LAND COVER, LAND USE AND THE GLOBAL CHANGE

Willy Verheye
National Science Foundation Flanders/Belgium and Geography Department University Gent, Belgium

Keywords: acid rain, biodiversity, complexity of land cover changes, deforestation, desertification, greenhouse gases, integrated land use models, land, land cover, land use, land use dynamics, ozone.

Contents

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-facetted, 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 Verheye 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.

2.3. Research Organizations and Programs

A major reason of the possible confusions and inaccuracies depicted above is the multitude of research organizations, programs and projects which have emerged, in particular since the early 1990s, in the field of land use and land cover studies, environmental and biodiversity protection and monitoring, global climatic change and

other related topics.

Over the past three decades the study of earth systems has grown from a minor facet of science into a mainstay of research. Indeed, so many organizations now study global change that it can become difficult to track who is doing what. These have mushroomed as a result of the growing awareness on environmental issues created by a number of critical reports such as the Bruntland report, the UNCED in Rio de Janeiro in 1992 with Agenda 21, the Kyoto Conference, the recent World Summit on Sustainable Development known as the Rio plus 10 Conference in Johannesburg, and the many initiatives, national and international, derived from these. The excellent work and results which have often been obtained from these initiatives is, unfortunately, not always very well coordinated.

As is often the case in a successful research domain where a lot of funding and prestige are involved the mandates of many of these institutions and programs are not always very clear, and even if they were clear at the start of the project, they become often less well delineated with ongoing research. This is a logical trend in domains where an integrated approach is adopted, but if this evolution does not go at par with an agreement on strict terminologies it is not very beneficial for the transparency of the research topics.

All of these *think tanks* have moreover taken a modern habit to identify themselves by acronyms, the meaning of which might probably be clear for specialists in these matters, but not for the layman and neutral reader. The following is an incomplete (alphabetic) list of a number of important organizations or programs:

- BAHC: Biosphere Aspects of the Hydrological Cycle, one of the five core projects of the IGBP; this project couples field and remote sensing measurements to explore interactions amongst vegetation, the hydrological cycle and the atmosphere.
- CLAUDE: Coordinating Land Use and Land Cover Data and Analyses in Europe; hosted at Jackson Environmental Institute, University College, London, UK.
- DAPLARCH: Data Plan for Land Use and Land Cover Change Research, managed and co-ordinated by IGBP/IHDP LUCC-IPO in collaboration with IGBP-DIS-IPO, and with the technical support of the Institut Cartogràfic de Catalunya (ICC). Its objectives are: to harmonize international efforts on data systems, to determine the priorities of the needed datasets, to establish the methodologies and overall plan for specific datasets to be developed, to set up integrative procedures for establishing conceptual and geographical links between the existing data systems and specific science requirements, and to provide the basic knowledge necessary to promote operational data systems for monitoring and modeling.
- GCTE: Global Change and Terrestrial Ecosystems Study, one of the five core projects of IGBP; it develops a predictive capacity, through *inter alia* modeling, of changes in ecosystems in order to provide inputs to global models of climate and biogeochemistry; hosted at the International Geosphere-Biosphere Programme (IGBP), Canberra, Australia.

