Working Paper and Preprint 96/04

A QUALITATIVE ASSESSMENT OF WATER EROSION RISK USING THE 1:5 M SOTER DATABASE FOR NORTHERN ARGENTINA, SOUTH-EAST BRAZIL AND URUGUAY

N.H. Batjes

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ISRIC INTERNATIONAL SOIL REFERENCE AND INFORMATION CENTRE

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ABSTRACT

A simple pressure-state-response model for assessing the risk of water erosion at the continental scale is presented in which soil erodibility, slope, rainfall erosivity and land use —a coarse indicator of human-induced pressure on the land— are the main controlling factors. The qualitative model uses input data from the 1:5 M scale Soil and Terrain Database (SOTER) and the revised agro-ecological zones map of FAO/IIASA. The methodology and software was developed and tested for a pilot area bounded by latitude 49° W to 61° W and 28° S to 35° S, covering parts of Argentina, Brazil and Uruguay (about 656×10^3 km^2). This preliminary desk study shows the potential of the 1:5 M SOTER database for identifying areas at risk from water erosion. However, there was little possibility to evaluate the outcome of the model against 'ground-truth' nor to quantify effects of food production on water erosion, and *vice versa*, for which more detailed follow-up studies are needed.

Key words: land degradation; water-induced soil erosion; GIS; SOTER; Latin America

1 INTRODUCTION

Human-induced land degradation by water or soil erosion is one of the most destructive phenomena worldwide, and is fast becoming recognized as a key issue in affecting global food security (Barrow, 1991). Of the 1094×10^6 ha affected by soil erosion in the world, 43% is caused by deforestation and removal of natural vegetation, 29% by overgrazing, 24% by improper management of the agricultural land, and 4% as a result of over-exploitation of the natural vegetation (Oldeman, 1994). The above statistics are based on the 1:10 M GLASOD map, the main aim of which was to provide policy-makers with geographically specific data permitting the pinpointing of areas of concern for more detailed studies.

In the framework of UNEP's Pilot Global Environmental Outlook project, the Netherlands National Institute of Public Health and the Environment (RIVM) and the International Soil Reference and Information Centre (ISRIC) have been asked to perform a number of follow-up studies which would focus on impacts of land degradation on food productivity (UNEP/EAP, 1995). The focus of the ISRIC activities would be on assessing the importance of scale and structure of environmental databases and model formulation on the possible level of detail of conclusions drawn with respect to the assessment/quantification of the impact of water erosion on food production. Although several models have been developed to assess effects of erosion on soil productivity, their widespread use is often limited by their considerable demand for data and they are seldom suited for large scale extrapolation (Young, 1994). Possible impacts of environmental degradation on future food production are seldom considered in global studies (Bouma *et al.*, 1995).

The ISRIC activities include three studies:

(a) A global assessment of the vulnerability of land to water erosion at a scale of 1:5 M, on a ½° by ½° grid (Batjes, *in press*);

(b) A qualitative assessment of water erosion risk at scale 1:5 M, for a small section of the SOTER database developed for Latin America (**this study**);

(c) A mixed qualitative-quantitative assessment of water erosion impact for selected land utilization types using the 1:1 M SOTER databases developed for Argentina, Kenya and Uruguay (Mantel, *in prep.*).

The water erosion model, source of data, and methodological approach are described in Chapter 2. Results are presented in Chapter 3 and conclusions are formulated in Chapter 4. The appendices present information on how to install the accompanying SOT5M software and describe the structure of the various database files.

2 MATERIALS AND METHODS

2.1 Water erosion model

The state of current knowledge of the factors and processes which determine soil loss, sediment delivery and their impact as well as models which employ these processes and factors for predicting erosion-impact have been reviewed by El-Swaify and Fownes (1992). Hudson (1985) discussed how the availability of data, their reliability and accuracy largely determine modelling capabilities and thus the need for model simplification at a particular scale. Van den Berg (1992) developed a water erosion model, SWEAP, considered compatible with data held in a 1:1 M SOTER database (Van Engelen and Wen, 1995). Many of the soil and terrain variables needed to run SWEAP and similar models (Eilers *et al.*, 1987), however, are not considered in the 1:5 M SOTER database (Van Engelen and Peters, 1995a) on which the current study is based. Nor can they all be inferred from measured data using pedotransfer functions or rules (e.g. percentage of very fine sand or slope length and steepness). Consequently, the simple model of Batjes (1996) for identifying areas prone to water erosion (E) was adapted for the current study:

$$E = f(R,\ T,\ V) \tag{1}$$

with:

R, a factor for rainfall erosivity;

T, a factor expressing terrain erodibility which considers slope and soil type;

V, a factor for land use.

2.2 Data sources

Soil and terrain data

The current study is for a pilot area covering about $656\text{x}10^3$ km^2 in northern Argentina, south-east Brazil and Uruguay. It is bounded approximately by latitude 49° to 61° W and 28° to 35° S (Fig. 1). The soil and terrain data were derived from the 1:5 M SOTER database which UNEP/ISRIC/FAO and ISSS are developing for Latin America (Van Engelen and Peters, 1995b). The SOTER methodology uses physiography as the main entry for subdividing terrain units, the basic map units, into terrain components and soil components (Fig. 2).

Land use

Changes in land use and in management practices are important driving variables of land degradation. Information on contemporary land use was extracted from the 1:5 M SOTER database, where it is described at the level of the terrain unit (i.e. type and percentage of map unit represented). The effect of crop type and land management practices in reducing soil erosion could not be considered explicitly in the present 1:5 M scale study, as has been the case for earlier studies at the regional/continental level (Eilers *et al.*, 1987; EU, 1990). This also applies for the social, economic and cultural controls of soil conservation, which are essential in conserving and protecting the soil resources.

