The WINAND STARING CENTRE for Integrated Land, Soil and Water Research

Landforms and soils of Samburu District, Kenya

A site evaluation for rangeland use

L. Touber

Report 6

Netherlands), 1989

Landforms and Soils of Samburu District, Kenya

Survey carried out for:

The Water Resources Assessment and Planning Project (WRAP), TNO, The Netherlands, and the Ministry of Water Development, Nairobi, Kenya.

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ABSTRACT

Touber, L., 1989. Landforms and Soils of Samburu District. A site evaluation for rangeland use. Wageningen (The Netherlands), the Winand Staring Centre. Report 6, 50 p.; 7 figs,; 3 tables; 1 map; 3 Annexes.

Within the framework of the Range Management Handbook Project, Kenya, an inventory of landforms and soils at 1 : 1 000 000 scale of Samburu District has been carried out. It concerns a site evaluation for rangeland uses which is based on a limited amount of field observations, and relies heavily on visual interpretation of satellite imagery.

The physical data of landforms and soils are interpreted for aspects of primary production (fertility and soil-water relationships) and for managements aspects (erosion status and hazard); accessibility for livestock; flooding hazard; possibilities for construction of dams and waterpans.

Annex I deals with the organizational and logistic aspects.

Keywords: Kenya, Samburu District, Landforms, Soils, Range Management

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IN FOLDER:

Map and legend sheet: "Landforms and Soils of Samburu District" at scale 1:500 000

Figures

1 INTRODUCTION

For the realisation of a water development plan for Samburu District, Kenya, the Water Resources Assessment and Planning Project (WRAP), T.N.O., requested the Range Management Handbook Project (RMHP) for information regarding the potential of rangeland in that District.

The Range Management Handbook Project is a collaboration project between the Ministry of Livestock Development of Kenya and the German Organisation for Technical Cooperation (GTZ). It aims at the inventory of the potential for extensive rangeland use of the dry Northern and Northeastern regions of Kenya, through studies on climate, landforms, vegetation, soils and hydrological and socio-economic aspects.

It is the purpose to present the results of these inventories per District in the form of 1 : 1 million scale maps and their interpretation. Maps and reports should be easily intelligable to staff of the extension services and planning division of the Ministry of Livestock Development.

The Winand Staring Centre for Integrated Land, Soil and Water Research*) already participated in the inventory of landforms and soils of Marsabit and Wajir Districts. The present report deals with the landforms and soils of Samburu District, scheduled earlier than originally planned in the Range Management Handbook Project, at the request of the Water Resources Assessment and planning Project (WRAP) of the Ministry of Water Development. As was the case with former district surveys, the present one is based on satellite image interpretation and a restricted amount of field observations. The relatively small size of the Samburu District called for the production of a 1 : 500 000 scale map. This is for presentation purposes only. The survey intensity does not justify a publication scale, larger than 1 : 1 000 000, as is the case with the former surveys. Field checks were directed towards the assessment of range potential rather than towards the execution of a conventional "multi-purpose" soil survey. Hence it is preferred to use the term "Site evaluation for rangeland use" as subtitle for these land inventories.

Acknowledgements are contained in the mission report, Annex I.

*) Continuing the research of the former Soil Survey Institute (STIBOKA).

2 METHODS

2.1 General

Survey methods have been described in a separate volume, dealing with the general approach to small-scale inventories of soil and vegetation resources in the context of the Range Management Handbook Project (Touber, 1988). Aspects of this methodology, as far as specific for the present survey, will only be dealt with here.

2.2 Materials

All existing previous studies concerning the area were consulted as much as possible during the interpretation of satellite imagery. These comprise mainly the Exploratory Soil Map of Kenya (Sombroek et al., 1982) and all available geological maps and reports. The literature list (p. 35) contains these publications.

During preparation of the field surveys, much emphasis was given to interpretation of remote sensing material. Use was made of 1 : 500 000 scale prints of Landsat images taken during the dry season of 1976. The more recent images (thematic mapper) have a higher resolution so that roads and tracks can be discerned. This facilitates the planning and identification of field observation points greatly, hence TM images are preferred, if available.

2.3 Survey activities

Field survey was conducted from May 18th to June 10th 1988, continuously. Two aerial reconnaissance flights were made at May 25th and June 9th for viewing the larger inaccessible areas.

The number of actual field survey days that were spent on field data gathering amounts to twenty two. A total of 124 observation points were established, at which points both the soil surveyor and the vegetation scientist recorded their data simultaneously.

Apart from recording field data at these points, vegetation and soils were viewed while travelling between points. Fig. 2.1 gives the locations and reliability diagram. It may be clear that not all landform/soil/vegetation types have been covered by field visits as one would judge necessary for a 100% reliable description. This is however inherent to the scale at which the Project operates, and not in conflict with the planned projects output, which calls for a general overview of the natural resources of each District.

