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REVISITING THE GLASOD METHODOLOGY

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REVISITING THE GLASOD METHODOLOGY

by

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A. Introduction

Since the 1970's there has been an international recognition of the need for a global assessment of soil degradation. Although statements that soil erosion is undermining the future prosperity of mankind is holding an element of truth, these statements do not help planners to know where the problem is serious and where it is not (Dregne, 1986). The World Association of Soil and Water Conservation supports the view that maps showing where erosion has reduced long-term soil productivity in Africa are virtually non-existent at the continental, regional and national scale (WASWC, 1989). Such maps are needed to enable planners and donor agencies to make wise decisions on the allocation of scarce resources. In their review the WASWC indicates that in the absence of quantitative data on the impact of erosion on potential soil productivity recourse can be made to the information experienced people have accumulated over the years. The proposal to develop a structured, informed opinion analysis system to tap the wealth of knowledge among farmers, pastoralists, extension agents, scientists and conservationists in a meaningful way and to translate these observations into reasonably accurate maps, was also the basic philosophy behind the methodology for the Global Assessment of the Status of Human-Induced Soil Degradation (GLASOD).

The United Nations Environment Programme (UNEP) requested an ad-hoc expert panel convened in Nairobi (May 1987) to consider the possibility to produce, on the basis of incomplete knowledge, a scientifically credible global assessment of soil degradation in the shortest possible time (ISSS, 1987). Based on the recommendations of that meeting, UNEP formulated a project document, entitled: Global Assessment of Soil Degradation, which would lead to the publication of a World Map on the Status of Human-Induced Soil Degradation at a scale of 1:10 Million within a time frame of 28 months. The International Soil Reference and Information Centre (ISRIC), Wageningen, was requested to administer and coordinate the project. ISRIC was assisted in the execution of the activities by individual scientists of the International Society of Soil Science (ISSS), the Winand Staring Centre, the FAO, and the International Institute for Aerospace Survey and Earth Sciences (ITC). The immediate objective of the GLASOD project was: *"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"*.

B. Summary of the GLASOD methodology

Regional correlators - institutes or individual scientists - were designated to give their expert opinion on the status of human-induced soil degradation in close consultation with national soil and environmental scientists. The world was divided into 21 regions and over 250 scientists were consulted.

General guidelines were prepared for the assessment of soil degradation in order to ensure a certain degree of uniformity in reporting (Oldeman, 1988).

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A standard topographic base map was prepared at twice the scale of the final map on the basis of the Topographic World Map, published by the Institut Géographique National. Only continental and country boundaries, major hydrological features and major cities were indicated. The correlators were asked to delineate physiographic units on these base maps using available geological, topographical, soils, climate and vegetation maps.

The next step was to assess for each physiographic unit the occurrence of soil degradation types, their relative extent within the delineated unit, the degree of soil degradation and the kind of human intervention that has caused the soils to deteriorate. Although the general guidelines also suggested to indicate the apparent rapidity of the soil degradation process over the past 5-10 years, most correlators could not give that information at this scale. All data on the status of soil degradation was incorporated in matrix tables and returned to the coordinating institution.

The 21 regional segments of the world map were then compiled into one map. Reduction in scale to the final map scale resulted in unavoidable generalization. Although twelve different types of soil degradation were identified in total, it was decided to select only four colours to represent the major types of soil degradation (water erosion in bluish green, wind erosion in yellowish brown, chemical deterioration in red and physical deterioration in pink; see below). The seriousness of soil degradation ("Severity") was grouped in four classes, based on a combination of degree and relative extent of the degradation type within the mapping unit. This was visualized by four different shades of the base colour.

The draft world map on soil degradation was then sent back to the regional correlators for verification and approval before the final map was printed. The World Map on the Status of Human-Induced Soil Degradation was exhibited for the first time at the International Congress of Soil Science in Kyoto, Japan, 1990.

