Soil Erosion Hazards in Kieni Division, Kenya

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1. Abstract

Soil erosion was found to be localized in some parts of the Kieni area. In order to explain this phenomenon the following three relevant land qualities were rated; soil susceptibility to erosion, soil resistance to erosion and vegetation regeneration possibilities.

It was found that soil susceptibility to erosion was the best land quality for explaining the current soil erosion status. This is first and foremost because the study area is characterized by very steep and long slopes. Secondly, soil erosion is aggravated by very high rainfall intensities associated with Agroclimatic zones I to III. Hence severe soil erosion takes place whenever the vegetation cover has been affected by clearing or overgrazing.

It is recommended that the vegetation cover should be maintained in order to avoid soil erosion. However in areas where cultivation is inevitable, then strict soil conservation measures should be taken. Tourists and mountain climbers have also caused erosion along mountain paths especially on Mt. Kenya. Such paths should be properly.

2. Introduction

2.1 Soil Erosion Hazard Mapping in Kenya

For most areas of Kenya soil loss cannot be predicted using parametric equations such as the universal soil loss equation (USLE) because soil erodibility (K) data are not available for most of the soils (Wamicha, 1991). In order to overcome this, several land characteristics were rated and used to map soil erosion hazard in the Upper Migori area of Kenya (Mungai and Wamicha, 1985). Erosion hazard was judged on the basis of: soil susceptibility to erosion, soil resistance to erosion and vegetation regeneration possibilities. Land qualities (LQs) were determined following the FAO (1984) guidelines. The three land qualities after rating have been tested qualitatively and found to be appropriate for soil erosion hazard mapping (Wamicha, 1991, Wamicha, *et al*, 1993). Quantitative testing has also been carried out by correlating the ratings with the amounts of eroded soil deposited in Gerlach Troughs (Mutisya and Wamicha, 1996).
The specific objectives of this study were therefore to: (i) map soil erosion hazard using the Kieni area as a case study and (ii) give recommendations on the soil conservation measures that should be taken.

3. Environmental Background of Kieni

3.1 Location of the Study Area

The study area is administratively called Kieni Division of Nyeri District in Kenya. It lies within the longitudes of 36°40" East to 37°20" East. The northernmost point of Kieni Division just touches the Equator (0°) and then extends to 0°30" South. This is an "intermontane" division since it lies between Mt. Kenya to the east and Nyandarua (Aberdare) ridges to the west (Fig.1). To the north is the Laikipia District while to the south are Mathira (East) and Tetu (West) Divisions of Nyeri District.