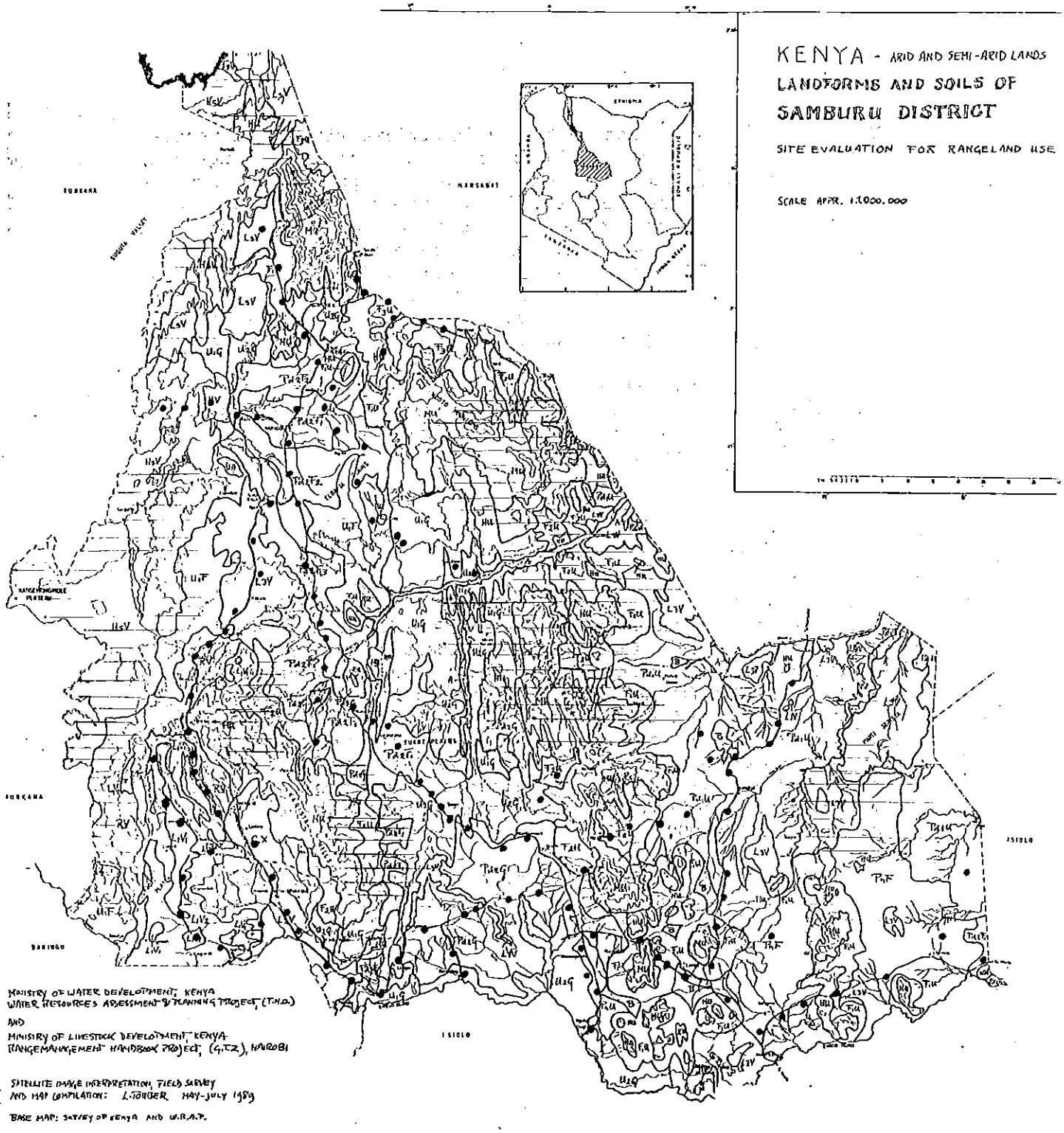

fig. 1 LOCATION OF OBSERVATION POINTS AND DISTRIBUTION OF RELIABILITY

- OBSERVATION POINT

AREA WITH COMPARATIVELY LOW DENSITY OF FIELD DATA

The vegetation scientist initiated interviews with local people, knowledgeable as to the performance of the habitat as rangeland, and as to plant species. Similar to the approach during the earlier Wajir District Survey, it was attempted also in Samburu District to include vernacular soil names in the obtained information. These names denominate rangeland habitats rather than mere soil types, and contain information regarding preferences of livestock and constraints to pastoralism during the various seasons. This type of data is obviously very valuable for the evaluation of soil and vegetation data for rangeland use.

In the present case these attempts have been largely unsuccessful: the majority of terms obtained proved to indicate localities (e.g.: "rocks where the pump broke down" or "area where many cattle died") rather than landscape types.

2.4 Map and report preparation

Map and legend have been prepared according to the standard procedure as described in volume I of the Range Management Handbook (Touber, 1988). The 1 : 500 000 scale satellite image interpretation map has been corrected and amended according to the field data. The final basic document is a landforms and soils map at scale 1 : 500 000. All further information contained in the present report is based on this map. Ozalith prints of this map are available on request from the Kenya Soil Survey at NAL and/or the Range Management Handbook Project, GTZ, Nairobi. The final map for the Handbook will be a simplified, reduced version at scale 1 : 1 000 000.

In contrast to previous surveys, attention is paid here to the obvious and omnipresent "status of erosion", more than the rather speculative landquality "erosion hazard".

3 SURVEY RESULTS

3.1 Summary of landforms, rocktypes and soils

Samburu District is characterized by strongly contrasting landforms at various altitudes and of very different rock types. As a consequence the variation in climate, soil and vegetation types is also wide. An attempt is made here to give a brief description of the landscape features in a sequence from "high" to "low" and "old" to "young".

Most prominent is the NNW-SSE-stretching range of mountains and hills that dominate the North and Central/Eastern part of the District. It is formed by the Nyiru Range, Ndoto Mountains and Matthews Range. A similar range is formed by the Karisia Hills near Maralal. All consist of Precambrian Basement system rocks (mainly gneisses and granites) (mapping unit 1 : MU). Most of this unit is covered by forests, that are degraded to a greater or lesser extent. Soils vary with altitude and steepness of the terrain. Thick humus rich topsoils over deeply weathered rock are thought to be common at higher altitudes, where the forest has not been removed.

The Mountains and Hills are surrounded by long, straight, sedimentary footslopes (mapping units 10-12 : FU). These have deep, well drained sandy loam soils in the upslope parts, merging towards sandy clay textures downslope. Footslopes are subject to widespread gully erosion, often of dramatic dimensions. This is due to the pastoralists preference to establish manyatta's at the upslope side of footslopes.

Apart from the Mountains, Hills and Footslopes, the main topography consists of lesser to stronger undulating Plains and Uplands (also developed on Basement System rocks), that gradually rise from 700 m (2200 ft) in the East to 1300 m (4500 ft) in the Northwest and 2500 m (8000 ft) in the Southwest, when reaching the upper edge of the Rift Valley escarpment.

The Uplands (mapping units 13-15: U1G-U2G) are formed by a network of deeply incised valleys of tributaries to the Seya, Milgis and Ewaso Ngiro rivers. The resulting topography of short, moderate to steep slopes is under attack of sheet erosion, so that shallow, gravelly and stony soils prevail.

The less dissected Peneplains (mapping units 17-23: Pn and Pd) bear deeper, sandy clay loam soils, which in some areas are also heavily degraded by sheet erosion.

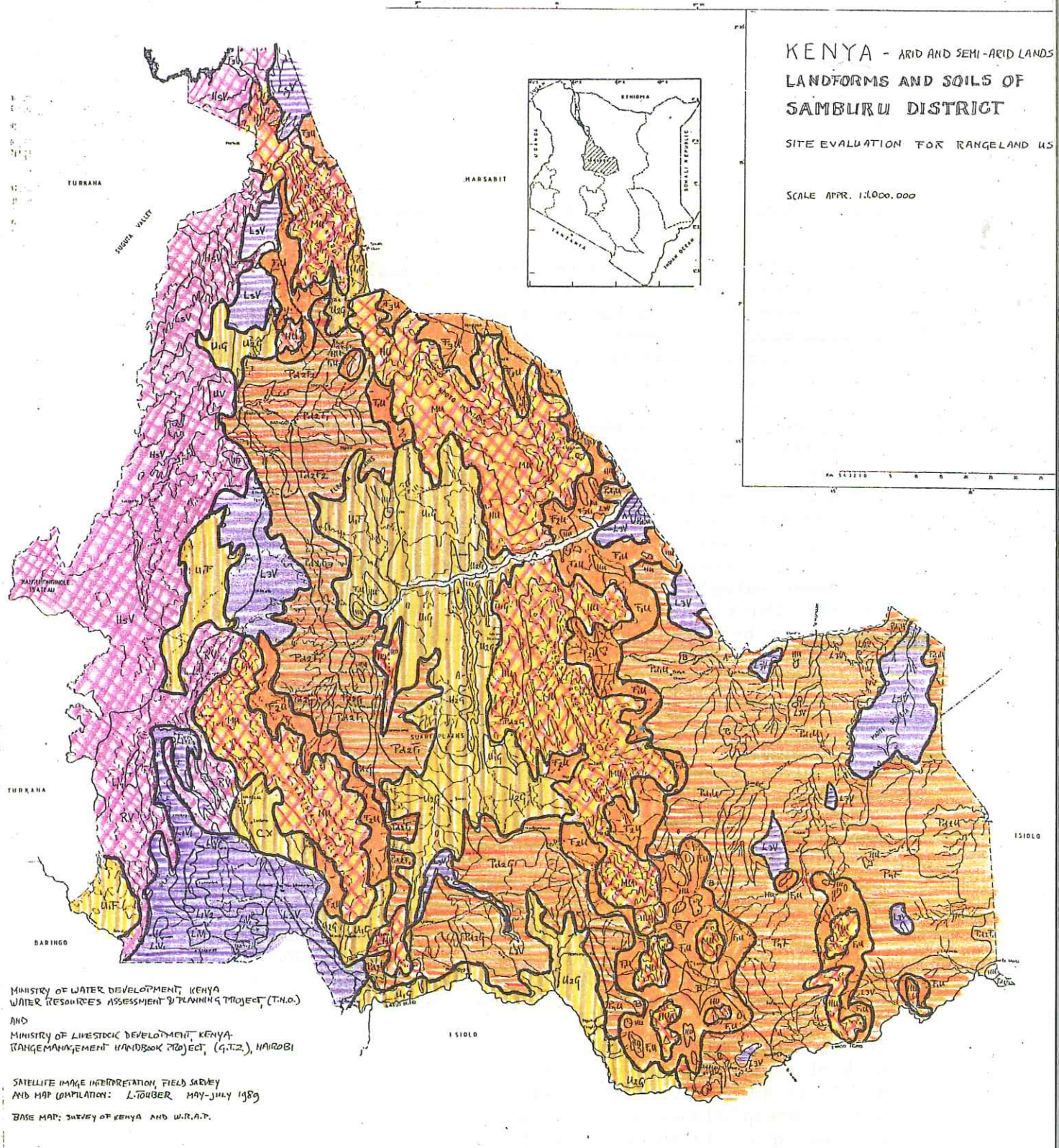

fig. 2 SUMMARY OF LANDFORMS, GEOLOGY AND SOILS

- MOUNTAINS AND HILLS; PRECAMBRIAN BASEMENT SYSTEM ROCKS
- FOOTSLOPES
- UPLANDS, DEVELOPED ON BASEMENT SYSTEM ROCKS
- PLAINS, DEVELOPED ON BASEMENT SYSTEM ROCKS
- RIFT VALLEY ESCARPMENT; PLEISTOCENE VOLCANIC ROCKS
- PLATEAUS; PLEISTOCENE VOLCANIC ROCKS.

