SÉRIE TERRA E ÁGUA
DO INSTITUTO NACIONAL DE INVESTIGAÇÃO AGRONÓMICA

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EROSION HAZARD MAPPING
MOZAMBIQUE

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FOREWORD

This report is one of a series of SADCC country reports on the Erosion Hazard Mapping of the region. It arises from a project initiated in September 1985 in the first phase of the work programme of SADCC Coordination Unit for Soil and Water Conservation and Land Utilization, based in Lesotho. The aims of the Erosion Hazard Mapping project are:

- Define main danger areas for erosion and the principal processes contributing to the Hazard;
- Assist the design of appropriate conservation strategies;
- Give guidance in regional planning, environmental monitoring and land utilization programmes;
- Provide an action- learning exercise and training forum for SADCC participants.

Erosion Hazard Assessment is a technique to express the natural danger of soil erosion over large areas. As such it is an appropriate exercise for the SADCC Coordination Unit which is very much concerned with land degradation problems and the safe utilization of land resources, especially soil. Details of the technique have already been published in Report n° 9, "A Methodology for Erosion Hazard Mapping of the SADCC Region", April 1987. Local staff members from SADCC countries have done all the data collection and processing necessary for the national maps.

All participants at the four Erosion Hazard Workshops: Harare, September 1985; Maseru, March 1986; Mbabane, November 1986; Lusaka, April 1987 as well as their departmental heads work. Several of the country teams have laboured under severe manpower constraints with competing demands on their time and resources. That this project is nearing completion is a tribute to SADCC cooperative spirit. This country report was compiled from draft reports submitted by the country team under the overall technical supervision of Dr. Michael Stocking.

ACKNOWLEDGEMENTS

This report is part of the work programme of the Departamento de Terra e Água, Instituto Nacional de Investigação Agronómica, Maputo, which is to assess the land productivity potential and population supporting capacity for agricultural development in Mozambique (Kassam et al, 1983). Technical assistance has been provided through the FAO/UNDP project "Natural Resources Survey and Land Evaluation".
The assistance of technical staff at INIA and the support of the Head of the Land and Water Department. Mário Ruy Marques, is gratefully acknowledged. Antipas Ozias Mate, Agronomist / Pedologist at INIA, also took part in the series of Erosion Hazard Mapping workshops.

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Introduction

Soil erosion hazard is one aspect of the assessment of productive potential of land. As such it needs to be considered alongside surveys of natural resources and the evaluation of the quality of land. The main objective of this study on erosion hazard is to indicate the extent and severity of soil erosion so that land use can be planned on a sustainable basis and that populations can be supported adequately from their own resources.

Erosion hazard as presented in this report is not a survey of actual erosion, but is a description of the natural propensity of the environment to allow soil erosion to happen. It should thus be seen as the potential for erosion rather than the historical amount of erosion that has already occurred.

In the Mozambique analysis of erosion hazard, we have not considered land use patterns and how this affects vegetation cover. The relevant data are extremely difficult to obtain. Nevertheless, in future work we anticipate the inclusion of land use characteristics so that the final erosion hazard map is broadly comparable with those of the other SADCC countries. Therefore, the erosion hazard map included here at Annex 4 presents erosion hazard classes for bare conditions, without the influence of vegetation and cropping.

The Data Set

In line with the SLEMSA methodology (Elwell, 1980) which is used to calculate erosion hazard in this exercise, the factors of erosion are taken to be (1) rainfall erosivity, (2) soil erodibility and (3) slope gradient and lenght. Almost no pre- existing information on these factors was available in Mozambique prior to this study.

