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EROSION HAZARD IN KENYA

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ABSTRACT

Erosion hazard is highly variable in Kenya and is dependent on rainfall erosivity, soil erodibility, slope length and angle and soil cover (land use).

Presented in this paper is an assessment of the erosion hazard in Kenya using three major erosion factors; climate, soil and slope angles. The results are presented in the form of an erosion hazard map obtained by land evaluation methods. The map could be an important tool for many applications. The results are however not the real estimates of actual erosion. The map shows that areas with steep slopes in the mountainous region have the highest risk of erosion while the gentle slopes on the plains have the lowest risks. 43 percent of the country suffer the lowest risk while 24 and 10 percent of the country suffer moderate and highest risks respectively.

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Introduction

Uncontrolled soil erosion is currently a major environmental concern both at the national and global level. Observations in parts of Kenya during the last three decades indicate that the rate of soil loss has been increasing.

The disastrous effects, both in magnitude and distribution, of the soil loss are not well appreciated in most parts of Kenya for two reasons. Firstly, improved crop production technologies of the late sixties which resulted in increased productivity per unit area, obscured the detrimental effects of soil erosion. Secondly there is a common notion that gully erosion is the most damaging form of erosion, thus in areas where gullies do not exist, the damaging effect of erosion is again obscured. The same notion on gullies is also apparent on the global level, thus the notorious gullies of South East USA, Lesotho, Nepal and the Loess plateau of China are very often cited as examples of water erosion damage. Contrary to the common notion and belief, sheet and rill erosion are now believed to be the major processes causing soil loss and productivity decline on most landscapes, (Dregne, H.E., Barber, R.G. 1982).

Quantitative data on erosion is limited both in volume and distribution in many parts of the world. In Kenya, only a small fraction of the quantitative data on erosion is of regional importance. Catchment soil loss studies through river sedimentation in the highlands east of the Rift Valley, (Dunne, 1974; Dunne and Ongweny, 1976; Edwards, 1979; Thomas. et. al. 1981; Wain, 1982; Aubry and Wahome, 1982), have generated information on the magnitude of soil loses for the region. Few studies have been carried out in other areas, Baringo and Kericho. However, these are site and land use specific. Soil erosion maps are very few and site specific. On the whole there is an information gap on erosion in Kenya as in many other parts of the world.

Given the existing information gap, statements are made about economic destruction brought about by accelerated erosion without detailing exactly where the destruction occurred or the basis for the conclusion.

Soil conservation planning requires maps indicating both the distribution and magnitude of actual erosion. This information is however not available therefore erosion hazard maps are in many places used as locating soil areas where particular attention is needed to prevent potential erosion damage. Soil erosion hazard maps must however be viewed with caution since there may be a disparity with the actual erosion when determined.

The major factors determining soil erosion are climate - through erosivity, soil-through erodibility, topography through slope length and angle and vegetal cover. The combination of rainfall erosivity, soil erodibility and topography represent the potential erodibility of a site. These factors are fairly stable and were used in this erosion hazard assessment for Kenya.

Materials and methods

The erosion hazard map of Kenya presented in this paper was produced based on the land evaluation methods of rating different land qualities. In this case the land quality 'resistance to erosion' was assessed.

The different factors affecting erosion were each considered separately and a final rating derived from their combinations.

The factors analysed included climate, slope and soils. Cover was not analysed due to unavailability of the data to the authors. However by definition erosion hazard excludes cover and management aspects of land use (Dregne 1989).

Climate Factor

In assessing the climate factor, the amount of rainfall and peak intensity of rainfall are the two most important characteristics of a rainstorm that affect its erosivity (Foster, 1988). For this study, the erosivity of the rainstorms were based on the longterm average annual rainfall. This follows results by Fournier (1962) who found that catchment sediment yields were closely related to the index p^2/P where P is the mean annual rainfall and p the maximum mean monthly rainfall. This index was found to combine factors of rainfall energy with those of ground cover since it covers the seasonal variations of the rainfall. It therefore gives a good indication of the relative erosion risk. Rowntree (1983) made an assessment of the erosion risk for Kenya using this index and found a good relationship between this index and the total annual rainfall and it's seasonality. Moore (1979) found that there exists a strong relationship between rainstorm erosivity and the agro-climatic zones of Kenya. As a result Gachene and Weeda (1986) based their rating of the land quality 'resistance to erosion' to the agroclimatic zones of Kenya.

