual land-use decisions produce land-use/cover changes at higher spatial levels. Land managers respond, however, mostly to internal and external influences on the land-management unit, and their decisions are influenced by their personal traits and local environmental conditions as well as by the immediate and broader environmental, socio-economic, institutional, and political settings within which the land unit is embedded. A first distinction, thus, emerges between those factors that are pertinent to the level of the individual land parcel (the micro-level) and those

that apply to higher spatial/organizational levels (the macro-level). At both the micro- and macro- levels, the factors influencing land-use and land-cover change are broadly distinguished further into biophysical and societal, depending on their origin.

Biophysical and societal factors at the micro and the macro levels are intricately interrelated and interdependent. Local weather conditions are affected by and affect the regional and global climate. Local soil and ecosystem types are determined by and determine regional soil and ecosystem types. The decisions of individual land managers are influenced, sometimes strongly, by decisions of persons or organizations at higher levels so that, in essence, local land-use change is often the result of higher level decisions as Blaikie and Brookfield have demonstrated. Land-use and land-cover changes produce environmental and socio-economic impacts that frequently feedback and modify the biophysical and societal factors causing them. Thus, new rounds of change come up as the ensuing discussion will demonstrate.

Turner et al. distinguish the macro-level societal factors further—according to the role they play in the process of change—into human driving forces, human mitigating forces, and proximate sources of change. Human driving forces are those fundamental societal forces that are the essential, deeper causes of land-use change, bringing about changes in population, technology, and socio-cultural and economic organization, that lead to land-use change. Human mitigating forces are forces that counteract the negative effects of human driving forces such as all forms of formal and informal regulation, market adjustments, technological innovations; mitigating forces may become driving forces of land-use change to cope with the adverse effects of past land-use change. Proximate sources of change are human actions that directly affect land cover. They refer to the immediate land management strategies employed that convert land cover from one type to another or that modify an existing land-cover type, under the influence of the underlying driving forces. Table 1 presents a listing of large-scale proximate sources of change suggested by Meyer and Turner.

Processes of land-cover conversion		
Harvesting	Replacement	External inputs
Hunting/fishing	Clearing/firing	Plant or animal introductions
Gathering	Plowing/tilling	Supplementary livestock feed
Fuelwood cutting (industrial and domestic)	Hydrological control (irrigation, drainage)	Supplementary water
Timber cutting	Terracing	Fertilizer/trace elements
Grazing	Planting/vegetation change	Energy/machinery
Slash-and-burn cultivation	Pasture improvement	Herbicides/pesticides
Mining/quarrying/drilling	Construction, paving, earth shaping	

Table 1. Proximate sources of land-cover change

Source: Adapted from Meyer W.B. and Turner B.L., II, eds. 1994. *Changes in Land Use and Land Cover: A Global Perspective*. Cambridge: Cambridge University Press.

At lower scales, similar proximate sources of change operate being more detailed and

site- and place-specific; these are the particular actions land managers take in the process of modifying the use of their land from one type of use or utilization to another. At the farm level, Stomph and Fresco distinguish "operations sequences" involving the types and timing of nutrients, energy, water, and implements involved. For other types of land management units, similar manipulations of land resources can be identified.

The establishment of unambiguous causal relationships among the particular biophysical and societal factors that act as driving and mitigating forces of land-use and land-cover change is not straightforward because their relative influence and importance as well as their interactions depend on the spatial and temporal level of analysis and the geographical and historical context of study, their intricate spatial and temporal interplay, their changes over time and the difficulties to observe and describe many of them as well as the processes through which they influence land-use change.

4. Factors Influencing Land-Use and Land-Cover Change at the Level of the Individual Land Unit

The individual land unit is a parcel of land of any size that may belong to an individual, a group of individuals, or to the state. This parcel may be unused, or, more commonly, it may be under agricultural (crops, pastures, etc.), forest, housing, recreation, or other use. The particular ownership, current use, and the geographical setting in which this parcel is located determine the associated land decision process and, consequently, the factors that enter into play and influence land-use change. Frequently, farm units are considered as making most land-use (and change) decisions, as agriculture is often the most extensive user of land, though this is not always and exclusively the case.

Land use is influenced by the characteristics of the local biophysical environment that determine, to a considerable extent, land suitability for a range of uses. In the case of contemplated or planned changes of use, these factors act as constraints on the range of choices considered by land managers and determine the final decision. The most important of them include: local climate and weather conditions (temperature, rainfall, snowfall, wind, moisture); local topography (slope, aspect); bedrock type; soil type (and associated physico-chemical characteristics); water resources (surface and groundwater, access to water); current state of the quality of land (e.g. erosion, contamination, salinization).