The whole western edge of Samburu District is marked by the spectacular Rift Valley escarpment. It stretches from north of Tum, near Lake Turkana to West of Suguta Marmar. It is built up of Pleistocene volcanic Plateaus that have been broken and tilted ("step-faulted") by the movements of the earth's crust during the Rift Valley formation. It concerns a 20-30 km wide strip of stepfaulted hills and plateaus, volcanic footridges and uplands (mappung units 3, 4, 9 and 16: HsV, RV, LsV and UV). These landforms are generally marked by flat and sloping plateau tops and precipitous scarps and gorges. Inaccessibility is a major constraint to the use of this land. Soils are mostly very rocky and stony in the steeper parts, while gravelly clays are common on the flat-topped plateau remnants.

Volcanic Plateaus (LV) are also common, along the Rift Valley, as well as in the East of the District. They are almost flat to very gently undulating surfaces, their edges being marked by a rocky and bouldery minor escarpment. Three types have been identified, separated largely on the basis of the altitude at which they occur (mapping units 5-8: LV). At the highest levels (the Lherogi plateau) imperfectly drained shallow clay loams with ironstone gravel are characteristic; at the lowest levels (under much drier climatic conditions) stony and bouldery clay soils prevail.

3.2 Evaluation of soil properties relevant to primary production and range management aspects

3.2.1 General

Methods of data gathering and interpretation is contained in volume I of the Range Management Handbook (Touber, 1988). The system followed is based on the Framework for Land Evaluation (FAO, 1976). This Framework was, among others, discussed by Zonneveld (1984) as to its applicability for extensive grazing.

Within a given climatic zone the availability of soil moisture and of nutrients are the land qualities that have a prevailing influence the primary production of rangelands. Land qualities that are related to aspects of management, are erosion hazard, accessibility for livestock and possibilities for the construction of pans and dams.

In reality more parameters are of influence of course, but data on these were not obtainable in the context of the present site evaluation, or are judged of less importance in Samburu District. The landqualities are rated in the following sections, in order to establish a comparison among the various mapping units identified. The figures given do not pretend to have any absolute value or quantitative connotation.

3.2.2 Soil moisture availability

Soil moisture availability depends on the course of the rainfall/ evaporation ratio through the seasons; the infiltration capacity of the surface soil; the water holding capacity of the soil material and the depth of the rooting zone.

Infiltration capacity depends on the porosity of the surface soil, which in turn is influenced by such parameters as vegetation cover, soil texture, soil structure and organic matter content. Important is that the surface soil is not "sealed". This is the case on "overutilized" soils, where due to too frequent grazing and trampling the vegetation cover, the organic matter content and hence structure stability and porosity have diminished. A low infiltration capacity causes (part of) the rainwater to run off along the surface. This water will not become available to the vegetation on the soil where the rain falls.

Water holding capacity is estimated according to its connection with the soil texture (see separate volume on methodology). The depth of the rooting zone may be limited by shallow rocks or an abrupt change in texture or a change in chemical composition, such as a strong increase with depth in salinity or sodicity.

Table 1 gives a comparison among the mapping units concerning effective soil dept, available water capacity and eventual run-off losses. A combination of these is given as "final rating", of soil moisture availability in a separate column. These ratings are expressed on the map of figure 3.

Constraints to the productivity of standing crop in grazing land due to limited soil moisture availability are found on shallow stony soils.
These concern mostly the Hills (mapping unit 2: HU) and steep components of the Rift Valley escarpment (mapping unit 3: HsV). Also the Uplands (mapping units 13-16: U1G, U1F, U2G and UV) score low, mainly due to shallowness of the soil.

Dissected Plains (most of the Pd-units) are rated low as well, mainly due to low infiltration capacity, causing run-off losses.

A good performance is expected on the Plains in the Southeast, the Lherogi plateau, the El Barta Plains, and the Footslopes, as far as these are not affected by erosion (mapping units 5: L1V1; 10 and 11: FU; 20: Pd2F2; 22: PnF and 23; PnU).

3.2.3 Soil chemical fertility

In addition to rainfall and water holding capacity, the productivity of soils depends on their chemical richness.

Table 1 Ratings of soil characteristics, relevant to productive capacity of rangelands.

Unit No.	Mapping Unit	Effective soil depth 1: v. deep 5: v. shallow	Available water capacity 1: v. high 5: v. low	Run-off losses 1: negligible 5: v. high	Final rating soil moisture availability 1: high 5: low	Rating relative chemical fertility 1: v. high 5: v. low
1	MU	1-5	2-4	1-3	2-4	2-1
2	HU	3-5	3-5	3-5	4-5	2-3
3	HsV	5	2	3	4	2
4	RV	3-5	2-4	2-4	2-5	3
5	L1V1	4	2-1	1	2	2
6	L1V2	3	2	3	3	3
7	L2V	3	2	2	3	2
8	L3V	4	3	2	3	3
9	LsV	4(3)	2	2	3	3
10	F1U	1	3	2/5	2/4	2/4
11	F2U	1/4	2	2/4	1/4	1/3
12	F3U	2	2	4-5	4	2
13	U1G	5	3	4	5	4
14	U1F	5	1	3	4	1
15	U2G	4	3	5	5	4
16	UV	5	2	3	3-4	2-3
17	Pd1U	3	4	4	4	3
18	Pd2G	2-3	3	4-5	4	4-5
19	Pd2F1	2	2	4-5	4	4-3
20	Pd2F2	3	2	2	2	2-1
21	Pd2F3	4	2-3	2	3	2-1
22	PnF	2	2	2	2	4
23	PnU	1	3	1	1	4
24	A	1	4	1	2	1
25	B	2	3-5	1	2(-1)	2
26	CX	2	3	4	3	3

Note: soil moisture availability = climate (rainfall, evaporation), infiltration + waterholding capacity

water holding capacity = effective soil depth + available water capacity

available water capacity = property of soil material (pF2-pF4.2), mainly texture, organic matter and porosity/structure

Note [1] If the ratings for effective soil depth and run-off losses both score unfavourable, i.e. 4 or 5, the final rating is downgraded. Loss of rainwater due to run-off has been given most weight in the final rating; AWC least.

[2] Soil moisture availability according to soil properties only. Climate is not taken into account.

The mapping units have been rated according to the content of "dark minerals" (ferromagnesian minerals) of the rock type on which the soils have developed, as well as to the amount of "primary weatherable minerals" observed in the soil profile*).

*) Laboratory analyses of top soil fertility samples were not yet available at the time of report writing.

The latter parameter depends on the "age" of the soil mantle, i.e. on how intensive or for how long minerals have been weathered and leached out of the soil.

Table 1, last coloumn, lists the ratings of chemical fertility. They are expressed on the map of figure 4.
Generally speaking, the more shallow soils in "younger" relief-rich landforms have a higher amount of weatherable primary minerals. These concern the Mountains, Hills and Footslopes. High ratings have been assigned to the Uplands and dissected Peneplains developed on gneisses, rich in ferromagnesian minerals (mapping units 14: U1F; 20 and 21: Pd2F2 and Pd2F3) and in general also to mapping units in volcanic areas. Lower ratings have been given to units developed on granitoid gneisses (mapping units 13, 15 and 18: U1G, U2G and Pd2G) and the "old" landforms (mapping units 22 and 23: PnF and PnU).