B.1. Soil Degradation types

GLASOD adopted the definition of soil degradation of FAO, UNEP and UNESCO (1979): "*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*".

Human-Induced Soil Degradation can be defined by the **type** of soil degradation (the process that causes degradation) and by the **degree** of degradation (the present state of the degradation process). This implies that GLASOD does <u>not</u> assess the present and future rate of degradation processes and the potential hazards that may be the result of human influence. Two categories of human-induced degradation processes were recognized:

a. Displacement of soil material by water or wind, leading to a 'uniform' loss of topsoil by surface wash and sheet erosion or by deflation, or to terrain deformation resulting in irregular displacement of soil material characterized by rills, gullies, mass movement, or by major hollows, hummocks or dunes. By definition displacement of soil material has also off-site effects such as sedimentation, flooding, destruction of coral reefs, shellfish and seaweed, or as encroachment of blown soil material on buildings, roads or vegetation.

b. In situ deterioration of soil qualities. The processes leading to such deterioration are either chemical in nature (nutrient decline, loss of organic matter, salinization, acidification, pollution) or physical in nature (sealing and crusting of the topsoil, compaction, waterlogging, subsidence of organic soils). The general guidelines of GLASOD also identified biological deterioration leading to an imbalance of (micro)biological activity in the topsoil.

After the inventory by the regional correlators was concluded, the final list of recognized soil degradation types to be included in the world map was restricted to twelve types:

Wt Water erosion: loss of topsoil
Wd Water erosion: terrain deformation
Et Wind erosion: loss of topsoil
Ed Wind erosion: terrain deformation
Eo Wind erosion: overblowing
Cn Chemical deterioration: loss of nutrients and/or organic matter
Cp Chemical deterioration: pollution
Cs Chemical deterioration: salinization
Ca Chemical deterioration: Acidification
Pc Physical deterioration: compaction, sealing and crusting
Pw Physical deterioration: waterlogging
Ps Physical deterioration: subsidence of organic soils

Obviously in many instances mapping units include terrain that is not affected by human-induced soil degradation. These areas were subdivided in two categories: those with and those without appreciable vegetative cover. The first group (Stable terrain) can either have a natural cover, be stable under permanent agriculture or be stabilized by soil conservation activities. The second category (Wastelands) includes active dunes, deserts, salt flats, rock outcrops, ice caps, arid mountain regions.

B.2. Soil Degradation Status

The status of the degradation process is characterized by the degree of soil degradation. This qualitative expert estimate was related to observed changes in the agricultural suitability, declined productivity, possibilities for restoration and in some cases related to the biotic functions. Table I gives the main descriptive features to assess the soil degradation status.

Table I

	DEGREE			
	Slight	Moderate	Severe	Extreme
Agricultural suitability	suitable	still suitable	marginal	non
Agricultural productivity	somewhat reduced	greatly reduced	almost nil	nihil
Restoration potential	by modification of management system	structural alterations needed	major engineering required	beyond restoration
Biotic function	largely in tact	partly destroyed	largely destroyed	fully destroyed

B.3. Extent of soil degradation

For each soil degradation type, the relative frequency of occurrence within the delineated mapping unit is given in GLASOD according to the following five classes:

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

B.4. Causative factors

Human-induced soil degradation implies by definition pressure related action. The **causative factor** indicates the kind of human action that can be considered responsible for the occurrence of the degradation type involved. Some degradation processes may also occur naturally, such as erosion, but in the GLASOD inventory only those degradation types are considered that are the result of the human disturbance. GLASOD recognized five kinds of interventions that caused the present degradation of the soil:

* Deforestation and removal of natural vegetation
* Improper management of cultivated land
* Overgrazing
* Over-exploitation of the natural vegetation for domestic use
* (bio)industrial activities

It should be clearly stated that degradation of vegetation is not assessed in GLASOD. This implies that for example overgrazing in the GLASOD context is only indicated if it leads to erosion or compaction of the soil. Similarly, deforestation is only mentioned where it leads to erosion or organic matter decline.

