

LAND USE, LAND COVER AND SOIL SCIENCES

W. H. Verheye

Research Director, National Science Foundation, Flanders, Belgium, and Geography Department, University of Ghent, Belgium

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Summary

Land is one of our most precious assets, and its use is multi-faceted. It provides food and shelter, it stores and filters water, and it is a basis for urban and industrial development. Land is, however, finite in extent. The combination of population growth, limited expansion of arable land, and the growing need for land for non-agricultural purposes, increases the pressure on – and competition for – the available space. In certain areas of the world available land per capita has reached a critical value of 0.15.

Land which is physically available is not necessarily accessible to those who want to use it. First, the land surface and its inherent production potential are under continuous threat due to a variety of natural degradation processes and human-induced (mis)management.

Second, access to land is mainly determined by customary rules – ethnic and religious rules among them – and by land tenure regulations. Squatting and other types of informal access occur in areas where the land tenure system is unclear, as is the case in parts of South America.

Land derives its interest from the vegetation and crops that can be grown on it. Land cover and land use are, however, dynamic, and are affected both by natural phenomena, such as climatic events and natural disasters, and by human activities, although the impact of the latter has mainly been felt in the more recent centuries. Generally speaking, arable land is extending at the expense of forest and pasture. Non-agricultural uses, including those for urban and industrial infrastructure, are continuously on the rise.

There is a close link between land use (and its inherent changes), access to land as affected by land tenure, and land value. The common thread that binds all these together is the fact that land is becoming scarce and desired, and that it has become an asset and a primary tool for income generation, wealth, and power. In other words, land has an exchange value and a price.

The gradual change from a rural to an urban society, in combination with the evolution from a concept of common ownership to one that is more individual, is reflected in the free-market economy, where land acquires value that is on a par with other tools of production.

The value and the price of land are mainly determined by supply and demand, and by the underlying perception of the potential benefits that can be derived from the deal in question. There is a wide variety of valuation methods, focusing either on the inherent production potential and carrying capacity of land, or on its market value in a functional land market.

Concern about the growing competition for land by an increasing number of users, and the risk of further degradation of valuable land and biotopes, calls for a more rational and sustainable use of the available space. Land zoning and land use planning are therefore major issues for future decision-makers.

1. Introduction

The word “land” has many meanings. In *Webster’s Dictionary of the English Language* it applies to no less than ten subjects. Its common connotation is usually associated with a solid or specific part of the earth’s surface, a country, or a region, but land also stands for ground or soil, and for their specific qualities and properties. It is also used to distinguish rural regions from urban districts.

Land is one of our most precious assets, and its use is multi-faceted. Land represents surface and space; it provides food, it filters and stores water; and it is a basis for urban and industrial development, leisure, and a wide range of social activities. Land also stands for property, and is a production factor because of the vegetation and crops that can be grown on it. It even embodies a number of non-material dimensions, such as homeland, place of ancestry, a basis for survival or wealth. It is also an object that is taxed and desired by governments and interest groups.

The world’s land surface is finite in extent. Land is, moreover, constantly under threat of degradation, mainly as a result of intensive cropping, soil mining, and inadequate management, and of population pressure. Hence, agricultural outputs today have to procure food for twice as many people in the world as there were a generation ago, and in fifty years this is expected to be four times as many. The next generation is likely to see the highest population that the planet has ever experienced. This growing demand for food cannot be met indefinitely through intensification of crop production and biotechnological progress; it also requires the extension of arable land. The overall result is an increasing competition for land.

A commodity that becomes in short supply, that is desired, and for which different users are competing, acquires value. The more the competition for available land grows, the more its value increases.

2. Land Cover and Land Use

Under natural conditions the interaction between atmosphere, hydrosphere, and lithosphere results in the formation of a loose soil surface on which a natural vegetation develops. This contact layer at the earth’s surface defines what is commonly called “soil” or “land.”

Soil refers to the loose upper part of the weathering zone at the interface between the lithosphere and the biosphere. It constitutes the rooting zone for plants. The nature and properties of soils vary as a function of the type of parent rock, and of climate. It is rare for the land surface to remain bare and uncovered. This is the case under circumstances where the soil is too shallow and either chemically or physically too poor to allow plants to grow. Most often, the soil provides enough rooting depth, moisture, and nutrients for a plant cover to develop.

Land has a somewhat broader meaning than soil. It too involves 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. A technical and commonly accepted definition of land, as given by the UN's Food and Agriculture Organization, is:

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.

