

## LAND COVER, LAND USE AND THE GLOBAL CHANGE

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### Summary

There still exist confusion and misunderstandings of what is exactly meant with land, land cover and land use, and about how to study and classify these. This is partly due to the multitude of organizations, programs and projects which deal today, each with their own expertise, terminology and academic background, with land issues. As a result, many discussions could be avoided if, beforehand, people should point out what they mean with some specific terms.

The study of land cover and land changes relies nowadays mainly on remote sensing

techniques, using satellite images with high resolution and short revisit periods, and modeling. The latter allows us to develop scenarios of environmental change over the next 20 to 50 years based on the anticipated evolution of critical parameters in the future. Land cover changes are mainly due to human activities and were therefore most intensive over the past 300 years. A summary has been given of the most important agents and types of change.

Global change is mainly seen as the result of a gradual ecological collapse from the accumulation of impacts from millions of independent decisions made every day around the world. Global change is multi-faceted, and the different components of this change are closely interlinked. An overview is given of a number of relevant aspects of global change, including: deforestation, desertification and the expansion of agricultural land, climate change, population density and urban development, loss of biodiversity, air pollution and environmental side effects and, as an illustration of the former aspect, the effects of acid rain on European forests. In fine, some impacts of global change on the society are discussed.

## **1. Introduction**

The land surface in the world is estimated at 13,340 million ha. This represents the solid part of the earth's crust, in contrast to the areas covered by sea and oceans. This land is further specified as lowlands, hills or mountainous land; as agricultural versus forest or grazing land; as community land or private property; as good or bad quality land. The connotation of land embraces in the first place a location and a number of physical properties; in many cases it is also defined by its specific characteristics or composition and by the nature and density of its surface cover.

Land in its most straightforward meaning stands for soil, and this perception can be found back in almost all nine chapters presented under this topic. This soil develops as a direct result of the action of climate - temperature and moisture in particular - on the geological substratum at the interface between atmosphere, hydrosphere and lithosphere. The result of this process is the formation of a loose weathering product which can be shallow or deep; stony, sandy or clayey, deep red or yellow-brown, rich or poor in nutrients. The nature and properties of soils vary as a function of the type and composition of the parent rock, the nature of the climate and the intensity of the weathering processes.

Usually this soil mantle does not remain barren, but is rapidly colonized by plants and animals to form a more or less continuous vegetation and an established physicochemical and physical ecosystem. Areas which are not covered by a natural vegetation are generally too cold, too dry, too wet, too steep, too shallow or too saline.

The nature of the land, both in terms of soil composition and land cover or use is dynamic. When dealing with land different people (farmers, real estate managers, scientists, politicians) look at land very differently, and in particular refer more often to what is happening at the surface of that land in terms of ecological, socio-economic or legal aspects, and what are the consequences of this in a regional or global context.

## 2. Terminology and Other Sources of Confusion

Land has always been a focal point in human interest, not at least because it is a vital element in people's behavior, activities and survival. Land is described, classified and studied by a variety of people, each with their own background, approach and terminologies. Many terms are also used interchangeably and/or have lead to ambiguities and confusion for readers and users of information. This situation has further been worsened because of an increased globalization and easier access to communications. Obviously, many discussions and disagreements could have been avoided if, from the early beginning, people should agree on basic concepts and common definitions.

This is particularly true in the field of environment which has been, probably more than any other topic in modern society, a major focus of research and of social debate involving a wide range of specialists having their own technical expertise and background, or originating from different schools of thought. The simple term of land, for example, can be interpreted in a wide variety of ways according to outlook and perspective. In the strict sense it can stand for soil; in a broader sense as a consumer good or commodity, as location, property or a form of capital; or in an ecological view when it is associated to nature and ecosystems. In this context the confusion about what is exactly meant by land, land cover and land use, and about how to study and classify these topics is exemplary. It is striking that almost all chapters under this topic warn for confusion and misunderstandings of specific terms used in the context of the various articles. In *Land Use and Land Cover, including their classification*, Duhamel moves even into somewhat philosophical approach to the issue.

### 2.1. Land

Apart from its basic perception as the solid part of the earth's crust, the connotation of land has more than 10 different meanings in the English language. These can generally be associated to three major concepts: land as a country or a homeland, land as a type of soil with specific biophysical and chemical properties, and land in terms of property and asset.