C. Limitations of the GLASOD map

C.1. Although within a mapping unit several types of degradation and several degradation status conditions may occur, only two types of degradation would be indicated per mapped unit, each with its corresponding degree and relative extent.

C.2. The severity of soil degradation in GLASOD is by necessity an aggregation of the degree and relative extent of the degradation process. This is illustrated in Table II.

		PERCENTAGE OF MAPPING UNIT AFFECTED (Extent)				
		Infrequent	**Common**	**Frequent**	**Very frequent**	**Dominant**
DEGREE OF DEGRADATION	light	slight	slight	medium	medium	high
	moderate	slight	medium	high	high	very high
	strong	medium	high	high	very high	very high
	severe	medium	high	very high	very high	very high

A strong degree of soil degradation, occurring infrequently has the same severity class (medium) as a light degree occurring frequently or very frequently. This is the consequence of the cartographic restrictions in highlighting all possible combinations (20 in total) of degree and extent with a different colour and shade on the map.

C.3. The projection of the base map used in GLASOD is Mercator. This base map was chosen because it gives the least distortion of the continents. An additional advantage was the fact that the three map sheets - the America's, Europe and Africa, Asia and the Pacific - could be arranged next to each other in any desired order. The most obvious disadvantage relates to the variation in scale: at the equator the base map has a scale of 1:15 Million, at 48° longitude the scale is 1:10 Million, and 1:5 Million at 70° longitude. This implies that areas displayed on the map cannot be interpreted as actual surface areas. Still there was a need to express the status of soil degradation worldwide in actual size of the areas affected. Therefore, the GLASOD map was digitized and with a GIS the projection was changed into an "equal area" projection. Knowing the actual surface areas and the relative extent of the degradation process, its degree and causative factors, it was then possible to prepare global and continental statistics on the actual extent of human-induced soil degradation. These figures were published in 1991 (Oldeman, Hakkeling and Sombroek, 1991). Reference is also made to the World Resource Report 1992-1993 of the World Resources Institute (1993), to the Thematic Atlas of Desertification (UNEP, 1992,a) and to Oldeman (1994).

C.4. An informed opinion systems approach

The information derived from GLASOD is based on expert judgment and thus subjective. As stated by Thomas (1993), the approach is still susceptible to much of the criticism that earlier UN assessments received, "*particularly the fact that the data set is ultimately a qualitative interpretation of material from a range of sources, interpreted by a large number of individuals*". Nonetheless, he acknowledges that it is easy to criticize such an approach but difficult to suggest viable alternatives at this scale of investigation.

Yadav and Scherr (1995) compared various methodologies for making global estimates of land degradation (see Annex I). The GLASOD methodology (consultation of experts) was compared with studies reviewing and evaluating publications on land degradation from many different sites within regions and with assessments through extrapolation of results based on case studies, field experiments on a national scale. They state that although all these methods have serious flaws, their strength lies in providing a sense of nature and relative importance across large areas.

D. Suggestions for GLASOD follow-up studies

Reviewing the methods for the assessment of soil degradation as used in GLASOD, an ad-hoc panel convened by UNEP (1992,b) recommended that future degradation assessments should be directed towards land degradation and include vegetation and water resource degradation as well as soil degradation; that baseline conditions for assessing the current status of land degradation should be established; that where possible quantitative data should be used for degradation classes based on productivity or some surrogate for productivity, such as land evaluation; that degradation risk assessment (hazard, vulnerability) should be undertaken in future follow-ups to GLASOD and that the feasibility of conducting an assessment of degradation trends should be investigated; that the World Overview of Conservation Approaches and Technologies (WOCAT) programme should be endorsed to complement GLASOD. In this respect a similar recommendation was voiced at the Soil Resilience and Sustainable Land Use Symposium (Greenland and Szabolcs, 1994): "*The global database on soil degradation developed by UNEP, ISSS and ISRIC, in collaboration with countries, should be* *complemented by a similar assessment of areas with sustainable management systems, areas where degraded lands have been rehabilitated, and of the resilience of the land resource base in different ecosystems*".

