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Uganda Case Study: A sampler atlas of environmental resource datasets within GRID

GEMS
GLOBAL ENVIRONMENT MONITORING SYSTEM

UNITED NATIONS ENVIRONMENT PROGRAMME

UGANDA CASE STUDY:

A SAMPLER ATLAS OF ENVIRONMENTAL RESOURCE DATASETS WITHIN GRID

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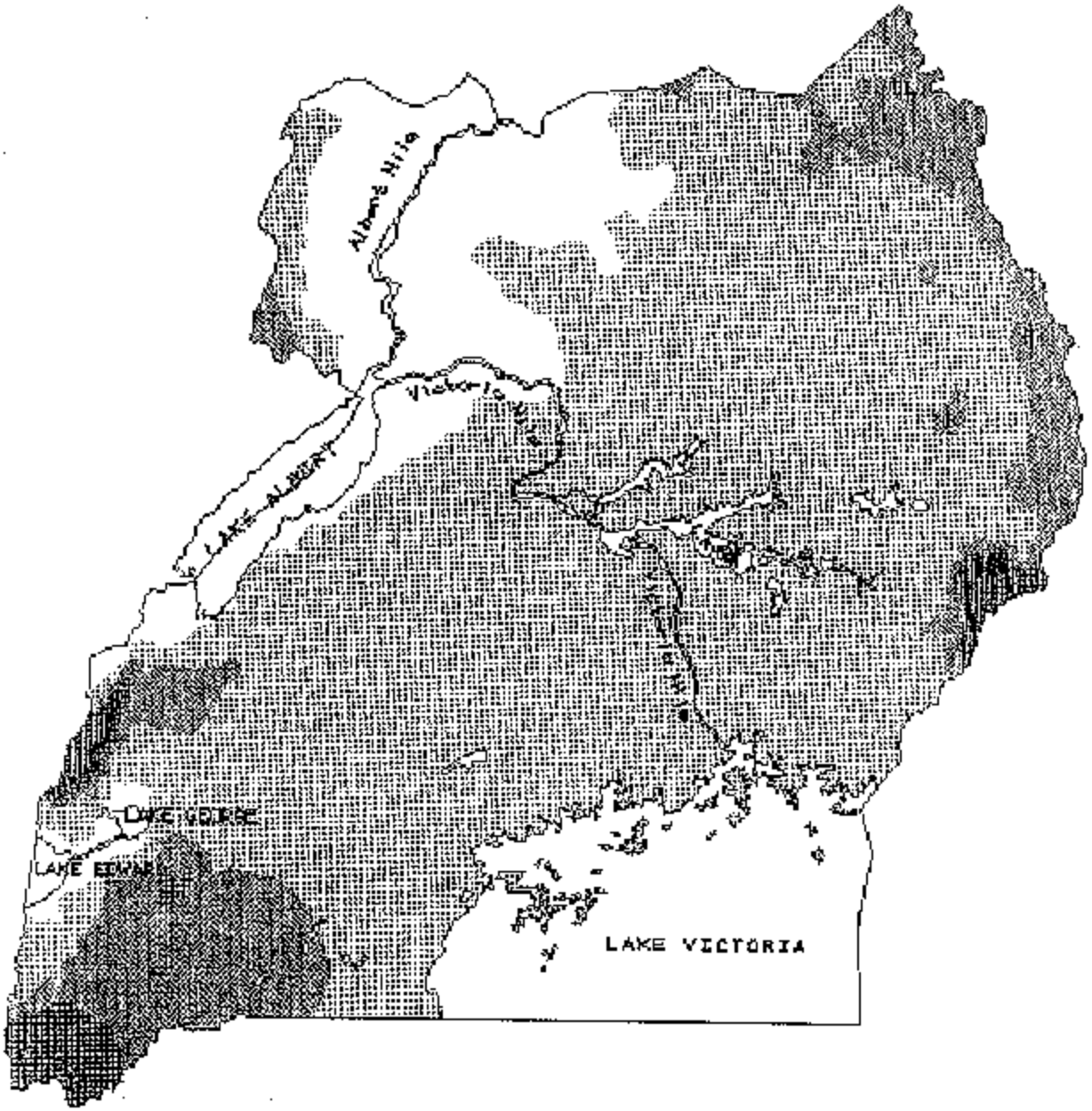

RELIEF

below 1000 m

1000 - 1400 m

1400 - 1800 m

1800 - 2200 m

2200 - 3000 m

above 3000 m

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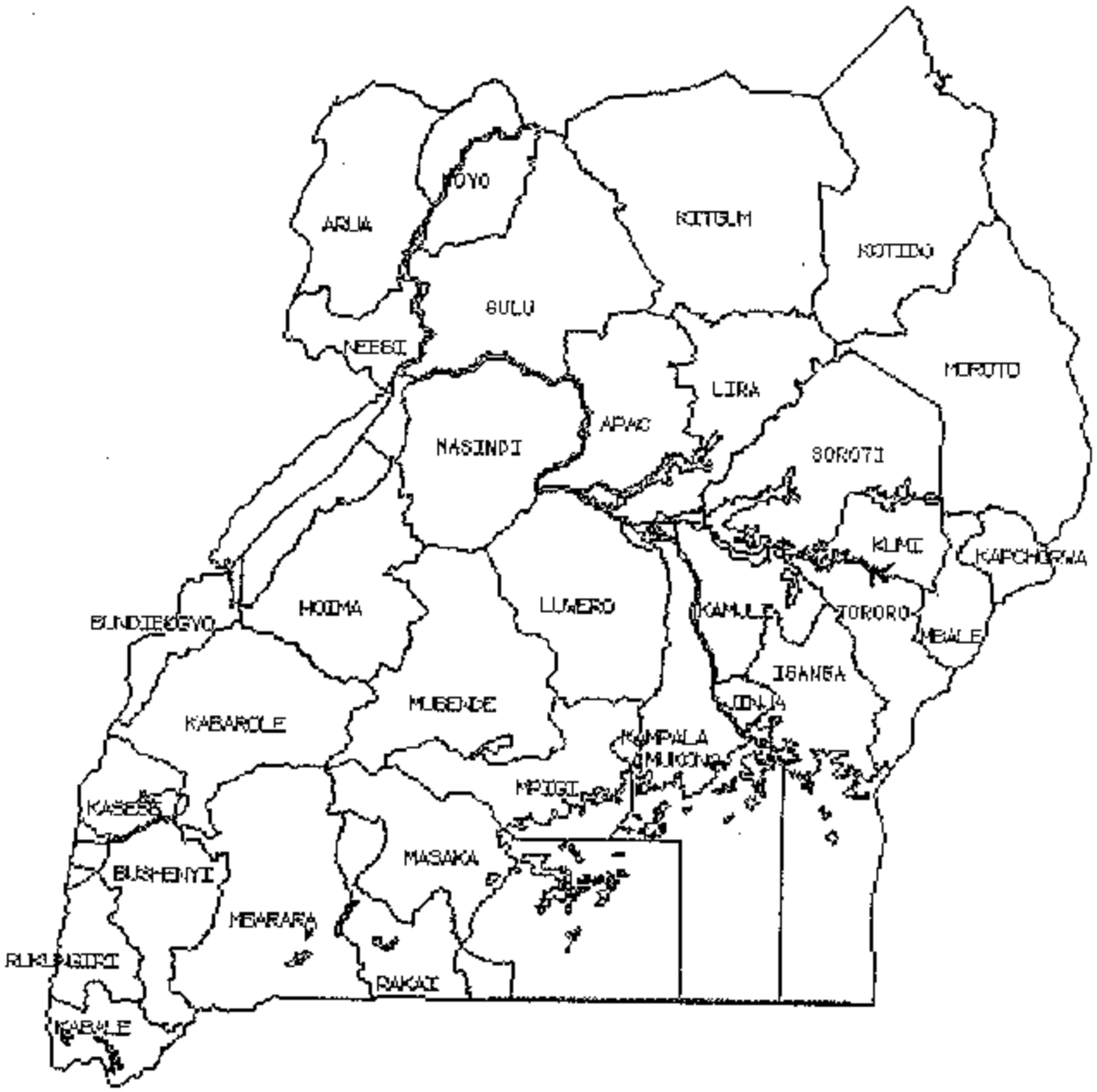

POLITICAL SUBDIVISIONS

Districts 1984

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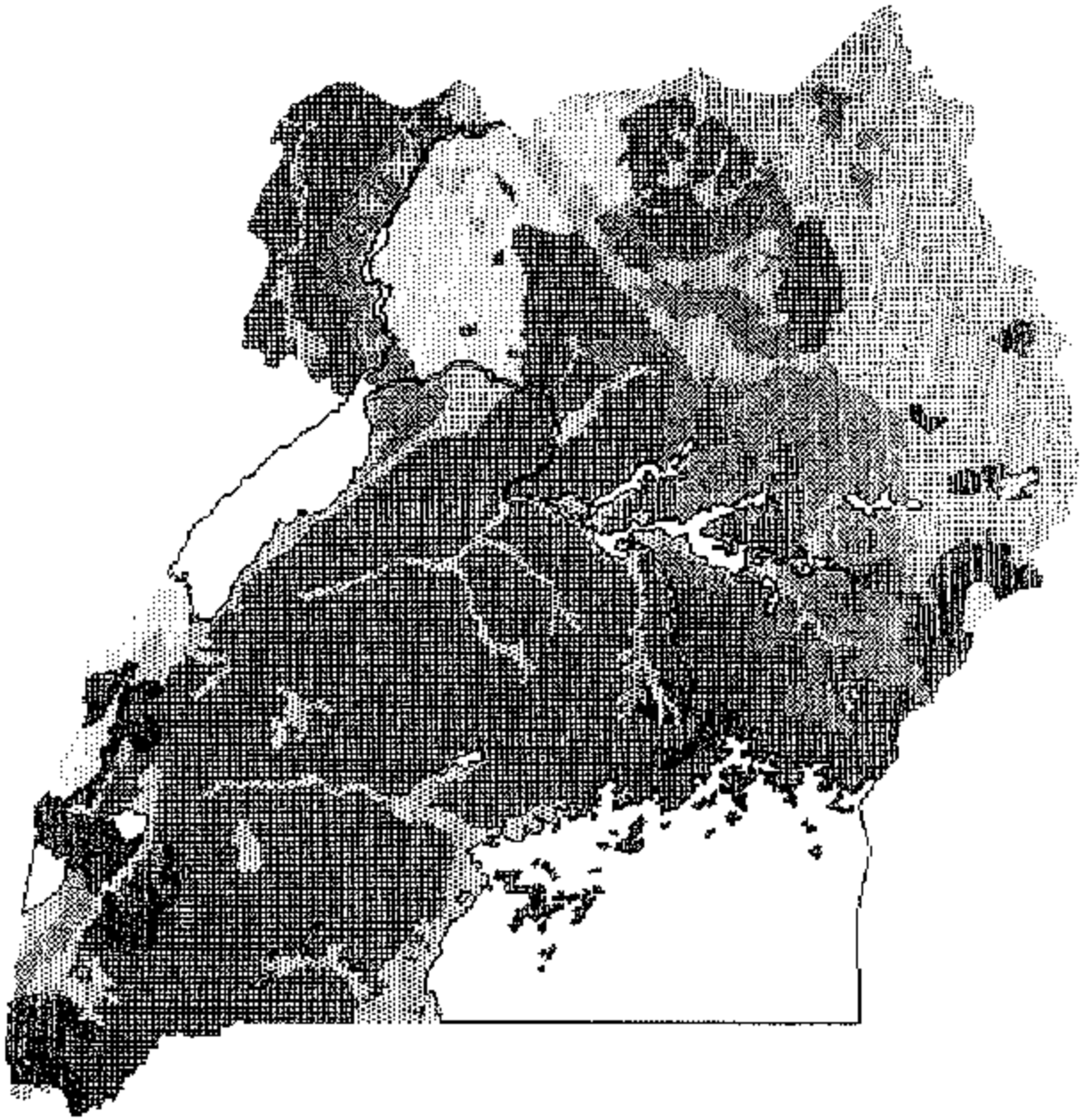
Soil Productivity