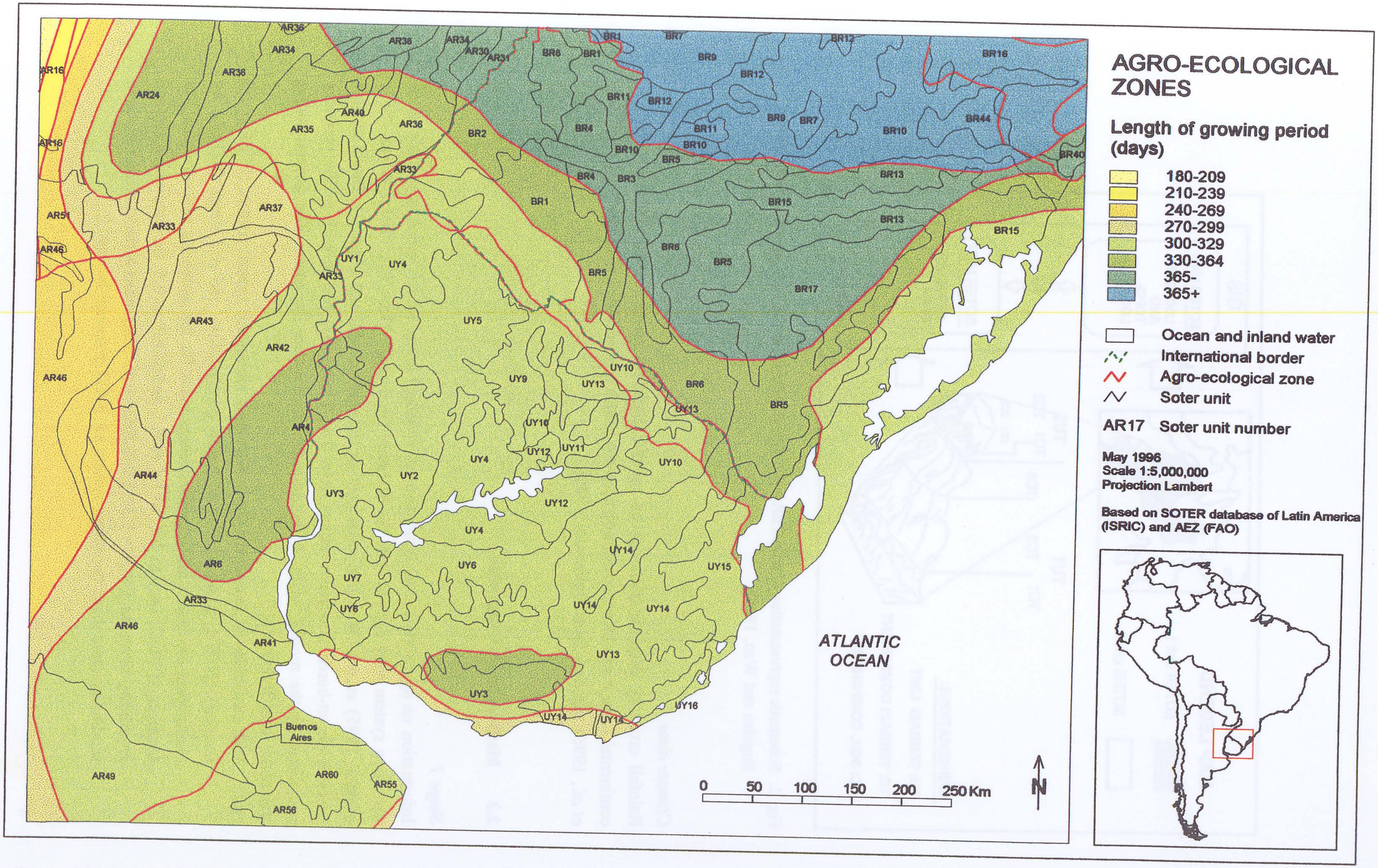

Fig. 1. Map showing location, agro-ecological zones and SOTER units of study area in Latin America

