WORLD MAP OF THE STATUS OF

HUMAN-INDUCED SOIL DEGRADATION

An Explanatory Note

L.R. Oldeman
R. T. A. Hakkeling
W .G. Sombroek

Global Assessment of Soil Degradation
GLASOD

ISRIC **in cooperation with** **UN**
Winand Staring Centre-ISSS-FAO-ITC

CIP-GEGEVENS KONINKLIJKE BIBLIOTHEEK, DEN HAAG

Oldeman, L.R.

World map of the status of human-induced soil degradation: an explanatory note / L.R. Oldeman, R.T.A. Hakkeling, W.G. Sombroek. -Wageningen: International Soil Reference and Information Centre; Nairobi: United Nations Environment Programme. -I11.
Global Assessment of Soil Degradation GLASOD, October 1990, second revised edition October 1991. - Publ. in cooperation with Winand Staring Centre, International Society of Soil Science, Food and Agricultural Organization of the United Nations, International Institute for Aerospace Survey and Earth Sciences. - Met lit. opg.
ISBN 90-6672-046-8
SISO 567.4 UDC 528.94:551.3.053
Tref.: bodemdegradatie

WORLD MAP OF THE STATUS OF

HUMAN-INDUCED SOIL DEGRADATION

An Explanatory Note

L.R. Oldeman
R. T. A. Hakkeling
W .G. Sombroek

Global Assessment of Soil Degradation
GLASOD
October 1990 – first edition
October 1991 – second revised edition

International Soil Reference
And Information Centre

United Nations
Envirionment Programme

in cooperation with
Winand Staring Centre-ISSS-FAO-ITC
International Society of Soil Science
Food and Agricultural Organisation of the United Nations
International Institute for Aerospace Survey and Earth Sciences

ACKNOWLEDGEMENTS

The world map of the status of human-induced soil degradation was prepared under a financial agreement with the United Nations Environment Programme (UNEP) through a cooperative effort of soil scientists and soil degradation experts throughout the world. Without their invaluable contribution this project could not have been accomplished. The authors wish to express their gratitude to those scientists who contributed towards the preparation of the general guidelines for the assessment of human-induced soil degradation (annex 1), to those regional and national correlators who prepared the first draft soil degradation maps (annex 2) and to the numerous experts who were consulted by the regional correlators (annex 3).

The efforts of the cartographic division of the Winand Staring Centre for Integrated Land, Soil and Water Research (WSC) in preparing the final world map on the status of human-induced soil degradation in a relative short time are highly appreciated (annex 4).

The administrative staff of the International Soil Reference and Information Centre (ISRIC) is greatly acknowledged for their assistance in coordinating the project activities.

The technical support of the Food and Agricultural Organization of the United Nations (FAO), the Winand Staring Centre, and the International Institute for Aerospace Survey and Earth Sciences (ITC) has been of great value.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS ii

FOREWORD iv

I TOWARDS THE PREPARATION OF A GLOBAL ASSESSMENT OF SOIL DEGRADATION 1
1.1 Historical Perspective 1
1.2 Objectives of GLASOD 2
1.3 Project Organization 3

II METHODOLOGY FOR THE PREPARATION OF A WORLD MAP OF SOIL DEGRADATION 6
2.1 The Topographic Base Map 6
2.2 Guidelines for General Assessment of the Status of Human-induced Soil Degradation 7
2.2.1 Human-induced Soil Degradation Processes 7
2.2.2 Miscellaneous Terrain Categories 7
2.2.3 Mapping and Reporting Procedures 8

III COMPILATION OF THE WORLD SOIL DEGRADATION MAP 10
3.1 Development of a Legend for the GLASOD Map 10
3.1.1 Cartographic Representation 10
3.2 Explanation of the Legend of the GLASOD Map 11
3.2.1 Key to the Colours 11
3.2.1.1 Soil degradation types 12
3.2.1.2 Mapped units without human-induced soil degradation 14
3.2.1.3 Wastelands 14
3.2.2 Soil Degradation Status 14
3.2.2.1 Degree of soil degradation 14
3.2.2.2 Relative extent of the degradation type 15
3.2.2.3 The severity of soil degradation 15
3.2.3 Causative Factors 18
3.2.4 Recent-past Rate of Soil Degradation 18
3.2.5 Off-site Effect 19
3.2.6 Key to the Symbols 19

IV CONCLUDING REMARKS 20

V REFERENCES 22

Annex 1 : List of persons who contributed to the 'Guidelines for General Assessment of the Status of Human-induced Soil Degradation' 23
Annex 2 : List of regional correlators 23
Annex 3 : List of national cooperators 24
Annex 4 : Persons who prepared the cartographic presentation of the map 26
Annex 5 : The extent of human-induced soil degradation (L.R. Oldeman, V.W.P. van Engelen, J.H.M. Pulles) 27

Errata : 34

World Map of the Status of Human-induced Soil Degradation

An Explanatory Note

FOREWORD

Past and present human intervention in the utilization and manipulation of environmental resources are having unanticipated consequences. The often-indiscriminate destruction of forests and woodlands, and the spectre of land degradation resulting in decreased productivity with dire social consequences is generally recognized. The earth's soils are being washed away, rendered sterile or contaminated with toxic chemicals at a rate that cannot be sustained. "There is a growing realization in national and multilateral institutions that not only many forms of economic development erode the environmental resources upon which they are based, but at the same time environmental degradation can undermine economic development" (Brundtland et al., 1987).

Although soil degradation is recognized as a very widespread problem, its geographical distribution and total area affected is only very roughly known. “Sweeping statements contending that soil erosion is undermining the future prosperity of mankind, while holding an element of truth, do not help planners, who need to know where the problem is serious and where it is not" (Dregne, 1986).

Late September 1987 the United Nations Environment Programme (UNEP) concluded an agreement with the International Soil Reference and Information Centre (ISRIC) for the execution of a project, entitled: Global Assessment of Soil Degradation (GLASOD). The three year project included the preparation of a world map on the status of human-induced soil degradation at a scale of 1:10 M.

This map can serve as a tool to strengthen the awareness of policy-makers and decision-makers of the dangers resulting from inappropriate land and soil management, and can lead to a basis for the establishment of priorities for action programmes.

In a follow-up activity all units of the map have been digitised and linked to a GLASOD database. Annex 5, which is added to this second edition of the GLASOD explanatory note discusses the actual areal extent of human-induced soil degradation.

I TOWARDS THE PREPARATION OF A GLOBAL ASSESSMENT OF SOIL DEGRADATION

Historical Perspective

The first United Nations Conference on the Human Environment held in Stockholm, 1972, was inspired by the increasing awareness of the continuing deterioration of the renewable environmental resources. As a result of this meeting the United Nations Environment Programme (UNEP) was born.

An expert consultation on soil degradation, convened by F AO and UNEP in Rome, 1974, recommended that a global assessment be made of actual and potential soil degradation in collaboration with Unesco[1], WMO[2] and ISSS. This assessment would have to be based on the compilation of existing data and the interpretation of environmental factors influencing the extent and intensity of soil degradation such as climate, vegetation, soil characteristics, soil management, topography and type of land utilization; the results of this assessment would be compiled as a World Map of Soil Degradation. During the next four years FAO, Unesco, and UNEP developed a provisional methodology for soil degradation assessment and prepared a first approximation to identify areas of potential degradation hazard for soil erosion by wind and water, and for salinization and sodication. Maps at a scale of 1:5 M covering Africa north of the equator and the Middle East were prepared (FAO, 1979).

As an outgrow within the ISSS of this Society's increasing concern for soil degradation and environmental quality, a Sub-commission on Soil Conservation and Environmental Quality was established during the ISSS Congress in New Delhi, 1982. In the same year the Governing Council of UNEP adopted a World Soils Policy document aimed at 'conserving this most important of natural resources and using it on a sustainable basis' (UNEP, 1982). One of the elements of the World Soils Policy was, and still is, the development of methodologies to monitor global soil and land resources. Methods are required which can reliably detect significant changes in those soil and terrain characteristics, which directly or indirectly effect the quantity and quality of the land and its ability to produce food, fibre and timber. An assessment of the status and risk of soil degradation will provide one of the essential data sets for such a global understanding.

In response to these objectives Sombroek (1985) prepared a discussion paper on the Establishment of an International Soil and Land Resources Information Base. This paper formed the basis of an international workshop early 1986 at 1SRIC, Wageningen, to discuss the aims and scope of a possible international programme to establish a digital soil resources map of the world and accompanying soil and terrain databases at a scale of 1:1M *(*ISSS*,* 1986a). The only available document on the geography of the World's soil resource at that time was the FAO/Unesco Soil Map of the World at 1:5M scale, prepared by conventional cartography and resulting from a major international action programme to aggregate a1l soil survey information of the past 15 to 20 years. There was a unanimous agreement as to the need and desirability of the proposed l:l M soil map, and a project proposal for a World Soils and Terrain Digital Database (SOTER) was prepared *(*ISSS*,* 1986b) and endorsed at the ISSS Congress in Hamburg, 1986.

---

[1] Unesco: United Nations Educational Scientific and Cultural Organization

[2] WMO: World Meteorological Organization

Recognizing the importance of the SOTER proposal, UNEP convened an ad-hoc expert meeting at Nairobi in May 1987 to discuss the feasibility of producing a Global Soil Degradation Assessment. SOTER would provide the scientific ingredients -soil and terrain attributes -to make a quantitative assessment of the rate and risk of soil degradation at sufficient detail for national and regional planning. A world coverage of SOTER however is expected to take at least 15 years. This approach did not solve UNEP's desire for a global soil degradation assessment *now*. Even in 1987 the public awareness of the problem of the world's soil degradation did not correspond to the magnitude of the problem. UNEP therefore requested the ad-hoc expert meeting to consider the possibility to produce, on a basis of incomplete knowledge, a scientifically credible global assessment of soil degradation in the shortest possible time. 'Politically it is important to have an assessment of good quality *now* instead of having an assessment of very good quality in 15 or 20 years' (ISSS, 1987). The meeting reached consensus and recommended to UNEP to undertake:

- a global assessment of soil degradation at a scale of 1: 10 M, to be completed in three years.
- a soils and terrain digital database and generation of soil degradation maps at a scale of 1: 1 M for five test areas in the framework of SOTER.

On the basis of these recommendations UNEP formulated a project document: Global Assessment of Soil Degradation (GLASOD) and a agreement was concluded in September 1987 with ISRIC for the execution of GLASOD. ISRIC was requested to administer and coordinate all activities related to the accomplishment of

- a world map on the status of human-induced soil degradation at a scale of 1: 10 M and
- a detailed assessment on the status and risk of soil degradation for one pilot area in Latin America, covering parts of Argentina, Brazil, and Uruguay, accompanied by a 1:1M map.

The project had a duration of 28 months. ISRIC was assisted in the execution of the activities by many individual members of the ISSS, the Winand Staring Centre (WSC), in which the Netherlands Soil Survey Institute STIBOKA has been incorporated since 1989, FAO, and the International Institute for Aerospace Survey and Earth Sciences (ITC).

1.2 Objectives of GLASOD

A realistic understanding of global environmental changes is needed. By some estimates about 10% of the land surface of our planet has been transformed by human activities from forest and rangeland into desert and as much as 25% more is at risk (World Resources Institute, 1990). The loss of agricultural land through erosion is estimated at 6 or 7 million ha per year with an additional loss of 1.5 million ha annually as a result of waterlogging, salinization and alkalinization (Brundtland et al., 1987). It should however also be recognized that not all interventions by human action are negative. The many effective soil improvement and protection programmes, undertaken by national and international bodies tend however to be obscured by the overall deterioration of the world soil resource potential. The GLASOD project can be considered as a first step towards a global assessment of the geographical distribution of soil degradation.