So that the work on erosion hazard mapping could be fully integrated with the survey of other natural resources and land evaluation, it was decided to utilise a (GIS) Geographical Information System data base upon which the individual factores could be quantified, on computer and then plottedd in map form. This considerably eased the burden of calculation and draft mapping. This package used was the commercially-available CRIES. Version 6.0, 1986. Map showing the geoagraphical distrbution of rainfall erosivity, soil erodibility and slope gradient were digitized and then converted into raster files with a grid resolution of 5x5 Km to cover the country. The data sources and input for each factor map are as follows:

a) Rainfall erosivity

Because of the paucity of information on rainfall erosivity in Mozambique, it was decided at the outset to adapt the original Zimbabwe data for SLEMSA realting mean annual rainfall to mean seasonal energy. After reviewing the literature and testing suggested relationships (e.g. van der poel, 1980) form the analsyses of rainfall charts for 13 meteorological stations stations widelymajor characteristics and components important to erodibility. Some Mozambican soils do not occur in Zimbabwe, at easr in FAO legend terms. In these cases, a vaule for erobility was assigend that would place the in its correct position relative to known soils.

b) Soil Erodibility

Table 1 lists the erodibility ratings Fb, for Mozambican soils with modifiers according to topsoil texture,substrata type and lithic phases. These ratings have been incorporated into the National Soil Inventory according to the specific erosidibility of dominant soil in each association, its texture and depth the soil map at 1:2.000.000 (two milion) was then digitized using te CRIES GIS package using the COLORDIG subroutine on a 5x5 Km grid. A soil erodibility map was then constructed running the GROUP subroutine and the result is presented at Annex 1.

c) Slope gradient and lenght

As a first stage, information on slope steepness was first gathered from the Soil Resources Inventory map which included steepness classes in each mapping unit. However, two problems arose. Slope classes were divided into three: 0- 8, 8- 30 and >30%. These categories are too broad to be useful in assessing the danger of erosion. Furthermore, because soil mapping units were used, more than one class of slope often occurred in each unit, thus making slope estimates meaningless in this exercise.

Instead, slope steepness classes have been directly mapped from available topographic maps through the analysis of contour intervals. The 1:250 000 topographic map series (Edition 1, Army Map Services, Washington DC, 1969) which covers all but about 15% of the country was employed. This is the most up-to-date and accurate series available. Contour intervals are mainly at 100 metre spacing but some sheets use 20, 40, 60 and 75 m spacing. Average distances between contours were then calculated for the following slope classes: 0- 2, 2- 6, 6- 10, 10- 14, 14- 20 and >20%.

A 10x10 km grid was drawn on transparent film maps. Slope classes were then directly mapped and boundaries drawn onto the transparent film along with three fixed control points. Boundaries were then transferred by hand onto the same grid square pattern on a 1:2 million base with the control points serving to align the map correctly.

Table 1. Soil erodibility ratings, Fb, for sheet erosion for the soil of Mozambique with modifiers according to substrata and lithic phases

FAO Soil Units	Toposoil texture			Substrata type (*)			Lithic phase
	Coarse	Medium	Fine	Coarse	Medium	Fine	
Ferric Acrisol	4.5	5.5	6.0	-	- 0.5	- 0.5	- 1.5
Gleyic Acrisol	4.0	4.5	5.0	-	- 0.5	- 0.5	- 1.5
Humic Acrisol	-	5.5	6.0	-	-	- 0.5	- 1.5
Chromic Cambisol	-	3.5	4.0	-	-	- 0.5	- 1.5
Eutric Cambisol	-	4.0	4.5	-	-	- 0.5	- 1.5
Orthic Ferralsol	-	5.0	6.5	-	-	- 0.5	- 1.5
Xanthic Ferralsol	5.5	-	-	-	- 1.0	- 1.5	- 1.5
Rhodic Ferralsol	-	5.0	6.0	-	-	- 0.5	- 1.5
Humic Ferralsol	-	5.5	-	-	-	- 0.5	- 1.0
Lithosol	-	2.5	4.0	-	not	applicable	
Orthic Luvisol	4.5	5.0	5.5	-	- 0.5	- 0.5	- 1.5
Chromic Luvisol	4.5	5.0	5.5	-	- 0.5	- 0.5	- 1.5
Ferric Luvisol	5.0	5.5	6.0	-	- 0.5	- 0.5	- 1.5
Gleyic Luvisol	4.5	5.0	5.5	-	- 0.5	- 0.5	- 1.5
Albic Luvisol	4.0	5.0	-	-	- 0.5	- 0.5	- 1.5
Haplic Phaeozom	-	5.5	6.0	-	-	- 0.5	- 1.5
Gleyic Phaeozom	-	4.5	5.0	-	-	- 0.5	- 1.5
Luvic Phaeozom	-	5.0	5.5	-	-	- 0.5	- 1.5
Eutric Nitosol	-	5.5	5.5	-	-	-	- 1.5
Dystric Nitosol	-	5.5	5.5	-	-	-	- 1.5
Humic Nitosol	-	6.0	6.5	-	-	-	- 1.0
Cambic Arenosol	6.0	-	-	-	- 1.0	-	- 1.5
Luvic Arenosol	6.0	-	-	-	- 1.0	-	- 1.5
Ferralic Arenosol	6.5	-	-	-	- 1.0	-	- 1.5
Albic Arenosol	6.0	-	-	-	- 1.0	-	- 1.5
Eutric Regosol	6.0	-	-	-	- 0.5	-	- 1.5
Pellic Vertisol	-	-	5.0	-	-	-	- 1.5
Eutric Planosol	3.5	4.5	-		not	applicable	- 1.0
Solodic Planosol	3.0	4.0	-		not	applicable	- 1.5
Orthic Solonetz	2.0	2.5	2.5		not	applicable	- 0.5
Orthic Solonchak	2.5	3.0	3.0		not	applicable	- 0.5
Gleyic Solonchak	2.5	3.0	3.0		not	applicable	- 0.5