Other site-specific characteristics of the individual land unit influence the decision. Accessibility figures prominently among them, referring to: access to road networks and other transport infrastructure (airports, ports, etc.), access to markets, sources of raw materials, and suppliers of needed inputs such as labor (of the required skill level), capital, agro-chemicals, technical assistance, and know-how in general. For agricultural land uses, the existence and state of landesque capital—such as irrigation and land drainage works, water supply networks, etc.—are important decision factors. The uses of land and trends in their changes in the neighboring land parcels and the greater region play an important role also, especially in the case of small properties.

Numerous interdependent demographic, economic, socio-cultural, organizational, technological, and institutional factors affect the decision of land managers to maintain

or change the current use and utilization of the land. Demographic traits include age and gender of the head of the household, family status, size of the household, age and gender of household members. Older, male heads of household exhibit a greater inertia to change, in general, than younger ones. Single (and frequently female) heads of household have different outlooks and life expectations than those married and with many children. In the latter case, the actual number of "decision makers" may be more than one and may affect the overall decision. The socio-cultural characteristics of land managers are also influential; they include education, place of living (urban vs. rural), employment status (single or multi-employment), attitudes, values, and personal traits (e.g., perception of problems, of alternative uses of land, of external influences on land and its productivity, etc.)

Economic considerations are critical land-use determinants as von Thunen's "land rent theory" emphasizes. Most important among them is the transportation cost to markets and the sources of primary inputs—a function of distance or accessibility—and of anticipated profits from the exploitation of a particular land parcel. The latter depend on the demand for the goods and services associated with a given land-use type. Changes in demand trigger changes in land use as they affect the associated profits. Profits are determined also by other factors such as cost (and availability) of labor, capital, and primary inputs (raw materials), the substitution potential among factors of production, the prices of final products and services associated with a particular land use, and state support (price supports, subsidies, tax exemptions, various economic incentives). Finally, the size of the parcel and the competition from other (usually, neighboring) land parcels affect the expected profits and, thus, the land-use change decision. In cases of keen competition, small parcels are usually the first to be bought out by strong land development interests.

Technological factors condition land-use decisions by influencing the profits accruing to land managers. The availability of new technologies and the ease with which they can be applied to land affect significantly the productivity of labor and capital employed. For example, mechanization is difficult in mountainous areas, and this constrains the types of land-use changes in these areas. The ease and rate of adoption of available technologies by land managers influence the potential for land use changes of some kind. In a broader sense, knowledge resources that land managers possess (as in the case with traditional knowledge) or are able to obtain (e.g., technical assistance) largely affect land-use decisions.

Formal and informal institutional arrangements influence directly or indirectly land-use decision making. Land ownership and tenure are perhaps the most influential factors. In the case of individual land ownership, decision making is quite different from the case where land is under communal or state ownership. Other influential institutional factors include national, supranational and international environmental and resource policies and regulations (e.g., nature conservation, pollution control, etc.), spatial planning and development policies, etc. Equally important are economic, financial, and social policies and institutions affecting the availability of capital, finance, labor, level of profit, etc.—institutions associated with the factors of production and their respective markets. Informal institutions that influence land-use decisions—especially in developing countries—are informal money lending institutions, informal labor markets, family

networks, etc.

Although land managers may make direct decisions, biophysical and socio-economic factors operating on higher, aggregate, spatial and organizational levels exert a significant influence on both local land-use change and the patterns of changes observed on regional and higher levels. These are discussed next.

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Biographical Sketch

Helen Briassoulis is a professor at the Department of Geography, University of the Aegean, Lesvos, Greece where she teaches quantitative methods in Geography. She holds a Ph.D. in Regional Planning from the University of Illinois at Urbana-Champaign, USA. She specializes in environmental planning, policy analysis and decision making. She has participated as coordinator and/or researcher in several research projects on environmental issues.

She has published in scientific journals and books on land-use change, desertification, sustainable development indicators, the informal sector, multicriteria analysis, tourism planning, tourism and the environment, environmental planning theory, environmental analysis, and integrated economic–environmental analysis. She is a reviewer in several scientific journals and member of the Editorial Board of *Environmental Management*. Her work includes a contribution to the Web Book of Regional Science published by the Regional Research Institute of the University of West Virginia entitled *Analysis of Land-use Change: Theoretical and Modeling Approaches* <<http://www.rri.wvu.edu/regscweb.htm>>. She is co-editor (with Jan van der Straaten) of the book *Tourism and the Environment: Regional, Economic, Cultural and Policy Issues* (Dordrecht: Kluwer Publishers, 2000). Her recent research focuses on the development of a policy support framework to combat desertification in the Mediterranean member states of the European Union.