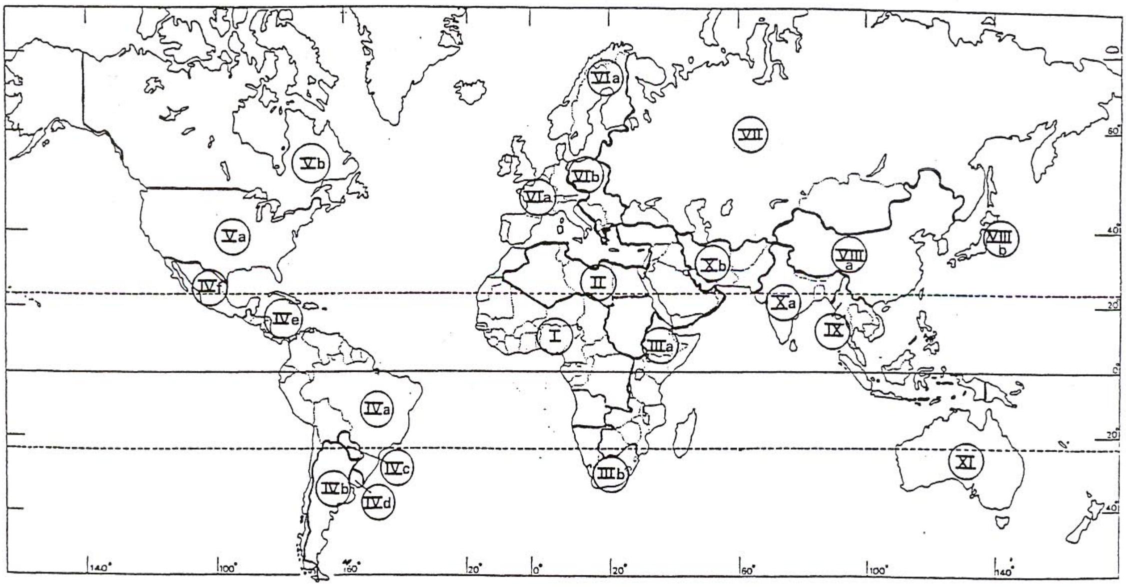
As formulated in the project document the immediate objective of GLASOD is:
'Strengthening the awareness of policy-makers and decision-makers of the dangers resulting from inappropriate land and soil management, and leading to a basis for the establishment of priorities for action programmes'.

1.3 Project Organization

In order to achieve the ambitious goal to prepare and publish a world map on the status of human-induced soil degradation within a time frame of three years, cooperation with a large number of soil scientists throughout the world was sought. They were asked to give their expert opinion on soil degradation in their particular geographic region.

The use of this 'expert-system' approach implied the need to prepare general guidelines for the assessment of the status of human-induced soil degradation. These guidelines were needed to ensure uniformity in reporting and delineating on maps the seriousness of various soil degradation processes. In order to avoid that maps of different scales and different projections would be used, a simplified geographic base map had to be prepared.

Obviously it was not feasible to request soil scientists in all nations of the world to prepare their own soil degradation maps. As soil degradation phenomena transcends national boundaries, the international panel of experts, which convened in Nairobi (May 1987) suggested dividing the world into ten geographic regions, and to assign a correlator for each region. Because of logistic, administrative and political considerations the project came up with 21 regions and/or individual countries (figure 1).



I : West + Central Africa
II : North Africa + Arab countries + Turkey
III^a : East and South East Africa
III^b : Southern Africa
IV^a : South America
IV^b : Argentina
IV^c : Paraguay
IV^d : Uruguay
IV^e : Central America
IV^f : Mexico.
V^a : USA
V^b : Canada.
VI^a : West + South + North Europe
VI^b : East + Central Europe
VII : USSR + Mongolia
$VIII^a$: China, North Korea
$VIII^b$: Japan, South Korea
IX : Southeast Asia
X^a : Indian Subcontinent
X^b : Iran + Afghanistan + Pakistan
XI : Australia + N. Zealand + P. New Guinea + S. Pacific

Figure 1: GLASOD Regions

Regional correlators -institutes and individual experts -were designated and requested to prepare draft regional soil degradation maps on the supplied geographic base maps following the general guidelines as closely as possible and in consultation with national soil experts in their region. Over 250 soil and environmental scientists have cooperated with these regional correlators and their expert opinion has been of invaluable importance. The regional correlators were requested to send their reports on the status of human-induced soil degradation, accompanied by a draft soil degradation map and complementary matrix tables to the project centre within 9 months. The first reports were received in February 1989, while the last regional report arrived in January 1990.

In the meantime, procedures were developed for the final preparation of the GLASOD map. Through a fruitful cooperation with the Winand Staring Centre in Wageningen, guiding principles were developed for the compilation of the 21 regional soil degradation maps. These were tested when the first regional maps arrived, improvements were made and comments of the regional correlators were, whenever possible, incorporated to ensure that the final GIASOD map was the best possible approximation of the global status of soil degradation.

The final draft version of the GLASOD map was then sent to national soil institutions throughout the world for their comments and acceptance. The response from a large cross section of the countries gave the project management sufficient confidence about the quality of the GLASOD map. At that stage the 'green light' was given to the cartographers to prepare the final version of the map. The experience of the Winand Staring Centre in the preparation of a wide variety of soil maps and the excellent facilities of their cartography division, which carried out the final map preparation, made it possible to publish the GLASOD map within three years after the start of the project.

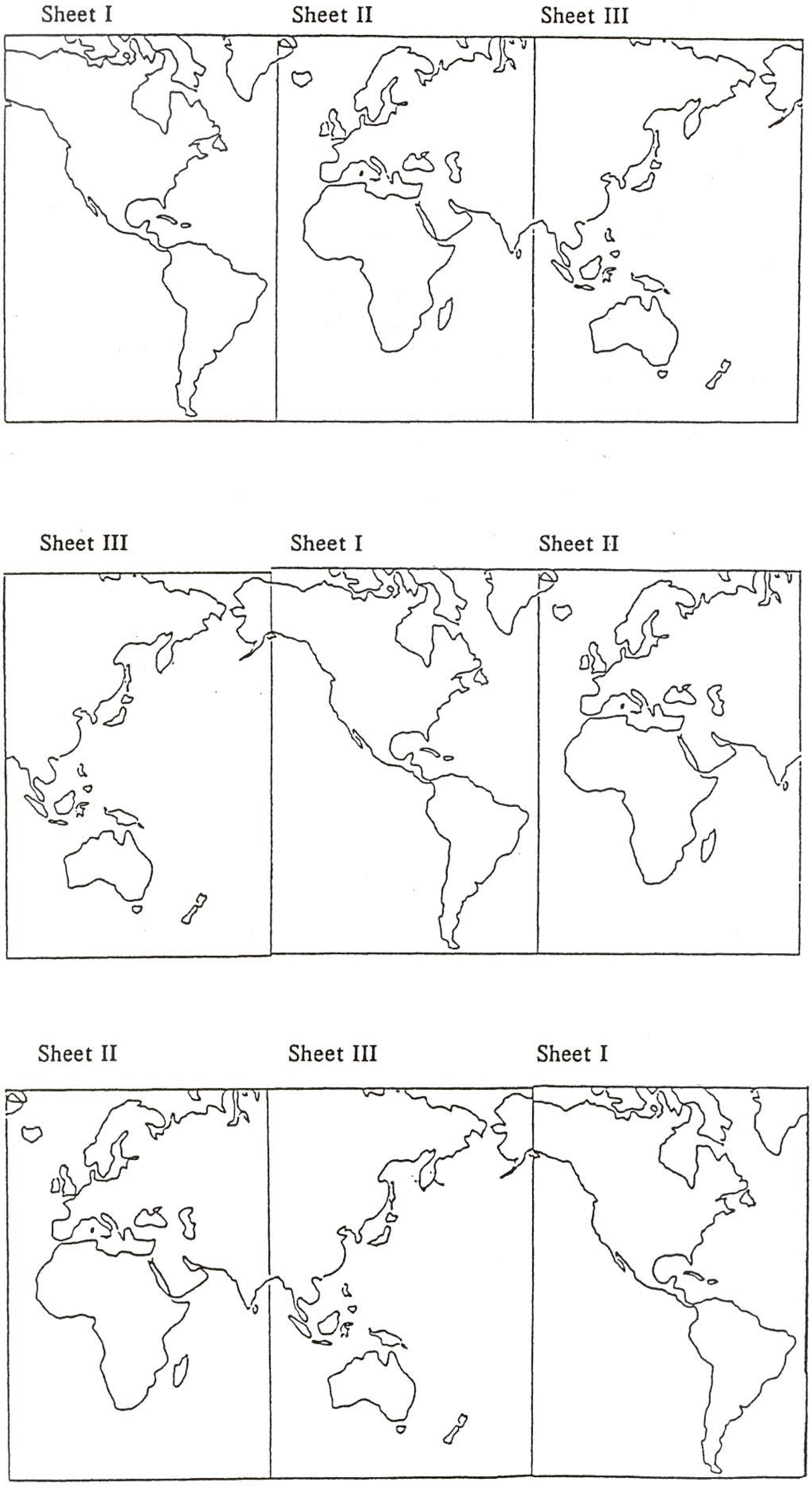


Figure 2: Three possible arrangements of the GLASOD map with Mercator projection

II METHODOLOGY FOR THE PREPARATION OF A WORLD MAP OF SOIL DEGRADATION

An overview is given on the technical aspects to prepare the world map of human-induced soil degradation.

The Topographic Base Map

UNEP requested a world soil degradation map at a scale of 1: 10 M. The immediate objective of the map was to create awareness of the present status of soil degradation for policy-makers, decision-makers, and the general public at large. This implied that a topographic base map was needed that could be conveniently displayed on an office wall, in conference centres, in classrooms, etc. The project therefore decided to use as topographic base a map on which the various continents would be displayed with as less distortion as possible: a world map with Mercator projection was the obvious choice. An additional advantage of this projection is that the three map sheets - the America's; Europe and Africa; Asia and the Pacific region - could be interchanged as desired (figure 2). A disadvantage is the variation in scale. At the equator the scale is smaller than at other longitudes. In fact the topographic base map that was chosen had a scale of 1:15 M at the equator; 1:10 M at 48° longitude; 1:5 M at 70° longitude (figure 3).

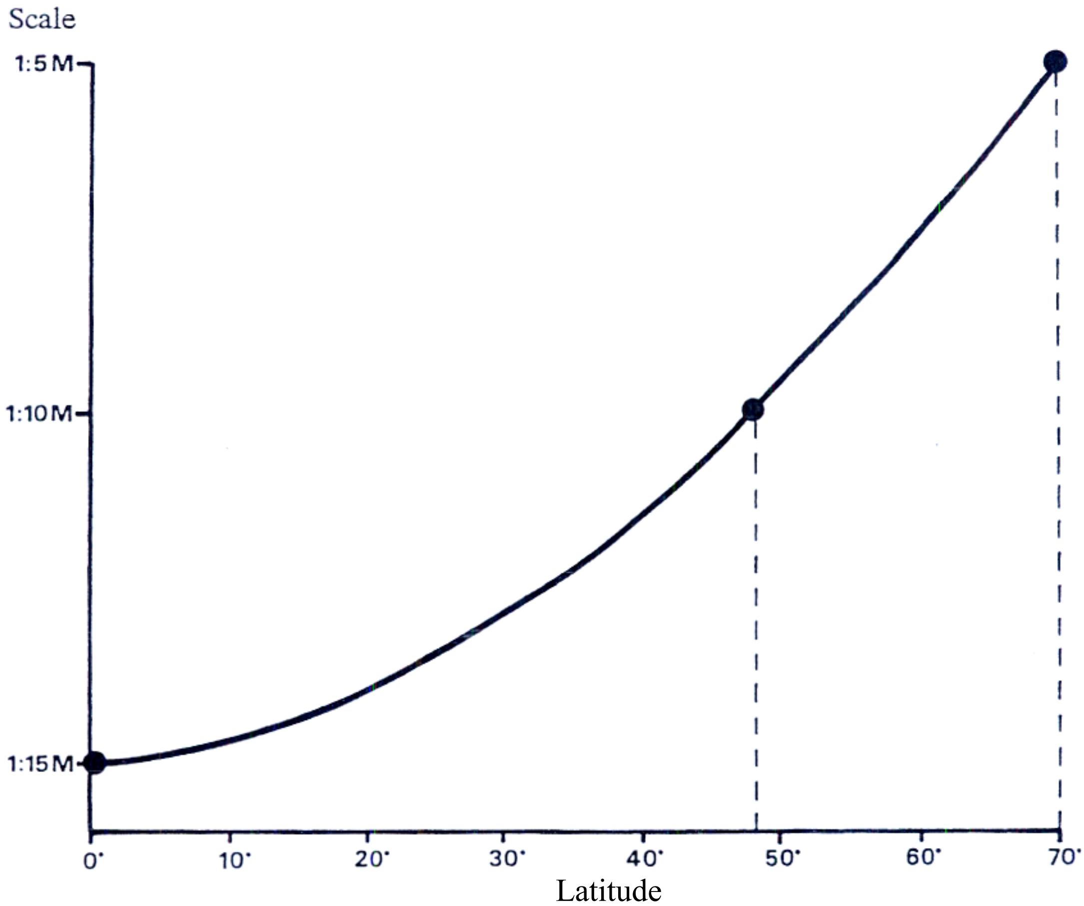


Figure 3: Relationship between scale and latitude as a consequence of Mercator projection.

This scale distortion should be realized when areas displayed on the map are interpreted as actual surface areas. It is however possible to calculate actual surface areas being affected once the map units are digitised and linked to a Geographic Information System, capable of converting Mercator Projection (see section IV) into 'equal area' projection. All regional correlators received a simplified topographic base map showing only continental boundaries, country boundaries, major cities and major hydrological features (lakes, rivers). This base map was enlarged to an average scale of 1:5M and the correlators were asked to delineate mapped units according to some general rules, described in the guidelines.