(*): Only applicable when topsoil and substrata texture classes are different. In addition substract 0.5 for clear textural changes (< 8 cm) and/or compact subsoil.

The exercise was repeated for all 65 map sheets and gave a country- wide slope class map. The map has then been digitized using the CRIES GIS package running the MONODIG subroutine and the processed into a raster file with a 5x5 km grid base. The resultant map is at Annex 3.

The Mapping

Approach - Since virtually no information on erosion existed in Mozambique before this exercise, it was recognized that predictive modelling techniques would have to be employed. Various models and techniques were examined:

- Soil Loss Estimation Model for Southern Africa (SLEMSA)
- Universal Soil Loss Equation (USLE)
- FAO Soil Assessment Methodology as outlined in FAO (1984)
- Soil loss degradation module of the Land Evaluation Computer System (LECS)Paying special attention to basic data input requirements and the availability of information that will provide reasonably accurate assessments, the SLEMSA technique was adopted as used in Zimbabwe (Elwell, 1980). The selection of SLEMSA was based primarily on its low data input requirement and relative simplicity. Although SLEMSA was originally intended to estimate mean annual soil loss by sheet erosion form lands which are protected by contour ridges, the present study used it to assemble the factors of erosion to measure the relative susceptibility of large areas to erode. This adaptation of SLEMSA for erosion hazard mapping (Stocking, 1987; see also Figure 1) was the subject of a series of workshops held by the SADCC Soil and Water Conservation and Land Utilization Programme.

