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GUIDELINES FOR GENERAL ASSESSMENT OF THE STATUS OF HUMAN-INDUCED SOIL DEGRADATION

Edited by L.R. Oldeman
International Soil Reference and Information Centre
Wageningen, April 1988

GLOBAL ASSESSMENT OF SOIL DEGRADATION (GLASOD)

UNEP in cooperation with ISRIC
STIBOKA-FAO-ISSS-ITC

ADDENDA

Guidelines for General Assessment of the Status of Human-Induced Soil Degradation (Working Paper and Preprint 88/4, ed. L.R. Oldeman).

I. page 4, section 4.2.1. sub.5. **Other chemical problems.**
In this group gleysation as a result of waterlogging can be included.

II. page 5, section 4.2.2. **Physical Deterioration**
In this type of soil degradation two other human-induced forms are suggested:
7) Cryoturbation and solifluction, caused by human-induced disturbance of the layer over the permafrost in the taiga/-tundra areas.
8) Concrete or tarmac (asphalt) covered areas; of particular importance in densely populated and industrial areas.

III. page 5, section 4.3. **Causative factors of Soil Degradation**
This section needs some more elaboration. It will read as follows:

4.3 Causative factors of Human-induced Soil Degradation.

Soil degradation can be caused by exploitation of the original vegetative cover, either through deforestation or through over-exploitation for consumptive use (fuel source, fence materials etc.). Exploitation of the original vegetation cover results in a loss of biological diversity often leading to a secondary type of vegetation with predominantly obnoxious and unpalatable weeds and shrubs.

It can also be caused by over-intensive use of the agricultural land, either by overgrazing of pasture lands, or by using heavy machinery, by intensive (an)organic fertilizer practices, by irrigation etc. Finally soil degradation can be the result of (bio)-industrial waste. The causative factors of soil degradation are grouped in the following categories:

1) Deforestation, (burning for clearing land or logging: "slash and burn")
2) Over-exploitation of vegetative cover for human uses (e.g. for fuel use, as fence material).
3) Over-grazing of pasture lands; extensive areas of land have been completely cleared of its original vegetation.
4) Over-intensive use of agricultural land; e.g. heavy machinery; intensive fertilizer use (inorganic and organic); irrigation.
5) (Bio)-Industrial waste. (contamination of ground water; acid rain, etc.).

IV. page 9, section 8.3.2 **Evaluation of Soil Degradation Status**
This section is rephrased to stress that often one mapping unit consists of several soil degradation types, which cannot be inserted on the base map because of lack of space.

8.3.2 Evaluation of Soil Degradation Status per mapping unit.
Give each mapping unit a unique number.
Determine for each delineated mapping unit whether it includes one or more human-induced soil degradation types or not. Evaluate for each type the degree, recent past rate and the relative extent of the land per mapping unit being affected. The result of this evaluation process is a symbol for each of the relevant degradation processes as will be discussed in section 8.4. These symbols should be listed in the matrix table (section 8.6). The type which affects the largest area per mapping unit should be listed first, to be followed by other types that may also occur in the same mapping unit.
Insert on the base map in each mapping unit its unique number as well as the mapping symbol for the type which affects the largest area of that mapping unit.
If the mapping unit is not affected by any type of human-induced soil degradation, mapping symbols as discussed in section 8.4.7 or 8.4.8 should be used.

V. page 9, section 8.4.1. **Mapping symbols for soil degradation types**
As a result of suggested changes mentioned above in remarks I and II, the following additional mapping symbols for soil degradation types are to be used:

Cg: gleyzation
Pt: cryoturbation and solifluction
Pu: concrete or tarmac (asphalt) covered areas.

As a result of suggested changes mentioned in remark III the following additional mapping symbols for causative factors are to be used:

i: over-intensive use of the agricultural land
e: over-exploitation of vegetative cover for consumptive use
w: (Bio)-industrial waste.