Guidelines for General Assessment of the Status of Human-induced Soil Degradation

An International advisory committee and a large group of soil degradation specialists were consulted in the preparation of 'Guidelines for General Assessment of the Status of Human-induced Soil Degradation'. In its final version (ISRIC, 1988), these guidelines were distributed to the regional correlators to ensure uniform application of methodologies for the assessment and mapping of soil degradation. Correlators were asked to assess the status of human-induced soil degradation. In other words, they would indicate regions where the balance between the attacking forces of climate and the natural resistance of the terrain against these forces has been broken by human intervention, resulting in a decreased current and/or future capacity of the soil to support life.

The present status of soil degradation was to be characterized by the degree to which the soil is presently degraded, by the percentage of the mapped area that is affected, and by the apparent rapidity of the soil degradation process estimated over the past 5 to 10 years. Also the kind of physical human intervention that has caused soil degradation had to be indicated.

Human-induced Soil Degradation Processes

Two categories of human-induced soil degradation processes were recognized. The first category deals with soil degradation by displacement of soil material. The two major types of soil degradation in this category are water erosion and wind erosion. Displacement of soil material will also lead to off-site effects: reservoir, harbour or lake sedimentation; flooding, river bed filling and riverbank erosion; excessive situation of the basin land; coral, shellfish beds and seaweed destruction are all examples of water erosion off-site effects. In case of wind erosion off-site effects are encroachment of sand sheets on roads, buildings and vegetative cover. The second category of soil degradation deals with internal soil physical and chemical deterioration. In this category only on-site effects are recognized of soil that has been abandoned or is forced into less intensive usages. It does neither refer to cyclic fluctuations of soil chemical and physical conditions of relatively stable agricultural systems, in which the soil is actively managed to maintain its productivity, nor to gradual changes in the chemical composition as a result of soil forming processes. The various soil degradation types belonging to these two categories are discussed in detail in section 3.2.1.1.

Miscellaneous Terrain Categories

While human-induced soil degradation occurs widespread throughout the world, the many effective soil improvement and protection programmes, undertaken by national and international bodies to stabilize the terrain should be recognized. Moreover, large areas are not affected at all by human intervention by the mere fact that the population density is very low. This category is recognized as stable terrain.

The map only indicates human-induced soil degradation; natural degradation phenomena are excluded. However those areas where natural soil degradation processes have led to extreme conditions such as deserts, salt flats, active dunes, rock outcrops, arid mountain regions, and also ice caps, will be recognized as a separate category, mainly because of their potential impact on the land around its edges. (Deserts can be a source of concern because of sand blasting and drift along its edges; a salt flat is a source of salt, capable of causing salinization of the nearby terrain).

Mapping and Reporting Procedures

The guidelines also indicated the procedures of mapping and reporting of human-induced soil degradation.

The first step involves delineation of physiographic units on the provided base map. These units should show certain homogeneity of topography, climate, soils, vegetation, and land use. Correlators would make maximum use of existing land inventory maps and reports and remote sensing materials. Each delineated unit should be given a unique number and the above aspects of each mapped unit, also including human population densities should be documented on a matrix table (figure 4).

The second step is an evaluation of the status of human-induced soil degradation that may occur in the mapped unit. The degree, relative extent, recent past rate and forms of human intervention that caused soil degradation should be evaluated. The result of this evaluation process is a list of human-induced soil degradation types per physiographic unit, to be filled in on the supplied matrix table forms and ranking them in order of importance. Also the relative extent of the stable terrain and non-used wasteland should be included.

Finally the correlators showed prepare a technical report with a detailed description of human-induced soil degradation for their respective regions, in particular the criteria used in defining the degree and rate of the different processes,

GLASOD MATRIX TABLE

Map unit : D25
Country 1 : Kenya
Country 2 :
Country 3 :
Area(km2) : 16900

Physiography : Upland, undulating to rolling (dom)
Plateau, undulating (inc)
Soil : AC , clay, deep (ass)
FR , clay, deep (ass)
Geology : Metamorphic rock
Precipitation (an.mean) : 500-900 mm
Temperature (mean) : 21-23 degr.C
Population density : Medium to high
Land use : Mixed farming
Vegetation : Grassland

General remarks :

DEGRADATION CHARACTERISTICS

Type	Caus	Degr	Rate	Ext	Remarks
Wt	g	3	3	4	Caused by sealing, Pk occurs in same area
Wd	g	3	3	2	On steeper slopes
Pk	g	1	1	1	No Wt yet
SN				5	

GLASOD MATRIX TABLE

Map unit : D26
Country 1 : Kenya
Country 2 : Tanzania
Country 3 :
Area(km2) : 42100

Physiography : Plain, undulating (dom)
Hills, steep (inc)
Soil : FRr, clay, deep (dom)
LPe, shallow (inc)
Geology : Metamorphic rock
Precipitation (an.mean) : 200-700 mm
Temperature (mean) : 23-29 degr.C
Population density : Low to medium
Land use : Pastoralism
Vegetation : Bush/shrubland

General remarks : Large area occupied by Tsavo national park, no degradation.
Taita hills: heavy erosion in past, now stabilized by
conservation practices

DEGRADATION CHARACTERISTICS

Type	Caus	Degr	Rate	Ext	Remarks
Wd	g	3	1	1	On footslopes around hills, now stabilized
Wt	g	1	1	4	Result of Pc in same area
Eo	g	1	1	3	
SH				2	Taita hills, stabilized by cons. practices (SHc)
SN				4	

Figure 4: Two examples of matrix tables, provided by the regional correlators (from Hakke1ing, 1989).

III COMPILATION OF THE WORLD SOIL DEGRADATION MAP

The draft maps on the status of human-induced soil degradation from 21 regions, prepared by 21 groups of soil scientists arrived at different times. They were prepared at twice the final scale. Despite the fact that all correlators made use of the same guidelines a major job lay ahead to put together all the information received in the matrix tables and displayed on the maps and to compile the final World Soil Degradation Map. Guiding principles were developed for the compilation, and a generalized soil degradation map for each region prepared and resumed to the regional correlators for their comments. These were incorporated and the final draft was then sent to national soil institutions for their remarks and approval. Only then the map was finalized and submitted to the cartography division of the Winand Staring Centre for drawing and printing.

3.1 Development of a Legend for the GLASOD Map

Several concepts were developed for the legend of the GLASOD map, keeping in mind that the map should create awareness on the seriousness of soil degradation in a global perspective among policy-makers and decision-makers and among the general public. At the same time however the map would provide information in sufficient detail on the various aspects of soil degradation, as it was supplied by the regional correlators.

The regional draft maps were prepared at twice the scale of the final map. Reduction in scale was necessary and therefore a generalization was unavoidable. Furthermore matrix tables accompanying the map often listed many types of soil degradation occurring within the same mapped unit. It was decided that a maximum of two types of soil degradation would be indicated per mapped unit. After evaluation of the contributions of a11 regional correlators, it was noted that some of the degradation types listed in the original guidelines had not been distinguished at all, or were distinguished only very few times. Also, many correlators had added the degradation type acidification (through drainage of acid sulphate soils or through fertilization). Therefore, the original list of degradation types as specified in the guidelines (ISRIC, 1988) had to be adjusted.

3.1.1 Cartographic Representation

Four colours were selected to represent the four main types of soil degradation (water erosion, wind erosion, chemical deterioration and physical deterioration). The colour of a mapped unit is determined by the dominant degradation type occurring in the unit. Only occasionally two types of degradation had the same weight of importance. In these cases a colour mosaic was shown on the map.

A major point of deliberation was in which way the seriousness of a certain soil degradation type could best be represented on the map. The status of soil degradation is indicated by its degree, relative extent in a mapped unit, and recent-past rate. This last element in the assessment was the most difficult and was not always reported on, while reasons for giving a degradation type a certain degree and indicating how widespread it occurred within a mapped unit was in most cases well documented. After careful consideration a decision was made indicating the seriousness of a type of soil degradation by a combination of the degree and relative extent. Since there are four degrees specified (light, moderate, strong, extreme) and the relative extent is given in five categories (infrequent, common, frequent, very frequent, and dominant) a total of 20 combinations are possible. As it would be very difficult to give an individual cartographic representation for these 20 combinations, they are assembled into 4 groups. On the map, each group is represented by different colour shades:

light shades refer to low degradation severity, dark shades to very high severity (see figure 5; section 3.2.2.3).

This approach implies that for example a strong degree of degradation occurring infrequently is given the same degradation severity as a light degree of degradation occurring frequently. However, as degree and relative extent of the individual degradation types are always given on the map by a number combination, actual situations are easy to deduct. Sections 3.2.2.3 and 3.2.4 elaborate on this subject. The recent past rate and the type of human intervention that bas caused soil degradation -the causative factors -are indicated as symbols in the mapped unit.

Stable areas and non-used wasteland are given separate colours on the map and are identified only when 100% of the mapped unit belongs to that category of land. It showed be kept in mind that the G1ASOD map is prepared to create awareness on the seriousness of soil degradation. This implies that a mapped unit with a light degree of soil degradation occurring infrequently (Less than 5% of mapped unit affected) bas already a light shade of the colour of that particular soil degradation process. However 95% or more -but not 100% -of the mapped unit is in that case not affected by soil degradation as a rest of human intervention.

3.2 Explanation of the Legend of the GLASOD Map

Mapped units represented on the GLASOD map are characterized by a colour and by a symbol. The colours indicate the main degradation type; the shading of the colour indicates the severity of the degradation taking place in a mapped unit. Each mapped unit has also a symbol giving a more detailed description of this type of degradation.

3.2.1 Key to the Colours

A total of 12 soil degradation types are recognized on the map. They are grouped into four main types: 'water erosion' (2 types); 'wind erosion' (3 types); 'chemical deterioration' (4 types); and 'physical deterioration' (3 types). Each type is discussed in more detail in section 3.2.1.2. Each main type is represented by a different colour:

- water erosion: bluish green
- wind erosion: brown
- chemical deterioration: red
- physical deterioration: pink.

Within each colour group different shades of that colour are used to indicate the severity of the degradation process. The colours range from a light shading referring to a low degradation severity to a dark shading referring to a high degradation severity. More details on the interpretation of the severity class are given in section 3.2.1.3.

A total of 9 miscellaneous terrain types are indicated on the map. They are grouped in two main types: 'stable terrain' (3 types) and 'wasteland' (6 types). The various types are briefly discussed in section 3.2.1.2. The main types of miscellaneous terrain are represented by a grey colour on the map:

- stable terrain: light grey
- wasteland: dark grey
- Reddish dots in a dark grey background indicate desert areas with scattered degraded oases.

All soil degradation types and miscellaneous terrain types are given special symbols on the map (see section 3.2.1.1 and 3.2.1.2).

3.2.1.1 Soil degradation types

A total of 12 types is recognized and mapped. Each degradation type is characterized by a symbol.

W : Water Erosion

Wt : Loss of topsoil

Loss of topsoil through water erosion is the most common type of soil degradation. It is generally known as surface wash or sheet erosion. It occurs in almost every country, under a great variety of climatic and physical conditions and land use. As the topsoil is normally rich in nutrients, a relatively large amount of nutrients is lost together with the topsoil. This process may lead to an impoverishment of the soil. Loss of topsoil itself is often preceded by compaction and/ or crusting, causing a decrease in infiltration capacity of the soil, and leading to accelerated run-off and soil erosion. On very steep slopes, natural loss of topsoil may occur frequently. This 'geologic erosion' is not indicated on the degradation map, unless it is accelerated by human intervention.

Wd : Terrain definition/mass movement

The most common phenomena of this degradation type are rill and gully formation. Rapid incision of gullies, eating away valuable soil is well known and dramatic in many countries. Control of active gullies is very difficult and total reclamation is almost impossible. Other phenomena of this degradation type are riverbank destruction and mass movement (land slides).

E : Wind Erosion

Et : Loss of topsoil

This degradation type is defied as the uniform displacement of topsoil by wind action. It is a widespread phenomenon in arid and semi-arid climates, but it also occurs under more humid conditions. In general, coarse-textured soils are more susceptible to wind erosion than fine-textured soils. Wind erosion is nearly always caused by a decrease of the vegetation cover of the soil, either due to overgrazing or to removal of vegetation for domestic use or for agricultural purposes. In (semi-)arid climates natural wind erosion is often difficult to distinguish from human-induced wind erosion, but natural wind erosion is often aggravated by human activities.