Frequently the GLASOD authors have been approached to give national estimates on soil degradation, based on GLASOD. These requests have always been turned down, since GLASOD can only be seen as a global or continental assessment on soil degradation. The global compilation of regional degradation maps is not appropriate to be used for assessing the degradation status at national levels. For possible follow-up activities however, it would be better if the objectives are founded on systematic observations at the national level (Young, 1991). As stated by Speth (written communication, 1992): "*The World Resources Institute considers the GLASOD study as an important milestone that establishes the global extent of soil degradation. There is a critical need for further study to more accurately portray soil degradation problems at a national and local level and to link soil degradation with its social and economic consequences*".

The following section discusses a national approach to GLASOD, presently being conducted in 17 countries in South and Southeast Asia in close cooperation with FAO's Regional Office for Asia and the Pacific, in the framework of a project supported and formulated by UNEP on the basis of recommendations of the third Expert Consultation of the Asian Network on Problem Soils (FAO, 1994).

ANNEX I Comparison of GLASOD statistics with other soil degradation estimates

The following information is taken from Yadav and Scherr (1995)

UNEP (1986) argued that 2000 Million hectares of once biological productive land has been rendered unproductive through irreversible degradation. Smyth and Dumanski (1993) estimate that out of 1950 Million hectares of degraded agricultural, forestry and rangelands, some 750 Million hectares has been affected by slight degradation, while 900 Million hectares are moderately affected and 300 Million hectares severely degraded. The primary cause for this degradation is human-related activities such as deforestation (37%), overgrazing (35%), improper agricultural practices (28%) and industrial pollution (2%).

Lal (1994) reviewed literature from throughout the tropics. According to his estimates, the land area degraded by water erosion is 915 Million hectares against 474 Million hectares by wind erosion, 213 Million hectares by chemical degradation and 50 Million hectares by physical degradation.
Dregne and Chou (1992) have used anecdoted accounts, research reports, individual opinions and local experience to derive estimates of degraded lands in the dryland zones of the world (3600 Million hectares). These assessments refer to human-induced land degradation and include the deterioration of vegetation. These data hence cannot be compared with GLASOD data on soil degradation (1035 Million hectares) for the drylands, although they are interrelated. During a technical expert consultation at FAO in 1991 it was concluded that 2600 Million hectares of degraded rangelands are affected by vegetation degradation without associated soil degradation. This would leave about 1000 Million hectares with degradation of both soil and vegetation.

The following table shows some relevant figures based on GLASOD. There is a striking agreement between the GLASOD figures and the estimates cited above.

Table III GLASOD estimates of human-induced soil degradation worldwide, for the tropics[1] and for the dryland zones[2] of the world, in million hectares (from Oldeman, 1994)

	Global estimates	Tropics[2]	Drylands[3]	Other zones (non-drylands)[3]
World	1964	1651	1137	829
Water Erosion	1094	920	478	615
Wind Erosion	548	472	513	36
Chemical Degradation	240	213	111	130
Physical Degradation	83	46	35	48
Light	749	671	488	261
Moderate	910	689	509	401
Severe and extreme	305	290	139	166

1 In this context "the tropics" include Africa, Asia, South and Central America and Australasia

2 "Dryland zone" is defined as the climatic region with an annual precipitation/evaporation ratio of 0.65 or less (UNEP, 1992)

II REVISION OF THE GLASOD METHODOLOGY
for an assessment of human-induced soil degradation in South and Southeast Asia

A. Introduction

As mentioned above, since the publication of the GLASOD map (Oldeman et al., 1991) frequent requests for more detailed information were received, to which it was often difficult to respond in view of the small scale and global character of the GLASOD inventory. Many inquiries and comments also referred to the impact of soil degradation and what is being done about it.