(FAO, 1976)

The land cover defines the biophysical state of the earth's surface and immediate subsurface, thus embracing the soil material, vegetation, and water status. Originally, the term had a narrower meaning, and referred only to the type of vegetation that covered the land surface, but this concept was later broadened to include soils and biodiversity as well.

The natural land cover is generally a good expression of the soil and vegetation pattern that goes with the natural environment. Hence in the humid tropics, where high temperatures and ample moisture are present throughout the year, soils are deep, highly weathered, and often devoid of major nutrients, and the corresponding vegetation tends to be dense tropical forest.

In the subtropics, with an alternate dry and wet season, soil weathering is less intense; the profile is less deep, and still holds a good number of weatherable minerals in the root zone; the vegetation is moderately dense and includes many drought-resistant grasses and xerophytic trees. Towards the higher latitudes, soil materials are less developed, and the natural vegetation holds more and more cold-resistant perennials or seasonal plants, which develop only in the warmer summer period.

The close relationship between the natural land cover, in terms of soil and vegetation, and global bioclimatical zones was first studied and identified by Russian and German geographers. Voloboyev correlated dominant zonal soil types with thermo- and hydro-ranges (Figure 1), while Trewartha's work made it possible to integrate soil type and weathering zones with vegetation and bio-climatological areas at world level (Figure 2).

In Voloboyev's system (Figure 1) the world is subdivided into eleven major soil zones, closely related to the natural vegetation they carry. These zones range from Serozems and Desert Soils in the drier areas, to Tundra Soils in the arctic regions, and Laterites and Red Brown Savanna Soils in the tropics.

The extension of these soils follows a world zonal pattern determined by moisture supply and temperature/energy criteria, technically translated into hydro- and thermo-ranges respectively. Hydro-ranges are defined on the basis of the ratio of annual rainfall to evapo-transpiration, and are hence an expression of the plant-available moisture. Thermo-ranges are based on average annual temperatures with a direct impact on photosynthetic activity and related biomass production.