Method

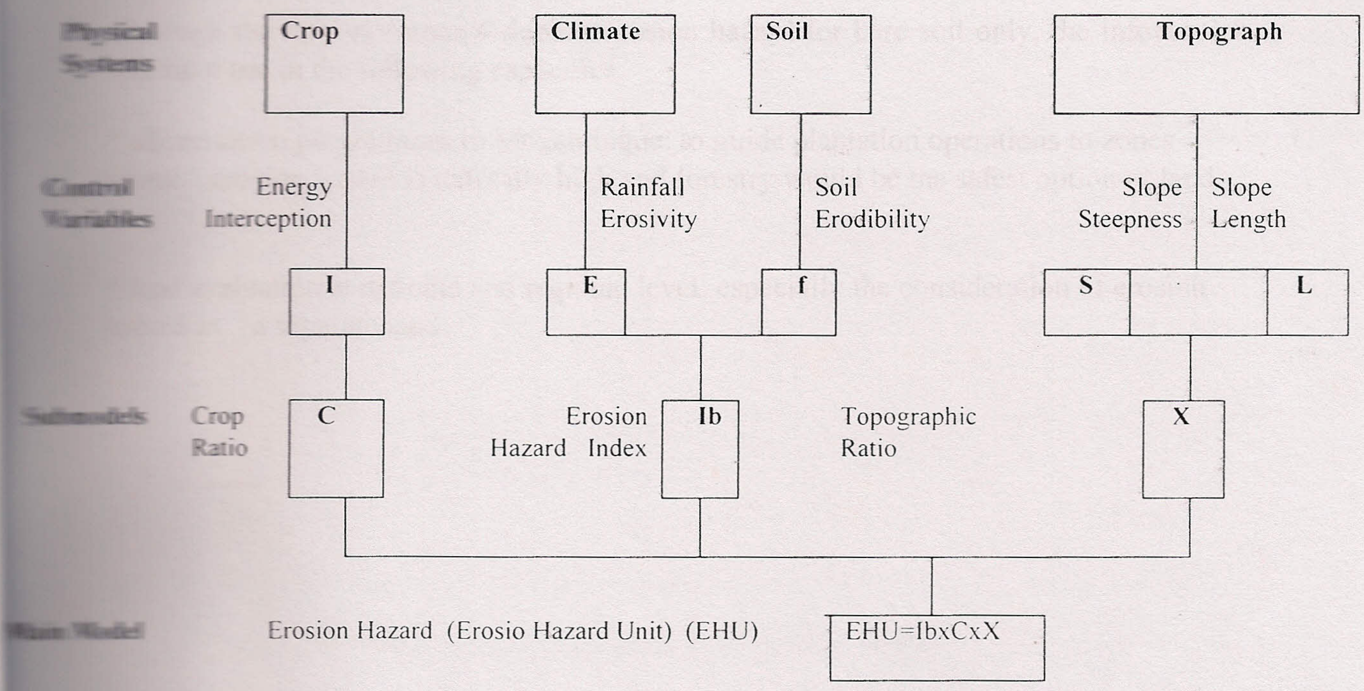
Fortunately, at the time of this exercises the Land and Water Department of the Instituto Nacional de Invstigação Agronómica in Maputo was installing a computerized data bank as described earlier. This poweful software permits the manipulation of maps including their overlapping, grouping and matching of grid- based attributes.

The intention is to analyse four factors, namely rainfall erosivity, soil erodibility, slope steepness and land use/ vegetation, on a grid basis for the whole country, and the mechanism of calculation. On a 10x10 km grid for a country the size of Mozambique, this would entail individual analysis of more than 7800 squares an impossibly large number to do with the lack of trained Mozambican personnel and without the use of computerisation.

To date three factors of erosion have been considered, and the data prepared, digitized and output in the form of computer printed maps at a scale of 1:4 million. The grid cell base that has been defined is 5x5 km for whole country. Through a series of computer operations as shown diagrammatically in figure 2, erosion hazard has been mapped in Mozambique for bare soil conditions (Annex 4).

The last step will consist of the incorporation of land use characteristics and the completion of sensitivity tests to analyse for the potential effect of errors in the final calculation fo Erosion Hazard Units.

Figure 1: The SLEMSA framework



Symbols	Explanation	Units
Control Variables		
E	Seasonal rainfall energy	J/m2
f	Soil erodibility	Index
I	Rainfall energy intercepted by crop	%
S	Slope Steepness	%
L	Slope length	m
Submodels		
Ib	Erosion hazard index	Index
C	Crop canop	-
X	Topography	-
Output		
EHU	Erosion Hazard Units	-