In this context, the Asia Network on Problem Soils at its third meeting in Bangkok in 1993, made a recommendation (FAO, 1994) for the preparation of a soil degradation assessment for South and Southeast Asia at a scale of 1:5 million, based on the GLASOD methodology but modified where deemed necessary. This recommendation was endorsed by FAO and UNEP, and the latter organization formulated a project for which it provided funding support. In accordance with the recommendation, ISRIC is the coordinating institution for this project.

A new physiographic map for Asia that was compiled by ISRIC and FAO (Van Lynden, 1994) was used as a basis for this assessment. Also, links were made with the WOCAT project (World Overview of Conservation Approaches and Technologies) of the World Association of Soil and Water Conservation and the Group for Development and Environment, University of Berne to cover some remediation aspects of degraded areas.

The ASSOD project, provides information on soil degradation in South and Southeast Asia at a scale of 1:5 M, while increasing awareness on soil degradation problems among policy- and decision makers and the general public in the region. Like the GLASOD map, it describes the current status of human-induced soil degradation, with a general indication of the "recent past rate". Data are provided by national institutions, and can always be retrieved for individual countries. However, ASSOD is more than just a revised and magnified GLASOD map for Asia and therefore several changes in the approach were adopted. More emphasis is placed on trends of degradation (recent past rate) and on the impacts of degradation on productivity (see below), while some elements of conservation/rehabilitation are added as well, providing linkages to the WOCAT project. Another major difference with GLASOD is that, where the main GLASOD output was a map, which was later digitized and entered into a GIS and database, the ASSOD project first generates a comprehensive database on the soil degradation status of the region which can be used for the production of various types of outputs such as maps.

B. Physiographic base map

A major difference with the GLASOD map is the physiographic base map, compiled with standardized criteria using the SOTER methodology (Van Engelen et al., 1992). At a request of FAO, this 1:5 M physiographic map of Asia (excluding the former Soviet Union and Mongolia) was completed by ISRIC (Van Lynden, 1994), and sent to the participating countries for comments prior to using the map units for assessing degradation.

Soils and terrain are two closely linked natural phenomena which together determine to a large extent the suitability of land for different uses. An integrated concept of land has been adopted in the SOTER methodology viewing "*land as being made up of natural entities consisting of a combination of terrain and soil individuals*". The physiographic map for Asia has been prepared following this concept and is largely based on the hierarchy of landforms in SOTER, with minor modifications, as already applied for similar projects in Latin America (Wen 1993) and Africa (Eschweiler, 1993) respectively. Terrain units were delineated on a handdrawn map and their respective physiographic codes were entered into a database. The map was then digitized and linked to the database through a GIS (ILWIS and ARC-INFO).

C. Types of Soil Degradation

The GLASOD definition of soil degradation (see B.1) is applied. This definition of soil degradation is very broad and requires some further refinement. Soil degradation has been defined in many ways (e.g. Barrow, 1991), most often referring to the (agro)productive function of the soil. In a general sense soil degradation could be described as the deterioration of soil quality, or in other words: the partial or entire loss of one or more functions of the soil (see Blum, 1988). For the purpose of this inventory, the emphasis will be on soil degradation processes that lead to a deterioration of the production function of the soil. This implies that in the present context "soil quality" should be interpreted in terms of soil fertility, soil depth, structure, infiltration rate and water retention capacity, erodability, eco-toxicity, etc. Factors that are more important for other soil functions (e.g. for construction purposes) will receive less attention. This means that severely degraded soils shown on the map may still be useful for instance for building houses or roads upon.

Similar to GLASOD, the **main type** of soil degradation refers to the major degradation process: displacement of soil material by water (W) or wind (E), in-situ deterioration by physical (P), chemical (C) and biological (B) processes. These main types are subdivided into more specific subtypes, most of which are the same as in the GLASOD methodology, but with some modifications and additions.