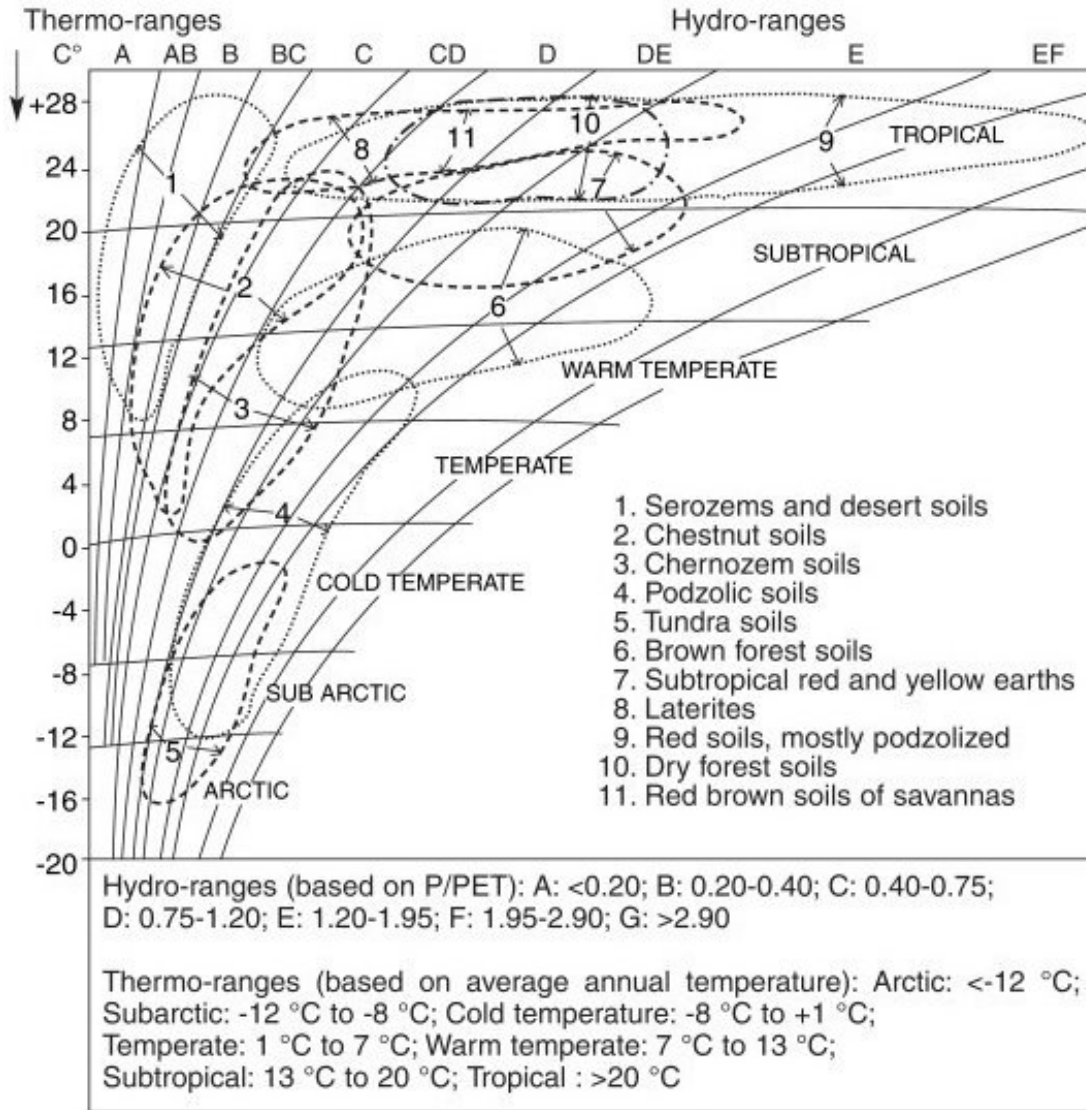


Figure 1. Distribution of major world soil groups in relation to climate (Voloboyev, 1956).

Zonal soils are interrupted at the regional level by so-called azonal and intra-zonal soil and vegetation types.

These are linked to the appearance of site-specific features such as the presence of salts or alkalis in the soil and their related vegetation, the presence of marshland areas with a swamp vegetation, and so on.

Modern soil classifications like the FAO or USDA Soil Taxonomy systems nowadays put more emphasis on inherent soil properties, but have still maintained the underlying principle of world zonal differentiation, and the link with either the natural land cover or the land use potential for crop production.

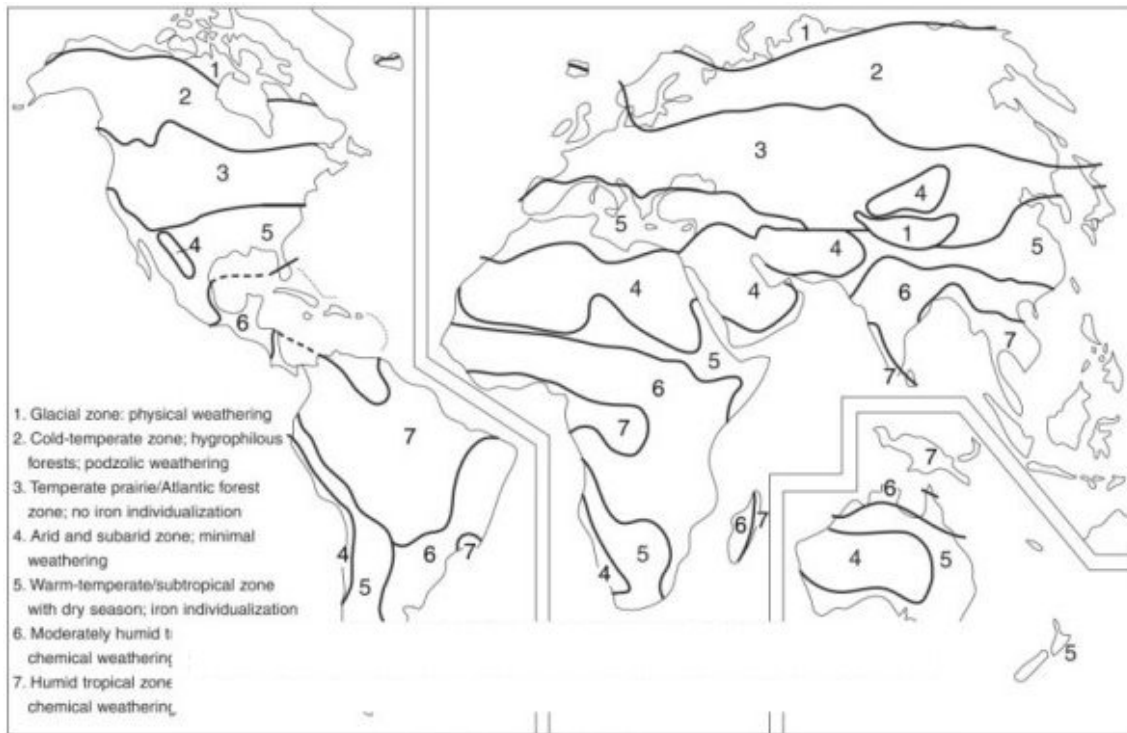


Figure 2. Major bio-climatological areas and soil weathering/major vegetation zones in the world (adapted from Trewartha, 1954).