A **first rather neutral** connotation of land refers to the space and location of a geographical entity in terms of a country, a homeland, or a rural land area in contrast to forestry or urban areas. This meaning reflects to some extent the perception - especially in traditional societies - that land is a gift from God that can not be alienated to humans, but that can only be temporarily used by them. This creates a socio-ethnic link between the different members of a clan, group or society to defend the common property against third parties.

A **second meaning** which is currently used in a natural sciences context, associates land to the concept of soil or ground, embracing mainly its physical properties like depth, texture, wetness, etc. and, derived thereof, its production potential. This is the most current meaning of land, and it is also the most commonly accepted by people from various disciplines.

While in earlier times soil and land were often intermixed, in recent years - and in particular since the publication of the FAO Framework for Land Evaluation in 1976 - land has received a broader meaning than the narrow connotation of soil, which stands for the loose part of the weathering zone at the interface between lithosphere and biosphere, and the rooting zone for plants. Land on the other hand involves also the natural resource attributes occurring at the earth's surface but, unlike soils, it incorporates the wide range of environmental conditions and processes which, directly or indirectly, are related to those attributes. The FAO definition of land can nowadays be considered as the standard concept in modern environmental sciences. It reads as “an area of the earth's surface, the characteristics of which embrace all reasonably stable, or predictably cyclic attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man”.

The third meaning refers to land in its **economic context**, whereby the focus is more on a property, an estate or a commodity usually linked to an investment. In other words, in contrast to biodiversity and water, land is not considered a global common, but it belongs to an individual or a group. Land in the economic theory is considered one of the major factors of production, including all natural resources, but different from capital. Although the chief economic role of land is vital for the production or provision of food, water, fuel and shelter, it is also a consumer good, to the extent that it supplies space for residential or industrial sites, infrastructure or parks and recreation.

The great difference, in the economic perception, between land and other factors of production is that the supply of land is fixed. In this context David Ricardo, an early 19th century English economist, developed the theory that because land can not be reproduced by man, it has no economic cost of production. Increases in rent can therefore not expand the supply of land, neither can its price be influenced by demands and competition on this fixed supply. Competition among users might create rent differentials, but these result only from differences in fertility or location; in rural areas rent is mainly determined by the yield potential of the land; in more industrialized countries rental differences are mainly due to the location of plots, the one compared to the other. Hence, the value or rent of land in city centers may reach astronomical levels, whereas plots in remote rural areas may have much less value. The problem of evaluating the value and price of land has been discussed *in extenso* in *The Value and Price of Land*.

Economists make a clear distinction between land and capital. Land is regarded as a gift from nature, whereas capital goods are the result of human efforts to explore/exploit (natural) resources. Likewise will the value of land in the long run depend upon the intensiveness of its use, while value of capital goods will depend upon the cost of producing them? The difference between land and capital gives also rise to the distinction between rent and interest whereby, in the Ricardian theory, rent is specifically meant to be compensation to the land owner for the use of the inherent potential of that land, whilst interest is a compensation for the temporary use of capital.

## 2.2. Land Cover and Land Use

Land cover and land use are often intermixed. This is rather logical because both terms are closely linked and to some extent even overlap. In its natural state, land cover (comprising both the nature of the soil and the vegetation) constitutes a perfect expression of the ecological equilibrium between parent rock, soil, climatic conditions and vegetation.

As long as people were few in number and were used to live from the collection of natural tree products or roots, without disturbing the environment, the natural vegetation was hardly modified. This changed from the moment Man converted from a nomadic to a sedentary lifestyle and the natural vegetation was replaced by cultivated crops or by grasslands for stock raising. In this evolution people first used the land to cultivate food and meet their needs for fuel and shelter, but in a later stage land use involved more than only rural land use, pushing gradually towards residential, industrial and infrastructure uses.

**Land cover** deals in the first place with a description of the biophysical state of the earth's surface and the immediate subsurface, embracing soil material, vegetation and water. Briassoulis, in *Factors Influencing Land-Use and Land-Cover Change*, argues that originally the term had a much narrower meaning and referred only to the type of vegetation that covered the land surface, but this concept was later broadened to include also soils and the biodiversity. This enables various categories of land cover to be distinguished: areas of vegetation, bare soil or rock outcrops (if there is a lack of vegetative cover), wet areas, water bodies, etc. In other words, land cover is exclusively the result of observations.