VI. page 11, section 8.4.7. **Mapping symbols for stable terrain.**
In this category terrain that is stable (either because of a permanent natural vegetation cover, or because of a permanent agricultural cover) is distinguished from terrain that is stabilized as a consequence of human interaction. In this category the degree of present soil degradation is none, although there may have been soil degradation in the past (see section 8.4.5). The following symbols are to be used:

SN: Terrain is naturally stable (e.g. tundra, extensive natural forest; marshes/swamps.
SA: terrain is stable as a consequence of a permanent agriculture type of land use (without conservation intended practices).
SH: terrain is stabilized by human intervention (conservation practices)
SHp: stabilized as a consequence of paddy (wetland rice) field terracing
SHc: stabilized as a consequence of conservation practices for rainfed crops or other forms of permanent conservation measures
SHr: stabilized as a consequence of reforestation, permanent planta-

tion crops etc.
SHe: stabilized as a consequence of empoldering.

VII. page 11, section 8.4.8 **Mapping symbols for non-used wasteland**
The heading of this section is changed and another group is included: land that is being degraded at present under natural conditions, but that has not yet reached a state of ultimate degradation. The new version reads as follows:

8.4.8 Miscellaneous terrain types

In this category we recognize terrain that is being degraded at present or that has reached ultimate degradation under natural conditions and that is or has become non-vegetated and/or non-used wasteland.

Mapping symbols:
U: unstable land, undergoing present natural degradation
D: active dunes
Z: salt flats
R: rock outcrops
A: deserts
I: ice caps

VIII. 8.6. **Matrix table**
(This section is added to the original version to emphasize the importance of the matrix table).

The matrix table which accompanies the soil degradation status map, should be prepared for each mapping unit, which has been delineated. This table is a listing of all types of soil degradation, caused by human activity, their degree, relative extent, recent past rate and causative factor as recognized in that mapping unit. The table could be complemented with the relative extent of the mapping unit, which is stabilized, has reached ultimate degradation, or is undergoing natural degradation.
The lower part of the matrix table can be used for descriptive remarks by the correlator.
Annex 8.6.1 gives an example of the information for a mapping unit, that is required.

GLASOD MATRIX TABLE

PHYSIOGRAPHY :..... MAP UNIT:.....
..... SYMBOL :.....
SOILS :..... COUNTRY:.....
..... REGION :.....
GEOLOGY :..... AREA(km2):.....
CLIMATE (an.mn.):P(mm).....PE(mm).....T(°C)..... COMPILATOR:....
POP.DENS.(I/km2):..... .....
LAND USE :..... EXPERTS:.....
VEGETATION :..... .....

	TYPE	CAUS	DEGR	RATE	EXT.	REMARKS ON DEGRADATION TYPE
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

GENERAL REMARKS :.....

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GLOBAL ASSESSMENT OF SOIL DEGRADATION

(GLASOD)

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

edited by
L.R. Oldeman

ISRIC
Wageningen
April 1988

FOREWORD

The guidelines for general assessment of the status of human-induced soil degradation will serve as an operational manual in the description and global mapping of the status of soil degradation. The first draft was prepared by Dr. J. Riquier. His ideas were thoroughly discussed at a meeting in ISRIC, Wageningen, December 1987, which was attended by J.H.V van Baren, E. Bergsma, L.R. Oldeman, W.M. Peters, I. Pla-Sentis, J. Riquier, W.G. Sombroek, C.R. Valenzuela, R.F. van de Weg. The second draft was then sent for comments to an international panel of reviewers. Comments were received from J.P. Abrol (India); A. Ayoub (Kenya); G. Aubert (France); T.T. Cochrane (Bolivia); F.J. Dent (Thailand); H.E. Dregne (USA); M.A. Garduno (Mexico); E.G. Hallsworth (Australia); B.G. Rozanov (URSS); I. Szabolcs (Hungary).

Their constructive criticism and comments were incorporated in a third draft, which was then discussed in detail during the first regional workshop on a Global Soils and Terrain Digital Database (GLASOD) in Montevideo, Uruguay (21-25 March 1988). Some revisions were suggested at that meeting by a special working group with the following members: M.F. Baumgardner (USA); T. Cochrane (Bolivia; D.R. Coote (Canada); L.R. Oldeman (Netherlands); M. Purnell (FAO, Rome); W. Reybold (SCS, USA); W.G. Sombroek (Netherlands); A. Szögi (Uruguay). Subsequently, additional comments were received from D. Sims, D. Sanders and A. Brinkman (FAO, Italy).