Chemical toxicities are not expected to play a significant role. Deeply weathered, strongly leached tropical soils may have problems of aluminium toxicity. If this is at all present in Samburu District, it might be encountered in unit 22: PnF. This is an agricultural problem rather than one in rangeland, however.

Salinity and sodicity is found in river valleys and bottomlands (units 24 and 25: A and B), but only at greater soil depths.

3.2.4 Erosion

The volume on methodologies gives an explanation of types of erosion, the factors involved and of the performance of certain soil types in general. Erosion is a widespread and very prominent feature in Samburu District. Therefore it is preferable to report on the status of accelerated soil erosion as presently found in the field, rather than giving the more theoretical prognosis of "erosion hazard" in case of (future) overutilization of the rangeland.
Table 2 summarizes the map unit ratings of erosion status. The erosion observed is proof of an alarming degradation of the rangelands of rather large parts of the district.

The table includes an estimation of the possibilities for recuperation. The ratings of these possibilities are largely based on the factors of infiltration capacity (or degree of sealing of the surface soil) and soil fertility, assuming a proper management and sufficient rainfall (i.e. no "failing" rainy seasons). These ratings could be considered indicating an amount of time needed for the land to recuperate (e.g. 1: two or three seasons; 4: eight to ten years).

Mountains and Hills have been left without ratings, partly due to lack of data, partly due to the difficulty to discern man-induced accelerated erosion from natural geomorphological processes. It

is from large distances observable, however, that the original cover of forest vegetation has strongly diminished. One may hold this partly responsible for the dramatic gully erosion that takes place on the surrounding Footslopes, especially mapping unit 11: F2U.

Footslopes are badly affected by both sheet erosion and locally serious gully development. This is in part due to the relative high density of manyatta's. The gully development is concentrated locally, but very common on the footslopes of the larger mountain ranges. It is much less severely present on footslopes around the more individual hills towards the Southeast and Northeast.

The Uplands (mapping units 13-15: U1G-U2G) have mostly developed around the valley incisions of Ewaso Ngiro, Seya and Milgis rivers and their tributaries. This topography is favourable to rainwater run-off. Soils show a concentrated gravelly surface layer over weathered rock. This points to an "end" stage in sheet erosion where a protective, erosion resistant surface layer has developed. The present strong deepening of water courses is accompanied by gully development in upstream direction, attacking the surrounding units.

The Plains (mapping units 17-19: Pd) in the central parts of the district, between Wamba and Barsaloi, bear soils that are heavily degraded by severe sheet erosion, which locally has developed into rills and gullies. Remnants of vegetation (e.g. stands of sansievieria) are found on pedestals of 20-30 cm high above the surrounding, strongly sealed, bare soil. Downslope the rills deepen into gullies towards the valleys of the adjoining uplands. These gullies are in the process of developing backwards, gaining terrain in the higher ground of the Plains.

The plains in the Southeast, between Archers post and Kom (mapping unit 22: PnF) and the El Barta Plains near Baragoi (mapping unit 20: Pd2F2) are relatively unaffected by accelerated erosion.

The mapping units of the Rift Valley escarpment (mapping units 3 and 4: HsV and RV) have not been rated as to their present status of erosion. From the very few amount of observations it should be concluded that most of the steep components (the numerous escarpments, faultlines and gorges) have a thin, extremely gravelly and bouldery type of soil, from which there is little to be eroded. Whatever soil mantle is present, is, however, very vulnerable to degradation.

Volcanic Plateaus are generally unaffected by sheet or gully erosion, due to their flat topography. Wind erosion could play an increasing role towards the drier areas. The surroundings of Marti, with a relatively high population pressure, seem affected by this type of erosion, exposing an increasing concentration of stones and gravel at the surface.

Figure 5 gives the distribution of the ratings contained in Table 2.

Table 2 Ratings of erosion, and possibilities for recuperation of the natural vegetation towards productive grazing.

Unit No.	Mapping Unit	Status of erosion 1: none; 5: extreme			Possibilities for recuperation 1: good; 5: none	Final Rating Present Degradation 1: none, slight; 5: severe
		Sheet	Rill	Gully		
1	MU	-	-	-	-	-
2	HU	-	-	-	-	-
3	HsV	-	-	-	-	-
4	RV	-	-	-	-	-
5	L1V1	1	1	1	1	1
6	L1V2	2	2	1	1	2
7	L2V	2	1	1	1	1
8	L3V	2	1	1	1	2
9	LsV	2	1	(5)	1	2
10	F1U	1/4	3/5	5/1	3/5	5/3
11	F2U	1	1/3	1/5	1/3	3/5
12	F3U	4	3	1	4	3
13	U1G	5*	1	1	3	4
14	U1F	4*	1	1	3	4-3
15	U2G	5*	3	1	3	5
16	UV	4*	1	1	1	3
17	Pd1U	3	3	1	3	3
18	Pd2G	5	3	1	4	4
19	Pd2F1	5	4	2	3	5
20	Pd2F2	3	2	1	1	2
21	Pd2F3	4	1	1	2	3
22	PnF	2-3	1	1	2	1-2
23	PnU	2	1	1	1	1
24	A	2	1	1	3	1
25	B	1	1	(5)	(5)	1/(5)
26	CX	5	3	(5)	4	4

3.2.5 Accessibility

Limitations in accessibility are determined by steepness of terrain forms and surface ruggedness, due to gullies and/or stones and boulders. Such conditions restrict livestock movements, limiting the daily "action radius" of herds and thus the actually available rangeland.

Apart from such permanent, year round restrictions additional limitations to accessibility are posed during the wet season by flooding/ponding of areas and/or stickiness/muddiness of the surface in certain areas. The ratings for these land characteristics are specified in the volume on methodology.

Results for Samburu District are summarized in Table 3. The first two columns give subratings for steepness and terrain ruggedness. The final ratings express a combination of these, and are specified according to animal type.

Table 3 Map unit ratings of limitations to accessibility.

Unit No.	Mapping Unit	Subrating Constraints due to slope, topography 1: none, slight 3: severe	Subrating Constraints due to surface rocks, stoniness etc. 1: none, slight 3: severe	Final rating Permanent, year round constraints: 1: none, slight 5: severe			Additional wet season constraints -: none 5: severe*)
				sheep goats	camel	cattle	
1	MU	3	2	3	4	5	-
2	HU	3	3	3	4	5	-
3	HsV	3	3	3	4	5	-
4	RV	3	2	4	5	5	-
5	L1V1	1	1	1	1	1	2
6	L1V2	1	1	1	1	1	-
7	L2V	1	1	1	1	1	2(5)
8	L3V	1	1	1	1	1	5
9	LsV	3	3	2	3	5	5
10	F1U	1/2	1	1	1/3	1/5	-
11	F2U	1	1	1	1	1/3	-
12	F3U	1	1	1	1	1	-
13	U1G	3	2	2	3	5	-
14	U1F	2	2	1	2	4	-
15	U2G	2	2	1	2	4	-
16	UV	2	1	1	1	2	-
17	Pd1U	2	1	1	1	2	-
18	Pd2G	1	1	1	1	1	-
19	Pd2F1	1-2	1	1	1	2	-
20	Pd2F2	1	1	1	1	1	-
21	Pd2F3	1-2	1	1	1	1	-
22	PnF	1	1	1	1	1	(3)
23	PnU	1	1	1	1	1	-
24	A	1	1	1	1	1	(2)
25	B	1	1	1	1	1	5
26	CX	1	1	1	1	1	-

*) Figures between brackets reflect conditions expected in years of "above average" rainfall.

Obviously the areas of high relief energy such as mountains, hills and the rift valley escarpment, pose strong restrictions.

To a lesser extent also the uplands are of a limited accessibility. Figure 6 gives these ratings in map form, expressing accessibility for cattle in dry season conditions.

Ratings for additional wet season constraints are contained in the last column of Table 3. Only some units with relative flat topography and heavy clay soils are expected to be inaccessible during the rains. These concern mainly the volcanic plateaus (mapping units 8 and 9: L3V and LsV) and bottomlands (mapping unit 25: B). See figure 7.