Ed : Terrain deformation

Terrain deformation by wind erosion is much less widespread than loss of topsoil. It is defied as the uneven displacement of soil material by wind action and leads to deflation hollows and dunes. It can be considered as an extreme form of loss of topsoil, with which it usually occurs in combination.

Eo : Overblowing

Overblowing, which is defined as the coverage of the land surface by wind-carried particles, is an off-site effect of the wind erosion types mentioned above. Overblowing may occur in the same mapped unit as those other types, or in adjacent units. It may influence structures like roads, buildings and waterways but it can also cause damage to agricultural land.

C : Chemical Deterioration

Cn : Loss of nutrients and/or organic matter

Loss of nutrients and/or organic matter occurs if agriculture is practised on poor or moderately fertile soils, without sufficient application of manure or fertilizer. It causes a general depletion of the soils and leads to decreased production. Loss of nutrients is a widespread phenomenon in countries where low-input agriculture is practised. The rapid loss of organic matter after clearing the natural vegetation is also included in this type of soil degradation. The loss of nutrients by erosion of fertile topsoil is considered to be a side-effect of erosion, and not distinguished separately.

Cs: Salinization

Human-induced salinization can be the result of three causes. Firstly, it can be the result of poor management of irrigation schemes. A high salt content of the irrigation water or too little attention given to the drainage of irrigated fields can easily lead to a rapid salinization of the soils. This type of salinization mainly occurs under (semi-)arid conditions and covers small areas. Secondly, salinization will occur ii seawater or fossil saline ground water bodies intrudes the ground water reserves of good quality .This sometimes happens in coastal regions with an excessive use of ground water but can also occur in (closed) basins with aquifers of different salt contents. A third type of salinization occurs where human activities lead to an increase in evapo(transpi)ration of soil moisture in soils on salt-containing parent material or with saline ground water .

Ca: Acidification

Two types of acidification occur which are difficult to separate on the map. The first may occur in coastal regions, upon drainage of pyrite-containing soils. As a result, pyrite will oxidize to, among others, sulphuric acid, which strongly reduces the agricultural potential of the soils because of extremely low pH values. The second type of acidification is caused by over-application of acidifying fertilizer, which may also lead to strong acidification and reduced agricultural potential.

Cp : Pollution

Many types of pollution can be recognized, best known is probably industrial or urban waste accumulation. Other types of pollution are the excessive use of pesticides, acidification by airborne pollutants, excessive manuring, oil spills, etc. Degree and distribution of these individual types vary strongly.

P : Physical Deterioration

Pc: Compaction, sealing and crusting

Compaction, sealing and crusting occur in all continents, under nearly all climatic and soil physical conditions. Compaction is usually caused by the use of heavy machinery on soils with a low structure stability. Sealing and crusting of the topsoil occurs in particular if the soil cover does not provide sufficient protection to the impact of raindrops. Soils low in organic matter content with poorly sorted sand fractions and appreciable amounts of silt are particularly vulnerable. Both compaction and crusting can be caused by cattle trampling. Compaction and crusting will make tillage more costly, impede or delay seedling emergence, and lead to a decrease in water infiltration capacity, causing in its turn a higher surface run-off, which may lead to significant water erosion.

Pw : Waterlogging

Waterlogging includes flooding by river water and submergence by rain water caused by human intervention in natural drainage systems. The construction of paddy fields is not included, as this is considered to be an improvement rather than a degradation of the soil.

Ps : Subsidence of organic soils

Subsidence of organic soils, as caused by drainage and/or oxidation, is only recognized if the agricultural potential of the land is negatively affected. In many cases however, drainage of organic soils will lead to an increase in agricultural potential, and is not mentioned on the map.

3.2.1.2 Mapped units without human-induced soil degradation

S : Stable terrain

SN: Stable terrain under natural conditions

Areas which are stable under natural conditions show little or no agricultural practices, and usually show very little other human activities. This absence of human activities is in general due to the fact that the type of land concerned is not suitable for agriculture practices. Large areas of stable terrain under natural conditions are found in Canada, Scandinavia and the Soviet Union, where mean summer temperatures are too low for large scale agriculture. Low temperatures and steep slopes account for the absence of agriculture in large parts of the Himalayas and the Andes. The extensive rainforests of South America and Africa also comprise some stable, virtually uninhabited areas. Other reasons for the absence of human activities are highly unfavourable soil conditions, semi-desert conditions such as in large parts of Australia, and inaccessibility due to, for instance, poor drainage. Nature or wildlife reserves also fall in this category, but are often too small to be mapped at the GLASOD scale.

SA : Stable terrain with permanent agriculture.

If agricultural land is well managed, no soil degradation of any kind will occur and productivity levels will not decrease.

SR: Terrain stabilized by human intervention

As the awareness of the dangers of soil degradation grows, so do the efforts concurring conservation programmes. Increasingly, regions do show positive effects of conservation practices. In general, these practices are rather recent, but locally they may originate from centuries ago. Examples of conservation practices are reforestation, terracing, gully control, water management, etc.

3.2.1.3 Wastelands

Historic or recent natural processes have turned these terrains into wastelands without appreciable vegetative cover or agricultural potential. On the map the following six types are recognized:

D : active dunes

Z : salt flats

R : rock outcrops A deserts

I: ice caps

M : arid mountain regions

3.2.2 Soil Degradation Status

The status of soil degradation is an expression of the severity of the process. The severity of the process is characterized by the degree in which the soil is degraded and by the relative extent of the degraded area within a delineated physiographic unit.

3.2.2.1 Degree of soil degradation

The degree to which the soil is presently degraded is estimated in relation to changes in agricultural suitability, in relation to declined productivity and in some cases in relation to its biotic functions. Four levels are recognized:

1. light: The terrain has somewhat reduced agricultural suitability, but is suitable for use in local farming systems. Restoration to full productivity is possible by modifications of the management system. Original biotic functions are still largely intact.

2. moderate: The terrain bas greatly reduced agricultural productivity hut is still suitable for use in local farming systems. Major improvements are required to restore productivity .Original biotic functions are partially destroyed.
3. strong: The terrain is non reclaimable at farm level. Major engineering works are required for terrain restoration. Original biotic functions are largely destroyed.
4. extreme: The terrain is irreclaimable and beyond restoration. Original biotic functions are fully destroyed.

3.2.2.2 Relative extent of the degradation type

At the chosen scale it is not possible to separate areas of soil degradation individually on the map. It is however possible to estimate the relative extent of each type of soil degradation within the mapped unit. Five categories are recognized:

1. **infrequent:** up to 5% of the unit are affected
2. **common:** 6 to 10% of the unit is affected
3. **frequent:** 11 to 25% of the unit is affected
4. **very frequent:** 26 to 50% of the unit is affected
5. **Dominant:** over 50% of the unit is affected.

3.2.2.3 The severity of soil degradation

The severity of soil degradation is indicated by a combination of the degree and the relative extent of the process. Since there are four degrees specified and the relative extent is given in five categories 20 combinations are possible. These 20 combinations were then grouped into four severity classes as illustrated in figure 5. Each severity class is given a different shading of the colour of the dominant soil degradation process occurring in a given mapped unit.

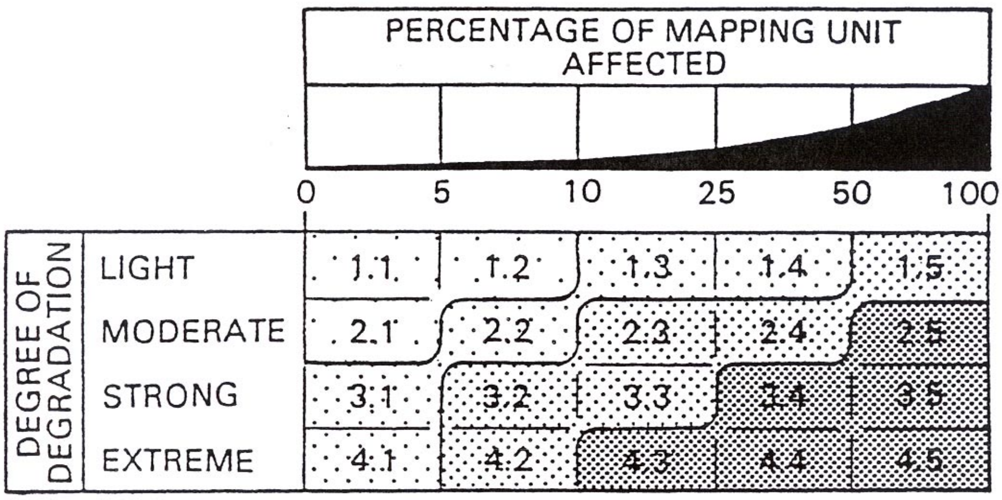


Figure 5. Severity classes of human-induced soil degradation.

The above mentioned interpretation of degradation severity becomes more complicated if two types of soil degradation are recognized in one mapped unit. When both types have the same weight of importance and also the correlator in the field did not indicate a difference in importance, a colour mosaic is shown on the map. The shade of the mosaic is determined by the so called 'aggregate severity', which may be higher than the severity of the individual degradation types (see also below). In case one of the two degradation types is subordinate, it is still possible that the aggregate severity is one class higher than the severity of the most important type. This will occur if the severity of the second type is significant enough to have a bearing on the overall severity.
These upgradings are carried out by examining:

- the total relative extent that is affected (e.g. Wt1.4 + Cn1.3; both types have a medium severity, but total relative extent is more than 50% (class 5), and thus overall severity is high).
- the degree of degradation of the second type, compared to the degree of the first type (e.g. Wt1.4 + Cn2.2; both types have a medium severity, but total relative extent is less than 50% (class 4). However, the higher degree of the second type will cause an upgrading to severity class high).

The upgraded degradation severity of the map unit is visualized by the shading of the colour of the most important degradation type, which will be one class darker than what could be expected from figure 5. In case of a colour mosaic, the constituting colours of the mosaic will also be one class darker. Table 1 gives the aggregate degradation severity of mapped units for all combinations of severity of degradation types.

For some mapped units, the expert opinion of the regional correlator conceding the relative importance of the degradation types and the aggregate severity, did not correspond with the principles used to compile table 1. This implies that for the units concerned colours and colour shadings cannot be deduced from the table. This situation occurs mainly in South America.

It should be realized that the shading of colours on the map is an interpretation of the situation based on the information supplied by the correlators. Other interpretations are possible and may result in different shadings. Since the actual degree and relative extent of both degradation types are given in the symbol on the map, the information on which the interpretation is based is always available (see also section 3.2.6).

Table 1 Severity and aggregate severity of one, respectively two soil degradation types in one mapped unit.