Based on the consensus reached at the Montevideo workshop this new version has been edited. The subject is complex and the scales envisaged (averagely 1:10 M for the world mapping; 1:1 M for some pilot areas) will force many arbitrary decisions to be made by the various regional and national collaborators, also in view of the limited time available for project execution. We nevertheless hope that this operational manual will serve its purpose.

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1. Introduction

Late September 1987 an agreement was signed between the United Nations Environment Programme (UNEP) and the International Soil Reference and Information Centre (ISRIC) for the execution of a project on: Global Assessment of Soil Degradation (GLASOD). The project has a duration of 28 months. It involves two separate activities:

a) to prepare a world map with an average scale of 1:10.000.000 on the status of soil degradation.
b) to prepare a detailed assessment on soil degradation status and risk for a pilot area in Latin America, covering portions of Argentina, Brazil and Uruguay, accompanied by a 1:1 Million map.

The guidelines discussed here are intended for the description and mapping of the status of soil degradation at a global scale. They will be used by institutions and/or qualified individual specialists, designated and contracted to prepare regional soil degradation status maps and complementary data sets at a working scale of 1:7,500,000. They should follow the procedures outlined in these guidelines as closely as possible to ensure a high degree of uniformity. The regional maps thus prepared will then be compiled and correlated to a final map of soil degradation status at an average scale of 1:10 Million. The reduction in scale from 1:7.5 Million to 1:10 Million inevitably implies that certain mapping units may disappear on the final map. The relative importance may be "flagged" by special symbols, this at the discretion of the compilation committee.

These guidelines will also be used for the detailed assessment of soil degradation status in the pilot areas; the basic concepts and the legend discussed below are also applicable for these pilot areas. They are therefore included in the "SOTER Manual for Small Scale Data Base Compilation, Volume II: Procedures for Interpretation of Soil Degradation Status and Risk".

2. Objectives of the global assessment of soil degradation

A realistic understanding of global environmental changes is needed. Past and present intervention in the utilization and manipulation of environmental resources are having unanticipated consequences. It should be realized that not all interventions are negative. While there are many causes of soil degradation - such as those associated with agricultural and pastoral land use and those resulting from mining and non-rural use -, we should also recognize the many effective soil improvement and protection programmes, undertaken by national and international bodies. However, these successes tend to be obscured by the overall deterioration of the world soil resource potential. This project can be considered as a first step towards a global soil degradation assessment. The immediate objective as defined in the project document is: **"Strengthening the awareness of decision makers and policy makers on the dangers resulting from inappropriate land and soil management to the global well being, and leading to a basis for the establishment of priorities for action programmes".**

The most direct way to create awareness is a visual representation of the status of global soil degradation induced by human activity on a map, which should be accompanied by a small document illustrating not only where soil degradation due to inappropriate use of the land takes place or has taken place in the recent past, but also what the various off-site effects of soil degradation are, such as flooding; sedimentation of reservoirs, overblowing of structures, etc. etc.

Our aim is to present data on a map that can be conveniently displayed on an office wall. The map scale therefore is necessarily small. It has been agreed with UNEP to draw a base map from a world geographic map, which is prepared by means of Mercator projection. This implies a scale of 1:15 Million at the equator; 1:13.7 Million at latitude 24°; 1:10.05 Million at latitude 48°; and 1:7.5 Million at latitude 60°. Such a map would cover a size of 270 x 130 cm. This small map scale implies that many cases of soil degradation of local importance cannot be delineated, but may be indicated only by special symbols on the map. However, a base map, outlining the continents, country boundaries and major river systems at a working scale of 1:7,5 Million will be supplied to the contractors.

3. Definitions

The balance between the attacking natural forces of climate - the climate aggressivity - and the natural resistance of the land against these forces determines the natural risk of degradation in a particular area. Human action can either increase or decrease this natural resistance of the land.

Definition: **Soil degradation is a process that describes human-induced phenomena which lower the current and/or future capacity of the soil to support human life.**

(The effect of perceived human-induced change in climate is not included in the framework of the objectives).

Although we will in general restrict ourselves to soil degradation, it is inevitable to indicate also important aspects of terrain degradation, particularly terrain degradation types such as deforestation, resulting in loss of biological diversity, and overgrazing, often - but not always! - leading to an infestation of undesirable weeds. "Terrain" being a more extensive concept than "Soils" includes soil, topography, vegetation cover, land use and hydrology.