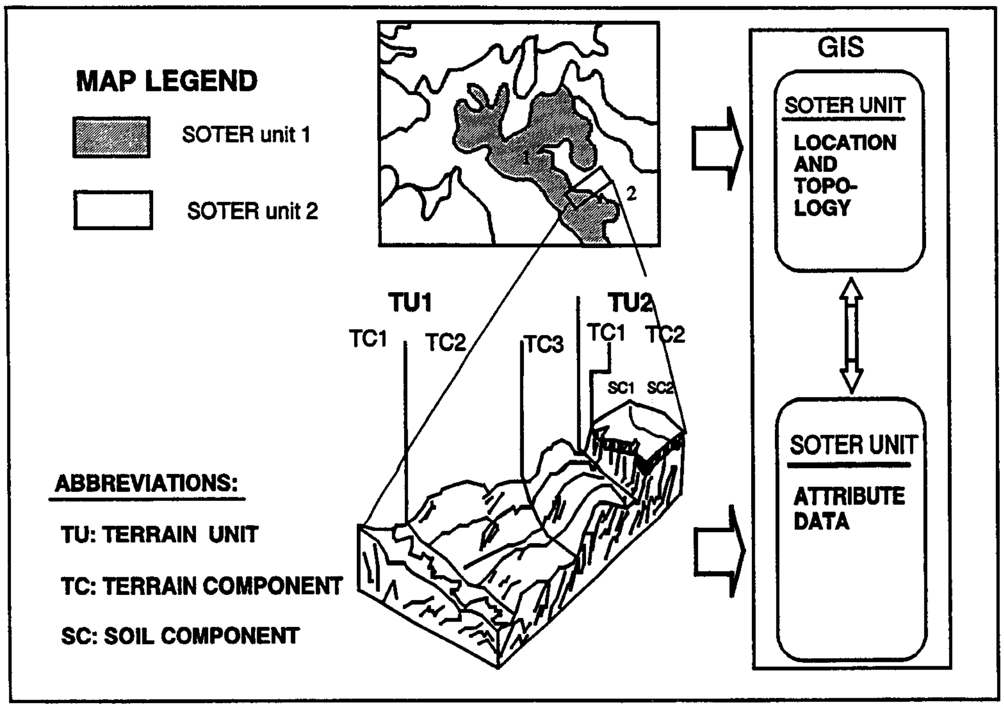

Fig. 2. Schematic representation of a SOTER unit with its terrain and soil components (Source: Van Engelen and Wen, 1995).

Climate data

Rainfall erosivity depends primarily on rainfall intensity, amount and distribution. At the continental scale it can be approximated from the Major Agro-ecological Zones map (De Pauw *et al.*, 1996) and data from Bouwman (1989).

2.3 Methodological approach

Stage 1

Information on appropriate class boundaries or threshold levels for the variables considered in the rating system were derived from the literature (Bouwman, 1989; EU, 1990; Landon, 1991; Mantel, 1995) as well as expert-judgement in the case of land use (App. 2). Based on this scheme, expert-based normative ratings from 0 to 1 were assigned to each of the variables considered in the model, where 0 indicates the most severe limitation. The general rating procedure is as follows:

(a) *Soil erodibility* is determined from individual ratings for topsoil texture (PSCL), soil structure (STTY, a surrogate for topsoil permeability) and soil depth (RDEP), by multiplying the lowest index by the average index for the remaining two attributes. For example, if PSCL rates as 1.0, STTY as 0.5, and RDEP as 0.8, the final rating for soil erodibility becomes: EROD= 0.5*(1.0+0.8)/2= 0.45. This index is then translated into an erodibility class using the rating system for RATI proposed in App. 2.

(b) Measured *slope gradients* (SLOP) are converted to one of 5 classes and assigned an index according to the rating scheme in App. 2.

(c) The rating for *rainfall erosivity* (EROS) is derived from the AEZ-code and tabular data of Bouwman (1989).

(d) The rating for *land use* (LUSE) is based on the categories of the SOTER land use files, and rated according to App. 2. Ideally, detailed information on land use and farming systems should be obtained from other sources, such as remote sensing, so that they can be characterized at the level of the soil component instead of the SOTER unit only (see Van Engelen and Wen, 1995 p. 6).

Table 1 shows the hierarchical level at which the considered input variables occur in the 1:5 M SOTER database, ranging from the terrain unit for slope and land-use to the individual horizon for particle size class.

Table 1. Hierarchical level at which input variables occur in the 1:5 M SOTER database

Topic	**Attributes**	**1:5 M SOTER database**	
		Hierarchical level	Database file
Soil erodibility (EROD)	- Particle size class (PSCL)	Horizon representative profile	REPHORIZ
	- Type of structure (STTY)	Horizon representative profile	REPHORIZ
	- Rootable depth (RDEP)	Soil component	SOILCOMP
Slope angle (SLOP)	- Slope gradient (SLOP)	Terrain unit	TERRAIN
Land use (LUSE)	- Land use (LUSE)	Terrain unit	LANDUSE

Stage 2

Once ratings have been calculated for EROD, EROS, SLOP and LUSE by soil component, the potential (POT) and actual (ACT) risk of water erosion are presented by Agro-Ecological Unit (Table 2). The assessment for POT only considers the relatively stable terrain factors (a to c of stage 1), giving an expression of the inherent susceptibility of the soils of each soil component in a SOTER unit for water degradation under bare conditions (worst-case scenario). The rating for ACT also considers current land use — a coarse indicator for the contemporary human-induced pressures on the land — and thus gives an expression of the "actual" risk of soils being degraded by water erosion. Differences in management levels on soil protection could not be considered explicitly in this study. The rating scheme, however, takes into account the positive effect of a closed vegetation cover in reducing the impact of severe rainfall.

Simultaneous to the above operations, all soil components for which one or more attributes needed for model execution are lacking, are flagged. This step is critical in order to ensure that:

(1) the program does not "hang up" if there is a data gap, and (2) the area for which there are sufficient data for the analysis can be specified by SOTER unit.

Table 2. Example of tabular output by agro-ecological unit

newSUID	AEZ	Percentage of AEU at risk from water erosion Potential	 Actual
AR24	180-209d	L0 M0 H100 [V0]	L0 M0 H100 [V0]
AR30	365-d	L0 M0 H100 [V0]	L0 M100 H0 [V0]
AR31	365-d	L0 M20 H80 [V0]	L20 M80 H0 [V0]
UY10	300-329d	L0 M30 H70 [V0]	L30 M70 H0 [V0]
UY11	300-329d	L0 M0 H100 [V0]	L0 M0 H100 [V0]
UY12	300-329d	L0 M0 H100 [V0]	L0 M40 H60 [V0]

Abbreviations: AEU= Agro-ecological unit; risk level= L: low; M: moderate; H: high; percentage of SUID affected is shown by a number (e.g L40 means 40% of the SUID has a low rating for water erosion risk); number between brackets shows the relative area of the Agro-Ecological Unit for which no assessment could be made due to missing data. Output file is C:\SOTER5M\DERIV\SOT_ERO3.PRT.