- HITE: Human Impacts on Terrestrial Ecosystems, hosted at the University of Liverpool, UK. Its objective is to inform about the status, dynamics and sustainable management of terrestrial ecosystems, now and in the future, from the study of human-environment interactions in the past.
- IIASA-LUC: Modelling Land Use and Land Cover Changes in Europe and Northern Asia; started in 1995 and hosted at IIASA- International Institute for Applied Systems Analysis, Laxenburg, Austria.
- IGBP: International Geosphere-Biosphere Programme, established in 1986 to deal with chemical and biological processes involved in global change; hosted at the Swedish Environmental Institute, Stockholm, Sweden.
- IHDP: International Human Dimensions Programme on Global Environmental Change, hosted at the University of Bonn, Germany; its objectives are to describe, analyze and understand the human dimensions of global environmental change.
- IMPEL: Integrated Model to Predict European Land Use; hosted at the University of Louvain-la-Neuve, Belgium.
- IPCC: Intergovernmental Panel on Climate Change, established by the World Meteorological Organization and the United Nations Environmental Programme to carry out periodic assessments of the scientific, technical and socio-economic aspects of issues related to climate change; it is hosted in the World Meteorological Organization, Geneva, Switzerland.
- LACOAST: Land Cover Changes in Coastal Zones, hosted at the Joint Research Centre, Space Applications Institute, Environment and Geo-Information Unit, in Ispra, Italy; its objectives are to make the exhaustive quantification of land cover changes of European coastal zones within the period 1975-1990.
- LIMPACS: Human Impacts on Lake Ecosystems, hosted at the Environmental Change Research Centre, University College, London, UK; its objective is to understand the past variability of lake ecosystems in order to better predict their future evolutions.
- LUCC: Land Use and Land Cover project; hosted at the Geography Institute, University of Louvain-la-Neuve, Belgium.
- LUCIFS: Land Use and Climate Impacts on Fluvial Systems during the Period of Agriculture, hosted at the PAGES International Project Office, Bern, Switzerland; its mandate is : to quantify land form change and river-borne fluxes of water, sediment, C, N, P both today and in the past, to identify and control these fluxes in the catchment cascade, both today and in the past, and to identify the feedback on both the human society and the biochemical cycles of change in the fluxes of these materials.
- MRI: Mountain Research Initiative, hosted in Bern, Switzerland; it aims to achieve an integrated multidisciplinary approach for observing, modeling and investigating global change phenomena and processes in mountain regions, including their impacts on ecosystems and socio-economic aspects.
- PAGES: Past Global Changes Project, one of the five core projects of the IGBP, is a study of past variations in climate, biogeochemistry and biomass, and the interactions among them; hosted in Bern, Switzerland.
- START: Global Change System for Analysis, Research and Training, jointly sponsored by IGBP, WRCP and IHDP on Global Environmental Change; hosted

in the International START Secretariat, Washington, USA.

▪ TREES: Tropical Ecosystem Environment Observations by Satellite, hosted at the Global Vegetation Monitoring Unit, Space Applications Institute, Joint Research Centre, Ispra, Italy; its objective is the development of techniques for global tropical forest inventory and for monitoring deforestation using satellite imagery.

▪ UNFCC: UN Framework Convention on Climate Change, with the objective to achieve stabilization of atmospheric concentrations of greenhouse gases at levels that would prevent dangerous anthropogenic (human-induced) interferences with the climate system; it is hosted in Bonn, Germany.

▪ WCRP: World Climate Research Programme, hosted at the World Meteorological Organization, Geneva, Switzerland; its objectives are: to develop the fundamental scientific understanding of the physical climate system and climate processes needed to determine to what extent climate can be predicted, and to evaluate the extent of human influence on climate.

3. Problems related to Land Cover Classification and Research

Most land cover classifications to date are single-purpose systems, tailored to the requirements of a specific project or based on a sectoral approach. Land cover classes produced by such systems are generally not comparable. Yet, the increasing number of regional and global projects urgently needs a universally applicable land cover classification system for objective international comparisons of the current state of the land cover and its changes.

Despite the large number of land cover classification systems in existence, none has been internationally recognized and selected. Di Gregorio and Latham in *Africover Land Cover Classification and Mapping Project* argue that this is because of their lack to fulfill the needs (1) of maximum flexibility (in the sense that the system must be able to describe the maximum number of thematic classes at any scale to cope with the real world), and (2) of meeting the highest level of standardization possible (e.g. the classes should adhere to strict class boundary definitions that should be unambiguous, clear and as neutral as possible in the description) to be really synergetic with the further use in a GIS system.