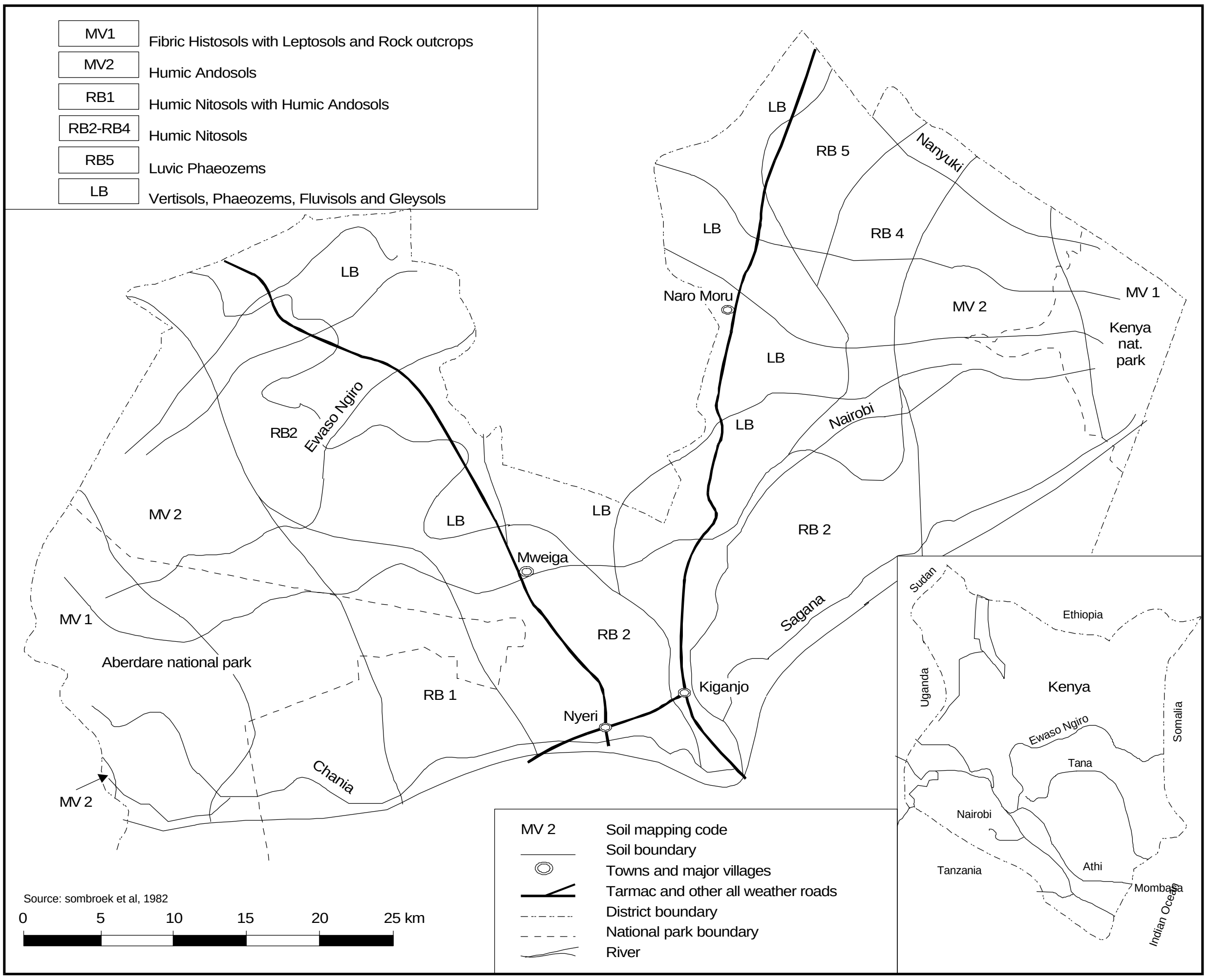

Figure 1. Soils and Topographic Units of the Kieni Division, Nyeri District.

3.2 Geology

The physical features of the area are mainly conditioned by the fact that volcanic lava flows originated from two major sources namely Mt. Kenya and the Nyandarua ridges. The oldest of these are Miocene (10 to 30 million years old) phonolitic, trachytic and basaltic lavas found to the west underneath the Nyandarua ridges (MERD, 1987). Mount Kenya, to the east, is underlain by Quaternary (less than 2 million years old) trachytic and basaltic lavas. These Mt. Kenya and Nyandarua volcanic lava flows meet in the middle of Kieni Division along the Kiganjo-Naru Moru axis. In addition the lavas are covered by different strata of volcanic ashes, pyroclastics and fluvial-lacustrine sediments all of which are of variable ages.

3.3 Altitudes and Climate

In terms of altitude Kiganjo (1830m) is the lowest area, from where the land rises northwards to the Equator at Nanyuki (2300m), eastwards to Mt. Kenya (>4000m) and westwards to Nyandarua (>3000m) above sea level (Fig.1). These altitudes are believed to affect the amounts of rainfall received in a given locality, for example Kiganjo receives about 850mm per annum. This then rises eastwards to 2300mm at Kabaru on the slopes of Mt. Kenya and westwards to 3100mm in the Abadare National Park (Wamicha, 1993). Hence the driest areas are Kiganjo and Naru Moru that are within Agroclimatic zones (V) and (VI) respectively (Table 1). Conversely the mountains (Kenya and Nyandrua) within zone (I) are the wettest.

3.4 Land Use Types

Jaetzhold and Schmidt (1982) classified the area into four main Agro-ecological zones namely; Tropical-Alpine, Upper Highlands, Lower Highlands and Upper Midlands. Due to the very high altitudes, very low temperatures, very steep slopes, bare rocks and its aesthetic value, the Tropical-alpine zone has been designated as a conservation area (Wamicha, 1993). The Upper Highlands comprise of the following sub-zones; Forest, Sheep-Dairy, Pyrethrum-Wheat, and Wheat-Barley (Jaetzhold and Schmidt, *ibid*). These authors further separated the sub-zones of the Lower highlands as Tea-Dairy, Maize-Pyrethrum, Dairy cattle-Sheep and Ranching. Finally the Upper Midlands were separated into Coffee-Tea, Main Coffee, Marginal Coffee and Sunflower-Maize sub-zones. It should be noted that these Agroecological zones are mainly based on climatic data with limited considerations of the soil conditions, hence hardly any coffee and tea are grown in Kieni (Wamicha, 1993).

4. Methods and Materials

4.1 Topographic and Soil Field Descriptions

The FAO (1977) and Kenya Soil Survey Staff (1987) guidelines were used to describe slope parameters and soil conditions in the field (Table 1).