A major problem while working with soil maps is the correlation of the many classification systems.
As a first step, the Ugandan map was correlated with the FAO/UNESCO Soil Map of the World. This allowed us to apply models from the Farm Management Handbook of Kenya (Jätzold and Schmidt 1983). With advice of Ugandan experts, we compiled the Soil Productivity Map. Soil productivity is defined as a combination of the following parameters: texture, depth, organic matter of topsoil, pH, drainage, water holding capacity, workability and fertility.



SOIL PRODUCTIVITY

as function of:
texture, depth, ph
fertility, organic matter
drainage, workability
water holding capacity

- very low
- low
- low to medium
- medium to high
- high
- very high

UNEP/GEMS/GRID 1987

Soil Erosion

Uganda is heavily dependent on agriculture, thus soil erosion can be a threat to the nation´s economy. In this case study the problem was examined at a small scale (1:1.5 million), so detailed answers cannot be given. The resulting maps, however, identifying potential trouble spots, can be used to allocate effort and for the selection of detailed study areas.

Rainfall is the most important climatic factor contributing to soil erosion in Uganda , so the study focussed on water erosion.

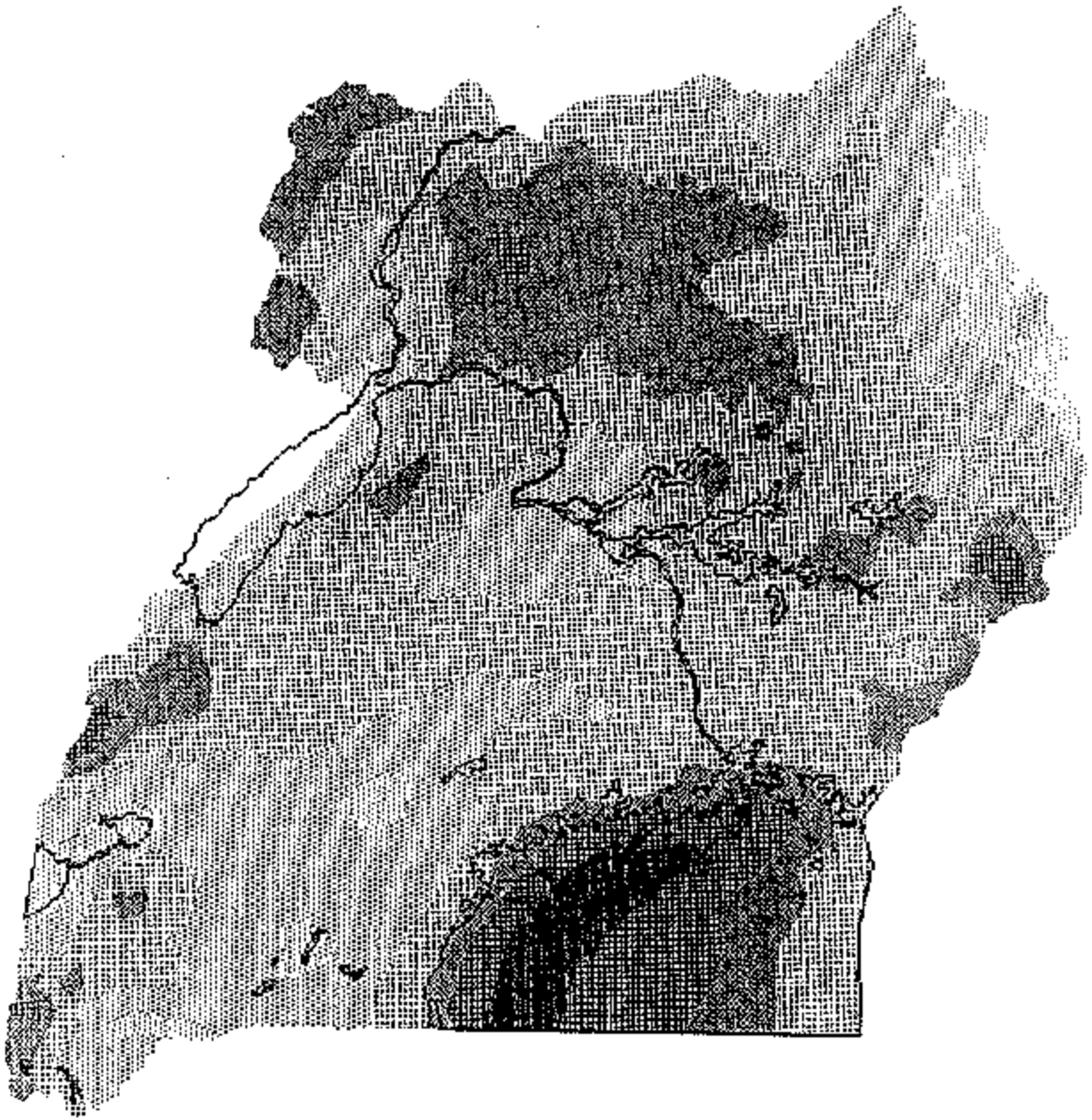
There is no generally accepted model of soil erosion assessment. For this analysis, the FAO/UNEP methodology (FAO 1979) was followed. It is basically a simplification of the Universal Soil Loss Equation (USLE). Factors to be considered in the assessment of water erosion are climate, soil, topography and human impact on the land.

GIS technology allows several models to be run, once the basic data are entered, thus emphasis was given to the production of maps of single factors contributing to soil erosion:

Rainfall erosivity	A simplification of Fournier´s Index was used, as described in the FAO Methodology (FAO 1979): $f[\sum_{1}^{12}(p^2 / P)]$ (p: monthly precipitation, P: annual precipitation) In Uganda, the Index map correlates very highly with the map of annual precipitation: it can be argued whether, in this case, the calculation of that particular index is useful.
Soil erodibility	This index is based on soil texture, as described in the FAO methodology (FAO 1979). Where available, organic matter of topsoil and water holding capacity were also included.
Slope	Slope was calculated from a digital terrain model

	derived from a contour map. At a scale of 1:1.5 million, details in the terrain are lost; this map can therefore only point out where problem areas may lay.
Land Use Pressure	The classification of this map follows the land use map of the Atlas of Uganda. The main influencing factors are the type of cropping (annual or perennial), grazing and protected areas.
Population Pressure	Population density by subcounties (census 1969) was digitized and converted to density contours. The contour map has the advantage of continuity; there are no sharp changes at political boundaries.

The soil erosion hazard map is a combination of the single factor maps, except slope, listed above. To include the slope factor, a more accurate slope map has to be compiled.
The map displayed points out critical areas and directs attention to where further studies have to be conducted .



SOIL EROSION

Rainfall erosivity

(modified Fournier-Index)