Degr. types (1)	Sev. class (2)	Rem. (3)
1.1	L	
1.1 + 1.1	L	(m)
1.2	L	
1.2 + 1.1	L	
1.2 + 1.2	M	(m)#
1.2 + 2.1	M	(m)#
1.3	M	
1.3 + 1.1	M	
1.3 + 1.2	M	
1.3 + 1.3	M	(m)
1.3 + 2.1	M	
1.3 + 2.2	H	(m)#
1.3 + 3.1	M	(m)
1.3 + 4.1	M	(m)
1.4	M	
1.4 + 1.1	M	
1.4 + 1.2	M	
1.4 + 1.3	H	#
1.4 + 1.4	H	(m)#
1.4 + 2.1	M	
1.4 + 2.2	H	#
1.4 + 2.3	H	(m)#
1.4 + 3.1	H	#
1.4 + 3.2	H	(m)#
1.4 + 4.1	H	(m)#
1.5	H	
1.5 + 1.1	H	
1.5 + 1.2	H	
1.5 + 1.3	H	
1.5 + 1.4	H	
1.5 + 2.1	H	
1.5 + 2.2	H	
1.5 + 2.3	H	
1.5 + 2.4	VH	(m)#
1.5 + 3.1	VH	#
1.5 + 3.2	VH	
1.5 + 3.3	VH	(m)#
1.5 + 4.1	VH	#
1.5 + 4.2	VH	(m)#
2.1	L	
2.1 + 1.1	L	
2.1 + 1.2	M	(m)#
2.1 + 2.1	M	(m)#
2.2	M	
2.2 + 1.1	M	
2.2 + 1.2	M	
2.2 + 1.3	H	(m)#
2.2 + 2.1	M	
2.2 + 2.2	H	(m)#
2.2 + 3.1	H	(m)#
2.3	H	
2.3 + 1.1	H	
2.3 + 1.2	H	
2.3 + 1.3	H	
2.3 + 1.4	H	(m)
2.3 + 2.1	H	
2.3 + 2.2	H	
2.3 + 2.3	H	(m)
2.3 + 3.1	H	
2.3 + 3.2	H	(m)
2.3 + 4.1	H	(m)
2.4	H	
2.4 + 1.1	H	
2.4 + 1.2	H	
2.4 + 1.3	H	
2.4 + 1.4	VH	#
2.4 + 1.5	VH	(m)#
2.4 + 2.1	H	
2.4 + 2.2	H	
2.4 + 2.3	VH	#
2.4 + 2.4	VH	(m)#
2.4 + 3.1	H	
2.4 + 3.2	VH	#
2.4 + 3.3	VH	(m)#
2.4 + 4.1	H	
2.4 + 4.2	VH	(m)#
2.5	VH	
2.5 + 3.4	VH	(m)
2.5 + 4.3	VH	(m)
2.5 + *.*	VH	
3.1	M	
3.1 + 1.1	M	
3.1 + 1.2	M	
3.1 + 1.3	M	(m)
3.1 + 2.1	M	
3.1 + 2.2	H	(m)#
3.1 + 3.1	H	(m)#
3.2	H	
3.2 + 1.1	H	
3.2 + 1.2	H	
3.2 + 1.3	H	
3.2 + 1.4	H	(m)
3.2 + 2.1	H	
3.2 + 2.2	H	
3.2 + 2.3	H	(m)
3.2 + 3.1	H	
3.2 + 3.2	H	(m)
3.2 + 4.1	H	(m)
3.3	H	
3.3 + 1.1	H	
3.3 + 1.2	H	
3.3 + 1.3	H	
3.3 + 1.4	VH	#
3.3 + 1.5	VH	(m)#
3.3 + 2.1	H	
3.3 + 2.2	H	
3.3 + 2.3	VH	#
3.3 + 2.4	VH	(m)#
3.3 + 3.1	H	
3.3 + 3.2	H	
3.3 + 3.3	VH	(m)#
3.3 + 4.1	H	
3.3 + 4.2	VH	(m)#
3.4	VH	
3.4 + 2.5	VH	(m)
3.4 + 3.4	VH	(m)
3.4 + 4.3	VH	(m)
3.4 + *.*	VH	
3.5	VH	
3.5 + 4.4	VH	(m)
3.5 + *.*	VH	
4.1	M	
4.1 + 1.1	M	
4.1 + 1.2	M	
4.1 + 1.3	H	#
4.1 + 1.4	H	(m)#
4.1 + 2.1	M	
4.1 + 2.2	H	#
4.1 + 2.3	H	(m)#
4.1 + 3.1	H	#
4.1 + 3.2	H	(m)#
4.1 + 4.1	H	(m)#
4.2	H	
4.2 + 1.1	H	
4.2 + 1.2	H	
4.2 + 1.3	H	
4.2 + 1.4	VH	#
4.2 + 1.5	VH	(m)#
4.2 + 2.1	H	
4.2 + 2.2	H	
4.2 + 2.3	VH	#
4.2 + 2.4	VH	(m)#
4.2 + 3.1	H	
4.2 + 3.2	VH	#
4.2 + 3.3	VH	(m)#
4.2 + 4.1	H	
4.2 + 4.2	VH	(m)#
4.3	VH	
4.3 + 2.5	VH	(m)
4.3 + 3.4	VH	(m)
4.3 + 4.3	VH	(m)
4.3 + *.*	VH	
4.4	VH	
4.4 + 3.5	VH	(m)
4.4 + 4.4	VH	(m)
4.4 + *.*	VH	
4.5	VH	
4.5 + *.*	VH	

(1) Number combination of degradation status of one or two types: first number refers to degree, second number refers to relative extent
**: other combinations possible

(2) Severity class: L = low (light); M = medium (medium); H = high (dark); VH = very high (very dark)

(3) Remarks: (m) = mosaic on map (equal severity of both degradation types)
= severity class "upgraded"

Note: many of the combinations given above do not actually occur in the GLASOD map.

3.2.3 Causative Factors

The word 'soil degradation' implies by definition a social problem. Only environmental processes such as leaching and erosion occur with or without human interference, but for these processes to be described as 'degradation' imply social criteria which relate land to its actual or possible uses (Blaikie and Brookfield, 1987). For this reason the correlators were requested to indicate what kind of physical human intervention has caused the soil to be degraded. For each mapped unit with some form of degradation, one or two of the following causative factors are given:

f : Deforestation and removal of the natural vegetation
This causative factor is defined as removal of the natural vegetation (usually forest) of stretches of land. Reason for this clearing may be the reclamation of land for agricultural purposes (cropping or cattle raising), large scale commercial forestry, road construction, urban development, etc.

g. Overgrazing
Besides the actual overgrazing of the vegetation by livestock, this causative factor also includes other effects of livestock, such as trampling. Overgrazing usually leads to a decrease of the soil cover, which increases the water and Wind erosion hazard. Trampling may cause compaction of the soil.
A widespread effect of overgrazing is the encroachment of unfavourable (unpalatable or noxious) shrub species. Although this phenomenon certainly influences grazing potential, it is not distinguished as soil degradation, as the soil itself is not affected.

a. Agricultural activities
This causative factor is defined as improper management of agricultural land. It includes a wide variety of practices, such as insufficient or excessive use of fertilizers, shortening of the fallow period in shifting cultivation, use of poor quality irrigation water, absence of anti-erosion measures, improperly timed use of heavy machinery, etc.

e. Overexploitation of vegetation for domestic use
This causative factor deals with the use of the vegetation for fuel wood, fencing, etc. Contrary to deforestation and removal of the natural vegetation, it usually does not lead to complete removal of all vegetation. However, the remaining vegetation does not any more provide sufficient protection to soil erosion.

i. (Bio)industrial activities
This causative factor usually leads to degradation type 'Cp: pollution'.

Note

If two causative factors are shown on the map, the sequence of appearance does neither indicate a sequence in importance, nor does it necessarily coincide with the sequence of degradation types indicated in the mapped unit.

3.2.4 Recent-past Rate of Soil Degradation

Recognition of the average rate of human-induced soil degradation should be estimated in dependence of changes in local population densities (bath human and animal), and/or in relation to intensification of mechanization, agricultural expansion, fertilizer use, industrialization, etc. during the last 5 to 10 years. Instances of soil degradation during critical periods should be totalled and averaged over the last 5 to 10 years in order to define whether the rate is slow, medium or rapid. Reasons for indicating various rates should be explained as detailed as possible in the accompanying report.

Since recent past rate is not strictly defined, the reliability is rather limited. If the recent past rate is slow, no indication is given on the map. Two categories are shown:

↑ medium

↑ rapid
↑

3.2.5 Off-site Effect

Only one form of off-site effect was reported by the regional correlators: uncontrolled human-induced flooding (symbol), occurring as a result of human intervention, like deforestation, in upstream areas. This does not imply that other off-site effects do not occur, but as the regional correlators did not indicate them in their reports, they do not appear on the map.

3.2.6 Key to the Symbols

Each delineated mapped unit bas been given a symbol, which can indicate a maximum of two human-induced soil degradation types.

EXAMPLE OF A SYMBOL:

Wt2.3
g ↑

The two letter codes identify the type of soil degradation. This letter combination is followed by two numbers: the first number refers to the degree, the second number refers to the relative extent of soil degradation. Wt2.3 means that the degradation type 'loss of topsoil through water erosion' (Wt) has a moderate degree (2) and occurs frequently (3). Below the symbols for degradation type one or two lower case letters indicate the causative factor(s), sometimes followed by a single or double arrow, indicating the recent past rate.

IV CONCLUDING REMARKS

The compiled world map of the status of human-induced soil degradation is a joint effort of a wide section of the international soil science community. Some aspects of soil degradation which were considered of importance when the general guidelines were drafted are not represented on the map, either because these aspects appeared to be of only minor importance, or because the requested information could not be provided with sufficient detail to be included.

A case in point was the suggestion to indicate human-induced soil degradation that occurred in the past. This aspect could not be mapped with precision because of lack of information. The general guidelines specified three historic periods:

a : Early civilization occurring in the ancient past up to 250 years ago.
b : Era of European expansion in the America's, Australia, Asia and Africa, 50-250 years ago.
c : Post second world war period, very much related to the human population explosion, particularly taking place in the third world countries.

Dregne (1986) elaborated on the occurrence of human-induced soil degradation in the past. Water erosion caused by human intervention occurred 1000 to 3000 years ago in the uplands of the Mediterranean area and the loessial highlands of China, where gully erosion has made the Yellow River the most silt-laden river in the world'.

Hallsworth (written comm. 1988) stated with respect to the second historic period, that much of the rangelands of Australia (the 60% of Australia that is too dry for agriculture or improved pastures, and without permanent rivers) have eroded seriously this century, after cattle and sheep were introduced, but much of it has now become stable again. Another era of accelerated erosion started in the second quarter of the 20th century. It is a phenomenon associated with wind erosion in developed countries (Australia, U.S.A., U.S.S.R) and with water and wind erosion in developing countries. The basic causes of this round of accelerated soil degradation are social and economic factors such as exploitative philosophy; ignorance of the seriousness of erosion or what to do about it; lack of short-term economic benefits; or government policies which promote the cultivation of fragile lands (Dregne, 1986). While the concern of continuing soil degradation is gradually growing and Soil Conservation Policies are implemented by governments in various countries throughout the world since the 1930's, soil degradation is still going on today as exemplified on the present map. The principles of soil conservation have been known for centuries, but because soils and landscapes differ per agro climatic zone the actual design of conservation practices to control soil degradation are site specific. Knowledge of soils and terrain attributes at sufficient detail is needed for an appropriate and effective programme to combat human-induced soil degradation.

The World Map on the Status of Human-induced Soil Degradation is the first of its kind that shows the severity of the problem of soil degradation in a global perspective. The information on the map in terms of areas being affected by various types of soil degradation, its degree of severity and the kinds of human intervention which is causing soil degradation should be further quantified. In a joint follow-up activity of UNEF and ISRIC, the mapped units of the GLASOD map will be digitised and the legend entries will be computerized in a GLASOD database. It will then be possible to estimate for any selected region the actual acreage of terrain being affected, by type, degree, and causative factor. A tentative assessment for the soil degradation status in South America -done by manual calculation - revealed that about 14% of the total land areas of South America was affected by human- induced soil degradation. The subdivision of this land by type and degree of soil degradation is illustrated in table 2.

Table 2: Relative extent of human-induced soil degradation in South America (Total area Affected is approximately 14% of total land area of South America)

	Degree			
Type	Slight	Moderate	Severe	Total
Water erosion	14 %	29 %	4 %	47 %
Nutrient Decline	12	17	5	34
Wind erosion	9	6	-	15
Waterlogging	3	+		3
Salinization	1	+	-	1
Total	39	52	9	100

Once the digitized mapped units are linked with the computerized legend database through a Geographic Information System more accurate estimates can be made.

Other follow-up activities include a more detailed assessment of human-induced soil degradation for the African continent (at a scale of 1:7.5 M, Mercator projection). Also various countries (U.S.S.R., Cuba, Mexico, Uruguay) are already using the guidelines at national level for large scale applications.

The GLASOD map and the complementary statistical information which can be derived from the map will hopefully serve as a guide to policy-makers and decision-makers to pinpoint regions of immediate concern; it may assist agencies concerned with the improvement of our natural resource database to concentrate their financial resources where they are needed most. Of course, this global map will not in itself solve the problem of soil degradation. Once areas of concern are determined there is a need for more detailed information on quantitative soil and terrain attributes. The SOTER project - a World Soils and Terrain Digital Database at 1:1 M or larger scale (see section 1.1) - can contribute towards that ultimate objective of an analysis of human-induced soil degradation: to combat and reverse the trend of declining food productivity by conserving and restoring our natural resources.

V REFERENCES

Blaikie P ., and H. Brookfield, 1987. Land Degradation and Society. Methuen, London and New York.

Brundtland, G.H., M. Khalid, a.o.1987. Our Common Future. Report of World Commission on Environment and Development presented to the chairman of Intergovernmental Intersessional Preparatory Committee, UNEP Governing Council. Oxford University Press, Oxford.

Dregne H.E., 1986. Soil and Water Conservation: A Global Perspective. In Interciencia, Vol.ll, no4.

FAO, UNEP, Unesco, 1979. A provision al Methodology for Soil Degradation Assessment.

F AO, Rome.

Hakkeling, R.TA., 1989. Global Assessment of Soil Degradation -Eastern and Southern Africa. Volume 1: Main Report, Volume 2: Matrix Tables/Mapping Unit Descriptions. Rep. nr. 2082, Netherlands Soil Survey Institute (STIBOKA), Wageningen.

Ha11sworth E.G., 1988. Review of Second Draft of GLASOD guidelines (written comm.). ISRIC, 1988. Guidelines for General Assessment of the Status of Human-induced Soil

Degradation. Ed. by L.R. Oldeman. Working Paper & Preprint 88/4, ISRIC, Wageningen, (in English and French).