Stage 3

The final rating for POT and ACT by agro-ecological unit in Table 3 is determined using the following rules:

- if the total area of SCIDs with missing data in a map unit exceeds the area of SCIDs with either a low, moderate or high rating, the final rating is *undefined.*
- if the total area of SCIDs with a low rating exceeds the area with either a moderate or high rating *and* the cumulative area of SCIDs with either a moderate or high rating is less than 33% of the map unit, the final rating is *low*;
- if the total area of SCID with a high rating is greater than or equal to the area with either a low or moderate rating, the final rating becomes *high*;
- otherwise, the final rating is *moderate.*

In addition to the above, the percentage of the map unit for which the model could be run is indicated. The categories considered are:

1 — *undefined* ≤ 10 % of map unit

2 — 10% < *undefined* ≤ 25% of map unit

3 — 25% < *undefined* ≤ 50% of map unit

4 — 50% < *undefined* ≤ 100% of map unit

Table 3. Example of tabular output aggregated by agro-ecological unit

newSUID	AEZ	Rating of water erosion risk†	
		Potential	Actual
AR24	180-209d	H 1	H 1
AR30	365-d	H 1	M 1
AR31	365-d	H 1	M 1
UY10	300-329d	H 1	M 1
UY11	300-329d	H 1	H 1
UY12	300-329d	H 1	H 1

† See text for abbreviations. For example, a rating of 'M 1' for 'actual' implies a moderate water erosion risk (M) in over 90% of the considered AEU under contemporary conditions of land use. Output is sent to file C:\SOTER5M\DERIV\SOT_ERO5.DBF.

Stage 4

The final ratings, obtained during the third stage, can be linked to the spatial data through the unique AEU codes using GIS; this is an auxiliary operation which has to be performed by the GIS section under ARC/Info.

2.4 SOT5M software

In order to facilitate data operations and model evaluation, the methodology outlined in section 2.3 has been computerized using dBASE IV® (Ashton Tate, 1988). The installation procedure, core modules and structures of the various database files are described in Appendices 1 to 5.

3 RESULTS AND DISCUSSION

Fig. 3 and 4 show examples of model output for the pilot area. Being a short-duration desk study, there was little possibility to evaluate the results of the model against ground-truth.

The map legend integrates information on the modelled risk class as well as information on the relative percentage of each map unit for which the analyses could be run. Even though there are relatively few data gaps in the soil and terrain data set needed for the current study, it is important that these be remedied by the institutes that compiled the initial data (see Van Engelen and Peters, 1995).

The actual risk of water erosion was determined only for the Argentinean and Uruguayan part of the pilot area, because there was no land use file for Brazil.