monthly and annual
precipitation from

Atlas of Uganda 1967

- below 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- above 500

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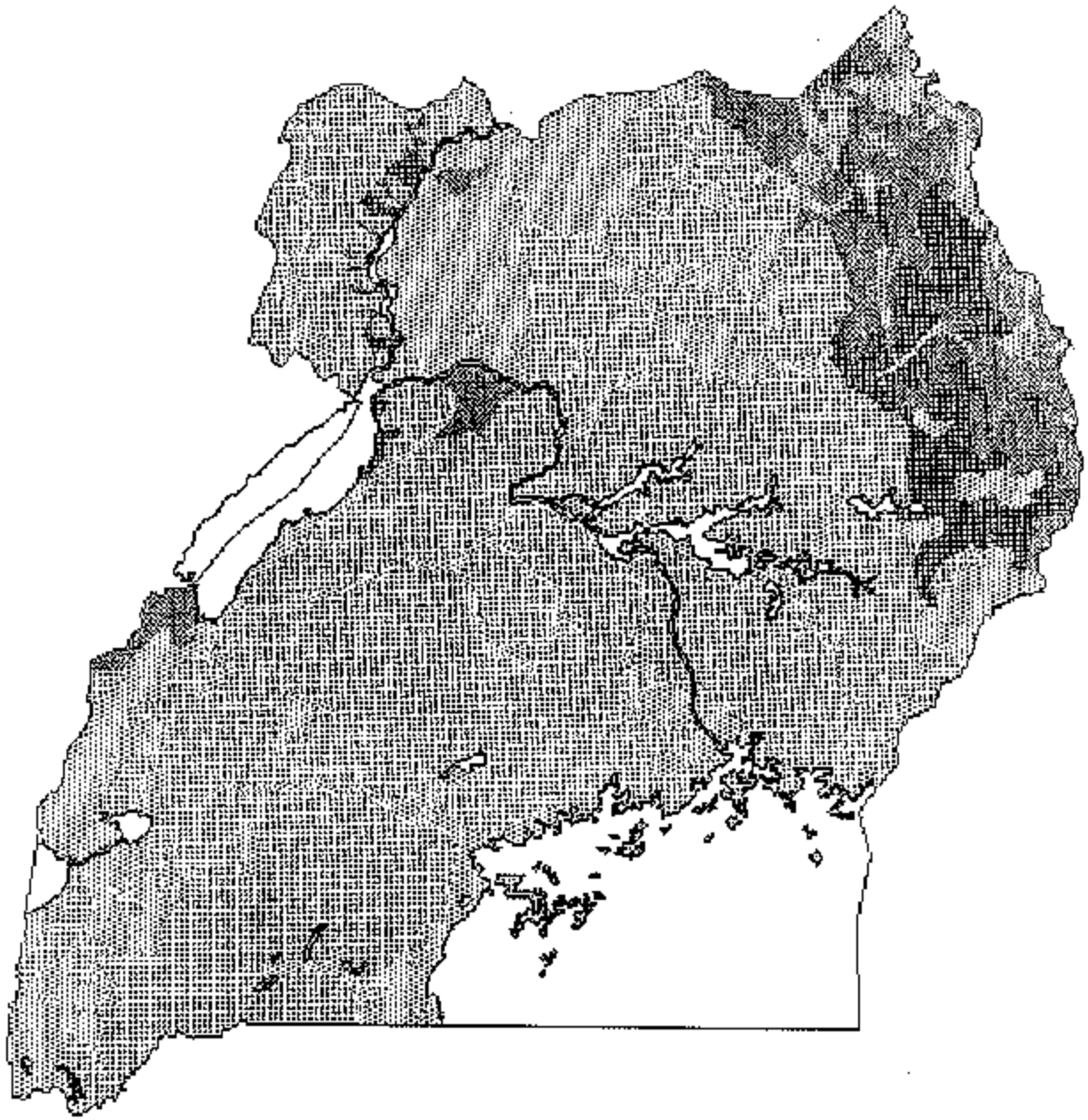

SOIL EROSION

Soil erodibility

Source of Soil map:
Atlas of Uganda 1967

very low

low

medium

high

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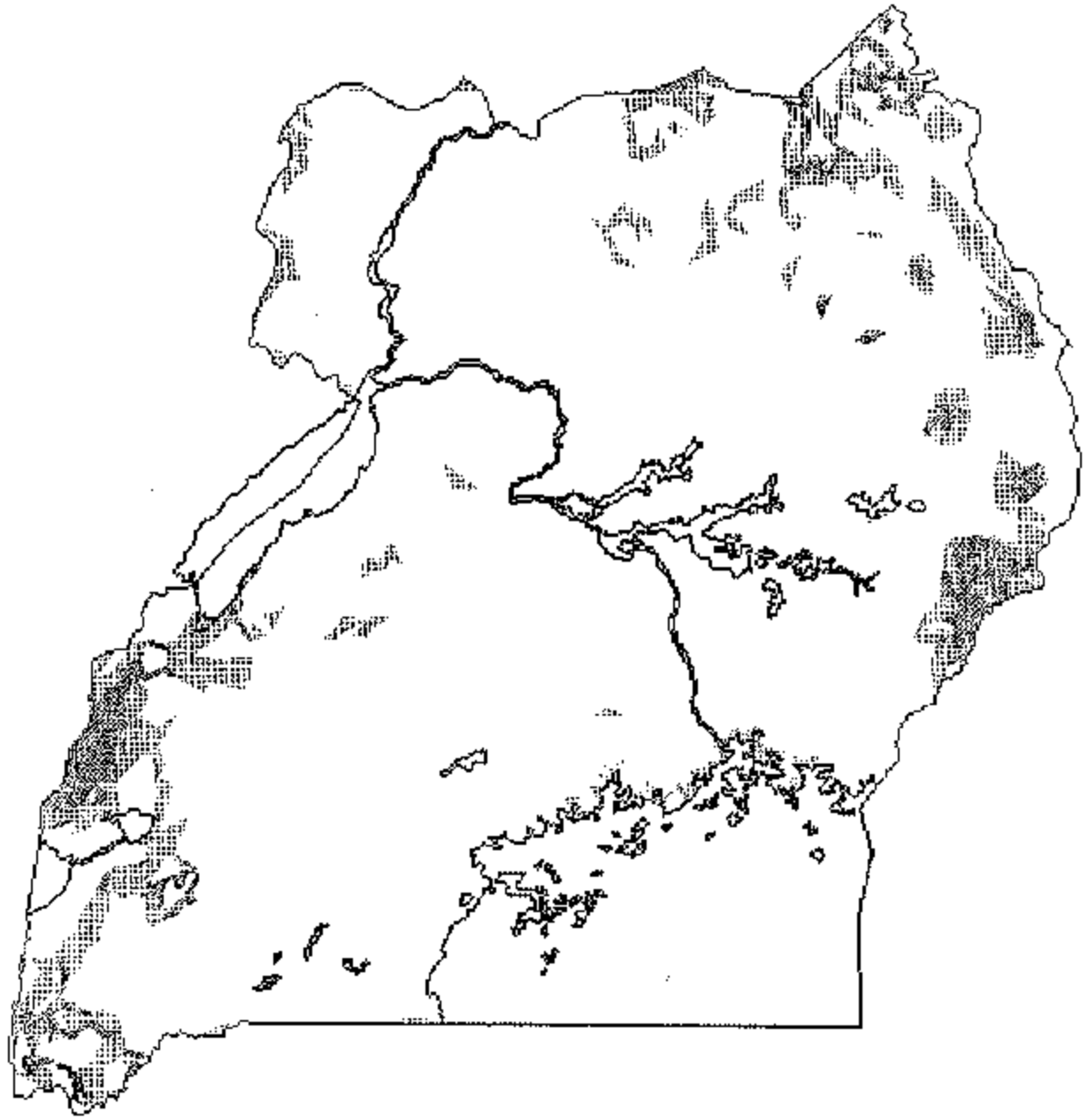

SOIL EROSION

Slope

absolute slope derived from
Digital Terrain Model

Source of contours:
Atlas of Uganda 1967

0 - 2 DEGREES

2 - 8 "

8 - 30 "

> 30 "

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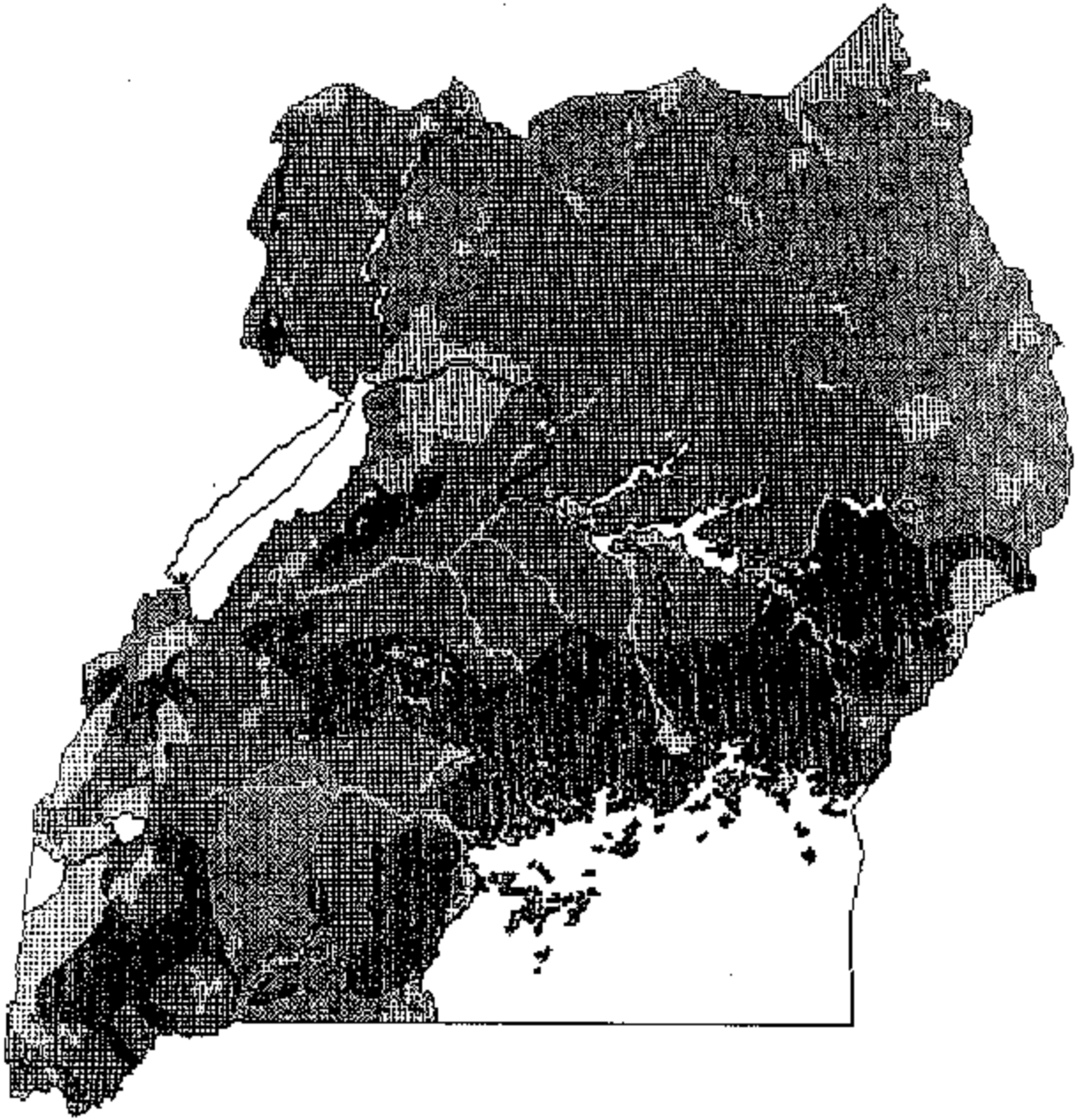

