

HUMAN-INDUCED LAND DEGRADATION

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Summary

Land degradation, indicated by its state of soil degradation, vegetation degradation and degradation of its water resources, is often linked to sustainability in terms of retaining its productivity. Human interventions which are causing land degradation are (1) deforestation, (2) overgrazing by livestock, (3) mismanagement of agricultural land, (4) overexploitation of the vegetative cover for domestic use, and (5) (bio)industrial activities.

Water erosion is the most important type of soil degradation occupying 56% of the world wide area affected by human-induced soil degradation and mainly occurring in Asia. The area affected by wind erosion occupies 28% of the degraded terrain, mainly occurring in Asia and Africa. Loss of nutrients and salinization (mainly in Asia) are important types of chemical soil deterioration, whereas compaction is by far the most important type of physical soil degradation.

Water and wind erosion, as the two main types of land degradation, are illustrated with two case studies, being (1) water erosion in Belgium, resulting from intensified cultivation of slopes, and where now grass-buffer strips are installed at the bottom of the slopes in order to trap sediments, and (2) wind erosion in Southeast Tunisia, due to overgrazing and the extension of olive cultivation in a steppe environment. Construction of wind barriers for sand trapping can result in a recovery of primary plant species.

1. Introduction

Land degradation is a human-induced or natural process which negatively affects the land to function effectively within an ecosystem. Land degradation is often linked to *sustainability* in terms of keeping its productivity. As sustainability and productivity are not easy to define, degradation of land can better be described in terms of non-sustainable actions or in terms of loss of *resilience*. Resilience is defined as the land's ability to recover from a shock, be it climatic or a change in land use. The main reason for a recurrent shock in dry lands for example is *drought*. *Drought* results from a 'temporary' (short-term) rainfall deficit in relation to the normal precipitation, while *aridity* refers to a 'permanent' (long-term) rainfall deficit tied to other climatic data as elevated temperatures and strong evapotranspiration.

In terms of reduced productivity, land degradation deals with changes either in the physical environment, or in crop yields and livestock outputs. The following biophysical indicators of change in the state of the land and of land degradation can be defined:

Soil degradation:

- erosion - rate of soil loss (tons/ha/year);
- fertility decline - soil organic matter/topsoil carbon;
- soil nutrient balance (under present land use);
- occurrence of soil deficiencies, including micronutrients;
- salinization - extent of patches of salinized soil.

Vegetation degradation:

- normalized difference vegetation index (NDVI) (total plant cover: forests/woodlands, croplands, grasslands);
- annual rate of forest clearance (forests/woodlands).

Water resources degradation:

- monitored levels of water tables;
- monitored river flow regimes.

According to GLASOD (Global Assessment of Soil Degradation) (Oldeman et al., 1991) land degrading occurs when its function is lost or its productivity is reduced in terms of quantity, quality, goods and services. A decline in productivity would be the most obvious sign of land degradation, but it would not be sufficient to establish degradation: a decline could have come about for purely social reasons.

The causes of a change in productivity are not always obvious. Warren and Agnew (1988) argue that it remains necessary in each case to demonstrate that declining productivity is associated with an environmental change. This would exclude changes, such as in the market, that could have extreme effects on people, but need not involve an environmental change.

Desertification is generally viewed as an advanced stage of land degradation mainly occurring in the arid, semi-arid and dry sub-humid areas of the world. At the 1978 UNCOD (United Nations Conference on Desertification), desertification was defined as "a diminution or destruction of the biological potential of the land which can ultimately lead to desert-like conditions". In 1991, in order to have a more scientific guide for its activities UNEP (United Nations Environmental program) redefined desertification as "Land degradation in arid, semiarid and dry sub-humid areas as a basic result of adverse human conduct". The term 'desertification' has in the meantime been broadened to almost all forms of land degradation and is even used to include resource degradation in humid areas.

2. Causes of Land Degradation

Land degradation, in terms of degradation of soil and water resources, is partially or mainly due to non-appropriate land use. This mismanagement can find its origin in economic and social problems, population pressure, changes in market prices and technical reasons. Global climate changes may contribute to accelerate land degradation processes but, obviously, to a lesser degree than the effects of land use changes.