ISSS, 1986A. Proceedings of an International Workshop on the Structure of a Digital International Soil Resource Map annex Data Base (20-24 January 1986, ISRIC, Wageningen). Ed. by M.F. Baumgardnerand L.R. Oldeman. SOTER Report 1. ISSS, Wageningen.

ISSS, 1986B. Project Proposal 'World Soils and Terrain Digital Database at a scale of 1:IM (SOTER)'. Ed. by M.F. Baumgardner, ISSS, Wageningen.

ISSS, 1987. Proceedings of the Second International Workshop on a Global Soils and Terrain Digital Database (18-22 May 1987, UNEP, Nairobi). Ed. by R.F. van de Weg. SOTER Report 2. ISSS, Wageningen.

Sombroek W.G., 1985. Establishment of an International Soil and Land Resources Information Base. Discussion Paper for the ISSS Working Group on Digital Mapping of Global Soil Resources, ISRIC, Wageningen.

UNEP, 1982. A World Soils Policy, UNEP, Nairobi.

World Resources Institute, 1990. World Resources 1990-1991: A Guide to the Global Environment. World Resources Institute in collaboration with the United Nations Environment Programme and the United Nations Development Programme. Oxford University Press, New York, Oxford.

ANNEX l:

List of persons who contributed to the 'Guidelines for General Assessment of the Status of Human-induced Soil Degradation' (ISRIC, 1988)

Abrol, J.P., New Delhi, India
Aubert, G., Bondy, France
Ayoub, A., Nairobi, Kenya
Baumgardner, M.F., West Lafayette, U.S.A.
Bergsma, E., Enschede, The Netherlands
Brinkman, A., Rome, Italy
Cochrane, T.T. La Paz, Bolivia
Coote, D.R., Ottawa, Canada
Dent, F.J., Bangkok, Thailand
Dregne, H.E., Lubbock, U.S.A.
Garduño, M.A., Chapingo, Mexico
Hallsworth, E.G., Mitcham, Australia
Moldenhauer, W., Volga, U.S.A.
Oldeman, L.R., Wageningen, The Netherlands
Peters, W.L., Maracaibo, Venezuela
Pla-Sentis, I., Maracai, Venezuela
Purnell, M.F., Rome, Italy
Reybold, W., Washington DC, U.S.A
Riquier, J., Villeneuve-Loubet, France
Rozanov, B.G. Moscow, U.S.S.R.
Sanders, D., Rome, Italy
Sims, D., Rome, Italy
Sombroek, W.G., Wageningen, The Netherlands
Stocking, M., Norwich, U.K.
Szabolcs, I., Budapest, Hungary
Szögi, A., Montevideo, Uruguay
Valenzuela, C.R., Enschede, The Netherlands
Van Baren, J.H.V., Wageningen, The Netherlands
Van de Weg, R.F., Wageningen, The Netherlands
Zinck, A., Enschede, The Netherlands

ANNEX 2:

List of regional correlators

Region (see figure 1)		Correlator	Institute
I	West + Central Africa	P. Brabant	ORSTOM, France
II	North Africa + Arab Countries	M. Ilaiwi	ACSAD, Syria
III^A	East + Southeast Africa	R.T.A. Hakkeling	WSC, The Netherlands
III^B	Southern Africa	M.C. Laker	Univ. Pretoria, South Africa
IV^A	South America	T.T. Cochrane	Bolivia
IV^B	Argentina	C.O. Scoppa	INTA, Argentina
IV^C	Paraguay	P. Alfonso	Univ.Nac.Asuncion, Paraguay
IV^D	Uruguay	L. Aguirre	Dir.de Suelos, Uruguay
IV^E	Central America	J.G.R. Beemster	ISRIC, The Netherlands
IV^F	Mexico	M.A. Garduño	Coll.Postgraduados, Mexico
V^A	U.S.A.	B.F. Smallwood	SCS, U.S.A.
V^B	Canada	D.R. Coote	LRDC, Canada
VI^A	S., W., N. Europe	P.J.M. Mulder	ISRIC, The Netherlands
VI^B	Central Europe	G. Varallyay	RISSAC, Hungary
VII	U.S.S.R. + Mongolia	V. Stolbovoy	Dokuchaev Soil Inst., U.S.S.R.
VIII^A	China + P.R. of Korea	Liu Liang-Wu	Academia Sinica, P.R. of China
VIII^B	Japan	T. Sakuma	Hokkaido Univ., Japan
IX	Southeast Asia	D.P. Shrestha	ITC, The Netherlands
X^A	India	J.L. Sehgal	NBSS, India
X^B	Iran, Pakistan, Afghanistan	A. Farshad	ITC, The Netherlands
X^C	Bangladesh	H. Brammer	United Kingdom
X^D	Sri Lanka	S. Dimantha	Land Use Division, Sri Lanka
XI	Australia, New Zealand + South Pacific	G. Hallsworth	Australia

ANNEX 3

List of national co-operators

Abdul Hamid, W., Iraq
Abu Arabi, G., Jordan
Achouri, M., Tunis, Tunisia
Adalsteinsson, Reykjavik, Iceland
Ahmad, N., St. Augustine, Trinidad and Tobago
Al Tai, F., Iraq
Aleksa, A., Buenos Aires, Argentina
Allaglo, L.K., Lomé, Togo
Alvarez, C., Montevideo, Uruguay
Alvarez, C., Santiago, Chile
Alvim, P. de T., Bahia, Brazil
Amano, Y., Tokyo, Japan
Andriesse, W., Wageningen, The Netherlands
Apostolakis, C.G., Ag. Parasevi, Greece
Arduino, E., Turin, Italy
Aru, A., Cagliari, Italy
Asiamah, R.D., Kumasi, Ghana
Aubrun, A., Paris, France
Bandy, D.E., Lima, Peru
Bao, R, Lima, Peru
Barber, R., Santa Cruz, Bolivia
Barreto Rodriguez e Silva, F., Recife, Brazil
Bazan, R., Brazilia, Brazil
Bellon, F., St. Paul-Trois Châteaux, France
Berasaluce J.P., Santiago, Chile
Bernus, E., Paris, France
Bindzi Tsala, J., Yaoundé, Cameroon
Blanco, F., La Paz, Bolivia
Blasco, F., Toulouse, France
Blum, W.E.H., Vienna, Austria
Boko, A., Cotonou, Benin
Boudouresque, E., France
Boulet, J., Paris, France
Boulet, R., Cayenne, French Guiana
Boulvert, Y., Bangui, Central African Republic
Bousquet, B., Montpellier, France
Bouwman, A.F., Wageningen, The Netherlands
Brandeau, E., Paris, France
Breuning Madsen, H., Copenhagen, Denmark
Broekhuis, J.F., 's Gravenhage, The Netherlands
Brouwers, M., Montpellier, France
Bruggeman, H.Y., Wageningen, The Netherlands
Buckmire, G.E., Georgetown, Guyana
Calero, E., Quito, Ecuador
Camara, M., Conakry, Guinea
Casas, R., Buenos Aires, Argentina
Cassi, F., Florence, Italy
Celik, O., Turkey
Chanduvi, F., Santiago, Chile
Chase, R., Samoa
Citeaux, R., Dakar, Senegal
Cock, J., Cali, Colombia
Comerma, J., Maracay, Venezuela
Cordova Rincon, S., Chapingo, Mexico
Cruz, R.V., Quito, Ecuador
D'Hiriart, A., Buenos Aires, Argentina
Da Costa Silva, A., Bissau, Guinea Bissau
Dazzi, C., Palermo, Italy
De La Cruz, S.J.M., Chapingo, Mexico
Delgado, M.E., Cape Verde
Demir, N., Turkey
De Ploey, J., Leuven, Belgium
Derksen, P.M., Turrialba, Costa Rica
Desire Rellum, P., Paramaribo, Surinam
De Soriza Silva, A., Petrolina, Brazil.
De Vries, W., Wageningen, The Netherlands
Di Giacomo, R.M., Buenos Aires, Argentina
Diamond, S., Wexford, Ireland
Dilkova, R., Sofia, Bulgaria
Dimitrov, D., Sofia, Bulgaria
Dogan, O., Turkey
Donadieu, Versailles, France
Dourojeanni, A.C., Santiago, Chile
Drummond, M.A., Petrolina, Brazil.
Du Plessis, H.M., South Africa
Egue, K., Lomé, Togo
Einarsson, T., Reykjavik, Iceland
El Qodat, B., Jordan
Elgala, A.M., Cairo, Egypt
Eppink, L.A.A.J., Wageningen, The Netherlands
Esu, I.E., Zaria, Nigeria
Fairbairn, J., Cali, Colombia
Falco, L., Montevideo, Uruguay
Favi, E., Italy
Fereira Silva, C.E., Cape Verde
Fierotti, G., Palermo, Italy
Figuerda Sandoval, B., Chapingo, Mexico
Filippi, N., Bologna, Italy
Fournier, F., Paris, France
Gavaud, M., Paris, France
Giordano, A., Turin, Italy
Glinski, J., Lublin, Poland
Godagnone, R., Buenos Aires, Argentina
Goedert, W., Planaltina, Brazil
Gomes Cordeiro, G., Petrolina, Brazil.
Gomes, J.F.M., Brazilia, Brazil
Gomes de Sousa, D.M., Planaltina, Brazil
Gondim Reis, J., Recife, Brazil
Gonzalez Meraz, J., Chapingo, Mexico
Granger, M.A., Mon Repos, Guyana
Grivas, G.C., Nicosia, Cyprus
Grof, B., Planaltina, Brazil
Grouzis, M., Dakar, Senegal
Gudbergsson, G.M., Reykjavik, Iceland
Guero, Y., Niamey, Niger
Gutierrez, R., Lima, Peru
Håkansson, I., Uppsala, Sweden
Hanegreefs, P., Butare, Rwanda
Hansen, L., Copenhagen, Denmark
Harindranath, C.S., Nagpur, India

Harrop, J., Bradford on Avon, United Kingdom
Heusch, B., Grenoble, France
Himyari, K., Iraq
Hla Aye, Rangoon, Burma
Hollis, J., Silsoe, United Kingdom
Hrasko, J., Bratislava, Czechoslovakia
Hurni, H., Bern, Switzerland
Irurtia, C., Buenos Aires, Argentina
Jamagne, M., Olivet, France
Janabi, K., Iraq
Jensen, N., Copenhagen, Denmark
Jones, P.G., Cali, Colombia
Kahn, Z., Mon Repos, Guyana
Kazuki Takamiya, Santiago, Chile
Kemper, Hannover, Germany
Khafaci, A., Iraq
Khalifa, R., Iraq
Kilinc, M., Ankara, Turkey
Klaij, M.C. Niamey, Niger
Kraayenhagen, J., Mohale's Hoek, Lesotho
Krammer, F., Cali, Colombia
Kuhlman, H., Copenhagen, Denmark
Kulnes, A., Santiago, Chile
Labrousse, P., Paris, France
Lagos, M., Santiago, Chile
Lal, R., Ohio, USA
Larach, J.O.I., Rio de Janeiro, Brazil
Leao, A.C., Bahia, Brazil
Lee, T.R., Santiago, Chile
Leite, O., Bahia, Brazil
Leon, L.A., Cali, Colombia
Leprun, J.C., Paris, France
Lobato, E., Planaltina, Brazil
Lopez, O., Lima, Peru
Lozi, S., Jordan
Magno, C., Planaltina, Brazil
Mainguet, M., Reims, France
Maître Mille, G., Paris, France
Malagon, D., Bogota, Colombia
Mapangui, A., Brazzaville, Congo
Marelli, H., Buenos Aires, Argentina
Marius, C., Paris, France
Marquez Rodiles, F., Chapingo, Mexico
Martens, P., Florence, Italy
Mathieu, C., Bangui, Central African Republic
Meijnen, H.G., Wageningen, The Netherlands
Mejia, L., Quito, Ecuador
Michelina, R., Buenos Aires, Argentina
Mietton, M.,Chambery, France
Molfino, J., Montevideo, Uruguay
Mon, R., Buenos Aires, Argentina
Mondjalis-Poto, M.P., Kisangani, Zaire
Morais, J.T., Cape Verde
Morel, A., Grenoble, France
Morote, O., Lima, Peru
Moscatelli, G., Buenos Aires, Argentina
Moutsinga, J.B., Libreville, Gabon
Murray, D.B., Port-of Spain, Trinidad and Tobago
Musto, J.C., Buenos Aires, Argentina
Mutwewingabo, B., Butare, Rwanda
Nani, L., Buenos Aires, Argentina
Ngouanze, F., Bangui, Central African Republic
Niemeyer, J.K.W., Managua, Nicaragua
Nikilov, V., Sofia, Bulgaria
Noordam, D., Paramaribo, Surinam
Nyborg, A., Ås, Norway
Okazaki, H., Tokyo, Japan
Oliveiro de Mello, A.A., Bahia, Brazil
Olivry, J.C., Paris, France
Ordogan, S., Turkey
Oros, R., Oruro, Bolivia
Ortiz Solorio C.A., Chapingo, Mexico
Osman, A., Damascus, Syria
Oster, R., Bamako, Mali
Overbo, E., Ås, Norway
Palmieri, F., Rio de Janeiro, Brazil
Papanicolau, E.P., Ag. Parasevi, Greece
Paris, S., Lilongwe, Malawi
Paz, J.G., Lisboa, Portugal
Peña Zubiate, C., Buenos Aires, Argentina
Peralta-Peralta, M., Santiago, Chile
Pereira Barreto, S., Dakar, Senegal
Petrie, R.A., Hastings, New Zealand
Peyer, K., Zürich, Switzerland
Phommasack Ty, Vientiane, Lao PDR
Pieterse, P.A., Pretoria, South Africa
Pittaluga, A., Buenos Aires, Argentina
Poesen, J., Leuven, Belgium
Pofali, R.M., Nagpur, India
Poncet, Y., Paris, France
Porto, E.R., Petrolina, Brazil.
Poss, R., Paris, France
Quirgo, S., Tarija, Bolivia
Ranzani, G., Brazilia, Brazil
Rauta, C., Bucurest, Romania
Reid, J.B., Hastings, New Zealand
Remmelzwaal, A., Gaborone, Botswana
Rethman, N.G.F., Pretoria, South Africa
Ribamar Pereira, J., Petrolina, Brazil.
Rickson, J., Silsoe, United Kingdom
Rihani, A., Jordan
Robain, H., Cayenne, French Guyana
Rofic, M., Iraq
Rojo, L., Madrid, Spain
Roman, R., Buenos Aires, Argentina
Roose, E., Paris, France
Rossi, R., Italy
Ruinard, J., Paramaribo, Surinam
Saif, T., Iraq
Sainz, A., La Paz, Bolivia
Salazar, J.C., Buenos Aires, Argentina
Sanchez, A., Maracay, Venezuela
Sanchez Guerra, M., Chapingo, Mexico
Sartaoui, W., Jordan
Saxena, R.K., Nagpur, India
Schaub, D., Zürich, Switzerland
Schmidt, R., Eberswalde-Finow, Germany
Schobbenhaus Filho, C., Brazilia, Brazil
Scoppa, C., Buenos Aires, Argentina
Seghieri, J., Switzerland
Sganga, J.C., Montevideo, Uruguay
Shaker, S., Iraq