SOIL EROSION

Land Use Pressure

source:

Atlas of Uganda 1964

very low

low

medium

high

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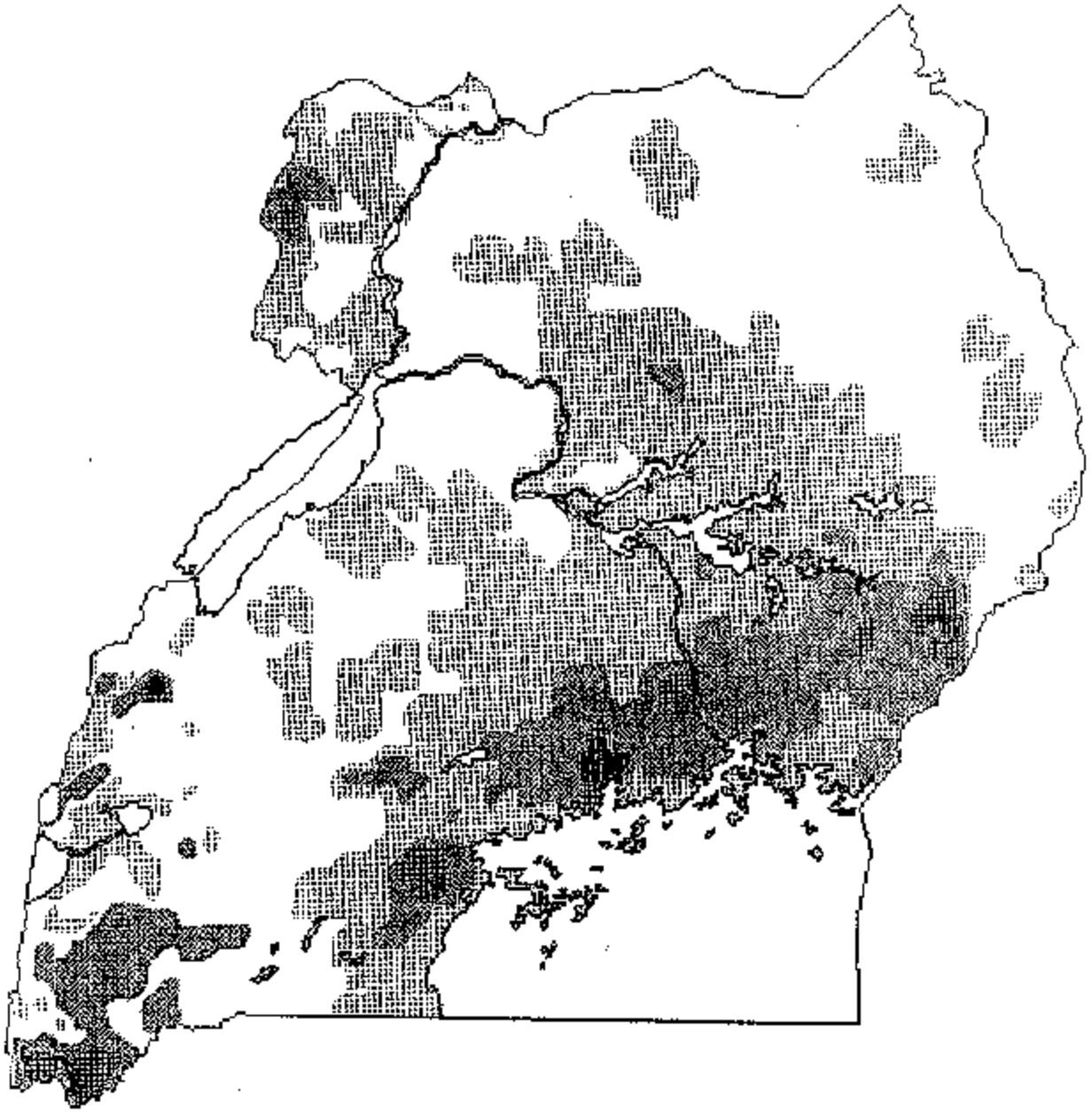


SOIL EROSION

Population pressure

Source of data :

Census 1969

very low
below 20

low
20 - 100

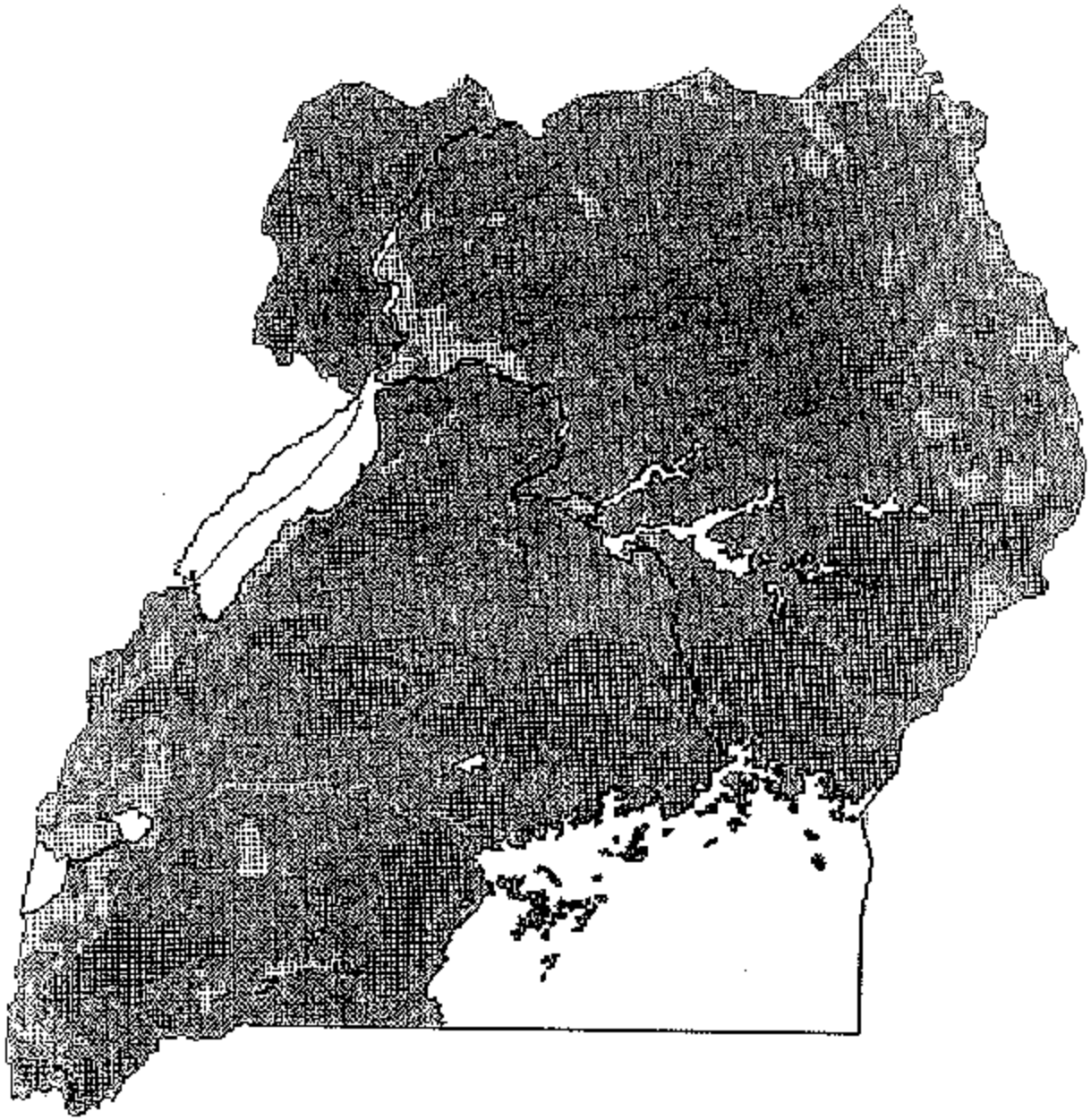
medium
100 - 200

high
200 - 400

very high
above 400

inhabitants/km2

UNEP/GEMS/GRID 1987



SOIL EROSION HAZARD

combination of:

rainfall erosivity
soil erodibility
land use pressure
population pressure

LOW

MEDIUM

HIGH

VERY HIGH

UNEP/GEMS/GRID 1987

Agro-Ecological Modeling

Geographic Information Systems offer a great potential for Agro-Ecological modeling. For the Uganda case study , models previously applied in Kenya were automated. They are described in the **Agro-Climatic Zone Map of Kenya** (Kenya Soil Survey 1982) and in **Farm Management Handbook of Kenya** (Jätzold and Schmidt 1983).

Agro-Ecological Zone Map

The purpose of an agro-ecological zone map is to show what areas are climatologically suitable for particular crops. Such maps can help to guide the work of planners and farmers.
Inputs for this map are temperature and moisture availability zones.
The temperature zones are derived from topography:
T mean (in °C) = 30.2-0.00650 h (meters)
Moisture Availability is a combination of annual rainfall and annual evaporation (Source: Atlas of Uganda 1967):
moisture availability = annual rainfall / annual evaporation
There are six temperature zones and seven moisture availability zones, combined (after some merging) into 34 agro-ecological zones as shown in the legend to the map.

Ecological Suitability

Crop- specific data (temperature and moisture requirements) merged with the agro-ecological zone map result in ecological suitability maps for single crops. The example shows Arabica coffee, which grows best in altitudes between 1500 and 2100 meters and requires 1200 to 1800 mm of annual rainfall.

Soil Suitability

Soil requirements of particular crops have been combined with the soil map, resulting in soil suitability maps. Arabica coffee needs medium textured, deep soil, free draining, with reasonable water retention capacity and a ph between 5.3 and 6.0.