The Land Cover Classification System (LCCS) developed as part of the **Africover** project is the only universally applicable land cover system in operational use at present. It enables a comparison of land cover classes regardless of data source, economic sector or country. Di Gregorio and Latham indicate that it is a variant of an *a priory* classification which means that all the classes must be defined before any data collection and their classification take place. The main advantage of such *a priory* classification system is that it allows for a standardization of the classes and is independent of the geographic area and data collection methodology. Its disadvantage is its inherent rigidity in having to select all the classes in advance. This method enhances in fact the standardization process and minimizes the problem of dealing with a very large amount of pre-defined classes.

The innovative approach of the Africover-LCCS is that, instead of pre-defining the

classes, it predefines the criteria that mark and identify the classes. The concept is based on the presumption that any land cover class, regardless of its type and geographic location, can be defined by a set of pre-selected independent diagnostic attributes, the *classifiers*. The number of classifiers used defines the detail with which land cover is classified. Thus, a larger number of classifiers is needed when a more detailed classification (description) of land cover is required.

The Africover project is not a research project in itself, but through its objectives and activities it promotes the standardization of data collection and allows for comparative research. The immediate overall objective of the project is to improve the availability of reliable, timely and location-specific land cover information in Africa, where such information is completely lacking. The Africover project is described in full detail in *Africover Land Cover Classification and Mapping Project.*

The IGBP-IHDP Joint Core Project on Land Use and Land Cover Change (LUCC) is not a research project either, but it promotes interdisciplinary research work, in particular between social and natural sciences and it intends to globalize research on land change processes through the study and evaluation of contrasting results obtained in a variety of regions and geographic situations.

The objectives of the project are (1) to build a compendium of information about local land use and cover dynamics; (2) to identify the principles that can better knit together local insights into a predictive science, and (3) to foster the development of models widely available to scientists. The project has developed regional and global data sets and is participating in several global observation systems, for example in the Global Observation of Forest Cover, or in human-environment actions through the Human-Environment Regional Observatory Project. More details on the activities of this LUCC project have been outlined in *The Land-Use and Cover-Change (LUCC) Project.*

A good overview of research projects dealing with land use and land cover changes and other related projects can be found in:

- the LUCC Newsletter, published in Louvain-la-Neuve, Belgium.
- Change - The Research and Policy Newsletter on Global Change from The Netherlands, published in Bilthoven, The Netherlands, and
- IIASA Options, published by the International Institute for Applied System Analysis in Laxenburg, Austria.

4. Land Cover and Land Use Changes

The analysis of land cover and land use change revolves around three central and interrelated questions: (1) What drives or causes land use and land cover changes? (2) What types of land use change can be observed? (3) And what are the environmental and socio-economic impacts of these changes? The answer to these questions depends largely on the identification and availability of the data needed, and on the nature and accuracy of the monitoring techniques for obtaining this information.

4.1. Data Collection

Over the past decennium enormous efforts have been undertaken to identify the needs associated with data collection for land use and land cover change, but none of these efforts have effectively resulted in a proper checklist for such information. This is logic because such needs are dependent on the specific topic to be tackled, as well as on the scale and detail of the data needed. Data which are relevant at a village level scale (corresponding to a 1/10 000 scale) do not behave as such when the study is undertaken at a national scale (corresponding to a 1/250 000 to 1/500 000 scale for example).

The problem of data collection has been discussed in full detail by several authors: Duhamel (*Land Use and Land Cover, including their classification*), Eiden (*Land-Cover and Land-Use Mapping*), Briassoulis (*Factors Influencing Land-Use and Land-Cover Change*), Antrop (*Land Use Changes Affected by Urban and Industrial Development*) and Di Gregorio and Latham (*Africover Land Cover Classification and Mapping Project*). In most other chapters the problem is at least indirectly touched.

In the CLAUDE project, Parry and Mortimer (1998) have identified four categories of needs associated with land use data. Though this project was mainly focused on Europe its conclusions can easily be extrapolated over a larger scale.