The close relationship between bio-climatology and soil properties is illustrated in Figure 2, in which the world is subdivided into seven climate/vegetation/ soil weathering zones. In arctic areas (unit 1) water is chemically inactive, and soil/rock weathering is limited to a physical breakdown only. Unit 2 defines the cold-temperate zone with a hydrophilous (tundra) forest vegetation, creating an aggressive acid soil weathering environment, and the formation of podzolic soils. Unit 3 characterizes the temperate prairie and Atlantic forest zone, dominated by bi-siallitic soil weathering (formation of expanding clays), but without iron individualization (which means that soils do not turn red in color). Zone 4 stands for the arid and subarid regions where, due to the lack of water in the soil profile, both the vegetation and chemical weathering are limited. Zone 5 defines the warm-temperate and subtropical areas with intermediate dry season, including the Mediterranean zone, covered by (forested or grass) savannas, and dominated by a bi-siallitic weathering and iron individualization (which means that soils become red in color). Units 6 and 7 stand for the tropical wet and very wet areas covered by a dense tropical forest vegetation, and with a dominance of mono-siallitic (formation of kaolinite) or allitic (formation of kaolinite and toxic aluminum oxides) weathering respectively, with clear individualization and accumulation of iron.

Land use differs from land cover because of the intentional role of people to adapt the natural land cover to their benefit. The land use connotation entails an interference by humans and an underlying intention to turn the natural land resources into a beneficial output. It entails both the manner in which the biophysical attributes of the land are manipulated, and the intent underlying that manipulation, namely, the purpose for which the land is used.

According to the FAO concept, land use defines the human activities which are directly related to land, making use of its resources, or having an impact on them. In that context the emphasis is on the function or purpose for which the land is used, and particular reference is made to “the management of land to meet human needs.” The term includes both rural and urban or industrial uses. Land use automatically involves the concepts of optimizing the land use potential, land evaluation for example, and of land use planning. A distinction should be made here between present land use (the way in which the land is used at present) and potential land use (how it could be used with or without improvements).

Land use may vary in nature and in intensity according to both the purpose it serves – whether it be food production, recreation, or mining – and the biophysical characteristics of the land itself. Hence, land use is shaped under the influence of two types of driving forces: human needs, and natural environmental features and processes. Land use and land cover are not equivalent. They may, however, overlap, and therefore be intermixed, because the distinction between the two is not always straightforward. The equivalence between natural pastoralism and unimproved grasslands is still clear, but it becomes vaguer when slight improvements in the grass cover have taken place. Likewise, it can be difficult to define the nature of forest exploitation if this takes place through a simple extraction of precious species from a natural forest (without further disturbing the original structure of the forest), or when this happens through the integration of a small recreation or wildlife reserve within the natural forest.

The topic of land use and land cover has received ample attention in the international literature from Turner, Meyer, Moser, Briassoulis and others. The subject is also discussed *in extenso* in the contributions of Duhamel, Briassoulis, Klein-Goldewijk, Ramankutty, et al., in “*Land Cover, Land Use, and Global Change*”.

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Bibliography

ARUA, E. O.; OKORJI, E. C. 1997. *Multidimensional Analysis of Land Tenure Systems in Eastern Nigeria. Land Reform, No. 2*, pp. 113–24. Rome, FAO. [Gives a comprehensive overview of customary land tenure practices in Africa.]

BRIASSOULIS, H. 2000. *Analysis of Land Use Change: Theoretical and Modeling Approaches*. In: S. LOVERIDGE (ed.), *The Web Book of Regional Science*. West Virginia University. <http://www.rri.edu/regscweb.htm>. [Deals with developments in land cover and land use changes and drivers over the past 100 years.]

DENT, D.; YOUNG, A. (eds.) 1981. *Soil Survey and Land Evaluation*. London, Allen and Unwin. 21 pp. [An overview of relevant items and methods used to describe and evaluate the soil.]

FAO. (Various years.) *Statistical Yearbooks on Agriculture*. Rome, FAO. [An annual publication with the most recent statistical information on land and crops at world and national levels.]

FAO. 1976. *A Framework for Land Evaluation*. *FAO Soils Bulletin*, No. 32, Rome, FAO. 79 pp. [Outlines the basic principles of the FAO approach to land evaluation and land use planning.]