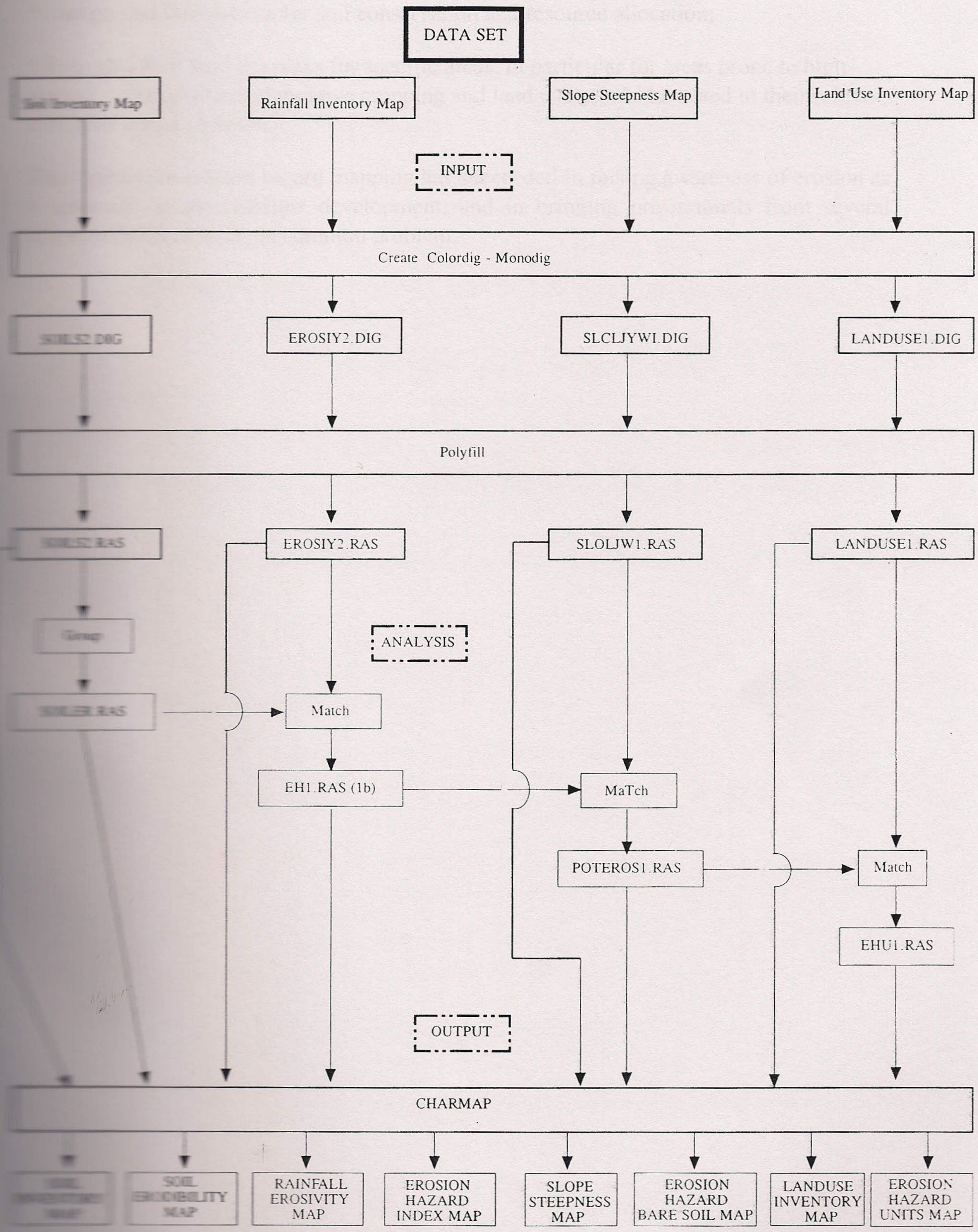
CONCLUSION

Although the map at Annex 4 depicts erosion hazard for bare soil only, the information will have use in the following capacities:

* afforestation programmes in Mozambique: to guide plantation operations to zones where erosion hazard is naturally high and forestry would be the safest option of land use;

* land evaluation at national and regional level; especially the consideration of erosion hazard as a separate land;