Overall Suitability

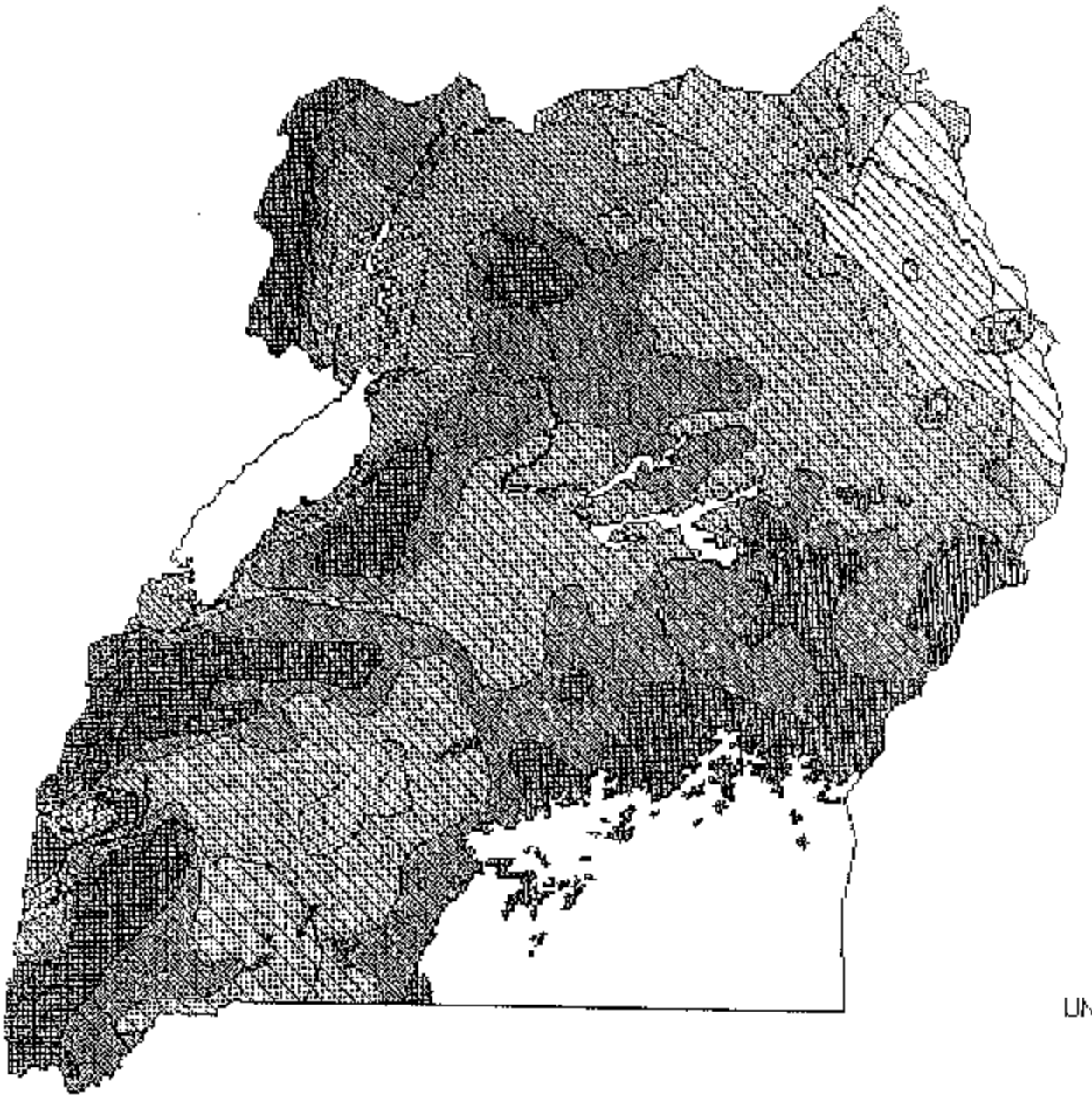
This map is a result of combining ecological and soil suitability maps. According to the models applied, the best areas for growing Arabica coffee in Uganda are Mount Elgon, Bushenyi and Mbarara District, Ruwenzori-Fort Portal and southern West Nile.

Competition of Cash Crops

The overall suitability maps for six major cash crops (tea, arabica coffee, robusta coffee, sugar, cotton and tobacco) were combined into a map showing competition between these crops. The areas with most competition are the belt around Lake Victoria, Gulu-Masindi, West Nile and Fort Portal-Mubende.

Climatic Change

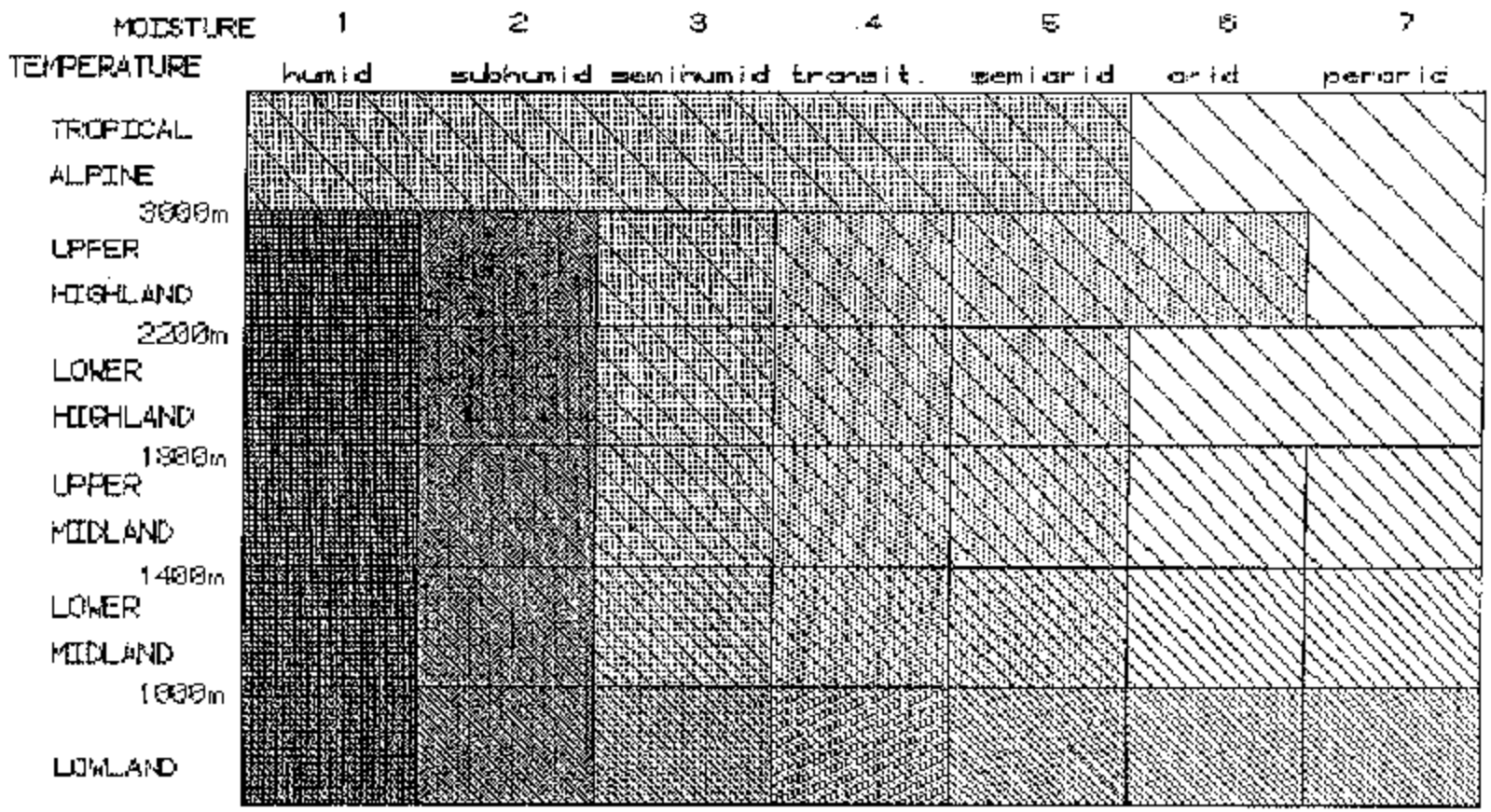
The use of GIS also allows simulation of climatic change. According to experts a warming of the atmosphere may well occur in the next decades. An overall change of 2 ° C was assumed. The impact of this change on ecological suitability of Robusta coffee - Uganda´s most important cash crop - is very dramatic.