It is not our intention to assess the relative fragility of an ecosystem. In other words, we do not intend to indicate and delineate the instantaneous present and future rate of degradation processes and the potential hazards that may occur under human influence. In our assessment we want to describe and delineate situations where the balance between climatic aggressivity and the potential resistance of the soil has been broken by human action. In other words, we want to describe the present status of human-induced soil degradation which can be defined mainly by the type and degree of soil degradation. However we also want an indication of the recent past medium-term estimated rate of soil degradation (i.c. averaged over the past 5 to 10 years).

Definition: **Type of soil degradation refers to the process that causes the degradation** (displacement of soil material by water and wind; in-situ deterioration by physical, chemical and biological processes).

Degree of soil degradation refers to the present state of degradation (slight, moderate, severe).

Recent past average rate of soil degradation refers to the apparent rapidity of the degradation process estimated and averaged over the past 5 to 10 years (slow, medium, rapid).

These three elements of soil degradation will be discussed in detail in section 4,5,6.

We have stressed repeatedly that we are only concerned with soil degradation types, degrees and recent past rates that are induced by human activity. This would exclude soil degradation occurrences that have occurred in the past as a result of geologic events or under past climatic conditions, such as the rising (uplifting) of mountain chains; volcanic eruptions and the subsequent erosion of fresh lava and ash materials; the melting of glaciers; rising and subsiding of ocean levels, occurrence of pluvial or interpluvial periods, etc. However, the final map should indicate those areas where natural erosion has lead to extreme conditions, such as deserts, salt flats, rock outcrops etc. Deserts could still be a source of danger to the lands around its edges by sand blasting and drift. In an analogous manner a salt flat is a source of salt, capable of causing salinization of the terrain around it.

We are concerned in this project with the status of human-induced soil degradation at the present time. However it should be realized that soil degradation under human influence has taken place in the past as well. The following three periods are recognized.

a) Early civilization occurring in the ancient past and up to 250 years ago.
b) Era of European expansion in the America's, Australia, Asia and Africa. 50 to 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.

In many parts of the world soil degradation occurred at various times in the past, and subsequently the land surface has come to equilibrium with the causative factors. The time periods for these changes in rate to occur are very variable. (Much of the rangeland in Australia has eroded seriously in the past, but has now become stable again).

Finally we have to stress that only a limited number of events can be delineated and mapped on a world soil degradation map at an average scale of 1:10,000,000. This can only be done with the assistance of experts having a good knowledge of the soil conditions in the various regions. In these guidelines we provide a limited number of keys to facilitate the description of type, degree and present rate of soil degradation in order to enhance the uniformity of delineation. We realize that the interpretation is to a certain extent subjective, but believe that it will be possible to come in a cooperative effort to a first assessment of global soil degradation.

4. Types of Degradation processes

We recognize two categories of human-induced degradation processes.

The first category deals with soil degradation by displacement of soil material. In this category we can distinguish between on-site effects, which are effects at or near the site ("on-farm" effects), including local deposition, and off-site effects, which are effects at a distance from the site (at least one km. away).

The second category describes soil degradation types as a result of internal soil deterioration. In this category only in-situ effects are recognized on soil that has been abandoned or forced into less intensive usages. It does

not refer to the cyclic fluctuations of soil chemical, physical, or biological conditions of relatively stable agricultural systems, in which soil is actively managed to maintain its productivity, nor does it refer to gradual changes in the chemical composition as a result of soil forming processes.

There is another category of human-induced terrain degradation. We refer to vegetation related degradation processes, such as deforestation, overgrazing of the land, often leading to an invasion of undesirable obnoxious, unpallatable weeds or shrubs. These human-induced terrain degradation processes will be considered as causative factors of the previously indicated two categories of soil degradation processes.

The following types of soil and land degradation processes should be recognized and delineated on the map. Off-site effects will generally not be delineated but "flagged" by special symbols (see section 8.4.6).

