Int. Agrophysics, 1998, 12, 37- 42

HUMAN-INDUCED SOIL DEGRADATION ACTIVITIES

J.H.V. van Baren, L.R. Oldeman

International Soil Reference and Information Centre (ISRIC)
P.O. Box 353, 6700 AJ Wageningen, the Netherlands, E-mail: soil@isric.nl

A b s t r a c t. Soil degradation is occurring over vast areas. The GLASOD and ASSOD projects reflect the present status of human-induced soil degradation and its impact on food productivity related to productivity changes observed in the recent past. However, there is a great need for well-documented, reliable soil information and other related data at national and regional levels to better understand and qualify the impact of changing soil conditions or biomass production.

K e y w o r d s: soil degradation, GLASOD project, SOTER project, ASSOD project.

INTRODUCTION

The soil is a very complex medium which displays a great diversity in physical appearance, in chemical processes, and in the flora and fauna present (bio-diversity).

The role of the soil is of vital importance to mankind and the maintenance of a healthy natural environment. The soil is a natural resource, which is not renewable in the short term and very expensive either to reclaim or to improve once it is eroded by water or wind, physically degraded or chemically depleted. This precious resource ought to be maintained for the future, while it should at the same time be used in an appropriate way [19].

One of the most intensively debated issues in projections on directions that agricultural policies should take over the next 25 years is the extent of land degradation and its effect on food production. While many argue that land degradation is a potential threat to global food production [6], there are others that indicate that land degradation is over-estimated and relatively unimportant to global food production [2].

There is a wealth of scientific literature, workshop proceedings and policy statements (e.g., [15-17]) that link rapidly increasing world population, stagnant aggregate cereal output and the extent of soil degradation worldwide. These are the central themes on the international and national agendas of policy-makers, decision makers and agricultural research organizations worldwide.

While there is wide-spread evidence that soil losses resulting from erosion are far in excess of the natural rate of soil formation the impact of such losses on crop yields or production has not been well-established in physical or economic terms, although there have been many attempts to do so [4,5].

The International Food Policy Research Institute (IFPRI) initiated in 1994 an initiative for "A 2020 Vision for Food, Agriculture and the Environment". This initiative aims to develop a shared vision and a consensus for action on how to meet future world food needs while reducing poverty and protecting the environment. It grew out of a concern that the international community is setting priorities for addressing these problems based on incomplete information [8].

Hurni [6] states that science faces the challenge of assessing the impact of soil erosion by water and wind. To what extent is soil productivity affected? Economic estimates only focusing on production can be misleading because the underlying problem of soil degradation, its long-term irreversible consequences on soil productivity and the urgent need for action are under-estimated.

In the past, the demand for more food by increasing population was for a large part satisfied by opening up new land for agriculture, partly by intensified management of the land to obtain higher yields per unit land. Although world cereal production almost doubled between 1966 and 1990, the growth in aggregate cereal output started to decline after 1982 [3,7], mainly as a result of a decline in quality and performance of irrigation systems, an inefficient use of fertilizers, a negative nutrient balance in most non-irrigated drylands in developing countries, increased losses from pests and diseases, and a deterioration of commodity prices, leading to reduced incentives to invest. Many of these issues were discussed at the World Food Summit, held in Rome in November 1996 [5,23].

In much of Africa and also in most non-irrigated drylands in Asia and Latin America the mining of soil nutrients, often induced by poor socio-economic conditions, are pushing average yields into decline [14]. In response, farmers are trying to produce more food by extending their traditional low-input practices into forest land, on steeper land, or onto drier and more fragile pasture lands, or by shortening fallow-periods. As a consequence, fertile topsoil is washed away by the erosive forces of water, or blown away by wind.

In OECD countries fewer farmers are producing more food on less land. However, excessive use of fertilizers and pesticides, inadequate nutrient and animal waste containment have resulted in pollution of soil and water resources, not only causing a health hazard for increasing human and animal populations, but also leading to loss of bio-diversity and contamination of surface water, including coastal waters and lakes. Excessive use of water in irrigated areas in the semi-arid and arid regions has led to waterlogging and secondary salinisation. Acidification by atmospheric deposition of sulphide from coal mining industries is another form of land degradation, which may trigger a whole range of pollution processes. Information about the role of soils in the sustainable development issue in OECD countries in the 21st Century are given in Steenblik *et al.* [18].

