FACTORS INFLUENCING 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.

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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.

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