LAND USE MANAGEMENT

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Summary

Land use management is multifaceted. While in the past it referred mainly to arable farming and crop production, it includes nowadays many other uses liking housing, urban and industrial development, infrastructure and roads, recreation and leisure, mining, nature conservation, landscaping, etc. This overview paper deals with both agricultural and non-agricultural land use management including land reclamation, soil conservation and protection of the environment.

In order to meet the high production objectives modern agriculture requires many fertilizers, herbicides and pesticides, and is based on highly mechanized field operations. This leads to a number of environmental problems which are mainly reflected in soil and groundwater pollution, soil compaction and increased surface erosion.

Non-agricultural uses become, however, more and more important in industrialized countries and they occupy a steadily increasing acreage. These uses focus in particular on urban and industrial development, roads and infrastructure, mining, forests and nature reserves. In the light of a growing concern for environmental protection, after-care and land reclamation become an important issue. These focus in the first place on the prevention of erosion and contamination, the introduction of environmental-friendly farming practices and production systems, and ultimately in the banning of the most toxic products and in the treatment and rehabilitation of polluted sites. The ultimate goal should be a sustainable land use in a healthy soil environment.

1. Introduction

Management refers to the act, art or manner to handle and control things carefully. It stands for technical ability, tactfulness and long-term vision. Land use management focuses in particular on land and on the way land is used for production, conservation or aesthetic reasons. Land management requires decision making and is determined by the purpose it serves, i.e. food production, housing, recreation and leisure, mining, etc., and by the nature and the properties of the land itself.

While in the past land use management focused mainly on agricultural production, it now deals also with many other uses like urban development and residential housing, infrastructure and industrial zoning, protection and maintenance of green areas and forests, and land reserved for or used as a support for buildings, a filter for water or a site for sewage disposal, mine spills, etc.

Good land management is closely linked with the principles of wisdom. It involves the application of traditional inherited knowledge (which has proven its value in the past) while at the same time it requires the incorporation of modern technical know-how. Land management, and agricultural land management in particular, has three main objectives. It has an economic or production target focusing on the optimization, in the sense of a sustainable maximization of outputs. It holds a conservation objective for maintaining the available properties, potentials and outputs. It finally involves a reclamation aspect with a view to eliminate constraints, avoid degradation and improve or restore the land properties and use potential. Good management requires also that good practices are maintained in time, and that it is prepared to adapt to changing conditions.

In this paper an overview is given of the major land management issues related to agricultural and non-agricultural land uses, land reclamation, rehabilitation and restoration, soil conservation and protection of the environment.

2. Agricultural Land Management

Agricultural land management has undergone very important changes over the past centuries, and has moved from an almost exclusive supplier of food products for local consumption to a market-oriented activity. The decisions related to agricultural land management are mainly determined by lifestyle, needs and risks. The key issues dominating present-day management have been outlined in more detail in *Land Quality Indicators(LQI): Monitoring Land Evaluation* and *Land Use Planning for Sustainable Development.*

2.1 Traditional Agricultural Land Management

Traditional agriculture has evolved from the need to reduce the risks of hazardous hunting and fruit collection, and to satisfy basic food requirements for individuals and local communities. It made use of the natural properties of the land without major amendments, applied the inherited knowledge of the elderly, and did not aim for high production but for food security with a minimum risk. It was the cornerstone of food production and food supply before the development of the major cities in Europe, and it is still in use in many subsistence economies in developing countries and remote areas in general. This system is gradually disappearing in the world.

Traditional farming focuses in first instance on satisfying the family food supply, without direct incentives for excess production. With a progressive development of the cities many people were no more able to produce their own food, and farm products were offered on the market. Under those conditions, a need was created for a better and higher production to satisfy market demands and to look for new products and production methods. This new situation stimulates also the improvement of land management practices.

This type of ameliorated traditional land management and comparatively low yields has dominated agriculture in the Middle Ages and beyond, and did not change much up to the time (see below, section 2.2) that biotechnological progress and the development of agrochemicals completely modified the farming practices. Farm operations in this period are still largely carried out by human labor force and animal traction, and farm implements remain rather rudimentary. This development stage is still widely observed in many developing countries, where most farming is of the level of subsistence agriculture, with only a small fraction allocated to the production of cash crops.

2.2 Modern Agricultural Land Management

In the late 1940s traditional agricultural land management has undergone tremendous changes as a result of biotechnological progress in seed selection and an increased use of agrochemicals and operational machinery at all production levels. A key issue in the development of modern agriculture has been the introduction of mineral fertilizers which, besides their low cost, are more efficient than manure, and of pesticides against diseases and yield losses. Agriculture from this moment has mainly developed as an economic activity at the same level as manufacturing, servicing and banking. Modern farmers have become land managers, and their agricultural output is almost completely sold on the market.

In modern agriculture farming has shifted from a labor- to a capital-intensive operation, and mechanization has taken over most human manpower, though for certain crops there might still be a temporary demand for labor force at critical periods in the season. Moreover, modern land management is characterized by a growing demand for record-keeping, enhanced administrative and financial skills, adapted management between different fields, increased capital inputs, and a higher specialization in land use options resulting in a partial take-over of specialists and firms over individual farmers.