4.1 Degradation by displacement of soil material

4.1.1 WATER EROSION

on-site:

1) Loss of topsoil. A uniform loss by surface wash and sheet erosion.
2) Terrain deformation. An irregular displacement of soil materials, characterized by major rills, gullies, or mass movement.

off-site:

1) Reservoir harbour and lake sedimentation.
2) Flooding, including riverbed filling; riverbank erosion; excessive siltation of basin land.
3) Coral, shellfish beds and seaweed destruction.

4.1.2 WIND EROSION

On-site

1) Loss of topsoil. A uniform displacement by deflation
2) Terrain deformation. An uneven displacement characterized by major hollows, hummocks or dunes.

Off-site

1) Overblowing, such as encroachment on structures as roads, buildings and/or sand blasting of vegetation)

4.2 Degradation by internal soil deterioration

4.2.1 CHEMICAL DETERIORATION

1) Loss of nutrients, often leading to seriously reduced production (e.g. accelerated acidification of soils in the humid tropics).
2) Pollution and acidification from bio-industrial sources. Excessive addition of chemicals (organic manure, acid rain, etc.).
3) Salinization, caused by human-induced activities such as irrigation.
4) Discontinuation of flood induced fertility. (This may occur as a result of any conservation method, that controls flooding and will lead to a discontinuation of natural replenishment of nutrients by flooding).
5) Other chemical problems, such as catclay formation upon drainage of some coastal swamps; negative chemical changes and development of toxicities in paddy fields. To be specified by the regional correlator.

4.2.2 PHYSICAL DETERIORATION

1) Sealing and Crusting of topsoil.
2) Compaction, caused by heavy machinery on a soil with weak structure stability, or on soils in which humus is depleted.
3) Deterioration of the soil structure due to dispersion of soil material by Na (and Mg) salts in the subsoil (sodication).
4) Waterlogging; human-induced soil hydromorphism; flooding and submergence (excluding paddy fields).
5) Aridification; human-induced changes of the soil moisture regime towards an aridic regime, caused for instance by lowering of the local base ground water level (deep groundwater depletion excluded).
6) Subsidence of organic soils (by drainage, oxidation).

4.2.3 BIOLOGICAL DETERIORATION

1) Imbalance of (micro)biological activity in the topsoil. This can be caused by deforestation in the humid tropics or by overemphasis of chemical fertilizer applications in industrialized countries.

4.3 Causative factors of Soil Degradation

1) Overgrazig of pasture lands, when extensive areas of land have been completely cleared of its original vegetation.
2) Deforestation, caused by burning or logging: "slash and burn" system.
(In both types there is a loss of biological diversity often leading to a secondary type of vegetation with predominantly obnoxious and unpalatable weeds and shrubs).
3) Over intensive annual cropping.

5. Degree of present degradation

Recognition of the degree to which the soil is presently degraded, can be done in relation to its agricultural suitability, but also in relation to its biotic functions. In some cases the degree of present degradation can be related to declined productivity. We recognize the following degrees of soil degradation:

None: there is no sign of present degradation from water or wind erosion, from chemical, physical or biological deterioration; all original biotic functions are intact. Such land is considered stable (see also section 8.4.7).

Slight: the terrain is suitable for use in local farming systems, but with somewhat reduced agricultural productivity. Restoration to full productvity is possible by modifications of the management system. Original biotic functions still largely intact.

Moderate: the terrain is still suitable for use in local farming systems, but with greatly reduced agricultural productivity. Major structural alterations are required to restore productivity (e.g. draining for water logging or salinity; contour banks if the land is eroding). Original biotic functions partly destroyed.

Severe: the terrain is unreclaimable at the farm level. Major engineering works are required for terrain restoration. Original biotic functions largely destroyed.

Extreme: the terrain is unreclaimable and impossible to restore. Original biotic functions fully destroyed. The terrain has become non-vegetated and non-used wasteland (see also section 8.4.8).

These generalized descriptions allow for some flexibility by the regional correlators to determine the present degree of degradation. Some descriptive terrain components and examples of possible circumstances are given for a slight, moderate, and severe degree of present degradation of water- and winderosion; salinization, and nutrient decline.