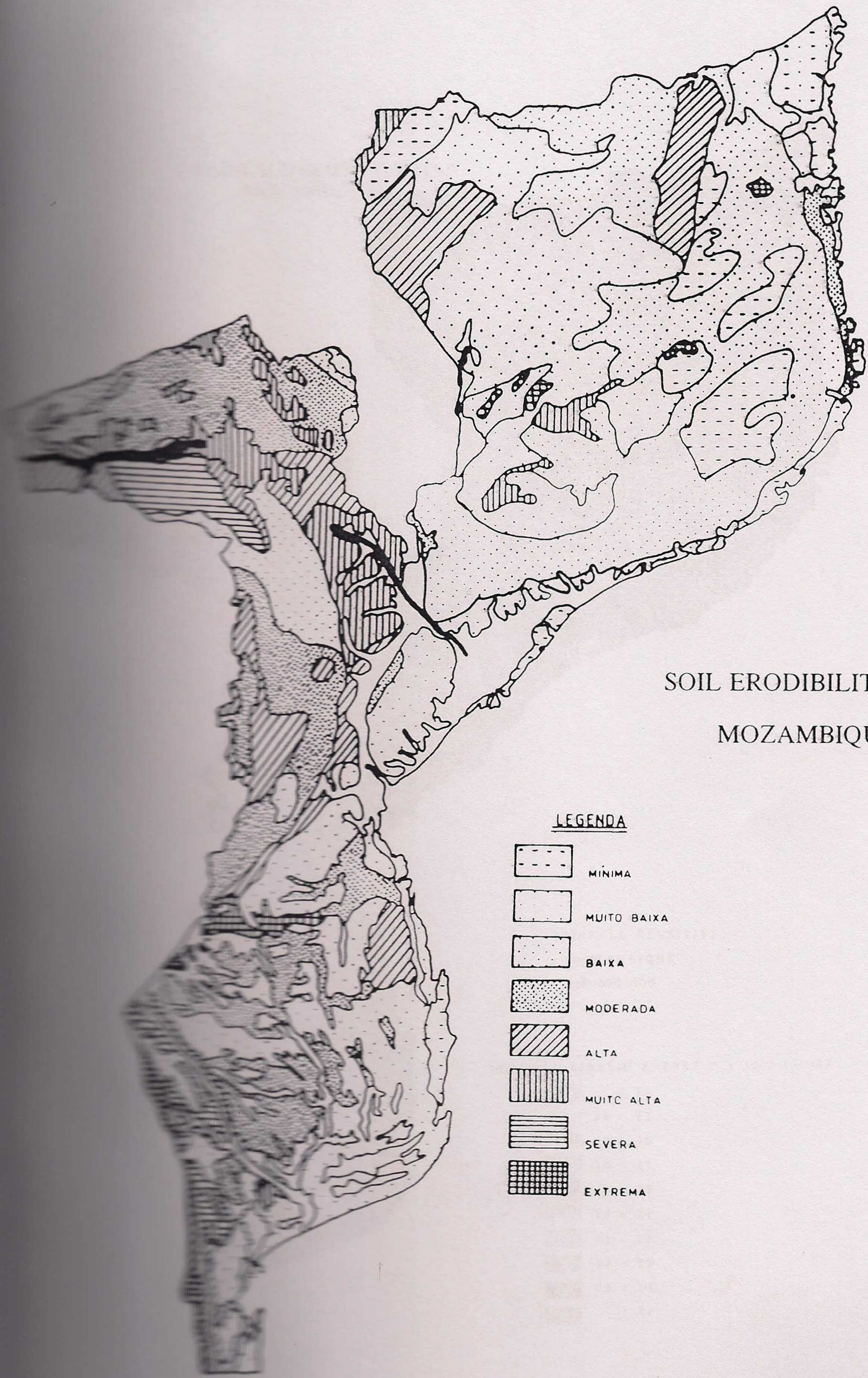
Figure 2: THE SEQUENCE OF OPERATIONS USING THE CRIES GIS FOR EROSION HAZARD MAPPING



* background information for soil conservation and resource allocation;

* formulation of land use plans for specific areas, in particular for areas prone to high erosion hazard where alternative cropping and land uses could be tested in their role to minimize actual erosion.