THE GLASOD PROJECT

Although soil degradation is generally recognized as a serious and wide-spread problem, its geographical distribution and total areas affected was only roughly known. The United Nations Environment Programme (UNEP) commissioned the International Soil Reference and Information Centre (ISRIC) in 1988 to prepare a scientifically credible global assessment of the status of human-induced soil degradation (GLASOD), which was presented at UNCED, Rio de Janeiro in 1992 and aroused world-wide interest [11,13]. This study was published at an average scale of 1:10 M and was complemented with statistics on the extent of the various types of soil degradation, their degree and causative factors. The Annex gives some results of this study.

Although the GLASOD statistics were considered more defensible than earlier calculations, the impact of soil losses resulting from erosion or the impact of chemical degradation or physical deterioration on crop yields has not been well established in physical or socio-economic terms.

In a follow-up study in South and Southeast Asia (ASSOD) the impact of human-induced soil degradation was assessed in relation to the level of management and the resulting changes in productivity. Five classes of soil degradation impact were defined (negligible, light, moderate, strong and extreme). The changes in productivity, ranging from a large increase, small increase, no increase, small decrease, large decrease, unproductive, are expressed in relative terms: the current average productivity compared to the average productivity in the non-degraded situation, or the change in productivity over the last 10-15 years [12,22]. A small increase in productivity under a high level of management implies that management improvements partly benefitted yields and were partly needed to compensate the impact of degradation. Therefore the impact is light. A small decrease in productivity under a high level of management, implies that the management measures could not or only partly compensate the impact of soil degradation. Therefore the impact is strong.

The GLASOD and ASSOD studies however only reflect the present status of human-induced soil degradation and its impact on food productivity related to productivity changes observed in the recent past. If the seriousness, and thus the need for soil conservation measures or for alternative land uses is to be made explicit, the initial productivity of a certain land use system must be known as well as the effect of soil degradation on its productive capacity

THE SOTER PROJECT

In order to assess future risks of soil degradation more precise and quantitative information is needed on the various soil and terrain attributes, on climatic variables, on present land use and vegetation cover. The International Society of Soil Science, FAO, UNEP and ISRIC have developed an internationally endorsed methodology for the systematic storage of detailed information on natural resources in such a way that attributes of this geographically referenced database - the Soils and Terrain Digital Database (SOTER) - can be assessed and combined in order to analyze each combination of land, water and land use within a country or region from the point of view of potential use, in relation to food requirements, environmental impact or conservation [21].

In the context of their Global Environmental Outlook (GEO) project, UNEP expressed the need for a quantitative assessment of the impact of soil erosion on food production. The SOTER database and complementary data files on climate can be used to assess the impact of water erosion (in this case, loss of topsoil) on the productive capacity of the soil. The following steps were involved in a case study using the National Soil and Terrain Database of Uruguay [10].

First the water and nutrient limited yield for mechanized, low input wheat was estimated for SOTER units in Uruguay, considered suitable for wheat cultivation. Then the erosion risk was calculated using the SOTER Water Erosion Assessment Programme (SWEAP) [20] under the same management scenario. This water erosion risk calculation was used to simulate soil loss over a 20-year period. Top soil losses ranged from 0 up to 50 cm for the dominant soils in the mapping units. Nutrient- and water-limited yields were calculated again. Comparison of yields before and after 20 years topsoil water erosion shows the impact of erosion on yield. This methodology gives a possibility to calculate the yield decline, and even more importantly gives a spatial impression where soil erosion shows the highest impact. Such information can be very useful for national land use planning agencies.

In other developments a two-year project on Mapping of Soil and Terrain Vulnerability in Central and Eastern Europe (SOVEUR) is recently implemented by FAO in cooperation with ISRIC. In close collaboration with national soil survey institutes in Central and Eastern Europe an environmental information system will be developed. With auxiliary information on climate, land use and the type of soil pollution, the status of human-induced soil degradation and the areas considered vulnerable to defined pollution scenarios will be identified and mapped (scale 1:3 Million).

CONCLUSIONS

Soil degradation is occurring over vast areas. As a consequence of increased population pressure and the scarcity of unreclaimed land, physically and socio-economically suitable for cultivation, there will be increasing pressure on all sectors of society to utilize the existing cultivated areas as efficiently as possible and on a sustainable basis. While it may be true that it is economically not interesting to reclaim already strongly degraded land, it appears essential that all available mechanisms be set in motion to prevent further degradation of the land and to protect the land which is not yet affected by soil degradation.

There is a great need for well-documented, reliable soil information and other related data at national and regional levels to better understand and quantify the impact of changing soil conditions on biomass production. These objectives necessitate a close collaboration of all stakeholders. Interesting remarks about the interaction between researchers in soil science and stakeholders are given in [1].