5.1 Degree of present degradation due to water erosion

1) Slight: in deep soils (rooting depth more than 50 cm): part of the topsoil removed, and/or with shallow rills 20-50 m apart.
in shallow soils (rooting depth less than 50 cm): some shallow rills at least 50 m apart.
in pastoral country the groundcover of perennials of the original/ optimal vegetation is in excess of 70%*.
2) Moderate: in deep soils: all top soil removed, and/or shallow rills less than 20 m. apart or with moderately deep gullies 20-50 m. apart.
in shallow soils: part of topsoil removed, and/or shallow rills 20-50 m apart.
in pastoral country: groundcover of perennials of the original/ optimal vegetation ranges from 30% to 70%*.
3) Severe: in deep soils: all topsoil and part of subsoil removed, and/or with moderately deep gullies less than 20 m. apart.
in shallow soils: all topsoil removed: lithic or leptic phases or with exposed hardpan.
in pastoral country: groundcover of perennials of the original/ optimal vegetation is less than 30%*.

5.2 Degree of present degradation due to wind erosion.

1) Slight: in deep soils: topsoil partly removed and/or with few (10-40% of the area) shallow (0-5 cm) hollows.
in shallow soils: very few (10% of the affected area) shallow (0-5 cm) hollows.
in pastoral country: groundcover of perennials of the original/ optimal vegetation is in excess of 70%*.
2) Moderate: in deep soils: all topsoil removed; and /or with common (40-70% of the area) shallow (0-5 cm) or few (10-40% of the area) moderately deep (5-15 cm) hollows.
in shallow soils: topsoil partly removed and/or few (10-40% of the area) shallow (0-5 cm) hollows.
in pastoral country: groundcover of perennials of the original/ optimal vegetation ranges from 30%-70%*.
3) Severe: in deep soils: all topsoil and part of subsoil removed and/or with many (>70% of the area) shallow (0-5 cm) or common (40-70% of the area) moderately deep (5-15 cm) or few (10-40% of the area) deep (>15 cm) hollows/blowouts.
in shallow soils: all top soil removed: lithic or leptic phases or with exposed hardpan.
in pastoral country: groundcover of perennials of the original/ optimal vegetation is less than 30%*.

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* Known maximum coverage of perennials under good management as practiced during some time in the past.

5.3 Degree of present degradation due to salinization.

Salinization should be considered as the relative change over the last ± 50 years in salinity status of the soil, the latter being defined as follows:

non-saline:
electrical conductivity less than 5 dS/m; E.S.P. < 15%; pH < 8.5
slightly saline:
electrical conductivity 5-8 dS/m; E.S.P. < 15%; pH < 8.5
moderately saline:
electrical conductivity 9-16 dS/m; E.S.P. < 15%; pH < 8.5
severely saline:
electrical conductivity more than 16 dS/m; E.S.P. < 15%; pH < 8.5

The present degree of human-induced salinization can now be identified as a change in salinity status as follows:
1) slight: from non-saline to slightly saline; from slightly to moderately saline, or from moderately saline to severely saline.
2) moderate: from non-saline to moderately saline, or from slightly saline to severely saline.
3) severe: from non-saline to severely saline.

5.4 Degree of present degradation due to nutrient decline

Criteria to assess the degree of present degradation are the organic matter content; the parent material; climatic conditions. The nutrient decline by leaching or by extraction by plant roots without adequate replacement is identified by a decline in organic matter, P, CEC (Ca, Mg, K).
1) slight: Cleared and cultivated grassland or savannas on inherently poor soils in tropical regions. Cleared or cultivated formerly forestland in temperate regions on sandy soils, or in tropical (humid) regions on soils with rich parent materials.
2) moderate: Cleared and cultivated grassland or savannas in temperate regions, on soils high in inherent organic matter, when organic matter has declined markedly by mineralization (oxidation). Cleared and cultivated formerly forested land on soils with moderately rich parent materials in humid tropical regions, where subsequent annual cropping is not being sustained by adequate fertilization.
3) severe: Cleared and cultivated formerly forestland in humid tropical regions on soils with inherently poor parent materials (soils with low CEC), where all above-ground biomass is removed during clearing and where subsequent crop growth is poor or non-existent and cannot be improved by N fertilizer alone.
4) extreme: Cleared formerly forested land with all above ground biomass removed during clearing, on soils with inherently poor parent materials, where no crop growth occurs and forest regeneration is not possible.