3.2.6 Possibilities for the construction of dams and waterpans

Landforms and soils are compared in respect of the opportunity for the collection of surface water in pans and dams. Such possibilities are largely contained in the landcharacteristics slope length and steepness, the density of the drainage network and permeability of the subsoil. Factors as rainfall evaporation, availability of construction material and the abilities of the local people to maintain these constructions, are not considered here.

Samburu District has only few areas where conditions are unsuitable for surface water collection. Only the volcanic plateaus are judged unfavourable, due to their generally flat topography, in combination with the swell-shrink properties of their clay soils. Further, the rugged terrain of the rift valley escarpment, where valleys are too ravine-like to be accessible at all, is possibly less suited. Within the uplands and plains, however, (mapping units 13-23), it seems possible at any given point to construct a dam or pan within a distance of ± 20 km.

4 MAPPING UNIT DESCRIPTIONS

Mapping Unit 1: **MU**

Surface Area:
Landform, relief: Mountains, relief energy generally over 300m; dominant slopes over 30%
Rock type, soil parent material: Undifferentiated basement system rocks: mainly gneisses, partly rich in basic minerals (Ferromagnesian minerals).
Soils: Complex of well drained, shallow to deep soils of varying textures, colour and consistence, locally stony and rocky. Top soils rich in humus, wherever original forest present.
Productive capacity: Soils contain high amount of Primary Weatherable minerals, are mainly of a friable consistence. Wherever soils are deep, productive capacity is high: good chemical and physical properties. Shallow soils have adverse soil water relationships, especially where the forests have degraded into a periodically burnt secondary bush vegetation.
Status of erosion: no data.
Erosion hazard: Degradation of the forest poses a severe erosion hazard, obviously because of the steep slopes and relative high rainfall.
Accessibility for livestock: Moderate to severe restrictions due to steepness and stoniness.
Observations: -

Mapping Unit 2: **HU**

Surface area:
Landform, relief: Hills, relief energy generally up to 300m. Dominant slopes over 30%, locally valleys with less steep slopes in downslope position.
Rock type, soil parent material: Undifferentiated Basement System rocks: mainly gneisses, partly rich in ferromagnesian minerals.
Soils: Rock outcrops, bouldery, stony and gravelly soils of varying texture, colour and consistence, mainly of very shallow depth; locally over deep weathered rock. Top soils have moderate to very low humus content.
Productive capacity: Soil chemical properties are no limitation to production due to high content of Weatherable Primary minerals. Soil moisture conditions/water holding capacity is very low on shallow and rocky stretches, localized deep pockets in between rock outcrops have good soil moisture availability, mainly due to run - on mechanisms, which is mainly beneficial to woody vegetation.
Status of erosion: No data.

Erosion hazard: The soil mantle as found within this unit, is inherently subject to erosional processes. The shallow stony soil mantle is an "end" phase in sheet erosion, stones and surface gravel maintains a status quo.
Accessibility for livestock: mainly suitable for goats, small stock, in part of the unit.
Observations:

Mapping Unit nr.3: **HsV**

Landform, relief: Hills of the step-faulted Rift Valley escarpment at the Western edge of the District. Complex of small, broken and tilted tablelands, separated by scarps and steep valleys and intricately dissected hilly areas.
Rock type, soil parent material: Various Pleistocene volcanic rocks: Basalts, Tuffaceous rocks and interbedded lava deposits.
Soils: Predominantly very shallow, rocky, stony and gravelly soils of clay loam texture, strongly calcareous. On isolated table lands also bouldery red clay.
Productive capacity: Mainly soils of high mineral content but of low water holding capacity.
Status of erosion: No human induced erosion. Soils are naturally shallow.
Erosion hazard: Gravelliness of the surface soil acts as protective layer against rain splash impact.
Accessibility: Moderate restrictions for small stock and camels. Severe restrictions for cattle.
Observations: 87, 88.

Mapping Unit 4: **RV**

Landform, relief: Footridges of Llerogi plateau, Loros plateau. Steep V formed valleys, of over 30% slope, and numerous small broken and tilted plateau remnants.
Rock type, soil parent material: Mainly volcanic rocks, undifferentiated.
Soils: Shallow bouldary and stony soils alternating with deeply weathered rock (on steep slopes) and soils as described under Mapping Unit 5: **L1V1** (on plateau remnants). Mainly "Forest" soils with a well developed humus rich top soil, that has disappeared where forest has degraded to secondary bush.
Productive capacity: Soils with moderate mineral reserve, and good soil-water relationships, where original forest soil is present.
Status of erosion: No clear signs of accelerated erosion. Top soil degradation is obvious where original forest disappeared.
Erosion hazard: Severe erosion is inevitable after removal of the original vegetation.

Accessibility: Severe restrictions for all stock in the majority of the unit.
Observations: 100, 102, 104.

Mapping Unit 5: **L1V1**

Surface area:
Landform, relief: Sloping, high level Plateau, slopes 2 - 3%.
Rock type, soil parent material: Basalts, various volcanic rocks.
Soils: Imperfectly drained, shallow, friable clay loam top soil over a layer of fine gravel sized iron - manganese concretions. This is underlain by a strongly mottled heavy clay subsoil or weathered rock.
Productive capacity: Well structured, humus rich top soil, when left under natural grassland. Water holding capacity is low due to shallow effective depth. Cultivation of these soils (wheat schemes) cannot be a sustained form of agriculture as the humus eventually will disappear, leaving highly erodible soils.
Status of erosion: Presently none.
Erosion hazard: Nil, when left under natural grassland. High, if cultivated for more than 5 years consecutively.
Accessibility: No restrictions. Wet season: slight restrictions for cattle (N.B. East coast feverinfested area.). (N.B. Area infested with East Coast Fever.)
Observations: 101, 103, 105, 106, 107, 120, 121, 122.

Mapping Unit 6: **L1V2**

Surface area:
Landform, relief: Scarps, river incisions and fringes of high level plateau.
Rock type, soil parent material: Undifferentiated volcanic rocks: mainly basalts.
Soils: (Moderately) well drained, shallow to moderately deep, strong brown, friable clay loam. Frequent rock outcrops at escarpments and river gorges.
Productive capacity: Soils of moderate high natural fertility. Presently supporting low density grass cover. Moderate soil water holding capacity.
Status of erosion: Slight sheet erosion.
Erosion hazard: Low, due to good infiltration of surface soil.
Accessibility: No restrictions, apart from rocky escarpments.
Observations: 119, 123, 124.

Mapping Unit 7: **L2V1**
as **L1V1**, soils somewhat deeper - (locally outcrops, vertisols)

Mapping Unit 8: **L3V**

Surface area:
Landform, relief: Volcanic Plateau ("Marti") almost flat, bordered by escarpment.
Rock type, soil parent material: Basalt.
Soils: Moderately well drained, stony and bouldery, shallow to deep, extremely gravelly dark brown clay loam to clay, locally cracking.
Productive capacity: Moderately fertile soils.
Water holding capacity of soil material moderate to high; soil depth varies.
Status of erosion: None to slight.
Erosion hazard: Low, due to flat topography, and protective gravelly/stony surface layer.
Accessibility: Slight restrictions for camel and cattle due to stony surface. Severe restrictions for camel and cattle during rains.
Observations: From aeroplane; 93, 94, 95.

Mapping Unit 9: **LsV**

Surface area:
Landform, relief: Stepfaulted Plateau. Parallel ridges and graben. Mostly gently sloping surface, intersected by steep slopes.
Rocktype, soil parent material: Basalt.
Soils: (Moderately) well drained, extremely stony and bouldery dark reddish brown clay. Locally rock outcrops - locally imperfectly drained, deep, cracking clay.
Productive capacity: Fertile friable clays of high water storage capacity. Effective surface area is strongly reduced by stones and boulders (50%).
Status of erosion: None to slight. Locally along escarpments gully erosion.
Erosion hazard: Slight.
Accessibility: The "broken" terrain poses locally moderate to severe restrictions. Also the bouldary surface restricts the accessibility for cattle severely and for camels to a moderate extent.
Observations: 84.