D. Impacts on Productivity

The **degree** of soil degradation refers to the present state of degradation (light, moderate, severe, extreme). It is difficult to give quantitative and objective criteria for assessing the degree to which soils have been affected by various degradation types. The GLASOD guidelines (Oldeman, 1988) gave some (semi-)quantified criteria for erosion by water or wind, salinization, nutrient decline, but not for others. In this assessment more emphasis is placed on the impacts of degradation on productivity than on the mere intensity of the individual processes (erosion, pollution, etc.). This means that the degradation type is more seen as the cause of eventual productivity decreases, while degradation itself can be the result of various types of human intervention (the "causative factors" as used in GLASOD).

Changes in soil and terrain properties (e.g. loss of topsoil, development of rills and gullies, exposure of hardpans in the case of erosion) may reflect the occurrence and intensity of soil degradation but not necessarily the seriousness of its impacts on (overall) productivity of the soil. Removal of a 5 cm layer of topsoil has a greater impact on a poor shallow soil than on a deep fertile soil. Therefore, it would be better to measure the degree of degradation by the relative changes of the soil properties: the percentage of the total topsoil lost, the percentage of total nutrients and organic matter lost, the relative decrease in soil moisture holding capacity, changes in buffering capacity, etc. However, while such data may exist for experimental plots and pilot study areas, precise and actual information are lacking for most of the ASSOD region. Models that indicate exact relationships between degradation of soil quality and productivity are still very rare and not suited for large scale extrapolation. Since ASSOD intends to reflect the actual situation in the field, the extrapolation of experimental data and/or the use of models were not considered for this purpose anyway. The degree of soil degradation is here expressed in terms of the **impacts of soil degradation on productivity.**

A significant complication in indicating productivity losses caused by soil degradation is the variety of factors that may contribute to yield declines. Falling productivity can seldom be attributed to a single degradation process such as erosion, but may be caused by a variety (and/or combination) of factors, like erosion, fertility decline, improper management, drought or waterlogging, quality of inputs (seeds, fertilizer), pests and plagues, etc. However, if one considers a medium to long term period (10-15 years), large aberrations resulting from fluctuations in the weather pattern or pests will be levelled out. Expert experience and knowledge of the region involved is required to eliminate other factors that may have contributed to yield declines, such as prolonged bad crop management.

Soil degradation can also be more or less hidden by the effects of various management measures such as soil conservation measures, improved varieties, fertilizers and pesticides. Part of these inputs is used to compensate for the productivity loss caused by soil degradation, for instance application of fertilizers to compensate for lost nutrients. In other words, yields could have been much higher in the absence of soil degradation (and/or costs could have been reduced). Therefore the impact of degradation on productivity should be seen in relation to the amount of inputs.

As a first simplified, approximation for assessing the magnitude of degradation impacts on productivity, a few major classes are proposed to indicate changes in productivity, taking the absence or presence and magnitude of management level/inputs into consideration (see Table IV). Inputs may include: introduction of fertilizers, biocides, improved varieties, mechanization, various soil conservation measures, and other important changes in the farming system. An estimation of their magnitude (where detailed figures are not available) can be made by considering their share of the total farm expenses.

The changes in productivity are expressed in relative terms, i.e. the current (average) productivity as a percentage of the average productivity in the non-degraded (or non-improved, where applicable) situation and in relation to inputs. For instance, if previously an average yield of 2 tonnes of rice per hectare was gained while at present only 1.5 tonnes is realized, in spite of high inputs (and all other factors being equal), this would be an indication of strong soil degradation.