In first instance, there is a need to understand the **spatial distribution** of land cover. This requires the development of spatially comprehensive geo-referenced data which are frequently up-dated. Secondly, users require information on the **function and environmental character** of the land cover. The collection of such data requires intensive surveys, including field observations and the identification and use of carefully chosen sample sites. Thirdly, it is important to have knowledge relating to the **performance** of particular areas, and this can only be obtained at the farm level. Fourthly, to enable an improved understanding of the human processes driving change at the local level, good information is required on land **management practices, institutional capacity and the enabling environment, e.g. policies or subsidies**.

-
-
-

TO ACCESS ALL THE **35 PAGES** OF THIS CHAPTER,
[Click here](#)

Bibliography

Elvidge C.D. (2002). *Global Observation of Urban Areas based on Nocturnal Lighting;* LUCC Newsletter, 2002 (8): 10-12 [Summarizes the possibilities to use the DMSP-Operational Linescan System of nocturnal light images in the study of urban sprawl and biodiversity studies].

FAO (1976). *A Framework for Land Evaluation*. FAO Soils Bulletin, 32, Rome, 72p. [A basic publication explaining the FAO approach to land evaluation].

FAO (2000). *Global Forest Resources Assessment 2000*. FAO Forestry Paper 140, FAO, Rome [A recent inventory of the status of forests in the world].

FAO (2001). *State of the Worlds Forests 2001*. FAO Rome. [Updated inventory of forest cover in the world, mainly based on country figures].

Geist H.J. and Lambin E.F. (2001). *What drives Tropical Deforestation?* LUCC Report Series 4, Ciaco Eds, Louvain-la-Neuve, Belgium, 116p.[A study quantifying the proximate and underlying causes of tropical deforestation based on a large number of case studies].

Kates R. (1998). *Expanding Our Directions*. LUCC Newsletter, 1998 (3): 2-3. [Identifies a number of topics in global change studies which need additional attention].

Mayaux P., Bartholomé E, Massart M. and Belwart A.S. (2002*). The Land Cover of Africa for the Year 2000.* LUCC Newsletter, 202 (8): 4-6 (A good overview of the new GTC2000 approach, with application to the African continent, with a full-page color map of the land cover map for Africa).

Nilsson S. (1990). *New Forestry Practices needed across Europe*. Options, IIASA Laxenburg, 6-8 [A report of IIASA's forest study. Makes a link to other more detailed reports published on the matter].

Parry M. (2001). *The ACACIA Report: Assessment of Effects and Adaptations for Climate Change in Europe.* Change, Research and Policy Newsletter on Global Change from the Netherlands, 57:5-8 [Gives a summary of objectives, findings and recommendations of the ACACIA study].

Parry M. and Mortimer D. (1998). *The CLAUDE Project*. LUCC Newsletter, 1998 (3): 23-24 [Gives an overview of the major topics worked out in this project focused on Europe].

Serneels S. (2001). *Drivers and Impacts of Land Use Change in the Serengeti-Mara Ecosystem.* LUCC Newsletter, 2001 (6): 12. [Describes a research project and its main findings].

Turner B.L. (2001). *Land Cover and Land Use Change (LULUC) in the Southern Yucatan Peninsular Region.* LUCC Newsletter, 2001 (6): 4-5. [Describes a research project and its main findings].

van Vliet, A. and de Groot, R. (2001). *Phenology and Climate: Evidence of Change*. Change, Research and Policy Newsletter on Global Change from The Netherlands, 56 (1): 12-14. [Refers to major conclusions of a seminar in Freising, Germany, where the impact of climatic change was assessed on growing period characteristics of plants].

Vogel C. (1998). *Vulnerability and Global Environmental Change*. LUCC Newsletter, 1998 (3):15-19 [A clear overview of concepts, definitions and problems related to vulnerability; with an excellent bibliography for further reading].

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.