Modern farming methods in developed countries have resulted in peak yields which are on average three to four times higher than 20-25 years ago. These are obtained from fully mechanized farms, specialized in the production of only a few crops and operating on large fields, with the use of high amounts of fertilizers and pesticides.

In developing countries the introduction of modern agricultural land management has mainly resulted in the creation of large plantations of industrial crops like oil palm, rubber, coffee, pineapple, etc. For an optimal scale effect those plantations must cover more than 3,000-5,000 ha, and crop production is supported by new and improved cultivars, sophisticated detection methods to identify and cure plant diseases, optimal planting densities, etc.

Various types of agricultural land management linked to modern farming are discussed *in extenso* in *Management of Agricultural Land: Climatic and Water Aspects,* and *Management of Agricultural Land: Chemical and Fertility Aspects.*

2.3 High-Tech Land Management: Precision Agriculture

Precision agriculture is a computer-guided cost-effective production method, which finds its origin in soil variability and the need to limit unproductive inputs to optimal yields, while at the same time reducing pollution. It starts from the anomaly that historic agronomic practices are mainly developed on a farm or field basis while recommendations on tillage, seeding, fertilizing, weed control and other farming practices focus mainly on specific soil properties. Spatial variations of those properties, even within the same soil unit, cause, however, uneven patterns in crop growth and production, and decrease the efficiency of fertilizers and of any other practices applied uniformly over the field.

Precision agriculture focuses on a more soil-specific management that aims to prevent over- or under-application of inputs resulting from such a uniform field application. In other words, this technology implies the application of inputs on a micro-scale rather than on a field scale. The technique is known under a variety of names: farming by soil, spatially prescriptive farming, and computer aided farming, farming by satellite, high-tech sustainable agriculture, soil-specific crop management, site specific farming, precision farming, etc. It has been extensively described and documented in the proceedings of a series of seminars in 1993, 1995 and 1999 respectively edited by Robert *et al*.

Precision farming is a new technology. Its basic research dates back to the early 1980s, but it is only since the 1990s that it has been effectively implemented in the US, and to a lesser extent in Canada. In Europe, it was promoted by environmentalists focusing on the need to adopt management practices which combine profitability with minimum impact on the environment; attempts to put it in practice have generally been restricted to a few innovator farmers in the UK and Germany. The main reason why the technique is not easily accepted in most European countries is because it is not cost-effective when applied on land parcels which are too small.

In most other parts of the world precision farming is practically unknown, except in those countries (Japan, Malaysia, Taiwan) where the use of component technologies such as Geographic Information Systems (GIS) and remote sensing are common.

Two important factors have speeded up the development of precision agriculture: modern technology and environmental concern. The advent of computer-processed spatial data, together with progress in geo-statistical analysis, has enabled the display of that soil, hydrologic and microclimatic features that are relevant to agronomic practices. With the recent development of global positioning systems (GPS) suitable to on-site applications, the capability became available to deliver real-time and real-space changes in almost any agronomic procedure.

The implementation of precision agriculture implies a number of consecutive steps. First it is necessary to identify the parameters that affect crop growth and at the same time are of concern to the farmer. In principle, these parameters refer primarily to soil nutrient status, organic matter content, pH, moisture storage and water movement in the root zone.

The next step is to prepare the variability pattern on the field maps for application of differential management within a field. This should in first instance be obtained from existing soil maps and reports, in particular through digitizing and linking them to a global positioning system (GPS) as a tool to control and navigate the fertilizer or other applications as they move across fields.

However, as conventional soil maps are usually not designed to provide these fine-scale variations in soil attributes, a re-interpretation of existing data is often required. This can be done through pedo-transfer functions, process-oriented simulation models, statistic and geo-statistic approaches (that relate information on point data such as fertility samples to a larger area), or by additional field data collection. The result is a new computerized map which can be "read" by high-technology chemical spreaders and be properly interpreted to adapt fertilizer and pesticide doses and blends as the machines move across the fields.

A good exercise of such an interpretative approach is given by Mulla (1993) for a wheat farm in Eastern Washington State, USA. The author first found a good correlation between organic matter, soil P and wheat yields using standard statistic and geo-statistic approaches. He then showed a relationship between topography and organic matter content especially in the eroded areas, and made a positive correlation with the N and P status of the soil, and with the water storage capacity of the profile. Refining the mapping of organic material through remote sensing techniques allowed then to divide the fields into management zones with different soil fertility and water retention levels, two factors which have a significant impact on soil composition and average crop yields.

The final step is to manage properly each site in the field for an optimal production at the greatest return without damaging the environment. Decision making in this respect depends both on a good knowledge of the local environment and on a number of factors, of which advanced technology (such as the choice of optimal crop cultivars and pesticide choice), productivity, profitability and environmental concern are amongst the most relevant.

3. Managing Side Effects of Modern Agriculture

The search for excessive yields through the application of high fertilizer doses, use of herbicides and pesticides, highly mechanized field operations, and the modification, especially in Western Europe, of the former small-size parceling into larger fields has created since the 1980s and early 1990s a number of environmental problems, which are mainly reflected in soil and ground water pollution, soil compaction and in increased surface erosion.

This has lead to a growing concern on the side effects of modern agriculture and to the promulgation of legislation for protecting the natural resources. This legislation has been enforced by the introduction of the principle that the polluter is directly responsible for the environmental damage and, hence, should pay for the reclamation costs.

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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.