The Science Academies Summit (Madras, July 1996) developed an agenda for future action to be adopted by world leaders at the World Food Summit in Rome in November 1996 [9]. They urged world leaders to revert the global trend of disinvestment in agricultural research and development, convinced that such short-sighted policy can only have tragic results. "Meeting the challenge of increasing food availability now and in the future demands equal focus on production systems and on the larger issues of access to food". They stress among other that a national natural resources conservation and enhancement strategy will be fundamental to a national food security system. "High priority must go to combating desertification and deforestation and to restoring degraded land".

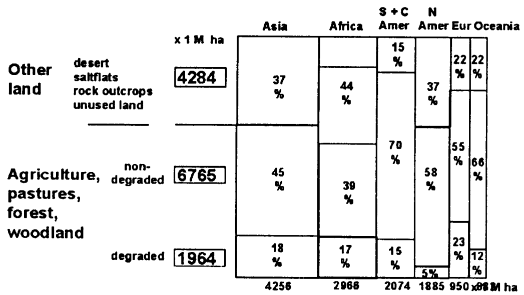
REFERENCES

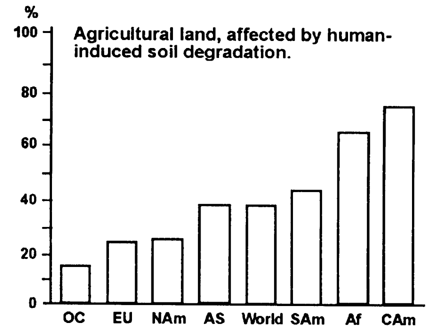
1. **Bouma J.:** The role of quantitative approaches in soil science when interacting with stakeholders. Geoderma 78, 1-12, 1997.
2. **Crosson P.:** Degradation of resources at a threat to sustainable agriculture. First World Congress of Professionals in Agronomy, Santiago, 1994.
3. FAO, 1990. FAO Yearbook 1989. Production. FAO statistical Series No. 94. Volume 43. FAO, Rome, 1990.
4. FAO, 1993. Agriculture: towards 2010. Conference Paper C93/24. FAO, Rome, 1993.
5. FAO, 1995. World Agriculture Towards 2010. FAO, Rome, 1995.
6. **Hurni H.:** With the assistance of an international group of contributors, Precious Earth: from Soil and Water Conservation to Sustainable Land Management. ISCO and Centre for Development and Environment (CDE), Berne, 1996.
7. IFPRI World Supply and Demand Projections for Cereals, 2020. A Vision for Food, Agriculture and the Environment. Brief No. 2. IFPRI, Washington, 1994.
8. IFPRI A 2020 Vision for Food, Agriculture and the Environment in Latin America. IFPRI, Washington, 1995.
9. IFPRI Uncommon Opportunities for Achieving Sustainable Food and Nutrition Security (ed. M.S. Swaminathan). A 2020 Vision for Food, Agriculture and the Environment. Brief No. 37. IFPRI, Washington, 1996.
10. **Mantel S., van Engelen V.W.P.:** The Impact of Land Degradation on Food Productivity. Case Studies of Uruguay, Argentina and Kenya. Report 97/01, ISRIC, Wageningen, 1997.
11. **Oldeman L.R.:** Global extent of soil degradation. In: Soil Resilience and Sustainable Land Use (Eds D.J. Greenland and I. Szabolcs), CAB International, Wallingford, 99-118, 1994.
12. **Oldeman L.R.:** Soil Degradation. A Threat to Food Security? Paper prepared for International Conference on Time Ecology: "Time for Soil Culture -Temporal Perspectives on Sustainable Use of Soil", Tutzing, April, 1997.
13. **Oldeman L.R., Hakkeling R.T.A., Sombroek W.G.:** World Map of the Status of Human-induced Soil Degradation: An Explanatory Note, second revised edition. ISRIC, Wageningen and UNEP, Nairobi, 3 maps and text, 1991.
14. **Paarlberg R.L.:** Sustainable Farming: a Political Geography. 2020 Vision, Brief 4, IFPRI, Washington, 1994.
15. **Pinstrup-Andersen P., Pandya-Larch R.:** Food Security and the Environment. In: Ecodecision, nr. 18, Quebec, 18-22, 1995.
16. **Saouma E.:** Soil Loss Accelerating Worldwide Hinders Effort to Feed Earth's Growing Population. Press release, FAO, Rome, 1995.
17. **Seragelding I.:** Foreword in "Global Research on the Environmental and Agricultural Nexus for the 21st Century". Report of the Task Force on Research Innovations for Productivity and Sustainability. Univ. Florida, Gainesville, 1995.