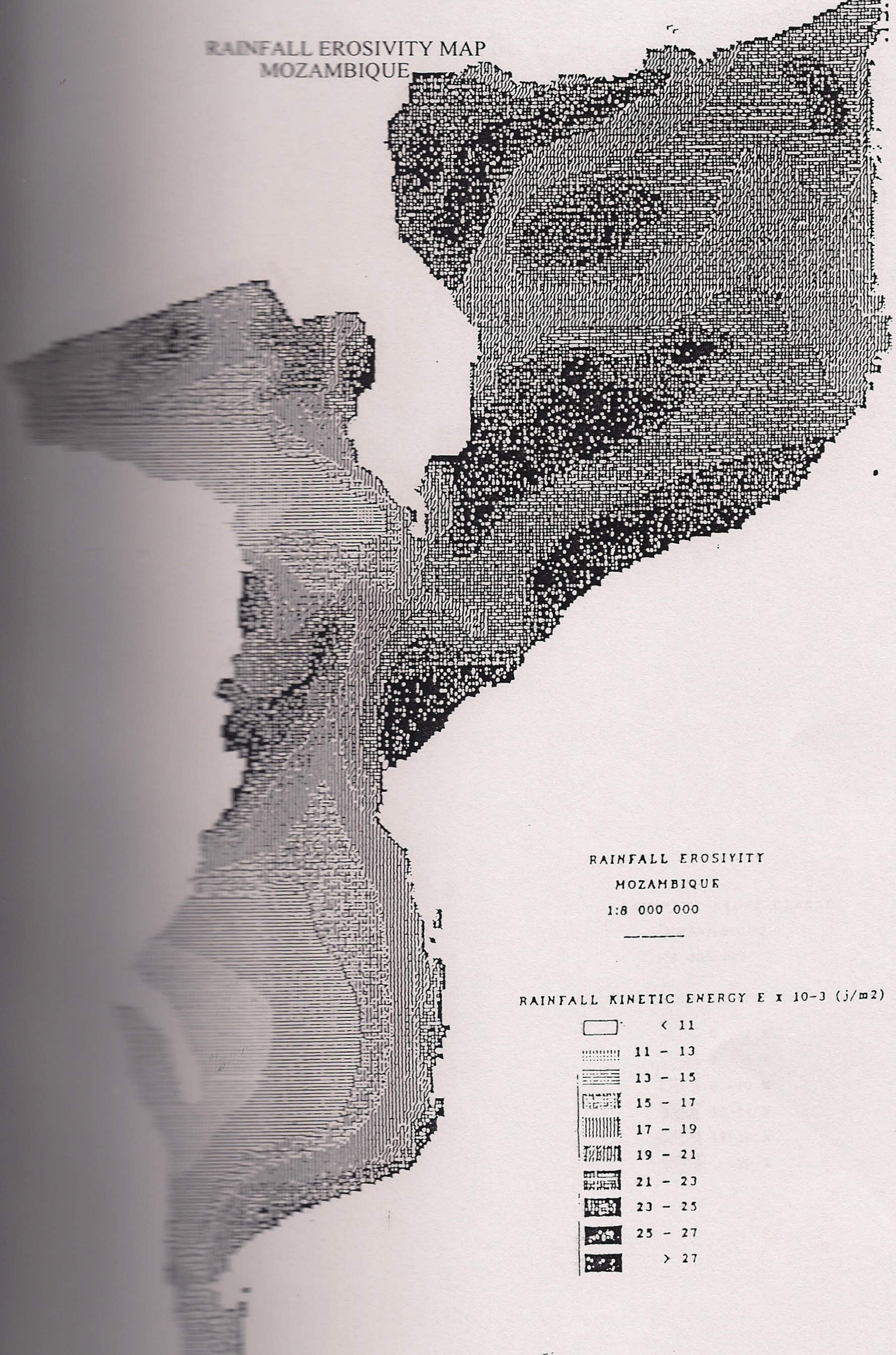
This exercise in erosion hazard mapping has succeeded in raising awareness of erosion as a constraint in mozambique development, and in bringing profissionals from several different fields to work on common problem.