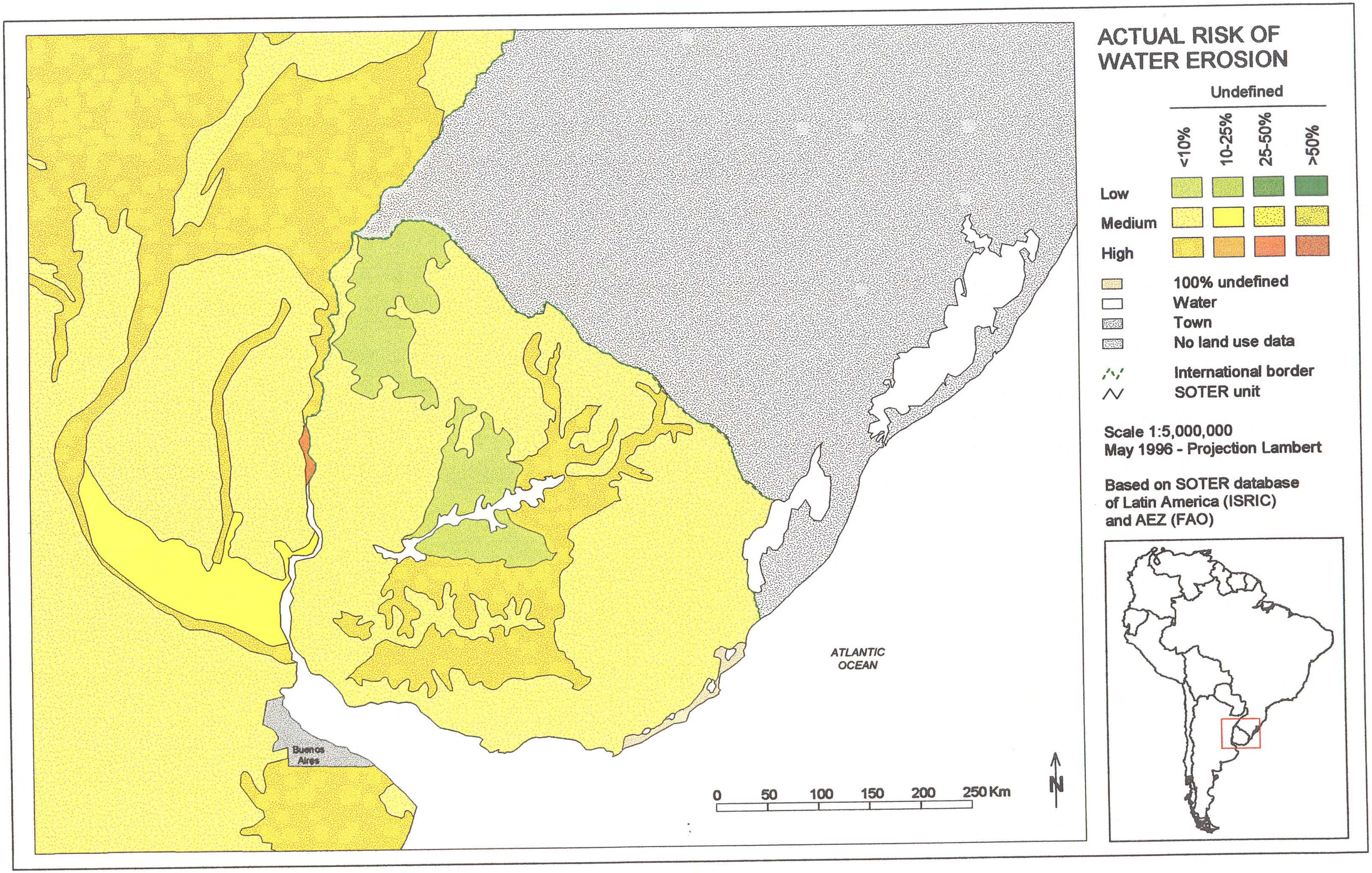

Fig. 4. Areas currently at risk from water erosion

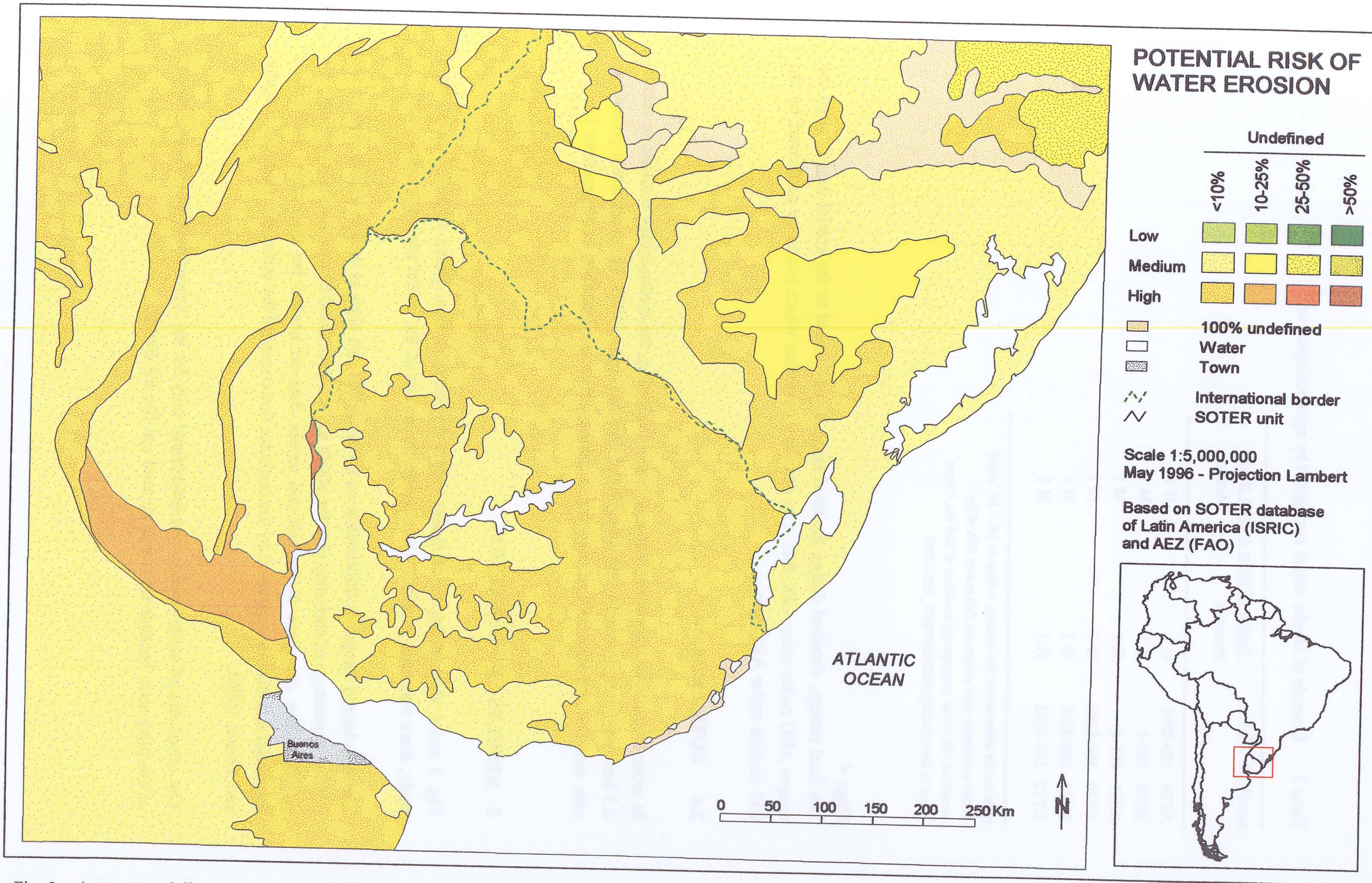

Fig. 3. Areas potentially at risk from water erosion

4 CONCLUSIONS

The main benefit of the current work has been to show the potential of a 1:5 M SOTER database in assessing areas at risk from water erosion for a pilot area in Latin America. The interpretations are aggregated over entire soil and terrain landscapes, and assume average climatic conditions (as depicted on the AEZ maps) as well as broadly defined land use categories. The output of the qualitative model is difficult to evaluate without the assistance of regional experts and ground observations of land degradation by water. Once such validation studies have been performed, the model can serve to identify regions at risk from water erosion where detailed studies on soil conservation are recommended.