FAO. 1981. *World Soil Charter*. Rome, FAO. 8 pp. [Gives a short enumeration of the different articles in the charter, without additional comments.]

FAO. 1983. *Guidelines: Land Evaluation for Rainfed Agriculture*. *FAO Soils Bulletin*, No. 52, Rome, FAO. 237 pp. [An overview of the practical application of the FAO approach to land evaluation for rainfed agriculture.]

FAO. 1991. *World Soil Resources: An Explanatory Note on the FAO Soil Resources Map at 1:25 Million Scale*. *World Soil Resources Report 66*, Rome, FAO. 61 pp. (Provides not only an explanatory note on how to interpret the soil resources map, but gives as well good background information on how to interpret the map in terms of agricultural potential).

FAO. 1993. *Guidelines for Land Use Planning*. *FAO Development Series*, No. 1, Rome. FAO/AGLS. 96 pp. [Overview of the principles which guide land use planning.]

FAO website. [Http://www.fao.org/WAICENT/FAOINFO](http://www.fao.org/WAICENT/FAOINFO) [Gives a good up-to-date overview of FAO's activities from its different divisions.]

FAO/UNEP. 1996. *Our Land, Our Future*. 48 pp.

FAO/UNEP. 1997. *Negotiating a Sustainable Future for Land*. Rome, FAO/AGLS. 61 pp.

FAO/UNEP. 1999. *The future of Our Land: Facing the Challenge. Guidelines for Integrated Planning for Sustainable Management of Land Resources*. Rome, FAO/AGLS. 71 pp. [A series of three publications illustrating how to operate participative land use planning.]

GTZ. 1998. *Land tenure in development co-operation: Guiding principles*. Wiesbaden, Germany, Universum Verlag/GTZ. 252 pp. [A comprehensive overview of various papers on the problems of land tenure and land access in developing countries.]

KUTTER, A.; NACHTERGAELE, F.; VERHEYE, W. 1997. *The New Approach to Land Use Planning and Management: Application to Sierra Leone*. Proceedings of International Conference on Geo-Information for Sustainable Land Management, Enschede, August 1997. *ITC Journal*, No. 3, pp. 278–83 [An example of how to apply the FAO approach to land use planning at country level.]

OLDEMAN, L. R.; HAKKELING, R. T.; SOMBROEK, W. 1990. *World map of the status of human-induced soil degradation: Global Assessment of Soil Degradation (GLASOD)*. ISRIC–UNEP. 27 pp. plus appendices. [A numerical overview of the importance of land degradation, classified per type of degradation at world and individual continental level.]

SINGH, R. B.; FOX, J.; HIMIYAMA, Y. (eds.) 2001. *Land use and land cover change*. Enfield/Plymouth, Science Publishers. 299 pp. [A compilation of twenty-four papers presented at a recent IGU–LUCC seminar in Honolulu, Hawaii, covering case studies from various parts of the world.]

UNEP (UNITED NATIONS ENVIRONMENT PROGRAMME). 1982. *World Soil Conservation Policy*. Nairobi, UNEP. 70 pp. (Gives an extensive explanation on what are the problems of soil degradation, and on the way to avoid or to reclaim these in terms of government policies).

VERHEYE, W. 2000. *Use of Land Evaluation Techniques to Assess the Market Value of Agricultural Land*. *Agropedology*, Nagpur, Vol. 10, No. 2, pp. 88–100. [Gives an overview of valuation methods to determine the inherent production potential of land.]

VERHEYE, W.; BRINKMAN, R.; SIMS, D. 1997. *Elements of a Different Approach to Land Development Issues*. *The Land*, Vol. 1, No. 2, pp. 143–52. [Explains the problems related to apply a more participative planning process with a greater involvement of stakeholders.]

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 soils potentials, and on the integration of socio-economic and environmental aspects in rural land use planning. He has been a guest-professor in the universities of Algiers, Constantine, Tunis, and Morogoro (Tanzania). He was scientific coordinator for the post-university cyclus on Soils and the Environment at the University of Antwerp.

Willy Verheye has served as 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 the inter-tropical belt. He has organized various seminars on applied soil science and management aspects at the EU in Brussels, and has been guest or key-note speaker at many international fora. Under a UNDP-supported program he established the M.Sc. and Ph.D. programs in land resource management at Nagpur-Akola, India, and was elected a Fellow of the Indian Society for Land Use Planning for this work. He has also published more than 100 papers in international journals.

In recent years his activities have been mainly focused on participative planning methods in developing countries, with due attention both to optimization of production and sustainable land management.