4.2 Soil Chemical and Physical Analyses

The soil texture, bulk density, organic carbon, CEC and bases were analyzed as outlined by Hinga, *et al* (1980).

4.3 Vegetation and Agroclimatic Zones

The Braun-Blanquet (1964) methods of vegetation classification were followed. The Agroclimatic zones (Table 1) were separated using the annual rainfall to evaporation ($^r/E_o\%$) ratios as outlined by Sombroek, *et al* (1982).

4.4 Rating of the Land Qualities (LQs)

First the soil susceptibility to erosion was rated using the slope parameters (length and steepness), vegetation cover and Agroclimatic zones (Table 2). Secondly the amount of organic carbon, silt to clay ratios, bulk density and the exchangeable sodium percentage were the land characteristics used for rating the soil resistance to erosion (Table 3). Finally the vegetation regeneration possibilities was rated by the use of soil fertility capability (Cation exchange capacity, Base saturation% and the % organic carbon) together with the Agroclimatic zones (Table 4).

Table 1. Land Characteristics

Mu	MV1	MV2	RB1	LB	RB2	RB4	RB5
1	I	I	II	V	II-IV	II	III
2	>15	5-12	5-12	2-5	5-8	10-12	10-12
3	80-100	100-150	100-120	50-100	100-150	20-100	20-50
4	Moor	Forest	Cult.	Grass	Grass	Thicket	Thicket
5	33	3.66	2.88	2.0	2.19	2.63	3.1
6	1.42	0.81	0.26	2.28	0.75	0.2	0.4
7	0.93	0.71	1.13	1.29	1.05	1.32	1.27
8	31.51	26.90	18.0	13.0	20.0	28.2	27.1
9	41	39	37	75	80	80	100
10	2.3	0.2	0.3	10.1	9.5	9.1	3.2

Key: MU=soil mapping units (see Fig.1):
The factors are 1= Agroclimatic zones; 2=Steepness of slope%; 3=Length of slope (m); 4= Vegetation type; 5=% Carbon; 6=Base saturation%; 7=Cation exchange capacity (CEC); 8=Silt to clay ratios; 9=Bulk density; 10=Exchangeable Sodium percent (ESP)
Source: Wamicha, 1993

Table 2. Susceptibility to soil erosion

Slope=r1					Cover=r2	Rate	ACZ
Length(m)	Angle (%)						
	0-2	2-5	5-8	8-16			
<50	1	2	3	3	F	1	VII
50-100	1	3	3	5	WG	2	V-VI
100-200	1	3	5	5	BG	3	III-IV
>200	3	5	5	7	G	4	I-II
Final Rating							
r1+r2+r3		<5	5-7	7-9	9-11	>11	
Rating		1	2	3	4	5	

Key: ACZ=Agroclimatic zones;
F=Forest; WG=Wooded grassland; BG=Bushed grassland; G=grassland and cultivated areas
Source: Wamicha, et al. 1993

Table 3. Soil Resistance to erosion

Subratings				
r	r1=%C	r2=Si/Cl	r3=BD	r4=ESP
1	>3	<0.2	<1.2	<15
2	1-3	0.2-0.4	1.2-1.5	15-40
3	<1	>0.4	>1.5	>40
Final rating				
r1+r2+r3+r4	<5	5-10	10-15	>15
Rating	1	2	3	4

Key: %C=percentage organic carbon; Si/Cl=silt to clay ratios; BD=bulk density;
ESP=exchangeable sodium percentage
Source: Wamicha, 1991

Table 4. Vegetation regeneration possibilities

Subratings					
R	1	2	3	4	5
CEC (r1)	>20	12-20	6-12	3-6	<3
Base saturation (r2)	>80	70-80	60-70	50-60	<50
%Organic carbon (r3)	>5	3-5	2-3	1-2	<1
Agroclimatic zones (r4)	I-II	III	IV	V	VI&VII
Final ratings					
r1+r2+r3+r4	<5	5-10	10-15	>15	
Rating	1	2	3	4	

Source: Wamicha, 1991

5. Results and Discussion

5.1 The Land Qualities

5.1.1 Soil Susceptibility to Erosion

The susceptibility to erosion is very high in the soil mapping units RB1, RB2 and RB4 (Fig. 1; Table 5). These are soil units associated with relatively steep and long slopes, which contribute to the generation of a lot of runoff after rains (Weeda, 1987; Wamicha, 1991). These three soil units are also in Agroclimatic zone (II) which is associated with many rainfall storms of very high intensities resulting in very high rainfall erosivity (Weeda, *ibid*; Wamicha, *ibid*). The vegetative cover of grass is also liable to overgrazing, drying and burning, hence it may not protect the soils especially at the onset of the rainy season resulting in accelerated soil erosion (Wamicha, 1993).