6. Recent Past Average Rate of Soil Degradation

Recognition of the recent past rate of human-induced soil degradation should be done in dependence of local population densities of human and animal form; also in dependence of climatic aggressivity or related to the degree of mechanization in the recent past. We are interested in an estimate of the present medium-term rate of soil degradation. 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. In the report which will accompany the map, the reasons for indicating various rates should be explained as detailed as possible.

7. Land Area within mapping Unit being affected

At the chosen scale it will not be possible to separate each type of soil degradation. Estimation of the frequency of occurrence of a certain type of degradation should come from local knowledge or through remote sensing. The frequency of occurrence of a certain type of degradation within each mapping unit is the percentage of land affected:

1. infrequent : 1-5% of the terrain affected
2. common : 6-10% of the terrain affected
3. frequent : 11-25% of the terrain affected
4. very frequent: 26-50% of the terrain affected
5. dominant : 51-100% of the terrain affected

It should be noted that the category 0: 0% of the terrain affected, implies that no degradation occurs in the mapping unit. Therefore this category can be omitted.

8. Methodology

On a regional level soil degradation induced by human action will be mapped using basemaps of an average scale of 1:7,500,000 presenting only the essential topographical phenomena like mountains, important rivers and townsites. These maps will be supplied by the GLASOD project.

The methodology of the assessment of human-induced soil degradation on a regional level will be the following:

8.1 Preparation

All the existing information on aspects related with soil degradation has to be collected and studied, included historic information. One of the tools might be the FAO Soil Map of the World scale 1:5.000,000. A list of relevant material available at ISRIC will be provided and if necessary black and white copies of maps will be provided on request. Other more detailed and more recent information about soils on a regional level is of utmost importance to update existing information. Copies or originals of maps and reports used and not present at ISRIC will be requested, and/or references of used materials should be listed.
Other specific fields of interest are climate, geology, hydrology, geomorphology, ecology, vegetation, erosion, land use, animal and population density. Existing small scale remote sensing material like satellite images are other tools that can be useful. Aerial photographs may also be used as these provide the possibility to see some soil degradation types on a test zone of the mapping unit, which are not visible on satellite images (e.g. gullies, siltation, relief etc.).

8.2 Consultation

To evaluate relevant aspects of human-induced soil degradation on a regional level it is suggested to consult specialists in related fields of each of the participating countries per region. Correlation of existing information on a regional level will be the main topic of these consultations together with the explanation of the GLASOD methodology.

8.3 Mapping procedures

To map the state of soil degradation caused by human intervention the following steps are to be taken:

8.3.1 Subdivide the region in physiographic units showing certain homogeneity of topography, climate, vegetation, geology, soils, and land use. Animal and human population density (excluding town population density if possible) can be another diagnostic criterion. This subdivision must be done using existing soil association maps and others with the aid of remote sensing material. The smallest area that should be mapped is 1 x 1 cm (5625 km^2 at a 1:7,500,000 scale). Only few exceptions are envisaged where compiled physiographic units at this scale are smaller than 1 x 1 cm. Most areas will be larger.

8.3.2 Evaluation of Soil Degradation Status

Determine whether the delineated physiographic unit has human-induced soil degradation types or not. Evaluate their degree, recent past rate, and the extent of the land per physiographic unit being affected .The result of the evaluation process is a symbol for each of the relevant degradation processes, its degree, extent and recent past rate. These symbols must be inserted in the corresponding mapping units. Since it is possible that one polygon may consists of several soil degradation types, that type which affects the greatest area should be inserted in full; the other types should be listed in a separate matrix table per polygon (see example, section 8.6). Each polygon should therefore be given a unique number.

8.4 Mapping symbols for polygons affected by soil degradation

8.4.1 Mapping symbols for soil degradation types

W : water erosion affected terrain
Wt : loss of topsoil caused by water erosion
Wd : terrain deformation caused by water erosion
E : wind erosion affected terrain
Et : loss of topsoil caused by wind erosion
Ed : terrain deformation caused by wind erosion
C : chemical deterioration of the soil
Cn : loss of nutrients
Cp : pollution and acidification from bio-industrial sources
Cs : salinization
Cd : discontinuation of flood-induced fertility
Co : other chemical problems
P : physical deterioration of the soil
Pk : crusting/sealing of topsoil
Pc : compaction
Ps : soil structure deterioration due to dispersing action of salts in the subsoil
Pw : waterlogging
Pa : aridification
Pl : subsidence of organic soils
B : biological deterioration
Bb : imbalance of (micro) biological activity

As indicated earlier human-induced terrain degradation, as a result of deforestation, or overgrazing, or intensive annual cropping will not be considered as a separate type of soil degradation, but specific symbols for these types should be added immediately after the symbol for the soil degradation type:
f: deforestation as causative factor
g: overgrazing as causative factor
i: over intensive annual cropping as causative factor
o: other forms
Example: **Wdf** : terrain deformation by water erosion caused by deforestation.