Mapping Unit 10: **F1U**

Surface area:
Landform, relief: Footslope, (pediment) ("Ntabas") straight to slight concave 2 - 5 km long slopes of 2 - 5% between hills and surrounding plains.
Rock type, soil parent material: Colluvium derived from undifferentiated Basement System rocks, and locally in situ weathered rock.

Soils: Well drained, deep to very deep, friable, dark reddish brown sandy loam, to sandy clay loam. In upslope position soils tend to be sandier, and have a high amount of Primary Weatherable minerals.
Productive capacity: Soils have a moderate natural fertility due to the relative young colluvial material that contains Primary Weatherable minerals. The higher parts have a good infiltration capacity (sandy top soils) and good soil moisture storage. Middle and lower slopes may however show unfavourable infiltration conditions.
Status of erosion: Many footslopes show severe gully and sheet erosion. This can be attributed to the popularity of this landform for the establishment of manyatta's and the relative high pressure on the land as a consequence.
Erosion hazard: Footslopes have a reasonable condition for recuperation at the upslope side, unless the area has aleady developed deep gullies. Shape, position and soil type of these landforms/ middle and lower slopes are more prone to sealing and sheet erosion.
Accessibility: No limitations, except where severe gully erosion has developed. Observations: 34, 22, 23, 37, 86.

Mapping Unit 11: **F2U**

Surface area:
Landform, relief: Footslope (delta - like) ("Nkutot" for situations when surrounded by hills/mountains) straight to slight concave, 2 - 5km long slope.
Rock type, soil parent material: Colluvium and alluvium derived from undifferentiated Basement System rocks.
Soils: Well drained, very deep, very friable, light brown, (stratified) sandy loam with high amount of Primary Weatherable minerals.
Productive capacity: High: "best" soils - high fertility, highest water holding capacity.
Status of erosion: Mainly deeply gullied around drainage lines.
Erosion hazard: Soil texture (fine sandiness, high silt percentage) can easily lead to surface compaction and sheet erosion when under heavy grazing pressure.
Accessibility: No restrictions.
Observations: 5, 40, 74, 53.

Mapping Unit 12: **F3U**

Surface area:
Landform, relief: Footslope, piedmont plain. Very gently sloping to almost flat; 1 - 2%; very long slopes.
Rock type, soil parent material: Colluvium and alluvium derived from undifferentiated Basement System rocks.

Soils: Well drained, very deep, loose to very friable, grayish brown, calcareous fine sandy loam, saline in the deeper subsoil.
Productive capacity: Moderate to high natural fertility. Unfavourable top soil conditions hamper infiltration, however, so that water holding capacity is not fully utilized.
Status of erosion: Moderate surface sealing and moderate to severe sheet erosion. Rills and gullies are locally well developed.
Accessibility: No restrictions.
Observations: 75, 76, 77.

Mapping Unit 13: **U1G**

Surface area:
Landform, relief: Uplands of rolling to hilly relief ("Lkarjaj") in a North - South orientated pattern., Slopes 10 - 30%.
Rock type, soil parent material: Basement System rocks, moderately rich to poor in minerals. Predominantly granitoid gneisses.
Soils: Well drained, very shallow, stony and gravelly yellowish brown coarse sandy clay loam; shallow, calcareous sandy clay loam at lower slopes.
Productive capacity: Soils have relative high mineral content, and low water holding capacity due to their shallowness ("skeletal" soils).
Erosion status & hazard: Upper and middle slopes have a protective surface cover of gravel and stones in a terraced pattern due to livestock tracks parallel to contour lines. There is little soil to be eroded. The downslope shallow soils are under heavy attack of sheet and rill erosion.
Accessibility: Steep slopes and stoniness restrict access for cattle and to a lesser extent also for camels.
Observations: 67, 68, 69.

Mapping Unit 14: **U1F**

Surface area:
Landform, relief: Uplands of moderate to hilly relief of irregular pattern.
Slopes 10 - 30%, mainly concave ("Lolrukon")
Rock type, soil parent material: Undifferentiated Basement System rocks, predominantly gneisses, rich in basic minerals (plagioclase amphibolites).
Soils: Well drained, very shallow, gravelly, stony and rocky, fine sandy clay loam soils shallow to moderately deep at downslope position.

Productive capacity: Soils of high mineral content but low water holding capacity due to their shallowness.
Erosion status: Protective gravel cover over weathered soil mantle. Downslope shallow soils are under attack of gully erosion.
Accessibility: Relief as well as the predominantly stony surface pose some restrictions to cattle.
Observations: (65), 70.

Mapping Unit 15: **U2G**

Surface area:
Landform, relief: Uplands of undulating to rolling relief, dense rectangular drainage pattern that is orientated in a distinct north -south direction. Short, convex - straight slopes of 8 - 15%. "Lkarjaj".
Rock type, soil parent material: Undifferentiated Basement System rocks, predominantly granitoid gneisses, moderately rich and poor in Ferromagnesian basic minerals.
Soils: As **U1G**: well drained, shallow, coarse sandy clay loam to sandy loam, but severely eroded; and very shallow, gravelly and stony, coarse sandy clay loam over weathered rock.
Productive capacity: Soils are relatively rich in Primary Weatherable minerals, but low in water holding capacity.
Erosion status: Wherever there is a soil mantle present, it is under heavy attack of sheet, rill and gully erosion. The major part of the area exists of a gravelly surface layer over weathered rock ("end"-phase of erosion processes) that is relatively resistant to further accelerated erosion.
These very shallow soils are however capable of supporting a good cover of dwarf shrub vegetation (mainly Indigoferea sp.) and a layer of woody vegetation.
Accessibility: Moderate restrictions due to steepness and stoniness for camels and cattle.
Observations: 7, 9, 11, 16, 17, 18, 47, 116.

Mapping Unit 16: **UV**

Surface area:
Landform, relief: Stepfaulted Uplands of volcanic origin: undulating relief with slopes of 5 - 10% and locally steep short slopes. Gentle wide concave valleys
Rock type, soil parent material: Tertiary volcanic rocks, undifferentiated. Mainly basaltic rocks.
Soils: Well drained, very shallow, extremely gravelly and stony, yellowish brown, calcareous clay loam.
Productive capacity: No restrictions in respect of lack of mineral supply; low water holding capacity due to shallowness of the soil and high amount of coarse particles.

Erosion status and hazard: No obvious signs of present erosion are observed. The surface is covered with protective gravel. Downslope, a long major drainage lines, gully erosion is in development.
Accessibility: No restrictions, apart from some local steeper parts.
Observations: 89.

Mapping Unit 17: **Pd1U**

Surface area:
Landform, relief: Dissected Erosional Plain, gently undulating; long slopes, somewhat irregular due to frequent rock outcrops in shallow ridges 3 - 5%.
Rock type, soil parent material: Undifferentiated Basement System rocks, predominantly gneisses.
Soils: Well drained, deep to shallow, dark reddish brown sandy clay to sandy loam, mostly rich in Primary Weatherable minerals. In places rock outcrops.
Productive capacity: Soils have a moderate fertility due to the presence of Primary Weatherable minerals. Water holding capacity varies strongly with soil depth, texture and infiltration capacity.
Erosion status and hazard: Widespread surface sealing alternating with shallow sandy wash. Moderate sheet erosion predominates. Recuperation mostly feasible.
Accessibility: No restrictions.
Observations: 26, 27, 29, 30, 30A, 32, 33, 42, 43.

Mapping Unit 18: **Pd2G**

Surface area:
Landform, relief: Very gently to gently undulating dissected Erosional Plain.
Long slopes of 1 - 2%, towards drainage lines 4 - 5%
Rock type, soil parent material: Basement System rocks, predominantly banded gneisses, poor in basic minerals.
Soils: Well drained, moderately deep, dark reddish brown, medium sandy clay to sandy clay loam containing few Primary Weatherable minerals.
Productive capacity: The soils are relatively low in natural fertility; have the character of being leached and strongly weathered. Top soil quality is poor due to omnipresent severe sheet erosion. Water holding capacity may not be explored fully due to strong run off features.
Erosion status and hazard: Present status is one of severe sheet erosion, moderate rill development. Moderate gully development takes place around drainage lines. A recuperation of the reportedly former once existing grasslands is an illusion.