The direct cause of land degradation is mismanagement of the land by man. The indirect causes of this mismanagement may be: land tenure regulations, policies related to export-import, land politics, drought, poverty, poor advisory and extension services, population pressures. While the direct cause of land degradation is mismanagement, indirect factors such as governmental policies and poverty usually are the root causes. Combating land degradation or desertification and developing a sustainable management program depends upon removing both kinds of causes.

In the preparation of a world map as a first systematic evaluation of the status of human-induced soil degradation, GLASOD identified five different causes of human interventions that have resulted in soil degradation worldwide:

(1) *Deforestation* and the removal of the natural vegetation for fuel wood, agriculture and industry is increasing at an alarming rate and this is causing serious land degradation on 579 million ha of which 50% is located in Asia, followed by South America with 17%. It is estimated for example that only 4 to 6% of Ethiopia is now forested where once it was 40%; another example is Ivory Coast which lost more than 50% of its forest in less than 3 decades.

(2) *Overgrazing* of the vegetation is particularly damaging where livestock concentrates around watering points destroying the land within a radius around wells and villages. Overgrazing accounts for 679 million ha, by far the most important cause of human-induced soil degradation in Africa (243 million ha) and Asia (197 million ha). Stock grazing is the most widespread use of dry lands and is regarded as a major cause of desertification. Soil degradation in Patagonia, Argentina is attributed to the heavy grazing pressure associated with the sheep monoculture in the region.

(3) *Mismanagement* of agricultural land (552 million ha), with 204 million ha found in Asia and 121 million ha in Africa, and being the most important causative factor of

human-induced soil degradation in North and Central America (91 million ha). Inappropriate and/or heavy machinery is applied on former grasslands and steep slopes are cultivated in areas that are marginal in terms of rainfall, even for the production of sorghum and millet. Land left uncovered after cropping is prone to water and wind erosion.

(4) *Overexploitation* of the vegetative cover for domestic use: 133 million ha of which 63 million ha is located in Africa and 46 million ha in Asia. In South America the overexploitation of vegetation for domestic use is largely confined to dry land areas of North-West Argentina and southern Bolivia where shrub is collected for firewood.

(5) *(Bio-)industrial activities* cause soil degradation only on 23 million ha of which almost 100% is located in Europe. Those activities account also for small areas of degradation of dry lands around Teheran in northern Iran due to industrial pollution and in the Aral Sea basin due to excessive application of pesticides.

GLASOD further recognized two categories of human-induced soil degradation processes. The first category deals with degradation of soil material, and the two major types in this category are *water erosion* and *wind erosion*; loss of topsoil through water erosion is the most common type of soil degradation. The second category of soil degradation includes internal *soil chemical deterioration* (salinization and acidification, soil pollution caused by excessive use of pesticides and manure, and soil pollution due to industrial and human waste accumulation) and *soil physical deterioration* (compaction, sealing and crusting, and water logging).

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Biographical Sketches

Donald Gabriels is an agricultural engineer and professor at the Department of Soil Management and Soil Care of the Faculty of Agricultural and Applied Biological Sciences of Ghent University, Belgium, where he is leading the research group on *Soil Erosion and Soil Conservation* and coordinating the *International Centre for Eremology*. He holds a MSc in Soil Physics of Iowa State University, USA; a PhD in Agricultural Sciences of Ghent University, Belgium, and has been a postdoctoral Fulbright fellow on 'Soil Erosion and Soil Conservation' at the Department of Agronomy of Purdue University, USA.

His research and teaching experiences cover the fields of soil technology, soil amelioration, soil physics, soil erosion and soil conservation, wind tunnel experiments on rain and wind interaction, drainage of agricultural lands, and soil physical and soil mechanical properties of sports fields. He has been an expert for national and international organizations as UNESCO, European Union, Belgian and Flemish Governments, the former ORSTOM and FAO, and is currently involved in projects on Soil and Water Management in China and Chili.

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He has 10 years of relevant research and educational experience in the field of soil physics, water erosion, wind erosion, dust pollution, wind tunneling, and soil and water conservation. He was in charge of several missions to mainly developing countries where he was engaged in training activities, research and development related to soil-water management.