8.4.2 Mapping symbols for the degree of soil degradation:

slight : use lower case letter of degradation type, w..., e..., c..., p..., b...
moderate: use upper case letter of degradation type, W..., E..., C..., P..., B...
severe : underline upper case letter of degradation type, W..., E..., C..., P..., B...
extreme : encircle upper case letter of degradation type, Ⓦ..., Ⓔ..., Ⓒ..., Ⓟ..., Ⓑ...

8.4.3 Mapping symbols for the extent of the terrain affected:

1: infrequent (1-5% of the terrain affected)
2: common (6-10% of the terrain affected)
3: frequent (11-25% of the terrain affected)
4: very frequent (26-50% of the terrain affected)
5: dominant (more than 50% of the terrain affected)

These numbers should be placed imediately after the degradation type symbol. e.g. **Cs1** - severe salinization problem in 1-5% of the mapping unit.

8.4.4 Mapping symbol to indicate the recent past rate of human-induced degradation

1: slow
2: medium
3: rapid

These numbers should be placed after the number indicating the land area percentage affected. e.g **Cs12** - this mapping unit has an infrequent (1-5%) frequency of occurrence of severe salinization taking place at a medium rate.

8.4.5 Mapping symbols to indicate human-induced soil degradation in the past

(a): early civilisation (more than 250 years ago)
(b): era of European expansion (50 to 250 years ago).

These symbols should be placed after the number, indicating the present rate of human-induced soil degradation, or after the mapping symbol for stable land (see section 8.4.7).

8.4.6 Mapping symbols for off-site effects.

Evaluate off-site effects. Man induced wind and water erosion might cause off-site effects that have to be evaluated. Each of the off- site effects will be represented by "flagging", by means of an arrow or coloured lines:

Wr sedimentation of reservoir, lakes
Wf flooding
Wc coral reef destruction
Eo overblowing

8.4.7 Mapping symbols for stable terrain.

We refer to mapping units with no present human-induced type of soil degradation. In these mapping units the degree of present soil degradation is none (see section 5), although there may have been soil degradation in the past (see section 8.4.5). We can recognize two types of stable terrain: stabilization naturally, or stabilization as a consequence of human intervention. The following symbols are to be used:

SN : terrain is stabilized naturally (e.g. tundra, extensive natural forest, ice)
SH : terrain is stabilized by human intervention
SHp: stabilized as a consequence of paddy (wetland rice) field bunding
SHc: stabilized as a consequence of conservation practices for rainfed foodcrops or other forms of permanent conservation measures
SHr: stabilized as a consequence of reforestation, permanent plantation crops etc.
SHe: stabilized as a consequence of empoldering.

8.4.8 Mapping symbols for non-used wasteland.

Mapping units of terrain that has reached ultimate degradation under natural conditions, that has become non-vegetated and/or non-used wasteland.

D : active dunes
Z : salt flats
R : rock outcrops
A : deserts
I : ice caps.

8.5 Report

A document with a detailed description of man-induced soil degradation should be prepared per region. This document contains a precise explanation of the different types of degradation processes, its degree, rate and relative importance as represented on the accompanying map or in the matrix (see section 8.6). All the criteria used for defining degree and rate of the different processes have to be explained very precisely to facilitate correlation on a worldwide level afterwards. Moreover, all kinds of soil degradation processes (on-site or off-site) in the region that are not mentioned in the matrix or that cannot be represented on the map because of the scale used should be described as detailed as possible, for instance man caused landslides, solifluction, on-site pollution, mine spoils and others.

The report should contain a complete list of all the collaborating scientists and institutes on a regional level and a list of all the existing material, maps and documents used during the evaluation process.