The same ratings (Gachene and Weeda, 1986) are used to evaluate the climate factor in this work to produce a final erosion hazard map after summing up the subratings for the different erosion factors.

The rating and the relation with the agro-climatic zones is given in Table 1.

Table 1. Rating of the agro-climatic zones

rating	$KE_{15} > 25$	agro-climatic zone
1	<5000	VI, VII
2	5,000-10,000	III, IV, V
3	>10,000	I, II

The Slope Factor

In order to rate the slope factor, different slope percentages were assigned to different landforms and landscapes occurring in Kenya. Table 2 gives the slope percentages of the different landscapes in Kenya.

Table 2. Classification of the landform types in Kenya

landform	slope (%)
Mountains	>30%
Hills and minor scarps	>16%
Dissected footridges	15-20%
Dunes	10-15%
Uplands	5-8%
Plateaus	<8%
Footslopes	5.8%
Plains	0-2%
Floodplain	0-2%

Source: Kenya Soil Survey Staff, Internal communication No. 17, (1978)

A fixed slope length of more than 200m in different landforms units was assumed to be representative due to the working scale of the map. The different slope ratings used for assessing the slope factor are give in Table 3.

Table 3. Ratings for the slope factors

rating	slope (%)
1	0-3
2	3-5
4	5-8
6	8-16
10	16-30
12	>30

The soil Factor

In rating the soil factor, different soil characteristics were subrated according to their severity and a final rating obtained from the summation of the sub-ratings. This follows the subratings tested by Gachene and Weeda (1986) and found to apply favourably in the Iuni Catchment Area.

The soil characteristics used are limited to the top 30cm, except where the subsoil was found to be sodic. In such cases the final soil rating was downgraded by one unit.

The information used was obtained from field and laboratory data available at the Kenya Soil Survey from exploratory, reconnaissance and other soil surveys. The characteristics rated included soil organic matter contents, bulk density, silt/clay ration and the flocculation index.

Following are the subratings and final ratings of the soil factor.

r_1	organic	matter
rating	% OM or	% C
1	>5	>3.0
2	2-5	1.2-3.0
3	<2	

r_2	Bulk density (g/cm^3)
1	<1.20
2	1.20-1.50
3	>1.50

r_3	silt/clay ratio (hydrometer method)
1	<0.20
2	0.20-0.59
3	0.60-1.00
4	>1.00

r_4	Flocculation index*
1	>70%
2	40-70%
4	10-39%
6	>10

* Flocculation index = (1 -% natural clay/% total clay) where total clay is obtained by using a dispersing agent, and natural clay determined without the use of dispersing agents

The overall soil factor classification is as follows:

Soil factor	rating	sum subratings ($r_1 + r_2 + r_3 + r_4$)
1	high	<g
2	medium	10=14
3	low	>15

Final rating "resistance to erosion"

The final rating "resistance to erosion" was obtained by the summation of the subratings shown by the individual factors climate, slope and soil. These final ratings are classified as follows:

Final rating	(class)	sum factors
1	very slight	4
2	slight	5-6
3	moderate	7-9
4	severe	10-14
5	very severe	15-18

The final ratings were then plotted on the exploratory soil map of Kenya following the soil, physiographic and agro-climatic zone boundaries to give an Exploratory Erosion Hazard Map of Kenya.

Magnitude and distribution of hazard

The magnitude and distribution of the erosion hazard in shown on the exploratory erosion hazard map of Kenya. The hazard is grouped into five classes ranging from 1 -very slight hazard to class 5 -very severe hazard.