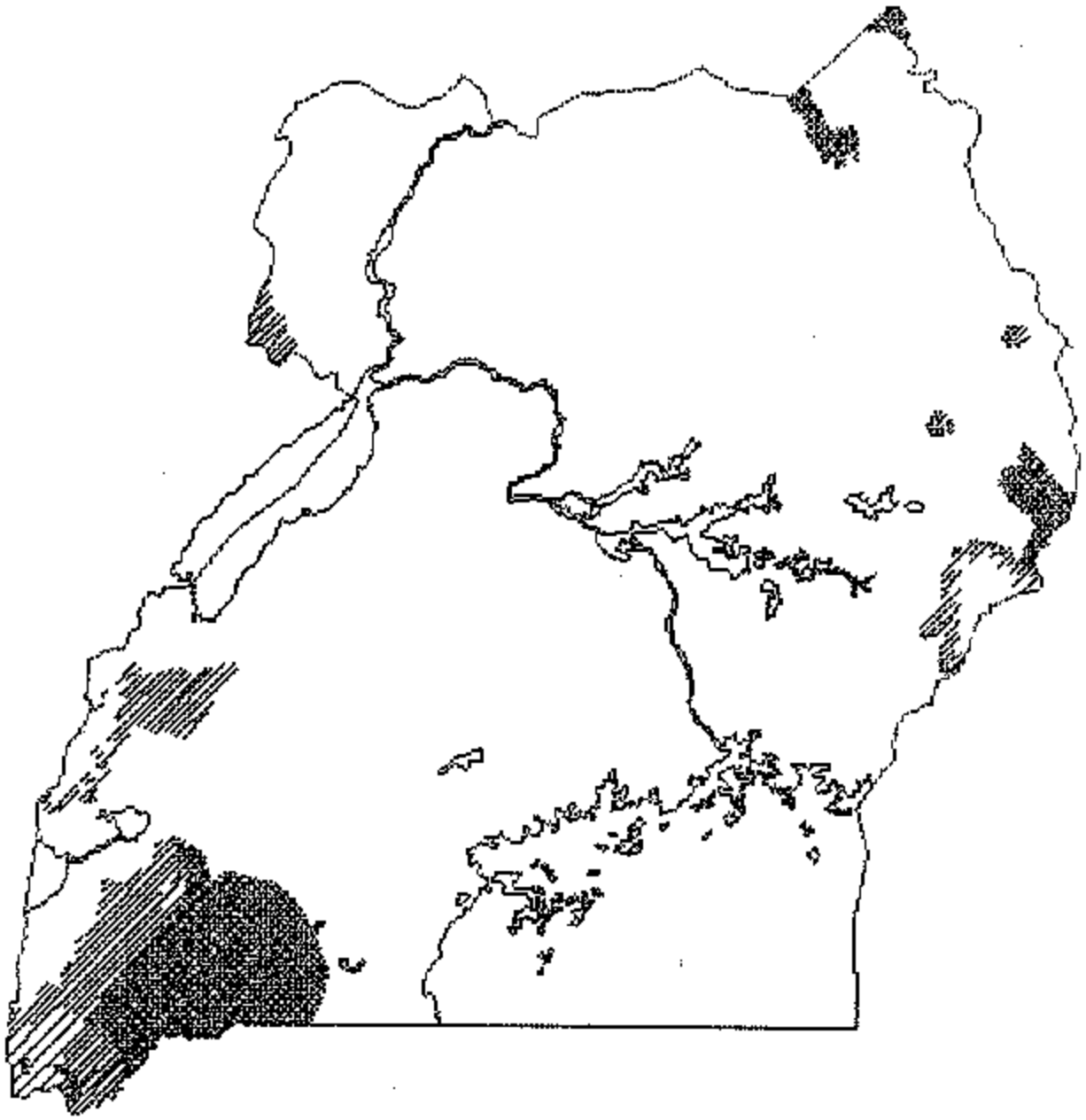


AGRO-ECOLOGICAL ZONES

UNEP/GEMS/GRID 1987

AGRO-ECOLOGICAL ZONES





Ecological suitability

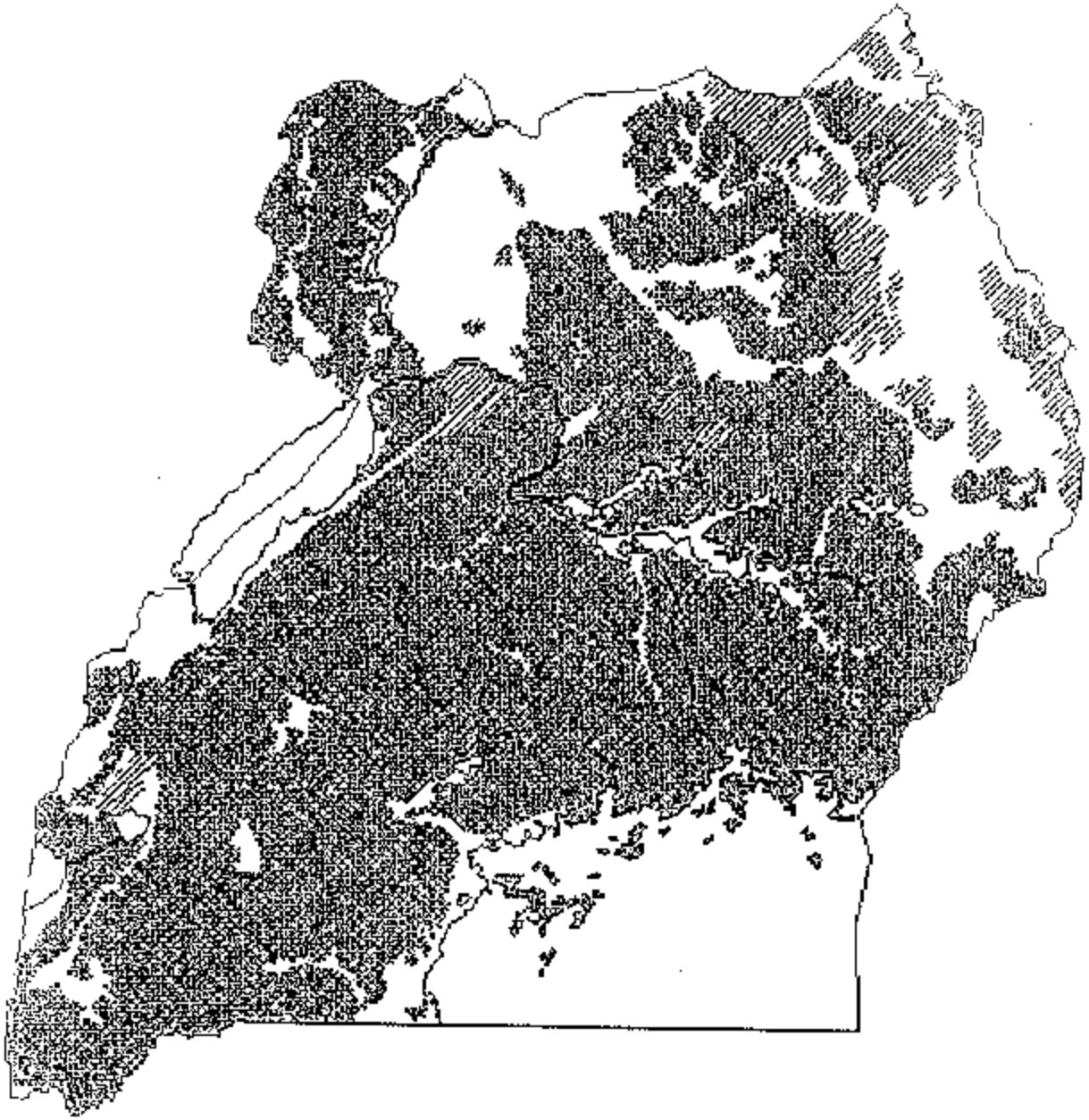
Arabica Coffee

fair

good

very good

UNEP/GEMS/GRID 1987

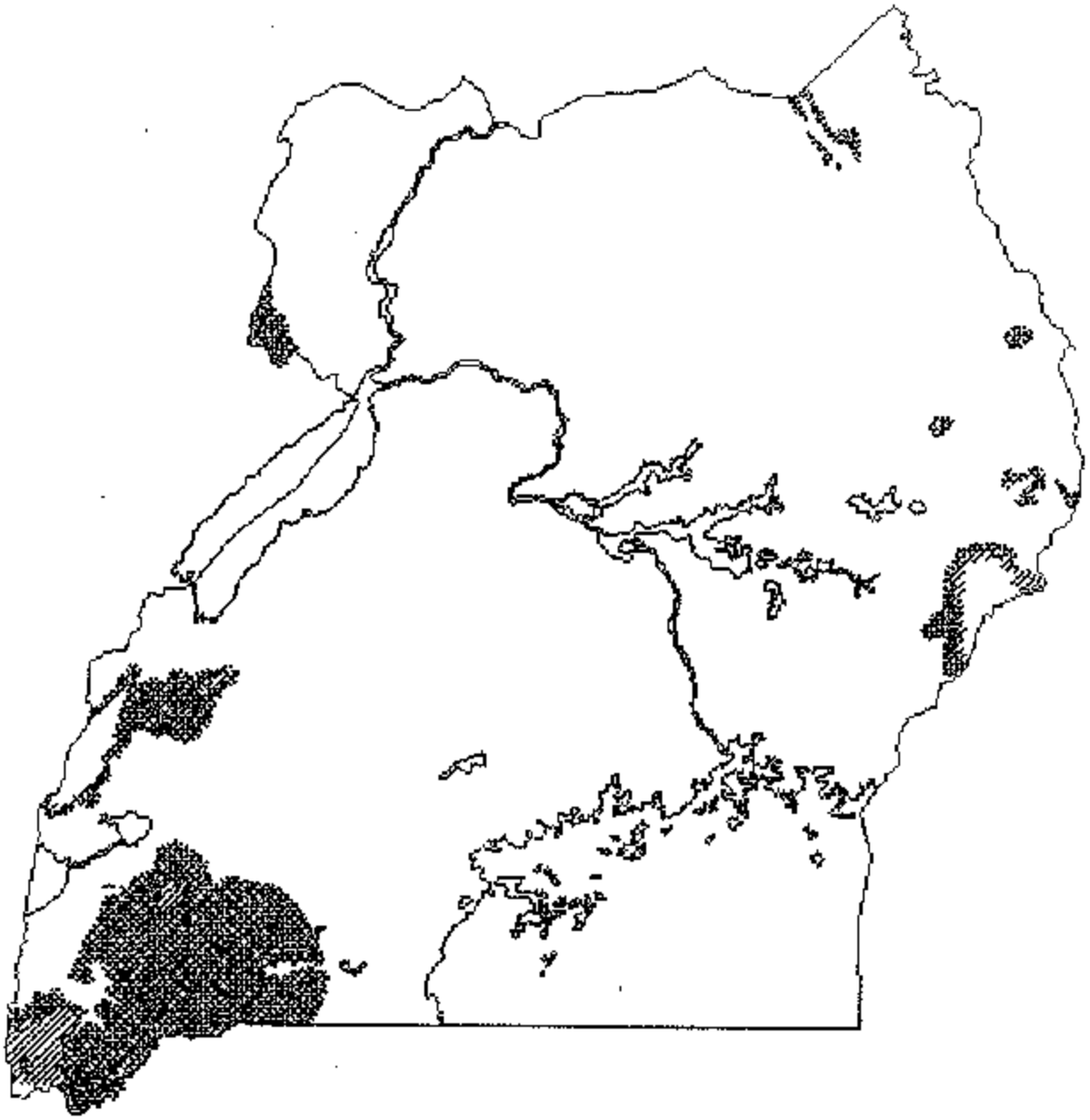