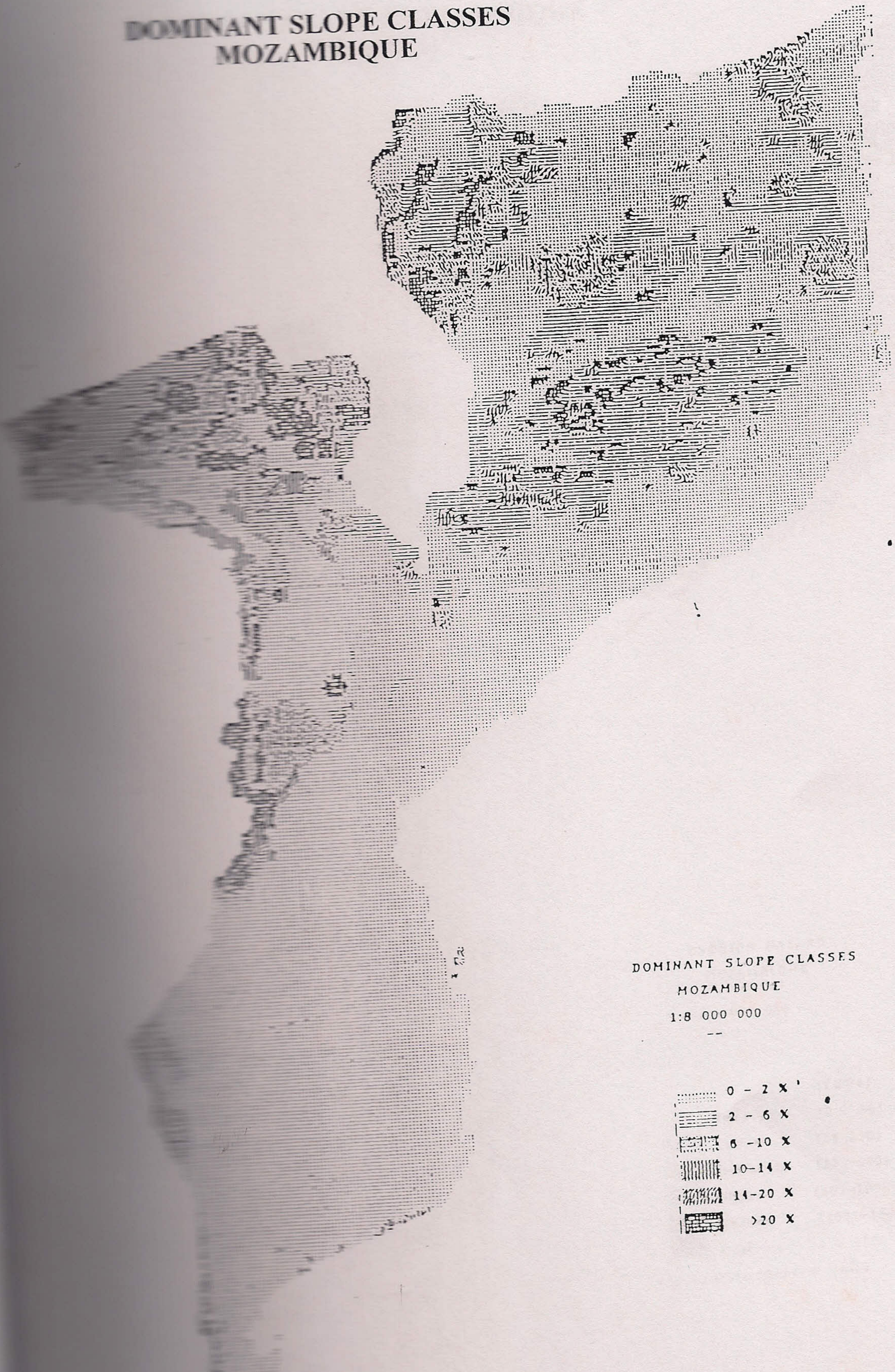
SOIL ERODIBILITY MAP

MOZAMBIQUE

RAINFALL EROSIVITY MAP
MOZAMBIQUE



DOMINANT SLOPE CLASSES MOZAMBIQUE



EROSION HAZARD MOZAMBIQUE (UPLANDS)