CLASS 1 - VERY SLIGHT HAZARD

The area falling within class 1 of hazard is about 253,900km^2 which approximates to 43% of Kenya. These are plain and floodplain landscapes in North Eastern, Eastern Coast and small parts of the Rift Valley Provinces. The plains are characterized by very gentle slopes, low rainfall erosivity (in arid zones) and moderate soil erodibility hence the very slight erosion hazard.

CLASS 2 - SLIGHT HAZARD

This hazard class covers about 51,600km^2 which is only 8% of Kenya. This hazard class mainly covers dissected plains of gentle slopes along Athi and Tana rivers, coastal plains and uplands of Kwale and Kilifi Districts, Kajiado district and North-Western Kenya. The rainfall erosivity is low while soil erodibility is low to medium.

CLASS 3 - MODERATE HAZARD

The hazard class 3 covers about 140,100km^2 approximating to 24% of Kenya. The humid to semi-arid uplands east and west of the Rift Valley fall under this class. Other areas under this class include parts of Rift Valley, Mandera, Laikipia, Samburu and the coastal belt. There is a wide variation of erosivity and erodibility within this class but the main determinant factor is slopes.

CLASS 4 - SEVERE HAZARD

The lower footlslopes of major mountains and mountain ranges falls under this class of hazard. It covers about 56,500km^2 which approximate to 10% of Kenya. Some Wadis along Tana River and coastal uplands on shales also fall under this class. In the footslopes slopes are steep, rainfall erosivity is high but the soil erodibility is very low. In the Wadis and along the coastal uplands are gentle and erosivity low but the erodibility is high.

CLASS 5 - VERY SEVERE HAZARD

This class covers about 22,100km^2 which is approximately 4% of Kenya. Areas under this class are mountains and Ranges. High volcanic covers within the Rift Valley are also included in this class. These areas are characterized by very steep slopes, high rainfall erosivity but very low soil erodibility.

)N-HAZARD AREAS

Areas of lava flows covering approximately 11% of Kenya are onsidered non-hazard. areas. These lava flows are extensive orthern Kenya and the Chulu Hills in Kajiado District.

Comparative analysis

An erosion hazard map is of no absolute value if not accompanied by actual erosion determinations of some parts covered in the ap.

In Kenya, catchment soil loss studies have been carried out in he upper Tana and Aberdares (Dunne and Ongwenyi loc.cit., ngwenyi .loc.cit) Table 4, and the Athi River (Wain, loc.cit) Table 5. These studies form a good reference base for the Exploratory soil erosion hazard map of Kenya as presented below.

Table 4. Suspended sediments from sub-catchments in Upper Tana and Aberdares (dunne and Ongwenyi, 1976)

atchment	Average field sediment $t/km^2/yr$	Sediment yield from cultivated land t/km/yr	
	1956-1970	1956-1970	1970-1977
athioya	886	3036	4706
Maragua	1356	1684	2610
'hika	447	507	786
Chania	369	719	1114
Jpper Sagana	415*	793	1229*

* based on 1960-1970 river flow data

Table 5. Suspended Sediment in the Upper, Middle and Lower Athi River Catchment. (Wain, 1983)

Catchment	average yield $t/km^2/yr$	$t/km^2/yr$	$t/km^2/yr$
	1957-1979	1980	1981
Munyu	118	40	156
Mavindini	636	186	657
Thwake	1265	362	1265
Galana	266	-	-

The soil loss from the sub catchments Mathioya, Maragua, Thika, Upper Sagana and Munyu of classes 4 and 5. Mavindini and Thwake catchments in Machakos district are representative of class 3. The average soil loss determination in the Galana at Lugard falls, is 266 t/km^2/yr which is significantly lower than the Thwake and Mavindini catchment. This implies that down the Galana river there is less soil loss. This is in good agreement with the Exploratory erosion hazard map.