Table IV Impact of degradation in relation to productivity and management levels

Level of production increase/decrease	**Level of Input/Management improvements**		
	A) Major	*B) Minor*	*C) Traditional*
1) Large increase	No significant impacts (negligible)	No significant impacts (negligible)	No significant impacts (negligible)
2) Small increase	Light	No significant impacts (negligible)	No significant impacts (negligible)
3) No increase	Moderate	Light	No significant impacts (negligible)
4) Small decrease	Strong	Moderate	Light
5) Large decrease	Extreme	Strong	Moderate
6) Unproductive	Extreme	Extreme	Strong-Extreme

Several areas that show the occurrence of soil degradation appear to be not very much affected in terms of productivity decrease: the impact is negligible. This could be the case of deep fertile soils, where soil erosion does not necessarily affect productivity in proportion to the intensity of the erosion process. In other words, eventual inputs or management improvements have the desired effects.

E. Extent of Soil Degradation

The **extent** of soil degradation as defined in GLASOD is given here as the area percentage of the mapping unit that is affected by a certain type of degradation (rounded to the nearest 5%, so no classes). For each physiographic base map unit, one or more specific degradation types is indicated.

If more than one type of degradation is present, overlaps may exist between the different types. Each map unit which does not show a 100% extent for degradation must by definition have some stable land. Clearly, overlaps do not occur between stable land and degraded land.

F. Rate of Soil Degradation

The recent past rate of degradation indicates the rapidity of degradation over the past 5 to 10 years, or in other words, the trend of degradation, which is a very important factor for planning purposes. A severely degraded area may be relatively stable at present (i.e. low rate, hence no trend towards further degradation) whereas some areas that are now only slightly degraded, may show a high rate, hence a trend towards rapid further deterioration. The latter area in principle has a higher conservation priority than the former (in terms of combatting degradation). For this reason, the ASSOD map will put more emphasis on hot spots, i.e. areas with a high degradation rate. At the same time, areas where the situation is improving (through soil conservation measures, for instance) can be shown on the map. To this end three classes with a trend towards further deterioration and three with a trend towards decreasing degradation (either as a result of human influence or by natural stabilization) were defined.

A comparison of the actual situation with that of a decade earlier may suffice, but often it is preferable to examine the average development over the last 5 to 10 years to level out irregular developments. Reasons for indicating various rates should be explained in the accompanying report with as much detail as possible .

NB: Whereas the degree of degradation in fact only indicates the current, **static** situation (measured by decreased or increased productivity compared to some 10 to 15 years ago) the rate indicates the **dynamic** situation of soil degradation, namely the **change in degree** over time.

G. Causative Factors

The same causative factors were recognized as GLASOD, but with a possibility to give more details as separate remarks.

H. Status, risk and trend

A clear distinction should be made between soil degradation status, rate and risk (Sanders, 1994). Soil degradation status reflects the **current** situation while the rate (or trend) indicates the relative decrease or increase of degradation over the last 5 to 10 years (leading to the current status). Although the rate of degradation as indicated on the status map also gives an idea of the danger of **further** deterioration, it does not include areas that are now perfectly stable but that may be under risk of considerable degradation if, for instance, land use is changed. The degradation risk defined in this sense depends on several soil and terrain properties that make the soil inherently vulnerable to soil degradation, for example when external conditions (climate, land use) change. A separate risk (or soil vulnerability) assessment could depict those areas that need to be protected against degradation, caused by certain changes in land use or other external factors. The ASSOD project however does not entail such an assessment.

When considering degradation or deterioration, the question is: compared with what? In many cases a natural, undisturbed situation is not possible as a reference base. Since our soil degradation assessment does not include historic developments (say > 50 years) one must take the situation of some 50 years ago, or even less in some cases, as a reference. This is particularly valid for the ASSOD region, since most developments potentially or actually leading to serious human-induced soil degradation have occurred during this period (population explosion, changes in land use and farming techniques, Green Revolution, mechanization and intensification, etc.). However, in view of data availability and comparability, it is more realistic to look at the last one or two decades.