Shamout, R., Jordan
Shaxton, T.F., Maseru, Lesotho
Shishov, L., U.S.S.R.
Silva, C.E., Cape Verde
Singh, A.M.P., Nagpur, India
Sippola, J., Jokioinen, Finland
Smaling, E.M.A., Wageningen, The Netherlands
Solbakken, E., Ås, Norway
Sonneveld, B.G.J.S., Turrialba, Costa Rica
Sourabié, F., Ouagadougou, Burkina Fasso
Spain, J.M., Planaltina, Brazil
Springett, J.A., Hastings, New Zealand
Spurway, J.K.R., Harare, Zimbabwe
Sticher, H., Zürich, Switzerland
Stitou, M., Rabat, Morocco
Stoner, E., Planaltina, Brazil
Stoorvogel, J., Wageningen, The Netherlands
Suleyman, Turkey
Tchemi, T.T., Lomé, Togo
Thomas, D., Cali, Colombia
Thorsteinsson, I., Reykjavik, Iceland
Toledo, J.M., Cali, Colombia
Torres Torres, R., Chapingo, Mexico
Torres, F., Cali, Colombia
Torrico, A., Cochabamba, Bolivia
Touber, L., Wageningen, The Netherlands
Troedsson, T., Uppsala, Sweden
Turski, R., Lublin, Poland
Ubierra-Costa, A.A., Santo Domingo, Dominican Rep.
Uribe, C.A., Lima, Peru
Urvas, L., Jokioinen, Finland
Valentin, C., Paris, France
Valev, V., Moscow, U.S.S.R.
Van Alphen, J.G., Wageningen, The Netherlands
Van Amson, F.W., Paramaribo, Surinam
Van Barneveld, G.W., Amersfoort, The Netherlands
Van Caillie, X., Ohain, Belgium
Van Campen, W., Koutiala, Mali
Van der Merwe, A.J., South Africa
Van Diepen, C.A., Wageningen, The Netherlands
Van Engelen, V., Wageningen, The Netherlands
Van Mensvoort, M.E.F., Wageningen, The Netherlands
Van Waveren, E., Gaborone, Botswana
Van Zyl, J., South Africa
Vargas Gil, J.R., Buenos Aires, Argentina
Velazquez Loera, A., Chapingo, Mexico
Venema, J.H., Lilongwe, Malawi
Villegas Delgado, R., La Habana, Cuba
Villeneuve, M., Dakar, Senegal
Vlaanderen, A.C., Rome, Italy
Voortman, R., Egmond, The Netherlands
Vos, J., Wageningen, The Netherlands
Wagner, E., Brazilia, Brazil
Walmsley, D., St. Augustine, Trinidad and Tobago
Wen Ting-Tiang, Lusaka, Zambia
Wenzel, W.W., Vienna, Austria
Wielemaker, W.G., Turrialba, Costa Rica
Yaalon, D., Jerusalem, Israel
Yolevski, M., Sofia, Bulgaria
Yoro Gballou, Abidjan, Ivory Coast
Zhao Qi-guo, Nanking, P.R. of China

ANNEX 4

Persons who prepared the cartographic presentation of the map.

De Jonge, R., Wageningen, The Netherlands
Jacobs, Th., Wageningen, The Netherlands
Onderstal, J., Wageningen, The Netherlands
Van Betuw, T.J.W., Wageningen, The Netherlands

ANNEX 5

The Extent of Human-Induced Soil Degradation
by L.R. Oldeman, V. W .P .van Engelen and J .H.M. Pulles

As indicated in chapter IV of the explanatory note of the World Map of Human-Induced Soil Degradation (Oldeman, Hakkeling and Sombroek, 1990) all units delineated on this GLASOD map have been digitised and linked to a GLASOD database, in which the legend entries of each delineated unit are stored. UNEP's Global Resource Information Database (GRID) bas conducted processing of this database for an assessment of desertification (Deichmann and Eklund, 1991). With the incorporation of the GLASOD database into GRID, this dataset is now available to scientists and decision-makers who wish to use it for specific projects. The GLASOD database is accompanied by a users guide.

ISRIC bas also processed this is database for the preparation of a chapter on global soil degradation for the State of the Environment Report of UNEP, to be published in 1992.

Since its publication in 1990, ISRIC bas been flooded with requests about the actual areal extent of the various soil degradation types as illustrated on the world soil degradation map. Because of the type of map projection -Mercator projection- the scale of the map increases from the equator towards the Poles (see section 2.1 of the explanatory note). Therefore there *is* a need to complement this note with some quantitative information on the areal extent of the delineated surfaces.

5.1 Major divisions of the earth surface

The GLASOD map covers the land surface between 72 degrees North and 57 degrees South. All quoted figures therefore relate to that portion of the earth surface (13013 million ha). The GLASOD map indicates not only units that are in frequently to dominantly affected by human- induced soil degradation, but also units that are considered to be for 100% so-called wasteland or for 100% stable: the dark, respectively light grey units on the map. These grey-shaded areas occupy a total of 5044 million ha. This implies that the areas on the map coloured in different shades of bluish green (water erosion), yellowish brown (wind erosion), red (chemical deterioration) and pink (physical deterioration) occupy a total of 7969 million ha.

As explained in section 3.2.2 the status of soil degradation is an expression of the severity of the process. The severity of the process is characterized by the degree to which the soil is degraded and by the relative extent of the degraded land within the delineated unit. This implies that only a portion of the delineated unit is degraded. A mapped unit may for example be indicated by Wt3.3 and Etl.2. This implies that strong topsoil loss by water erosion occurs frequent I y (10 to 25% of the unit affected) and that a light topsoil loss by wind erosion occurs commonly (5 to 10% affected). In other words, between 15 and 35% of the delineated unit is affected by human-induced soil degradation, while between 65 and 85% is not affected. This portion is called "other terrain" and includes terrain that is non-degraded (naturally stable, or stabilized by human activities). But it may also include non-used wasteland. This "other terrain" portion of the earth is about 6000 million ha. The terrain that is affected by human- induced soil degradation occupies an area of 1964 million ha worldwide. Table I gives these areal divisions for Africa, Asia, South America, Central America, North America, Europe and Australasia.

Table I. Major terrain divisions of the GLASOD map (in million ha)

	non-used wasteland (dark grey)	Stable land (light grey)	'Other terrain' (non-degraded by human activities)	human-induced soil degradation	Total Land surface
Africa	732	441	1299	494	2966
Asia	485	1426	1597	748	4256
South America	28	368	1129	243	1768
Central America	53	27	163	63	306
North America	75	1043	672	95	1885
Europe	1	116	614	219	950
Australasia	95	250	434	103	882
WORLD	1469	3671	5909	1964	13013

5.2 Types of Human-induced Soil Degradation

Water erosion is by far the most important type of soil degradation occupying around 1094 million ha or 56% of the total area affected by human-induced soil degradation. On a world scale the area affected by wind erosion occupies 548 million ha (or 38% of the degraded terrain). Chemical soil deterioration covers about 239 million ha (12%) while physical soil deterioration occupies around 83 million ha (4%). Loss of topsoil by water or by wind erosion is by far the most important subtype of displacement of soil material. These subtypes cover an area of respectively 920 million ha (water erosion) (365 million ha in Asia and 205 million ha in Africa), and 454 million ha (wind erosion). Loss of nutrients is the major subtype of chemical deterioration of the soils (135 million ha of which 68 million is located in South America) followed by salinization (76 million ha, of which 53 million ha in Asia). Soils affected by pollution cover worldwide an area of 22 million ha, of which]9 million ha is located in Europe. Compaction is by far the most important subtype of physical soil deterioration. It occupies worldwide 68 million ha: 33 million ha is found in Europe and]8 million ha in Africa. For further details reference is made to tables 2-9 of this annex.

5.3 Degree of ***Soil*** *Degradation*

Four degrees of soil degradation are recognized.

A light degree of soil degradation, implying a somewhat reduced productivity of the terrain, but manageable in local farming systems is identified for 38% of all the degraded soils (or 749 million ha). A somewhat larger percentage (46%) has a moderate degree of soil degradation. This portion of the earth surface -910 million ha- has a greatly reduced productivity. Major improvements often beyond the means of local farmers in developing countries are required to restore the productivity. More than 340 million ha of this moderately degraded terrain is found in Asia and over 190 million ha is located in Africa.

Strongly degraded soils cover an area of 296 million ha worldwide of which 124 million ha in Africa and 108 million ha in Asia. These soils are not any more reclaimable at farm level and are virtually lost. Major engineering work or international assistance is required *to* restore these terrains.

Extremely degraded soils are considered irreclaimable and beyond restoration. Their worldwide coverage is around 9 million ha, of which over 5 million is located in Africa.

For further details reference is made to tables 2-9.

Table 2: Human-induced Soil Degradation for Asia, expressed in million hectares[1)]

	Type	Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	99.8	215.0	50.5	-	365.2
Wd	Terrain Deformation	24.7	26.7	22.9	-	74.4
W	WATER	124.5	241.7	73.4	-	440.6(59%)
Et	Loss of Topsoil	116.7	48.9	+	0.2	165.8
Ed	Terrain Deformation	15.7	17.3	14.5	-	47.5
Eo	Overblowing	-	8.9	-	-	8.9
E	WIND	132.4	75.1	14.5	0.2	222.2(30%)
Cn	Loss of nutrients	4.6	9.0	1.0	-	14.6
Cs	Salinization	26.8	8.5	17.0	0.4	52.7
Cp	Pollution	-	1.5	0.3	-	1.8
Ca	Acidification	0.4	2.5	1.2	-	4.1
C	CHEMICAL	31.8	21.5	19.5	0.4	73.2(10%)
Pc	Compaction	4.6	5.0	0.2	-	9.8
Pw	Waterlogging	0.4	-	-	-	0.4
Ps	Subsidence organic soils	0.7	1.0	0.2	-	1.9
P	PHYSICAL	5.7	6.0	0.4	-	12.1(2%)
TOTAL		294.5 (39%)	344.3 (46%)	107.7 (14%)	0.5 (1%)	747.0(100%)

[1)] Asia includes the Asian part of the U.S.S.R.