18. **Steenblik R., Maier L., Legg W.:** Sustainable Agriculture. In: OECD, Sustainable Development. OECD Policy Approaches for the 21st Century. OECD, Paris, 1997.
19. **Stoops G., Cheverry C.:** New Challenges for Soil Research in Developing Countries: a Holistic Approach. Proceedings Workshop of the European Community, Life Science and Technologies for Developing Countries (STD 3 programme), Rennes, 1992.
20. **Van den Berg M., Tempel P.:** SWEAP, A computer program for water erosion assessment applied to SOTER. Documentation version 1.5. SOTER-report 7. ISSS, Wageningen, 1995.
21. **Van Engelen V.W.P., Wen T.T. (eds):** Global and National Soils and Terrain Databases (SOTER). Procedures manual (revised edition). UNEP-ISSS-ISRIC-FAO, Wageningen, 1995.
22. **Van Lynden G.W.J., Oldeman L.R.:** The Assessment of the Status of Human-induced Soil Degradation in South and Southeast Asia. UNEP, FAO, ISRIC, Wageningen, 2 maps and text, 1997.
23. World Bank. Food Security for the World. Statement prepared for the World Food Summit. Washington, 1996.

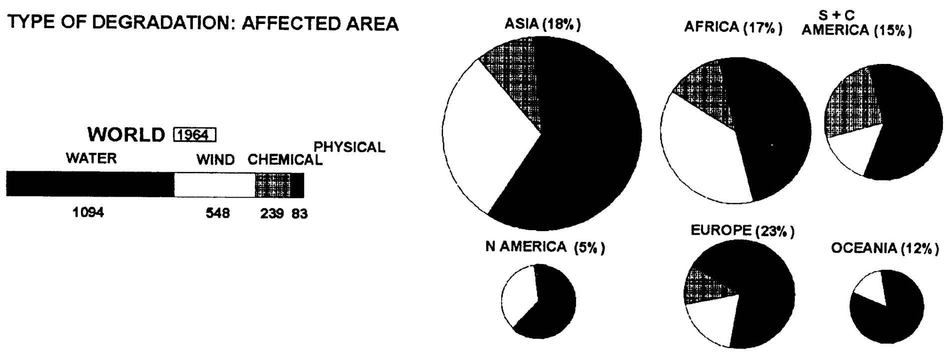
Annex

WORLD SOIL DEGRADATION

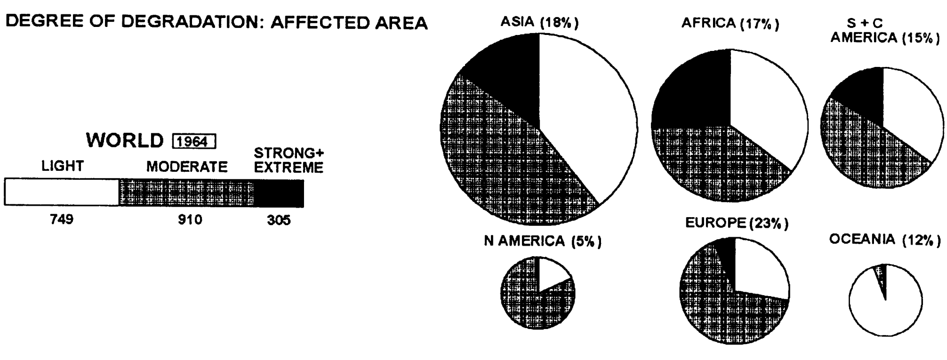




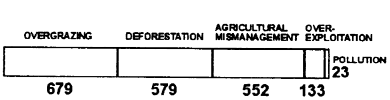
TYPE OF DEGRADATION: AFFECTED AREA



DEGREE OF DEGRADATION: AFFECTED AREA



HUMAN INTERVENTIONS



	OVERGRAZING	DEFORESTATION	AGRICULTURAL MISMANAGEMENT	OVER-EXPLOITATION	POLLUTION
AFRICA	243	67	121	63	+
ASIA	198	298	204	46	1
S. AMERICA	68	100	64	12	-
C. AMERICA	9	14	28	11	+
N. AMERICA	29	4	63	-	+
EUROPE	48	84	64	1	21
OCEANIA	83	12	8	-	-

(All data from GLASOD, 1991)