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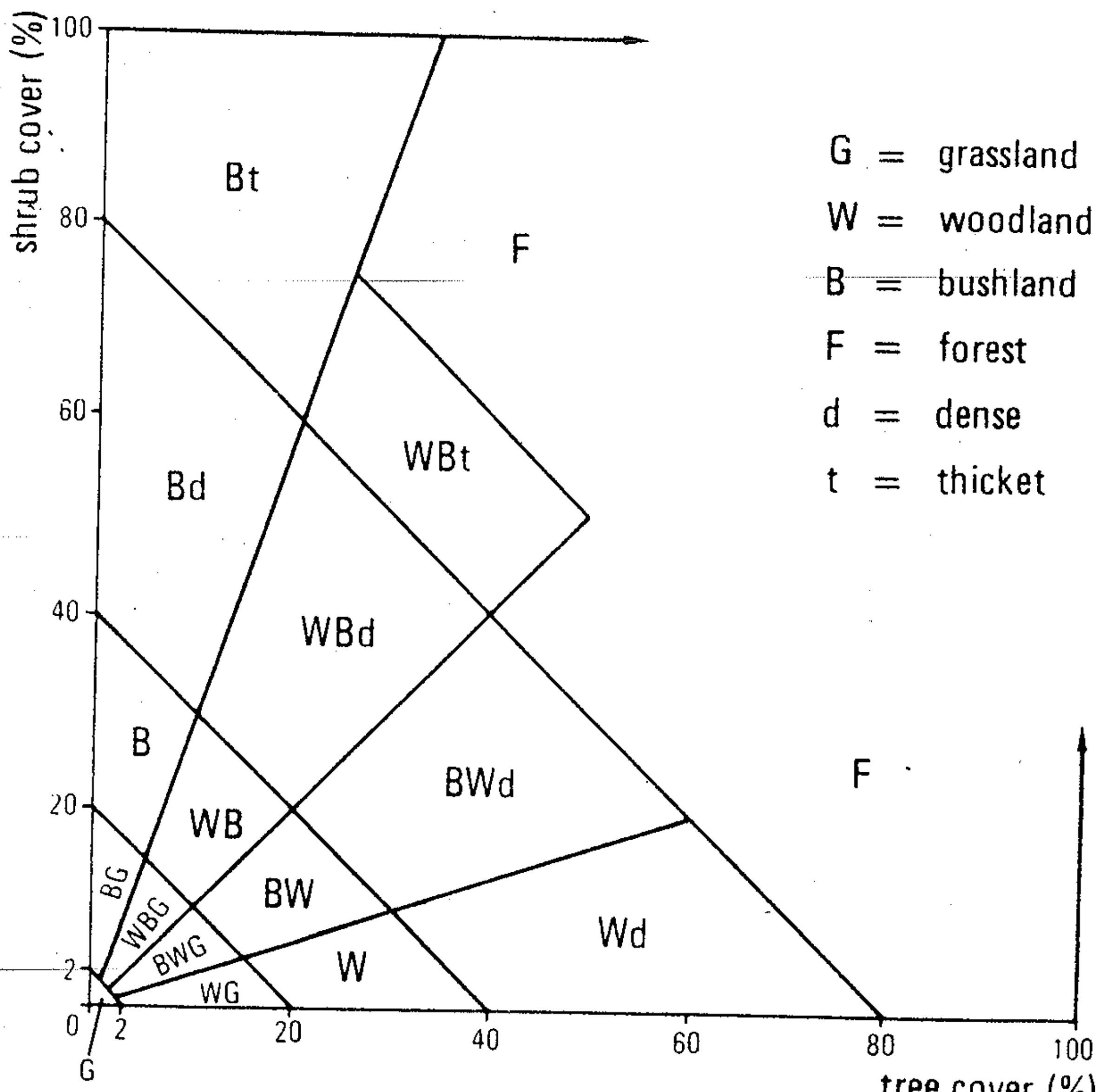
FIG. 2. KEY TO PHYSIOGNOMIC CLASSES



Example: 5% tree cover and 25% shrub cover = Bushland (B)