Table 3: Human-induced Soil Degradation for Africa, expressed in million hectares

	Type	Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	53.9	60.5	86.6	3.8	204.9
Wd	Terrain Deformation	3.6	6.9	11.7	0.4	22.5
W	WATER	57.5	67.4	98.3	4.2	227.4(46%)
Et	Loss of Topsoil	79.1	84.2	7.4	-	170.7
Ed	Terrain Deformation	9.2	5.1	-	-	14.3
Eo	Overblowing	-	-	0.5	1.0	1.5
E	WIND	88.3	89.3	7.9	1.0	186.5(38%)
Cn	Loss of nutrients	20.4	18.8	6.2	-	45.1
Cs	Salinization	4.7	7.7	2.4	-	14.8
Cp	Pollution	-	0.2	-	-	0.2
Ca	Acidification	1.1	0.3	+	-	1.5
C	CHEMICAL	26.0	27.0	8.6	-	61.5(12%)
Pc	Compaction	1.4	8.0	8.8	-	18.2
Pw	Waterlogging	0.4	0.1	-	-	0.5
Ps	Subsidence organic soils	-	-	-	-	-
P	PHYSICAL	1.8	8.1	8.8	-	18.7(4%)
TOTAL		173.6 (35.1%)	191.8 (38.9%)	123.6 (25.0%)	5.2 (1.0%)	494.2(100%)

Table 4: Human-induced Soil Degradation for South America, expressed in million hectares

	Type	Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	34.9	51.9	8.3	-	95.1
Wd	Terrain Deformation	11.0	13.2	3.8	-	28.1
W	WATER	45.9	65.1	12.1	-	123.2 (50.6%)
Et	Loss of Topsoil	12.7	10.0	-	-	22.7
Ed	Terrain Deformation	13.1	5.3	-	-	18.4
Eo	Overblowing	-	0.8	-	-	0.8
E	WIND	25.8	16.1	-	-	41.9 (17.2%)
Cn	Loss of nutrients	24.5	31.1	12.6	-	68.2
Cs	Salinization	1.8	0.3	-	-	2.1
Cp	Pollution	-	-	-	-	-
Ca	Acidification	-	-	-	-	-
C	CHEMICAL	26.3	31.4	12.6	-	70.3 (28.8%)
Pc	Compaction	2.9	0.8	0.3	-	4.0
Pw	Waterlogging	3.9	-	-	-	3.9
Ps	Subsidence organic soils	-	-	-	-	-
P	PHYSICAL	6.8	0.8	0.3	-	7.9 (3.2%)
TOTAL		104.8 (43.1%)	113.5 (46.6%)	25.0 (10.3%)	-	243.4 (100%)

Table 5: Human-induced Soil Degradation for Central America, expressed in million ha

	Type	Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	0.4	14.2	6.5	-	21.1
Wd	Terrain Deformation	0.2	8.1	16.9	-	25.2
W	WATER	0.6	22.3	23.4	-	46.3 (74%)
Et	Loss of Topsoil	-	2.4	0.5	-	2.9
Ed	Terrain Deformation	0.1	1.6	-	-	1.7
Eo	Overblowing	-	-	-	-	-
E	WIND	0.1	4.0	0.5	-	4.6 (7%)
Cn	Loss of nutrients	0.1	4.0	0.1	-	4.2
Cs	Salinization	0.3	1.5	0.5	-	2.3
Cp	Pollution	-	0.2	0.2	-	0.4
Ca	Acidification	-	-	-	-	-
C	CHEMICAL	0.4	5.7	0.8	-	6.9 (11%)
Pc	Compaction	-	0.1		-	0.1
Pw	Waterlogging	0.8	3.3	0.8	-	4.9
Ps	Subsidence organic soils	-	-	-	-	-
P	PHYSICAL	0.8	3.4	0.8	-	5.0 (8%)
TOTAL		1.9 (3%)	35.4 (56%)	25.5 (41%)	-	62.9 (100%)

Table 6: Human-induced Soil Degradation for North America, expressed in million ha

Type		Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	13.7	46.1	-	-	59.8
Wd	Terrain Deformation	-	-	-	-	-
W	WATER	13.7	46.1	-	-	59.8 (63%)
Et	Loss of Topsoil	2.5	30.8	1.3	-	34.6
Ed	Terrain Deformation	-	-	-	-	-
Eo	Overblowing	-	-	-	-	-
E	WIND	2.5	30.8	1.3	-	34.6 (36%)
Cn	Loss of nutrients	-	-	-	-	-
Cs	Salinization	-	-	-	-	-
Cp	Pollution	-	-	-	-	-
Ca	Acidification	0.1	-	-	-	0.1
C	CHEMICAL	0.1	-	-	-	0.1 (+)
Pc	Compaction	0.5	0.4	-	-	0.9
Pw	Waterlogging	-	-	-	-	-
Ps	Subsidence organic soils	-	-	-	-	-
P	PHYSICAL	0.5	0.4	-	-	0.9 (1%)
TOTAL		16.8 (18%)	77.4 (81%)	1.3 (1%)	-	95.5 (100%)

Table 7: Human-induced Soil Degradation for Europe[1)], expressed in million hectares

Type		Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	18.9	64.7	9.2	-	92.8
Wd	Terrain Deformation	2.5	16.3	0.6	2.4	21.8
W	WATER	21.4	81.0	9.8	2.4	114.5(52.3%)
Et	Loss of Topsoil	3.2	38.2	-	0.7	42.2
Ed	Terrain Deformation	-	-	-	-	-
Eo	Overblowing	-	-	-	-	-
E	WIND	3.2	38.2	-	0.7	42.2(19.3%)
Cn	Loss of nutrients	2.9	0.3	-	-	3.2
Cs	Salinization	1.0	2.3	0.5	-	3.8
Cp	Pollution	4.1	14.3	0.1	-	18.6
Ca	Acidification	0.1	0.1	-	-	0.2
C	CHEMICAL	8.1	17.1	0.6	-	25.8(11.8%)
Pc	Compaction	24.8	7.8	0.4	-	33.0
Pw	Waterlogging	0.5	0.3	-	-	0.8
Ps	Subsidence organic soils	2.6	-	-	-	2.6
P	PHYSICAL	27.9	8.1	0.4	-	36.4(16.6%)
TOTAL		60.6 (27.7%)	144.4 (66.0%)	10.7 (4.9%)	3.1 (1.4%)	218.9(100%)

[1)] Europe includes the European part of the U.S.S.R.

Table 8: Human-induced Soil Degradation for Australasia, expressed in million hectares

	Type	Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	79.4	2.2	0.1	-	81.7
Wd	Terrain Deformation		1.0	0.1	-	1.1
W	WATER	79.4	3.2	0.2	-	82.8(81%)
Et	Loss of Topsoil	16.3	-	0.1	-	16.4
Ed	Terrain Deformation	-	-	-	-	-
Eo	Overblowing	-	-	-	-	-
E	WIND	16.3	-	0.1	-	16.4(16%)
Cn	Loss of nutrients	0.2	0.2	-	-	0.4
Cs	Salinization	-	0.5	-	0.4	0.9
Cp	Pollution	-	-	-	-	-
Ca	Acidification	-	-	-	-	-
C	CHEMICAL	0.2	0.7	-	0.4	1.3(1%)
Pc	Compaction	0.7	-	1.6	-	2.3
Pw	Waterlogging		-	-	-	-
Ps	Subsidence organic soils		-	-	-	-
P	PHYSICAL	0.7	-	1.6	-	2.3(2%)
TOTAL		96.6 (94%)	3.9 (4%)	1.9 (2%)	0.4 (+)	102.9(100%)

Table 9: Human-induced Soil Degradation for the World, expressed in million hectares

	Type	Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	301.2	454.5	161.2	3.8	920.3
Wd	Terrain Deformation	42.0	72.2	56.0	2.8	173.3
W	WATER	343.2	526.7	217.2	6.6	1093.7(55.6%)
Et	Loss of Topsoil	230.5	213.5	9.4	0.9	454.2
Ed	Terrain Deformation	38.1	30.0	14.4	-	82.5
Eo	Overblowing	-	10.1	0.5	1.0	11.6
E	WIND	268.6	253.6	24.3	1.9	548.3(27.9%)
Cn	Loss of nutrients	52.4	63.1	19.8	-	135.3
Cs	Salinization	34.8	20.4	20.3	0.8	76.3
Cp	Pollution	4.1	17.1	0.5	-	21.8
Ca	Acidification	1.7	2.7	1.3	-	5.7
C	CHEMICAL	93.0	103.3	41.9	0.8	239.1(12.2%)
Pc	Compaction	34.8	22.1	11.3	-	68.2
Pw	Waterlogging	6.0	3.7	0.8	-	10.5
Ps	Subsidence organic soils	3.4	1.0	0.2	-	4.6
P	PHYSICAL	44.2	26.8	12.3	-	83.3(4.2%)
TOTAL		749.0 (38.1%)	910.5 (46.4%)	295.7 (15.1%)	9.3 (0.5%)	1964.4(100%)

5.4 Causative factors of soil degradation

Five different causes of physical human intervention were identified that have resulted in soil degradation: deforestation and removal of the natural vegetation; overgrazing of the vegetation; overgrazing of the vegetation by livestock; agricultural activities -an improper management of agricultural land; overexploitation of the vegetative cover for domestic use; and (bio)industrial activities leading to chemical pollution. Table 10 indicates the total areas affected by these five causative factors for each continent and worldwide.

Table 10 Causative factors of soil degradation, expressed in million ha of terrain affected.

	deforestation	overgrazing	agricultural mismanagement	over-exploitation	bio(industrial) activities
Africa	67	243	121	63	+
Asia	298	197	204	46	1
S. America	100	68	64	12	-
N.+ C. America	18	38	91	11	+
Europe	84	50	64	1	21
Australasia	12	83	8	-	+
WORLD	579	679	552	133	23

More than 50% of the degraded soils caused by deforestation is located in Asia. followed by South America (17%). Deforestation is the major cause of soil degradation in South America, Asia, but surprisingly also in Europe (mainly the eastern and central portion of Europe). In Africa deforestation is relatively speaking less important as cause for soil degradation.

Overgrazing is by far the most important cause of human-induced soil degradation in Africa and in Australasia, although the total area of degraded soils in Asia caused by overgrazing is also impressive (197 million ha).

More than 35% of the degraded soils caused by improper agricultural management can be found in Asia. It is the most important causative factor of human-induced soil degradation in North and Central America.

Overexploitation of the vegetative cover for domestic use is of secondary importance as a causative factor of soil degradation worldwide. Of the total of 133 million ha degraded soils by overexploitation almost 50% is located in Africa.

(Bio)industrial activities play as yet a minor role in soil degradation worldwide. It has been reported as cause for soil degradation on only 23 million ha. However, it is significant to note that 21 million ha are located in Europe.

5.5 Concluding remarks

Since no systematic evaluation of the status of human-induced soil degradation has been made in the past, it is not possible to indicate the rate of human-induced soil degradation. Although statements of annual loss of land as a result of soil degradation have been made frequently, Blaikie noted that 'statistics (on soil erosion and deforestation) are seldom in the right form, are hard to come by and even harder to believe, let alone interpret'. A reliable understanding of the consequences of human manipulation and natural perturbations of land is needed for policy formulation and decision-making. The global assessment of the status of human-induced soil degradation as presented here is the first systematic evaluation of the state of the human environment and will hopefully assist policy-makers and decision-makers to view the seriousness of human manipulations of the soil resources in a global perspective.

Deichmann, U. and L. Eklund, 1991. Digital data for land degradation studies: A GIS approach. GRID Case Study Series No.4.

ERRATA

location on GLASOD map	map symbol	correct symbol	map colour	correct colour
United Arab Emirates, eastern part	Et1.3/Cs2.2 g/a		medium brown	dark brown/ orange
Soviet Union, east of Kiev	Pc1.3/Wt2.2 f/a ↑		medium pink/blue	dark pink/blue
Ethiopia - Djibouti	Wt1.3/Et1.3 g		dark blue/brown	medium blue/brown
Australia, south-west	Wt1.3/Cs4.1 f/a	Wt1.3/Cs3.1 f/a	medium blue/red	
Brazil, NW Rio de Janeiro (2 units)	Wt1.2/Cn2.3 a		light blue	dark blue
France, central	Wt1.2/Cp1.1	Wt1.2/Cp1.1 a	light blue	
Greece south-west	Cn1.4/Wd2.2	Cn1.4/Wd2.2 f/a	dark red	
Mauritania - Mali	Et2.5 g/a ↑	Et2.5 g/a ↑	very dark brown	
Bhutan	Wt2.1/Wd1.1 f/g ↑		medium blue	light blue
New Caledonia	Wd3.2/Wt1.3 f/a		very dark blue	dark blue
Argentina	Wt1.3/Wd2.2 a	Wt1.3/Wd2.1 a	dark green	medium green
Spanish Sahara		Western Sahara		