The natural land cover is generally a good expression of the soils and vegetation pattern that is in equilibrium with the natural environment, and this observation is at the origin of the various bio-geographical classifications as described by Verheyne in *Land Use, Land Cover and Soil Sciences*, and in the various case studies described in *Deforestation in the Amazon: Past, Present and Future*.

**Land use** refers also to land cover but in terms of its socio-economic purpose and intentional use. This is in clear contrast with land cover as referred to above which is mainly descriptive and deals with physical observations. Land use may vary in nature and intensity with both the purpose it serves and with the biophysical characteristics of the land itself. Land use is therefore generally described as: areas **for** residential, agricultural or industrial purposes.

Land use differs from land cover because of the intentional role of people to adapt the natural land cover to their benefit. The connotation of land use involves an interference by humans and an underlying intention to turn the natural land resources into a beneficial output. Briassoulis, in *Factors Influencing Land-Use and Land-Cover Change*, argues that land use is shaped under the influence of two types of driving forces: human needs and natural environmental features and processes.

The main interest of land cover and land use studies is that they can be **quantified**, and that changes can be monitored. This can be done through a spatial/geographic approach

or through surveys and statistics. The advantage of the former is that, besides a numerical evaluation of the space occupied by the different land categories (which can equally be obtained from statistics), it gives also information on the geographical location of those categories.

In this respect an interesting exercise is going on through the Millennium Ecosystem Assessment, which looks beyond the characterization/classification of the land cover/land use. It takes into consideration the goods and services provided by the ecosystem.

In some cases the ecosystem is in good condition for food production, but in poor shape for the production of clean water. The approach to evaluate the condition of an ecosystem is to assess separately the capacity of the system to provide each of the various goods and services, and then to evaluate the trade-offs among those goods and services.

The quantification of land use and cover data is hampered by a number of technical problems, the average users of which are not always aware of. Land cover/use maps are generally compiled through the interpretation of aerial photographs, or remote sensing techniques in general, combined with ground control.

The advantage of aerial photographs is that they reflect a situation at a precise moment in time, and that over time the evolution of this situation can be monitored through successive flights. Another advantage is that aerial photographs are neutral in the objects they identify, and thus exclude erroneous information which could be introduced by those from where the information is obtained (referring to the so-called “lying index” in surveys).

Having to cope with both statistical information and remote sensing data might be at the origin of some confusions as well, as have been illustrated in *Land Use and Land Cover, including their classification* and *Land-Cover and Land-Use Mapping*.

The interpretation of an aerial photo requires however an additional field control and the establishment of an interpretation key. This can rather well be managed if categories are carefully defined and easily delineated on the photos. Hence, built-up areas can clearly be differentiated from lakes or arable land, but this situation becomes more difficult in the case of mixed land uses both in the spatial and temporal sense. In *Land Use and Land Cover, including their classification* Duhamel discusses the example of how to define a land cover which holds a mixed cropping pattern (spatial variability) or the succession of crops in a rotation (temporal variability), and the impact such situations have on the accuracy of the mapping.

An additional problem with the use of remotely sensed images is that in general they are linked to a specific scale, and it is this scale which defines the detail by which objects can be differentiated. In other words, what is observed at a scale of 1:10,000 is different of what is seen at scale 1: 250,000. The mixture of images with different scale or resolution in one and the same study might thus seriously affect the quality of the end product. Moreover, it may lead to confusion for non-specialists who are not aware of

the role of a scale in cartographic data collection.

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### **Biographical Sketch**

**Willy Verheye** is an Emeritus Research Director at the National Science Foundation, Flanders, and a former professor in the Geography Department, University of Ghent, Belgium. He holds an M.Sc. in Physical Geography (1961), a Ph.D. in soil science (1970) and a Post-Doctoral Degree in soil science and land use planning (1980).

He has been active for more than thirty-five years both in the academic world, as a professor/ research director in soil science, land evaluation, and land use planning, and as a technical and scientific advisor for rural development projects, especially in developing countries. His research has mainly focused on the field characterization of soils and soil potentials, and on the integration of socio-economic and environmental aspects in rural land use planning. He was a technical and scientific advisor in more than 100 development projects for international (UNDP, FAO, World Bank, African and Asian Development Banks, etc.) and national agencies, as well as for development companies and NGOs active in inter-tropical regions.