Uncertainty in model output is largely determined by: (a) generalizations in the water erosion model, the criteria used, and the spatial aggregation method adopted; (b) the quality, representivity and completeness of the attribute data; and, (c) the way in which the various attributes are accommodated in the hierarchical structure of the various database files. The present study has confirmed the importance of a thorough screening of all database files for internal consistency —which is standard in the SOTER data entry software— and for data completeness. Staff responsible for the collection, compilation, entry and checking of data play a critical role in guaranteeing the consistency and quality of the ultimate database. Identifying and resolving errors and inconsistencies in databases is a vital but time consuming task (Eilers *et al.*, 1989; EU, 1990; UNEP/EAP, 1995; Van Engelen and Peters, 1995b).

A novel, and important, element of the current study is that the compound nature of each SOTER unit has been taken into account during the analyses. Thereby, it differs from earlier studies in which only the spatially dominant soil component of a SOTER unit was considered (see Mantel, 1995). The approach/software presented in this paper could easily be modified by the author to permit assessment of main agricultural constraints or identification of simple "state-indicators" of land quality by agro-ecological unit.

A shortcoming of the current approach for regional planning purposes is that it cannot provide any information on the possible impact of food production on the rate of water erosion and *vice versa*; this is one of the key themes to be addressed during the 1996 World Food Summit and UNEP's Global Environmental Outlook Project. Staff at ISRIC are currently developing and testing a mixed qualitative-quantitative approach for this type of studies, using a 1:1 M SOTER database (Mantel, *in prep.*). Once this approach has been evaluated it may eventually be simplified to accommodate the lower spatial resolution and limited data set of the 1:5 M SOTER database. In a separate activity in South and South-East Asia, efforts are being made to describe soil degradation in terms of the associated decrease in productivity for defined levels of inputs and management (Van Lynden, 1995). Similarly, in the World Overview of Conservation Approaches and Technologies (WOCAT) attention is being paid to the issue of productivity changes when evaluating soil conservation practices (GDE, 1993). Once fully integrated with socio-economic models, quantitative pressure-state-response models can provide a powerful tool to guide the planning of soil conservation at the regional level, using scenario analyses.

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App. 1 Installation procedure and core modules

General

The methodology described in the body of this report has been computerized to facilitate updating and calibration of the procedure, and its application to other areas for which 1:5 M SOTER databases are available. This appendix describes the installation procedure of the SOT5M software as well as the core modules.

Installing SOT5M

SOT5M, version 1.0, is designed for hard disk based systems and comes on one 3½ inch double-sided and high-density floppy disk. No special preparation is required to install the software package on a suitable PC. It is strongly advised that a copy of the SOT5M distribution disk be made before installation.

In order to install the SOT5M data handling system and accompanying data set on your PC, simply insert the installation diskette into drive A, and type:

A:\SOT5MINS

Upon pressing enter, this command decompresses the SOT5M data handling system, system files and database files to the relevant directories on the C-drive. Should an earlier version of SOT5M already exist, the user will be prompted whether individual files are to be overwritten or not. If necessary, the installation procedure can be aborted by typing **CTRL-BREAK** [Note: In such situations it is **recommended** to make a backup of the existing data files first].

Path definitions

Prior to accessing SOT5M, a path must be set to the directory containing the dBASE IV® software and SOT5M data handling system. Note that SOT5M programs assume that the dBASE IV package is installed in sub-directory C:\DB4, which must be specified as default in the computer's path (see dBASE Language Reference Manual). Typically, a path command would look like:

PATH: C:\, C:\DOS, ... C:\DB4, C:\SOT5M

Accessing SOT5M

This is where the user starts once the dBASE IV and SOT5M software have been installed, and the proper path specifications have been specified in the AUTOEXEC.BAT file residing on the C drive.

In order to access the SOT5M system —at the level of the DOS prompt— simply type the following command:

C> **SOT5M**

On pressing the <enter> key the computer accesses SOT5M.BAT, the batch file that starts dBASE IV and initializes the system software, displaying a menu on the screen with general information on the SOT5M system.

The user can access the next screen by pressing <enter>, after which the main SOT5M menu appears on the screen, from which a number of operations can be performed. In case of a new installation, the system will automatically check whether the printer driver is correctly installed and update the index files.

Full data base structure definitions, indexing conventions, and coding conventions may be found in Appendices 2 to 5.

The core modules

Module 1:

The first module allows to off-load and merge the different 1:5 M SOTER data files from user- selected countries[1] into the directory C:\SOTER5M\MAINDATA. Individual data sets can be read either from a floppy disk or from a directory on the C drive. The relevant database files are: ANAMETH, CLIMDAT, CLIMSOUR, CLIMSTAT, LABMETH, LABNAME, LANDUSE, PROFILDB, PROFILE, REPHORIZ, SOILCOMP, SOURCMAP, TERRAIN, TERRCOMP, and VEGETAT. The structure of these files is described in Van Engelen and Peters (1995a) and the coding conventions in Van Engelen and Wen (1995).

Module 2:

The second module has two options, the first of which allows to extract the terrain, soil and land use data necessary for running the water erosion model for a particular geographic window. The input file for this window has to be generated first by the GIS section; it holds data on the agro-ecological zone (AEZ) and newSUID (e.g. see ARC/Info polygon attribute file in App. 5).

The second option identifies all unique combinations of AEZs and newSUIDs for the geographic window defined earlier. Based on this information, the soil and terrain data for the selected window are extracted from the appropriate files in C:\SOTER5M\MAINDATA. These then provide the input files for running the water erosion model.

In data compilation activities based on available data, a number of missing fields are likely to occur (Van Engelen and Peters, 1995b). Simultaneous to the data selection, the programme assesses if there are gaps in the SOTER soil profile (PRID) files. Should any gaps occur, blank records are created for each missing profile (PRID) in order to ensure that the model can be run without interruption. Missing alphanumeric data are recorded as "-", while missing numeric data are assigned a negative value by default.