Accessibility: No restrictions.
Observations: 1, 2, (6, 8), 12, 13, 14, 15, 19, 20, 114, 115.
Inclusions: At the Western side of the unit the drainage lines perform as high potential grazing areas (black cotton soil, or "nKisorro"). These unfortunately are under heavy attack of ravine like gully erosion, rapidly turning these bottomlands into badlands.

Mapping Unit 19: **Pd2F1**

Surface area:
Landform, relief: Gently undulating dissected Erosional Plain, slopes 3%, locally up to 7%.
Rock type, soil parent material: Basement System rocks, mainly gneisses rich in basic minerals, locally ultrabasic rocks.
Soils: Well drained, deep, dark red to dark reddish brown, friable sandy clay to clay (locally, on steeper slopes, shallow, very gravelly medium sandy loam).
Productive capacity: Soils of moderate natural fertility and high water holding capacity. The widespread strong topsoil degradation and surface sealing causes most rainwater to run off, however.
Erosion status and hazard: Widespread extreme sheet and severe rill erosion. Moderate capacity to recuperation under zero use.
Accessibility: No restrictions.
Observations: (35), 49, 50, 51, 52, (53), 54, (55), (56), 71, 81.

Mapping Unit 20: **Pd2F2**

Surface area:
Landform, relief: Gently undulating (non dissected) Erosional Plain.
Slopes 1 - 3%
Rock type, soil parent material: Basement System rocks, gneisses rich in basic minerals, (plagioclase amphibolites, some ultra basic rocks).
Soils: Well drained, shallow to moderately deep, dark reddish brown, friable, slight calcareous, fine sandy clay loam, with abundant Primary Weatherable minerals.
Productive capacity: Soils of moderate to high natural fertility of good physical (structure, consistence) quality. Water holding capacity is moderate due to restricted depth.
Erosion status: Moderate sheet erosion. Possibilities for recuperation are good. Sealing of the surface is moderate.
Accessibility: No restrictions.
Observations: (60), 61, 62, 63, 64, (65), 71, 81, (91).

Mapping Unit 21: **Pd2F3**

Surface area:
Landform, relief: Undulating dissected Erosional Plain, slopes 3 - 7%
Rock type, soil parent material: as mapping unit 20.
Soils: Well drained, very shallow to shallow, friable, calcareous, yellowish brown, loamy medium sand to fine sandy loam, rich in Primary Weatherable minerals.
Productive capacity: Low, due to restricted soil depth.
Erosion status: On many places "end-stage" of sheet erosion.
Accessibility: No restrictions.
Observation: 57, 58, 59, 90, (91), 92.

Mapping Unit 22: **PnF**

Surface area:
Landform, relief: Non-dissected Erosional Plain, very gently undulating. Widely spaced drainage system. Slopes 1 - 2%.
Rock type, soil parent material; Basement System rocks, moderately rich in minerals: mainly biotite gneisses.
Soils: Well drained, deep to moderately deep, very friable, dusky red to dark reddish brown, clay to clay loam (non - cracking) with few Primary Weatherable minerals.
Erosion status and hazard: Low sensitivity to sealing of the surface soil. Slight to moderate sheet erosion; no rill, gully development. High natural capacity to recover from over - utilization.
Productive capacity: Moderate infiltration capacity. Moderately high water holding capacity. Low natural fertility.
Accessibility: No restrictions.
Observations: 24, 25, 34, 36, 38, 39, 44, 45.

Mapping Unit 23: **PnU**

Surface area:
Landform, relief: Non dissected Erosional Plain, very gently undulating,
slopes 1 - 1.5%.
Rock type, soil parent material: Undifferentiated Basement System rocks, predominantly gneisses.
Soils: Moderately well (to well) drained, very deep, very friable, reddish brown, sandy clay loam to sandy clay.
Productive capacity: Non - degraded top soil. Low chemical fertility. Moderate to high water holding capacity. Good infiltration capacity.
Erosion, status, trend: Soils show slight to moderate sealing and a slight sheet erosion. In its present status (relative high grass cover) the soils have good opportunity to recuperate.

Accessibility: No restrictions.
Observations: 6, 8.

Mapping Unit 24: **A**

Surface area:
Landform, relief: River valley Floodplain and low terraces.
Rock type, soil parent material: Riverine alluvium.
Soils: Well drained, very deep, very friable, stratified sands to sandy loam. Mostly saline and calcareous at some depth.
Productive capacity: Moderate to high soil fertility; low to moderate water holding capacity.
Erosion: Locally riverbank erosion; locally severe gullying.
Accessibility: No restrictions. Locally temporary inaccessible due to flooding.
Observations: 66.

Mapping Unit 25: **B**

Surface area:
Landform, relief: Bottomland, at the bottom of valleys where run-on water collects; slopes less than 1%
Rock type, soil parent material: Mostly clayey sediments.
Soils: Poorly to imperfectly drained, very deep, calcareous, dark grayish brown clays with a dusty top soil and a saline deeper sub soil.
Productive capacity: Various. High mineral content, very high or very low water holding capacity, depending on climatic zone and run - on mechanisms.
Erosion status: Locally disastrous gully erosion.
Accessibility: During rains, inaccessible, especially for camels.
Observations: 21, 28.

Mapping Unit 26: **CX**

Surface area:
Landform, relief: Complex of Uplands and Footslope: gently undulating.
Rock type, soil parent material: Undifferentiated Basement System rocks and Footslope deposits.
Soils: Well drained, very deep to shallow soils of varying colour and texture, in places with rock outcrops.
Productive capacity: The average soil chemical fertility and waterholding capacity is estimated as moderate on the average.
Erosion status: Locally severe sheet and gully erosion.
Accessibility: Slight restrictions for cattle in areas of gully erosion.
Observations: (117), 118.

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ANNEX I

Mission Report

CONTENTS ANNEX I

ACKNOWLEDGEMENTS

I wish to convey my sincere thanks to the personnel of the Kenya Soil Survey, N.A.L., Nairobi, especially Mr. Wokabi, Acting Head, for providing survey equipment and office space, and Mr. Olulo (Head cartography section) for providing drawing room facilities.

Fieldwork activities were greatly facilitated due to hospitality received from the District Officers in the respective divisions, the Wamba/ASAL Food Security Project, and the Catholic Mission of Barsaloi.

Technical assistance was gratefully received from the Technical Officers of the Ministries of Water Development and Livestock Development in Maralal, Baragoi and Wamba.

1 INTRODUCTION

The Water Resources Assessment and Planning Project (WRAP); attached to the Ministry of Water Development, Kenya, is part of the International Cooperation Programme of T.N.O., the Netherlands. It is funded by the Directorate General for International Cooperation (DGIS), Ministry of Foreign Affairs, the Netherlands. The projects main output in its present phase concern the realisation of water development plans for Samburu, Meru and Isiolo Districts in Kenya.

As sound land-use planning is based on the inventory of natural resources in general, the planning of water development needs, in case of dry nomadic areas, information on the distribution of range potential. Hence the WRAP requested the Range Management Handbook Project to provide the necessary data on Samburu District. The development plans for the latter area have priority in the time schedule of the WRAP.

The GTZ-funded Range Management Handbook Project (RMHP) aims at the inventory of the natural resources of the arid and semi-arid lands of Kenya, and the interpretation of these data in terms of recommendations for sustained forms of rangeland use. Results will be presented in the form of reports and maps at a 1 : 1 M scale for each district separately. These are to be used by the Ministry of Livestock Development for both planning at ministerial level, as well as a first orientation for extension officers at district location or grazing block level.