The soils with high susceptibility to erosion are mapping units MV1, MV2 and RB5 (Fig. 1; Table 1, 5). These soils are also characterised by very steep and long slopes together with being in Agroclimatic zones (I to II). As already stated these are environmental conditions that are conducive for the generation of large amounts of runoff as it rains (Weeda, *ibid*, Wamicha, 1991). However these soil mapping units MV1, MV2 and RB5 are characterised by better vegetation cover of moorland, forest and thicket respectively (Table 1) and some parts are protected forests and/or National Parks (Fig.1; Wamicha, 1993).

The only soil mapping unit with moderate susceptibility to erosion is LB in the plateaus (Fig. 1; Table 5). This is owing to the fact the unit is relatively flat (slopes of 2 to 5%) compared with all the other units (Table 1, 5). Less runoff is also expected in this driest part (Agroclimtic zones IV and V) of Kieni (Table 1).

Table 5. Ratings of the soil susceptibility to erosion

Mapping Unit	MV1	MV2	RB1	RB2	RB4	RB5	LB
Slope (r1)	3	5	5	5	5	5	3
Cover (r2)	3	1	4	4	2	2	4
ACZ (r3)	4	4	4	3	4	3	2
r1+r2+r3	10	10	13	12	11	10	9
R	4	4	5	5	5	4	4
Class	High		Very high			High	Moderate

5.1.2 Soil Resistance to Erosion

All the soil types are characterized by good resistance to erosion (Table 6). This rating is also used as an indicator of the soil structural stability (Wamicha, 1991), which in this case is also good. Physical soil conservation structures (bench terraces, cut-off drains, etc) can therefore be constructed in most of the Kieni Division without the danger of collapsing. However on some of the ridge tops there are the dark coloured Planosols which are of low structural stability (Wamicha, 1993).

Table 6. Ratings of the soil resistance to erosion

Mapping Unit	MV1	MV2	RB1	RB2	RB4	RB5	LB
%C (r1)	1	3	2	2	2	2	2
Si/Cl (r2)	3	1	2	3	2	2	3
BD (r3)	1	1	1	1	2	2	2
ESP (r4)	1	1	1	1	1	1	1
r1+r2+r3+r4	6	6	6	7	7	7	8
Rr	2	2	2	2	2	2	2
Class	Good						

5.1.3 Vegetation Regeneration Possibilities

The vegetation regeneration possibilities are moderate to good (Table 7). This is because the soils are characterised by high fertility capability and most of the area is in Agroclimatic zones (I to II) which are humid to sub-humid (Table 1,4). The vegetation regeneration possibilities indicate that biological methods of soil conservation, like Agroforestry and Grass strips, can be applied in the whole of Kieni (Wamicha, 1991; Wamicha, *et al*, 1993).

5.1.4 Current Soil Erosion Status

Localised accelerated soil erosion has taken place first in areas where vegetation has been cleared either through cutting (burning) and/or overgrazing. Secondly there are also areas where the volcanic ash is mined as building sand. Finally along the mountain paths used by tourists and other climbers. Commonly therefore all these highly eroded localities have had vegetation cover removed in one way or another. Since the study area is characterised by moderate to very high soil susceptibility to erosion (Table 5) any removal of the vegetation cover results in high rates of soil erosion.

Table 7. Ratings of the soil vegetation regeneration possibilities

Mapping Unit	MV1	MV2	RB1	RB2	RB4	RB5	LB
CEC (r1)	1	1	2	2	1	1	2
Base Saturation% (r2)	5	5	5	2	2	1	2
% Organic Carbon	1	2	3	3	3	2	4
ACZ	1	1	1	3	1	2	4
r1+r2+r3+r4	8	9	11	10	7	6	12
R	2	2	3	2	2	2	3
Class	**Good**		Moderate	Good			

6. Conclusions and Recommendations

Since the Kieni Division is an area with relatively high soil susceptibility to erosion, severe soil erosion has occurred in localities where vegetation cover has been cleared. It is therefore necessary to maintain the natural vegetation cover. However in areas where clearing must be carried out, soil conservation measures must be taken whereby both physical and biological methods have been found to be possible. On Mt. Kenya, it is necessary to plan the mountain footpaths to avoid soil losses through erosion and hence maintain the aesthetic value of the mountain.

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