At the end of the program, the contents of the various working data sets — in terms of their component AEZs, newSUIDs, terrain components (TCID), soil components (SCID) and representative profiles (PRID) are displayed on the screen for overview purposes.

Module 3:

The third module carries out the assessment of the risk of water erosion. The methodological approach and sources consulted for defining the rating systems are discussed in section 2.3. The rating system and assumptions, which can be edited by the user using a simple text editor, are described in Appendix 2.

Module 4:

The fourth module allows to generate a listing of the database structures, to make a listing of the file with the rating system, and to create backups of the database files.

Output from the various operations is sent both to the screen and to a number of database and text files (in C:\SOTER5M\DERIV and C:\SOTER5M\REPORTS) for further consultation. The final ratings (in file C:\SOTER5M\DERIV\SOTWIND5.DBF) can be linked to the spatial data through the unique AEU codes using GIS.

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[1] A difficulty in merging the files from Argentina, Brazil and Uruguay has been that all SOTER units (SUID) in SOTER-LA have been numbered sequentially, by country. Thus, in a merged common database, the identification codes for the SUIDs would no longer be unique. Therefore, it has been necessary to introduce new, unique primary keys for each SOTER unit as follows: newSUID= country ISO-code + SUID. The unique combinations of AEZ and newSUIDs are termed Agro-Ecological Units (AEU) in this study.

App. 2. Rating system for assessing water-erosion risk[2]

Attribute	code	rating	definition
RATI	L	0.64	(note: 0.8*(0.8+1)/2)
RATI	M	0.33	(note: 0.5*(0.8+0.5)/2)
PSCL	C	1.0	clay
PSCL	SIC	1.0	silt clay
PSCL	SC	1.0	sandy clay
PSCL	SCL	0.8	sandy clay loam
PSCL	CL	0.8	clay loam
PSCL	SICL	0.8	silty clay loam
PSCL	LS	0.8	loamy sand
PSCL	S	0.8	sand
PSCL	L	0.5	loam
PSCL	SIL	0.5	silt loam
PSCL	SI	0.5	silt
PSCL	SL	0.5	silt loam
STTY	G	1.0	granular
STTY	B	1.0	crumb
STTY	N	1.0	single grain
STTY	A	0.8	angular blocky
STTY	S	0.8	subangular blocky
STTY	P	0.5	platy
STTY	R	0.5	prismatic
STTY	C	0.5	columnar
STTY	M	0.5	massive
STTY	W	0.5	wedge shaped
RDEP	X	1.0	very deep (=>150cm)
RDEP	D	1.0	deep (100-150cm)
RDEP	M	0.8	moderately deep (50-100 cm)
RDEP	S	0.5	shallow (30-50 cm)
RDEP	V	0.5	very shallow (<30 cm)
SLOP	A	1.0	<5% slope
SLOP	B	1.0	5-8% slope
SLOP	C	1.0	8-15% slope
SLOP	D	0.8	15-30% slope
SLOP	E	0.5	30-60% slope
SLOP	F	0.5	>60% slope
LUSE	S	1.0	Settlement
LUSE	AA	0.8	Annual field cropping
LUSE	AP	0.8	Perennial field cropping
LUSE	AT	0.8	Tree and shrub cropping
LUSE	HE	0.8	Extensive grazing
LUSE	HI	0.8	Intensive grazing
LUSE	FN	1.0	Exploitation of natural forest
LUSE	FP	1.0	Plantation forestry
LUSE	MF	0.8	Agro-forestry
LUSE	MP	0.8	Agro-pastoralism
LUSE	E	1.0	Extracting/collecting
LUSE	P	1.0	Nature protection
LUSE	U	1.0	Unused
EROS	V	0.5	Very high erosivity (R>1500)
EROS	H	0.5	High erosivity (1250-1500)
EROS	M	0.8	Moderate erosivity (800-1250)
EROS	L	1.0	Low erosivity (<800)

[2] The rating system for soil erodibility and rainfall erosivity is derived from the literature (Bouwman, 1989; EU, 1990; Landon, 1991; Mantel, 1995), while the rating system for land use is based on expert-judgement. Following model evaluation, the rating system can be fine-tuned using a text-editor (file: C:\SOTER5M\SOT-RATI.TXD). For SOTER attribute definitions see Van Engelen and Wen (1995).

App. 3. Structure of input datafiles

Structure for database: C:\SOTER5M\SOTWIND0.DBF†

Field	Field Name	Type	Width	Dec	Index
1	SUID	Numeric	11		Y
2	NEWSUID	Character	6		N
3	CNTRCODE	Character	7		N
4	CLIMATE	Numeric	2		N
5	LGP	Numeric	2		N
6	AEZ	Character	10		N
7	PERIOD	Character	15		N
8	EROS	Character	1		N

† Derived from map of agro-ecological units generated by GIS section (App. 5).