Soil suitability

Arabica Coffee

- fair
- good
- very good

UNEP/GEMS/GRID 1987



Overall suitability

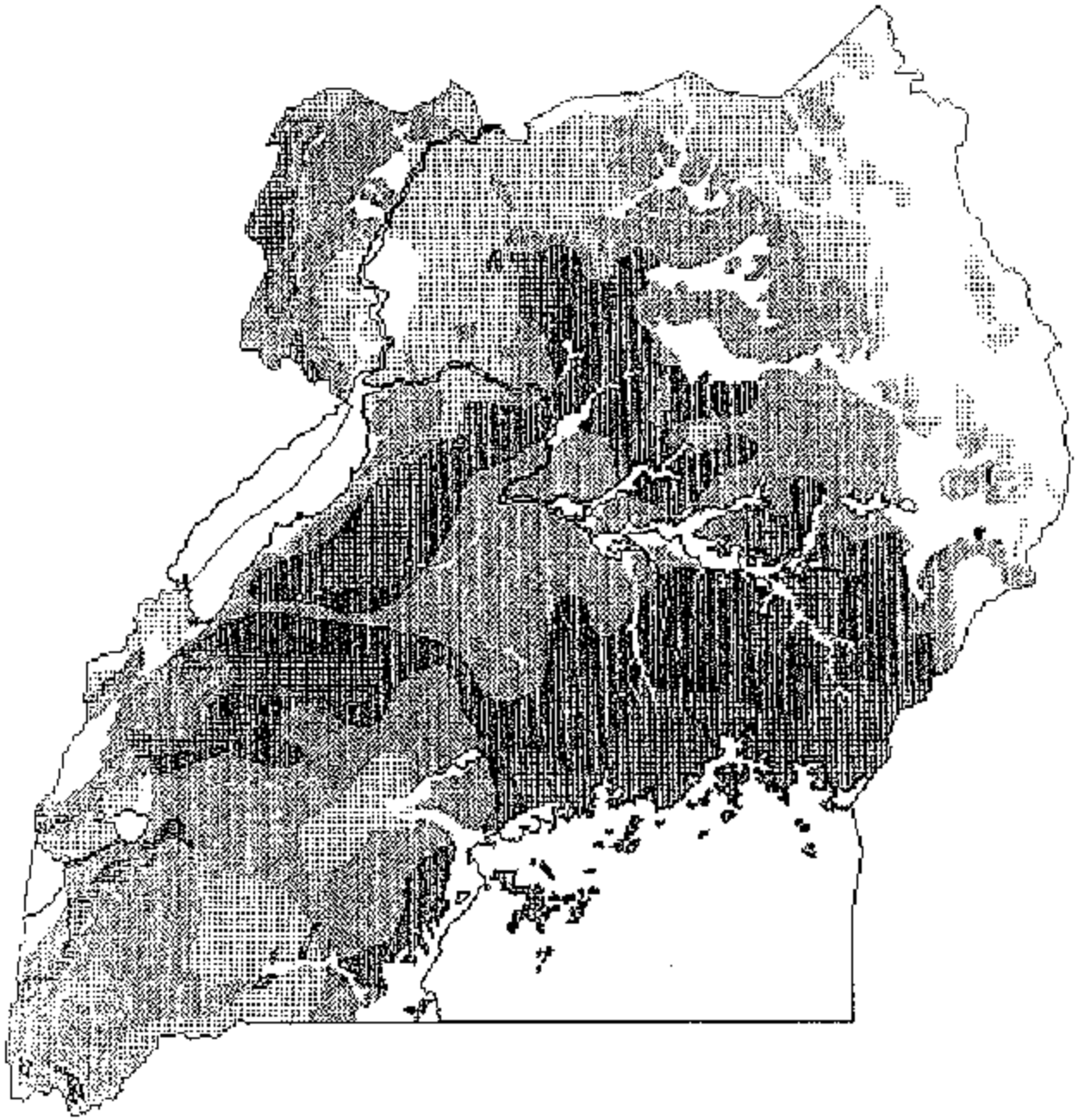
Arabica Coffee

fair

good

very good

UNEP/GEMS/GRID 1987

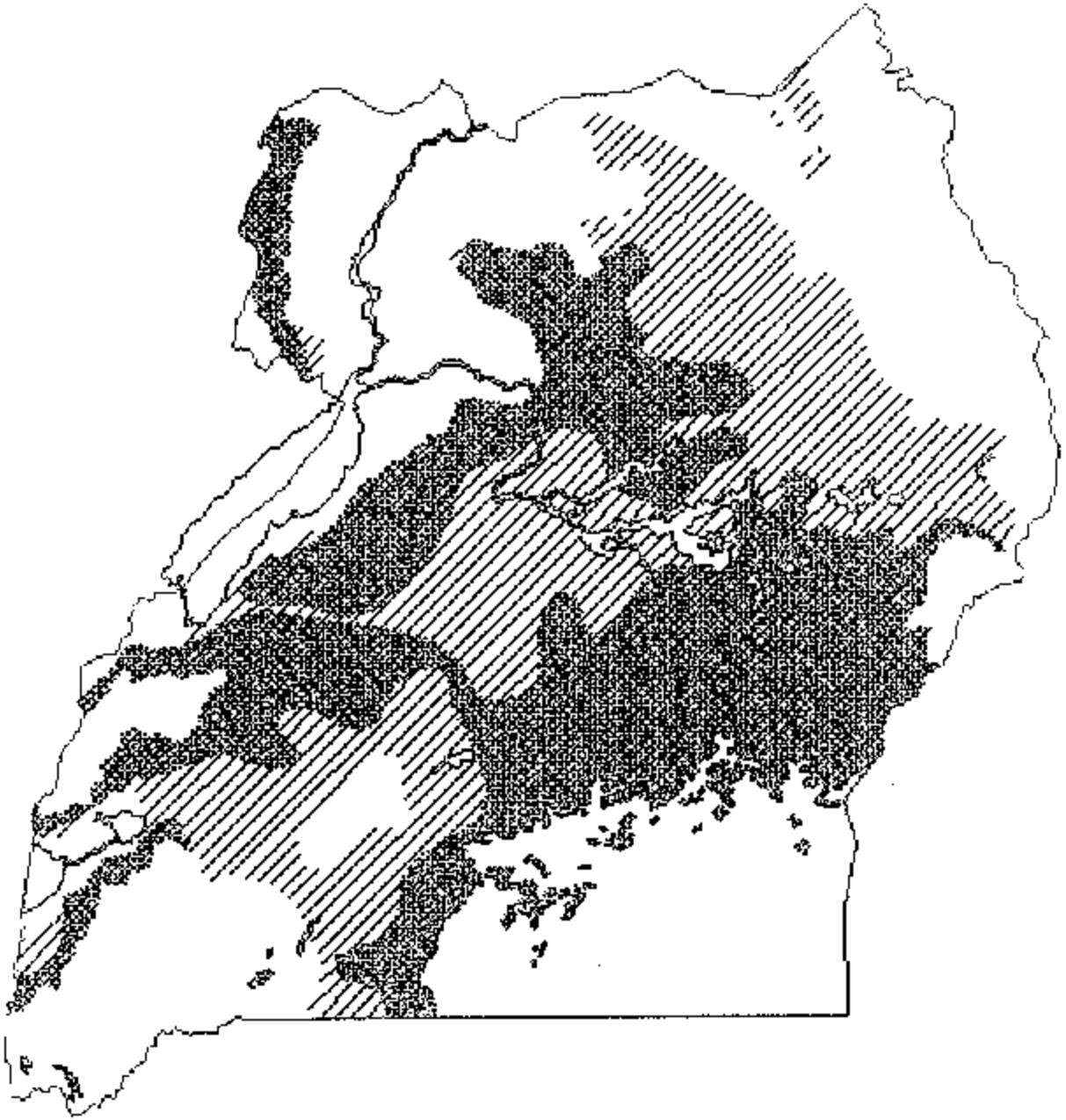


CROP SUITABILITY

Competition of cash crops:

Tea, Arabica coffee, Robusta coffee, Sugar, Cotton and Tobacco

- none
- low
- medium
- high
- very high



CLIMATIC CHANGE

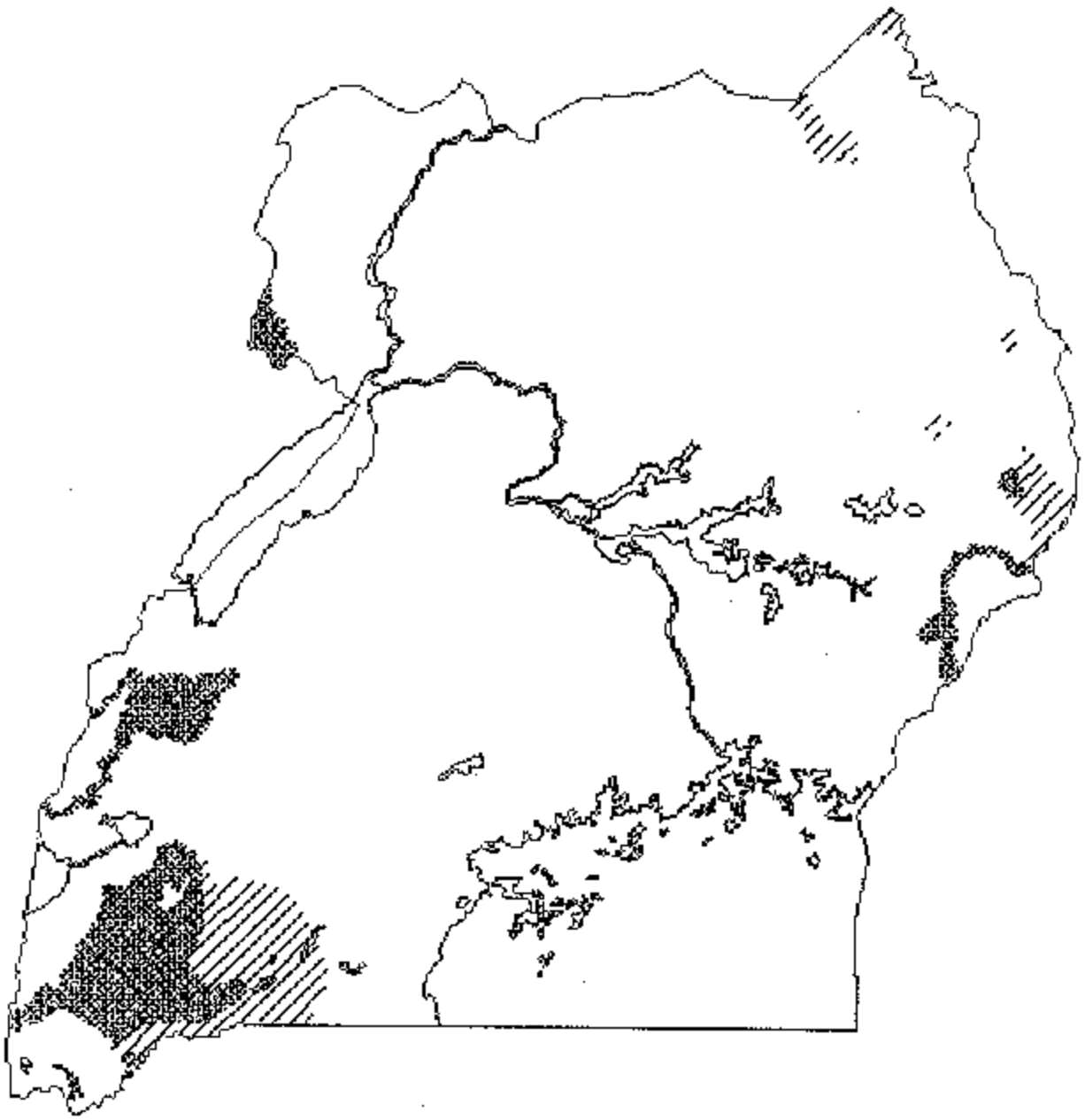
Today

Robusta Coffee

Ecological suitability

- fair
- good
- very good

UNEP/GEMS/GRID 1987



CLIMATIC CHANGE

2 degrees warmer

Robusta Coffee

Ecological suitability

- fair
- good
- very good

UNEP/GEMS/GRID 1987

Forest Change

An Ugandan team of experts interpreted two satellite mosaics, one from 1973 the other from 1986. The comparison of the two stages allows the detection of changes in forest cover. The map for Uganda as a whole has limitations, because due to cloud cover or missing imagery in the south important areas could not be compared.
Zooming in on Mount Elgon however, reveals a dramatic decline of the forest cover in only 13 years. Areas like this should be subject of further studies.

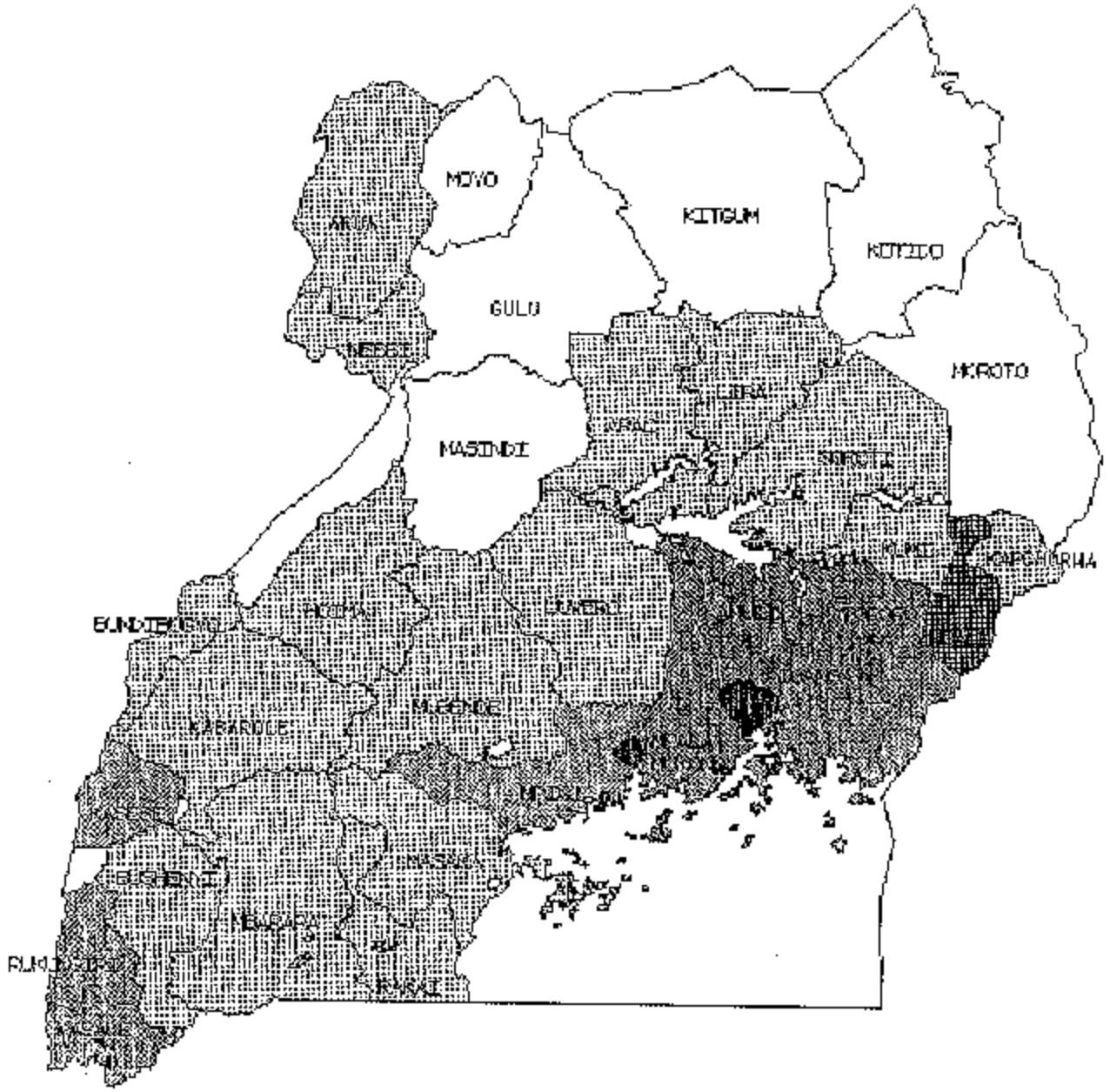
Population Density

Population Density by Districts

The most recent population census in Uganda took place in 1980. The population density map by districts was compiled from data of this census (The Republic of Uganda, 1982).

Three Dimensional View of Population Density

As an alternative to usual density maps this map shows population density as a three dimensional view. The original input map - population density by sub-counties - has been digitized. This map was overlayed by a regular point grid in order to calculate densities for point locations. This point map then was triangulated and as a next step density contours could be interpolated. Special software allows to view continuous surfaces from different heights and azimuths. In the map shown here we look at Uganda from southwest at an altitude of 40 degrees.



POPULATION DENSITY BY DISTRICTS

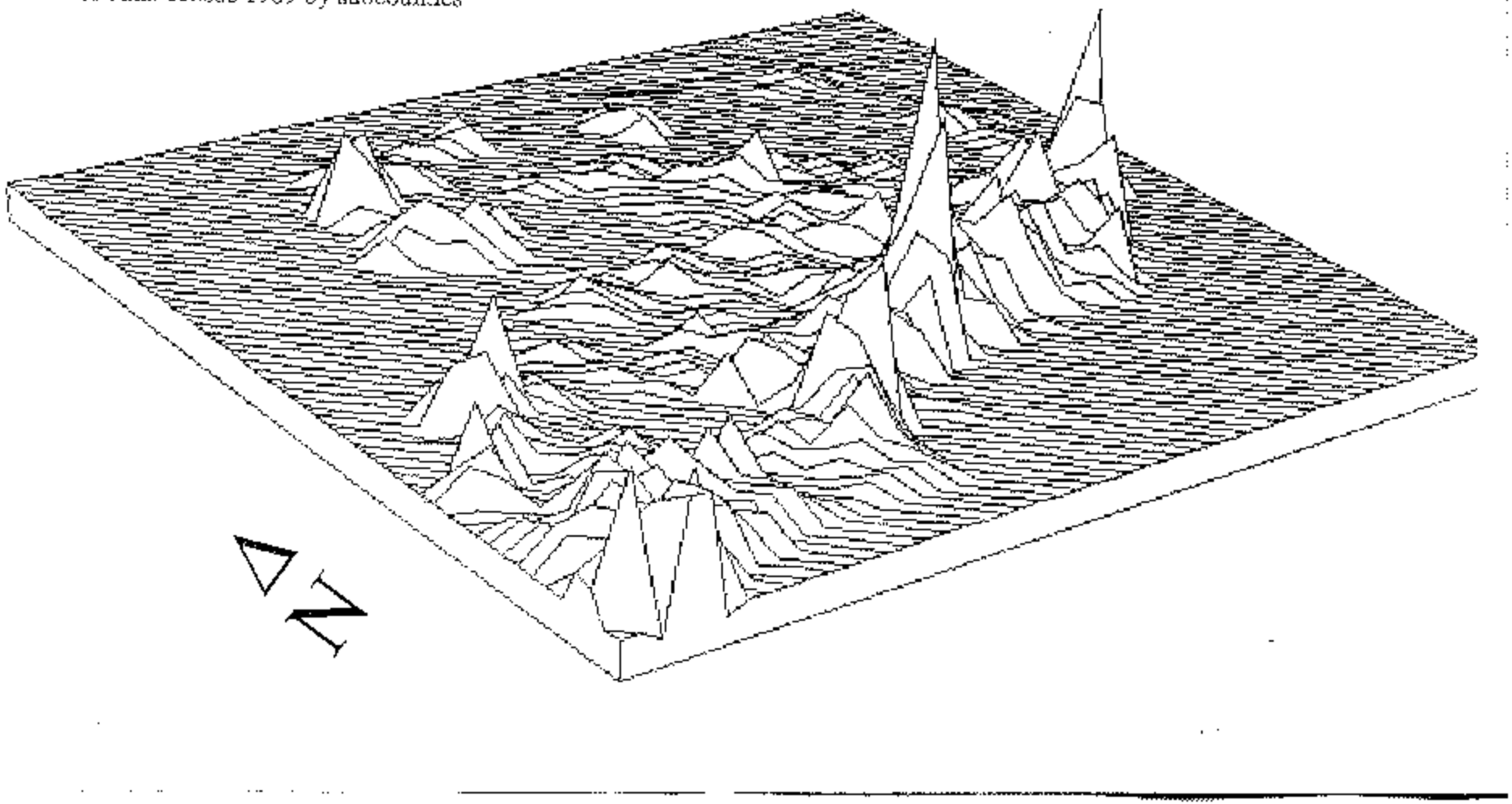
source: census 1980

- over 300
- 200 – 300
- 100 – 200
- 25 – 100
- below 25/km2

UNEP/GEMS/GRID 1987

Population Density
Three Dimensional View from Southwest

source of data: census 1969 by subcounties



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