The study is essentially a multidisciplinary one, in which are engaged a climatologist; a vegetation/range ecologist; a landforms/soils specialist; a hydrologist; a livestock agronomist and a veterinarian.

The project started in 1986 and will be on-going to at least December 1991. Of the nine districts concerned, so far the survey of Marsabit and Wajir Districts, have been completed.

The Winand Staring Centre participates in the project by providing the expertise for the landforms and soils inventory and for its interpretation in terms of productive capacity of rangelands and limitations to rangeland use.

The terms of reference of the contract with WRAP call for a survey, identical to those already carried out by the RMHP for other districts.
The Samburu Survey was scheduled to take place in June/July, after the survey for Mandera District would have been completed in May/June. Due to bad weather conditions in Mandera, it was decided, contrary to original planning, to carry out the survey in Samburu District first, and the Mandera District Survey thereafter.

2 ACHIEVEMENTS AND CONSTRAINTS OF THE SAMBURU DISTRICT SURVEY

2.1 Survey preparation

In field surveys of large areas for which only a short time period is available (25 000 km^2 in 3 weeks time in the present case), the interpretation of remote sensing material is of crucial importance. Prior to field survey, a few days were spent on the production of an interpretation map at scale 1 : 500 000 of the whole District. Twenty four different interpretation mapping units were identified with the help of 1 : 500 000 scale individual Landsat Images of 1976, dry season.

Unfortunately the more recent Thematic Mapper Images, that are of a higher resolution and more up te date (roads visible!) were only available after completion of the survey. The interpretation was further supported by the available geological maps and the Exploratory Soil Map of Kenya, by Sombroek et al., 1982.

A 1 : 500 000 scale base map was provided by WRAP, compiled from the series of 1 : 250 000 scale toposheets of the survey of Kenya.
During field survey it appeared that it was not possible to distinguish among landforms of the lower relief classes as appearing on the images available. Landforms of almost flat relief do not appear notably different from those of undulating relief, unless this difference is accompanied by a clear change in drainage pattern/density. There was no time available during the survey to establish proper criteria to solve this problem. As a consequence unit boundaries around Barsaloi and south of Maralal are more arbitrary than elsewhere on the map.

2.2 Field survey

The survey team consisted of a teamleader/technical adviser (Dr. Walther) and his counterpart of the Ministry of Livestock Development (Mr. Shaabani), a vegetation/range ecologist (Dr. Herlocker), a landform/soils specialist (Touber), a hydrologist (Dr. Bake), and a veterinarian (Dr. Dioli).

Field checks were located at points identified beforehand as representative according to the satellite image interpretation map. The vegetation scientist and soil surveyor conducted their observations simultaneously at the same sites. Soil and landform characteristics that play a role in the performance of rangeland were recorded c.q. estimated, i.e. topography, steepness, drainage condition, soil moisture availability, rooting space, degree of surface sealing, signs of rainwater run-off, flooding, ponding, humus content of the top soil, calcareousness, salinity (at

three standard depths), soil consistence and texture. At most of the sites soil samples were taken for the determination of the fertility status. These were delivered at the N.A.L. for "Mehlig" analysis, i.e. major nutrients, carbon content, pH and salinity. Results were not yet available by the time of report writing.

The cooperation with the vegetation surveyor proved very fruitful. A good correlation between the landforms/soils map and the vegetation map was ensured.
Interviews with local people, as conducted in the Wajir District Survey, proved less useful where it concerns local names for types of environment. It was hoped to obtain vernacular terminology for well defined landform/soils/vegetation units with their inherent management aspects, but this was attained only to a very limited extent.

In spite of some drawbacks mentioned of the "old" satellite imagery, there were no problems in field orientation and location of observation points, mainly due to the clear-cut and very prominent differences in landforms. Two survey flights were undertaken, mainly to view areas that proved inaccessible on the ground. This concerns the Matthews Range, Ndoto' Mountains, Seya and Milgis River Basins, and the extensive Rift Valley edge complex.
The survey was carried out between May, 18th and June, 10th.

2.3 Map and report preparation

After field work, data were put together, resulting in a draft 1 : 500 000 scale landforms and soils map with legend. At the request of the WRAP the map has been maintained at this scale for the time being, for purposes of presentation (seminar). For the same reason also the derived maps on productive capacity, erosion and accessibility have been produced on a 1 : 500 000 scale. The discrepancy between survey intensity and map scale is mentioned on the final draft map as delivered to WRAP. In a later stage the maps are to be reduced to the !.000 000 publication scale for the RMHP purpose, and the report adapted likewise.

ANNEX II Itinerary

11 May	Departure Amsterdam-Nairobi
12 May	Arrival Nairobi - Meeting with Mr. Wokabi (Acting Head, KSS) and Dr. Olulo (Head cartography, KSS). Collection of equipment and geological reports, Mandera Survey
12-14 May	Preparation for Mandera Survey
15-16 May	Meeting with Dr. Walther (teamleader RMHP) and other RMHP-teammembers. Discussions on Mandera Survey; Decision to postpone Mandera Survey
17 May	Preparation for Samburu District Survey
18 May	Travel Nairobi-Wamba, with Dr. Herlocker, range ecologist RMHP. Meetings with GTZ-ASAL Food Security Project personnel Messrs. Mburu (Natural Resources officer) and Muriuki (Livestock Development officer)
19 May	Meeting with District Officer, Wamba Division, Mr. C. Ngesa. Field checks from Wamba base camp
20-27 May	Field checks from Wamba base camp. At 25 May reconnaissance flight over Eastern half of the District
28-29 May	Field checks, travelling from Wamba-Barsaloi-Baragoi. Meeting with District Officer Baragoi. Meeting with technical officers Ministry of Livestock Development, Baragoi
30 May-2 June	Field checks from Baragoi base camp
3 June	Field checks, travelling from Baragoi-Maralal
4-8 June	Field checks from Maralal base camp
5 June	Meeting with D.O.I., Maralal
9 June	Reconnaissance flight over Western part of the District. Travel Maralal-Nyahururu
10 June	Travel Nyahururu-Nairobi. Return equipment
10-16 June	Data elaboration and map preparation Samburu Survey
17-21 June	Preparation Mandera Survey
22 June-13 July	Mandera Survey
14 July	Map and report preparation Samburu
15-16 July	Leave
17-21 July	Map and report preparation Samburu, meeting with Dr. Herlocker
22-23 July	Leave
24-28 July	Arrangements for cartography Marsabit Survey - meetings with Mr. de Souza, Geograph. Dept. University of Nairobi. Meeting with Dr. Walther
29 July-23 August	Leave
24 August	Travel Nairobi-Athens
25 August	Athens-Amsterdam

ANNEX III Terms of reference

SHORT MISSION SOIL SCIENTIST

For the technical assistance to the WRAP team, the assistance of a soil scientist engineer is required.

Tasks

The visiting expert will assist the planning team of WRAP in collection of data for the District Water Development Plan for Samburu District. The tasks will include:

- Execution of a field survey of Samburu District on scale 1 : 250 000*) to:
  - inventory of landscape and soil types,
  - inventory of accessibility with respect to livestock during rainy season and dry season,
  - inventory of regeneration potential of soils.
- Production of a series of maps, scale 1 : 250 000*) depicting the above inventoried data and associated results, among which:
  - rating of soil erosion hazard,
  - rated level of soil/vegetation production capacity (not considering climate).
- Elaboration of an inventory report with classification the field survey data.

The aim is to collect the information which enables the establishment of the capacity for livestock development in Samburu District, which presently is the economic mainstay of the population.

Qualifications

The job requires an academic degree in soil sciences with extensive field experience, specifically in developing countries.

Period

The mission is scheduled from 15th June until 14th of July 1989 and from 7 August until 21 August 1989.

Location

Ministry of Water Development, Nairobi, for the period 15 June - 14 July 1989 (field survey); The Netherlands, for the period 7 August - 21 August 1989 (reporting, maps).

Dr. J.L.J. de Sonneville

Chief technical Advisor
WRAP, 22-02-1989.

*) Changed into scale 1 : 500 000 in the final contract.