Structure for database: C:\SOTER5M\SOTWIND1.DBF

Field	Field Name	Type	Width	Dec	Index
1	NEWSUID	Character	6		N
2	AEZ	Character	10		N
3	TCID	Numeric	1		N
4	SCID	Numeric	1		N
5	PROP	Numeric	3		N
6	PRID	Character	12		N
7	POSI	Character	1		N
8	RDEP	Character	1		N
9	DRAI	Character	1		N
10	CLAF	Character	3		N
11	CLAV	Numeric	4		N

Structure for database: C:\SOTER5M\SOTWIND2.DBF

Field	Field Name	Type	Width	Dec	Index
1	SUID	Numeric	4		N
2	NEWSUID	Character	6		N
3	SLOP	Numeric	2		N
4	RELI	Numeric	4		N
5	LNDF	Character	2		N
6	RSLO	Character	2		N
7	LITH	Character	3		N
8	LUSE	Character	3		N
9	PROP_L	Numeric	3		N
10	VEGE	Character	3		N
11	PROP_V	Numeric	3		N

Structure for database: C:\SOTER5M\SOTWIND3.DBF

Field	Field Name	Type	Width	Dec	Index
1	PRID	Character	12		N
2	HONU	Numeric	1		N
3	HBDE	Numeric	3		N
4	STTY	Character	1		N
5	MINA	Character	1		N
6	SDTO	Numeric	3		N
7	STPC	Numeric	3		N
8	CLPC	Numeric	3		N
9	PSCL	Character	4		N
10	BULK	Numeric	5	2	N
11	PHAQ	Numeric	4	1	N
12	CECS	Numeric	5	1	N
13	TOTC	Numeric	4	1	N
14	TOTN	Numeric	5	2	N

App. 4. Structure of output datafiles

Structure for database: C:\SOTER5M\SOT_ERO1.DBF

Field	Name	Type	Width	Dec	Index	Description
1	PRID	Character	12		N	Profile_ID
2	HONU	Numeric	1		N	Horizon number
3	TEXT	Numeric	4	1	N	Textural class
4	DEPT	Numeric	4	1	N	Soil depth
5	STRUC	Numeric	4	1	N	Topsoil structure
6	SOILEROD	Numeric	4	2	N	Erodibility rating
7	SOILERODY	Character	1		N	Code, for above

Structure for database: C:\SOTER5M\SOT_ERO2.DBF

Field	Field Name	Type	Width	Dec	Index	Description
1	SUID	Numeric	4		N	SOTER unit number
2	NEWSUID	Character	6		N	Country ISO code + SUID
3	AEZ	Character	10		N	Code for AEZ (FAO, 1994)
4	TCID	Numeric	1		N	Terrain component number
5	SCID	Numeric	1		N	Soil component number
6	PROP	Numeric	3		N	Proportion in SOTER unit
7	PRID	Character	12		N	Mo. of repr. soil profile
8	POSI	Character	1		N	Position of prof. in TCID
9	EROD	Numeric	5	2	N	Rating for erodibility
10	EROS	Numeric	4	1	N	Rating for erosivity
11	SLOP	Numeric	4	1	N	Rating for topography
12	COVE	Numeric	4	1	N	Rating for land cover
13	FINACT	Numeric	4	1	N	Rating for actual risk
14	FINPOT	Numeric	4	1	N	Rating for potential risk
15	ACT	Character	1		N	Code for actual risk
16	POT	Character	1		N	Code for potential risk

Structure for database: C:\SOTER5M\SOT_ERO3.DBF

Field	Field Name	Type	Width	Dec	Index	Description
1	NEWSUID	Character	6		N	See SOT_ERO2.DBF
2	AEZ	Character	10		N	See SOT_ERO2.DBF

Structure for database: C:\SOTER5M\SOT_ERO4.DBF

Field	Field Name	Type	Width	Dec	Index	Description
1	NEWSUID	Character	6		N	See SOT_ERO2.DBF
2	LGP	Numeric	2		N	Length of growing period
3	AEZ	Character	10		N	Code for agro-ecol. zone
4	POTY	Character	15		N	Data for potential risk†
5	ACTY	Character	15		N	Data for actual risk

† Takes into account rating for all soil components of a SOTER unit.

Structure for database: C:\SOTER5M\SOT_ERO5.DBF

Field	Field Name	Type	Width	Dec	Index	Description
1	NEWSUID	Character	6		N	As above
2	LGP	Numeric	2		N	As above
3	AEZ	Character	10		N	As above
4	POT_R	Character	1		N	Rating for pot. risk†
5	POT_M	Numeric	1		N	Code for % missing data†
6	ACT_R	Character	1		N	Rating for pot. risk†
7	ACT_M	Numeric	1		N	Code for % missing data

† Percentage of SUID for which no rating can be given due to one or more missing data. Class 1: area < 10%; 2: 10≤ area <25%; 3: 25≤ area <50%; 4: 50≤ area < 100%. SUID.

App. 5. Structure of input files for Agro-Ecological Units

Structure for database: C:\SOTER5M\PAT_AEZ.DBF

Field	Field Name	Type	Width	Dec	Index	Description
1	AREA	Numeric	13	6	N	Area on map unit
2	PERIMETER	Numeric	13	6	N	Perimeter
3	AEZTTGG_	Numeric	11		N	Code for AEZ
4	AEZTTGG_ID	Numeric	11		N	ID for AEZ
5	CLIMATE	Numeric	2		N	Code for climate
6	LGP	Numeric	2		N	Code (see FAO, 1994)
7	CODE	Numeric	3		N	As above
8	PERIOD	Character	15		N	Textual for above
9	TYPE	Character	1		N	Type (FAO, 1994)
10	CLASS	Character	3		N	?

Structure for database: C:\SOTER5M\LASAEZ.DBF

Field	Field Name	Type	Width	Dec	Index	Description
1	SUID	Numeric	11		N	SOTER unit ID
2	NEWSUID	Character	6		N	ISO code & SUID
3	CNTRCODE	Character	7		N	As above
4	CLIMATE	Numeric	2		N	GIS defined code
5	LGP	Numeric	2		N	Code (FAO, 1994)
6	AEZ	Character	10		N	As above
7	PERIOD	Character	15		N	Description of AEZ
8	EROS	Character	1		N	Erosivity