I. Rehabilitation or Protection Measures

All areas shown as degraded, as well as stable areas, may have been influenced to a greater or lesser extent by rehabilitation or conservation activities. It is useful to know what these activities comprised and how much influence they have had upon the present situation. In this context the WOCAT project is worth mentioning (GDE, 1993). The aims of WOCAT are to assess the results of soil and water conservation activities on a global scale through the compilation of 1) a "Handbook on appropriate soil and water conservation technologies", referring to the actual measures being taken within a given bio-physical and socio-economical context, 2) a "Report on successful Approaches", referring to the larger framework in which measures are implemented, 3) a World Map of soil and water conservation activities and 4) a soil and water conservation Expert System, for planning and implementation of soil and water conservation measures at the field level and for training purposes.

WOCAT primarily focuses on activities to combat soil erosion, this being by far the most prominent type of soil degradation worldwide (and in Asia). Several elements pertaining to practices of plant management, cultivation system, land management and small construction works for correcting, preventing or reducing soil degradation have been incorporated in this assessment.

Conservation measures can be categorised in several ways. Often a combination of these categories will exist, in which case the most prominent one is ascertained. Within the context of ASSOD, four broad categories are distinguished.

Plant management (vegetative) practices: using the plant and cover influence. These practices against erosion may be very effective, relatively simple and cheap. Examples are: fertilisation, crop-rotations, increasing plant density, revegetation, stubble-mulching, agroforestry.

Land-management practices: using the land lay-out and soil management. These practices are used in addition to plant management practices, they involve some movement of soil. They may reduce erosion effectively to very low levels. Examples: contour-tillage, contour-strip-cropping, minimum-tillage, land lay-out

Structural practices: soil conservation through the construction of physical barriers to reduce or prevent excessive run-off and soil loss. Examples are: contour-terraces/banks, gully-filling, constructed flumes

Other practices: Soil protection or rehabilitation practices not focusing at erosion control, but for instance at pollution or salinization problems.

The rate of degradation is also a measure for the effectiveness of the practices: a negative degradation rate indicates a human-induced improvement (NB: this may entail the mere termination or diminution of degrading activities).

III CONCLUSION

The GLASOD objective *"to strengthen 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"* has been achieved. As stated by Yadav and Scherr (1995) the GLASOD Study is one of the most cited studies on the extent of global soil degradation. The Governing Council of UNEP noted that GLASOD, the World Atlas of Desertification and the Soil and Terrain Digital Database were capable of providing essential ingredients for the formulation of national soil policies (UNEP, 1991). Thomasson (1992), reviewing GLASOD, indicated that *"this is a brave and ambitious project aiming to present a vital aspect of our soil science know-how at global scale and in a format comprehensible by politicians , administrators and the informed general public"*, although he discovered a number of anomalies, *"no doubt due to the difficulty of applying common standards to the vastly different quality and quantity of information emanating from rich and poor countries"*. A major criticism is also the use of the base map with Mercator projection.

The GLASOD authors indicated repeatedly that this study should be considered as a first approximation to assess the global extent of soil degradation. The methodology developed in GLASOD was a compromise between availability in time and scientific credibility. The revised methodology, now being actively pursued in the more detailed soil degradation assessment for South and Southeast Asia (ASSOD), partially incorporates the critical comments received after GLASOD was peer reviewed. The concepts used in ASSOD have a more objective cartographic base, using the internationally endorsed SOTER approach for delineation of mapping units, and employing the concept of developing a GIS-georeferenced soil degradation database. However, the assessment of the degree, extent and recent past rate of soil degradation is still based on structured informed opinion. Although ASSOD uses as basis national assessments of soil degradation status, the scale (1:5 Million) is still too coarse to formulate national soil improvement policies. The next step would be to prepare national 1:1 Million Soil and Terrain digital databases as the starting point to prepare a more objective estimate of the status and risk of human-induced soil degradation.

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