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KENYA SOIL SURVEY

IRRIGATION SUITABILITY OF THE SOILS AND WATERS OF THE FLOODPLAIN OF THE KERIO RIVER NORTH EAST OF LOKORI (TURKANA DISTRICT)

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SITE EVALUATION REPORT

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Contents

1. Introduction

At the request of Dr. Anderson, of the Lokori Station of the Africa Inland Mission, a site evaluation was carried out from 16th to 18th January, 1974 of the soils and water conditions of an area North East of Lokori. The data gathered should give an idea of the feasibility for irrigated agriculture in the floodplain of the Kerio river.

The area presented on the adjoining map is situated at appr. 1° 55' and 36°5'E. It includes lands with lava flows and alluvial fans, but main attention was paid to the alluvial deposits along the Kerio river.

The photo interpretation was carried out on aerial photographs, scale 1:40.000 of reasonable quality. Soil samples collected during the site evaluation were analysed at the service laboratory of the National Agricultural Laboratories in Nairobi.

It should be stressed that the present evaluation is a preliminary one, based on aerial photograph interpretation, a few field observations (auger-holes and profile pits) and only some laboratory data of collected soil and water samples. A full scale feasibility study should be preceded by a proper semi-detailed soil survey, with the help of large-scale recent aerial photographs, as well as measurements, both in the field and the laboratory, of the water holding and transmitting properties of the various soils. Such a survey would take several man month.

The hospitality, co-operation and assistance of the members of the Lokori Mission Station during the fieldwork was of great help and is very much appreciated.

The delay of the official reporting, caused by the late availability of the laboratory data, is regretted.

2. Environmental conditions

2.1. General

The area presented on this map is part of a semi-arid region where rainfed arable farming is impossible. Average annual rainfall data are not available, but is probably somewhere between 200 and 350 mm. Data of comparable areas closest to Lokori are (E.A. Met. Dept., 1973).

Lodwar: 178 mm (average of 46 years)
Kekorongole: 203 mm (average of 6 years)
Kapeddo: 367 mm (average of 5 years)

Quantity and distribution of the precipitation are however extremely variable and it can happen that after a torrential shower (parts of the) floodplain of the Kerio river is more or less inundated by water coming via the alluvial fans, from the lava area.

2.2. The Kerio river

Any irrigation scheme in the area, will depend for its irrigation water supply predominantly on the availability of water in the Kerio river. Data on water transported by the river are very scanty. The water Development Division of the Ministry of Agriculture has measured the water flow at Lokori from September 1970 to April 1972. From this few data it appears that during the months December, January, February and March water transport is very limited (less than $1m^3$/sec) or that the river for a period of some weeks is completely dry. This was confirmed by verbal information from local people and also observed by ourselves:during the site evaluation there was not a drop of water in the river bed. On the other hand, occasionally the discharge of the Kerio river can increase suddenly because of torrential showers in its catchment area. This was already mentioned by Dames (1964). According to data of Water Development Division of the Ministry of Agriculture the mean daily flow on September 12, 1970 was 81.498 m^3/sec.

The occasional high discharges of the Kerio river leads in this area to :

(a) flooding of the extensive areas in the floodplain of the Kerio river. Signs of such flooding (straw, twigs and branches hanging in trees and around the trunks of trees) were observed on many places during the fieldwork, indicating that at times a sheet of water upto 30 or 40 cm thick, covers the river basin lands (unit Fb on the map) and parts of the undifferentated floodplain land (unit FUl). According to information from the local Turkana 's this flooding seldom lasts longer than a few days.

In periods when the water level of the Kerio river is high, water can also flow locally over parts of the river levee land (Unit Fl). However this lands are probably never really flooded.

(b) some sedimentation of fresh alluvial material in the floodplain, mainly in the area south and southwest of Lodeleng and Lotobai hills.

This sedimentation also resulted in a change of the main course of the Kerio river. Sometime ago (50 to 100 years?) the main bed was where now the Dead river is found. This former river bed is now completely filled up, mainly with coarse sand laminated with some thin silty sand layers, and is at places even difficult to trace in the field.

(c) erosion in many places in the whole floodplain signs of erosion can be noticed. They vary from some sheet erosion to steeply incised gullies which can be up to 7 m deep and 20 m wide. These gullies make large areas difficult or impossible to pass by Landrover.

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Flooding and the presence of the many erosion gullies make the construction of a large scale irrigation scheme very difficult and very expensive.

2.3. Groundwater

During the site evaluation nowhere groundwater was encountered within augering depth (2.50 m).

2.4. Suitability of the Kerio river water for irrigation

Two water samples, taken from the river water, one day after a period that the riverbed was dry, and analysed at the National Agricultural Laboratories in Nairobi showed that the water in that period was well suitable for irrigation. The quality of the water in the dry season, when the Kerio river has a small discharge, in not known. Experience with other rivers, like the Turkwell river and the Ewaso Ng'iro is however that the quality decreases with a decreasing water load of the rivers (verbal information).

3. Description of the soils and their suitability for irrigated agriculture

3.1. Introduction

The area discussed can be divided into:

the floodplain This flat to almost flat area consists mainly of thick layers of recent and subrecent alluvial deposits. Locally some hills (like Merulina, Atjebil, Namortungai, Lotubai) and low outcrops of lava rock occur. At places the alluvial deposits are covered with low sand to clay dunes or with thin sheets of wind-blown sand or clay.

the alluvial fans are generally found in a 1,5 to 6 km wide zone west of the floodplain. They consist of gravelly sandy loam and near the floodplain at places of sandy loam sediments, which vary in depth. Locally the alluvial fans are covered with sheets of wind blown sand.

the lava flows, are located to the west of the floodplain. Here only shallow and very shallow soils, in many places stony and rocky, are found. The mentioned units are subdivided according to differences in sedimentation pattern, drainage pattern, topography. These differences are in general rather easily recognised on the aereal photographs, and correlate very well with differences in soil. In the floodplain of the Kerio river north-east of Lokori the variation in physiography is however very vague due to reasons mentioned under 3.2.1.

3.2. Soils of the floodplain

3.2.1. general

These soils are deposited by the Kerio river. They are in general very deep (more than 2.50 m), moderately to strongly micaceous

(rich in mineral reserves) and strongly at some places moderately calcareous.
Profile development is very weak, because these soils are very young and the climate is semi-arid. Even A-horizons are thin and very vague. The whole floodplain is flat to almost flat and dips very gradually to the north with a slope of less than 1%. However some areas have some topography because of the presence of scattered, 30 cm to 2 m high sand to clay dunes (unit FU1 and FU2).

The change of the Kerio river course influenced the area very much and sparked a chain reaction:

(a) the original flooding pattern. Extensive areas which were in the past regularly provided with river water via the Dead river, get this now only occasionally during (short) periods of very high discharges of the Kerio river. At those times the water cannot completely be transported by the recent Kerio river and the Dead river starts functioning as an overflow or spillway.

(b) the drainage pattern. Branches of the Dead river transported in the past silt-loaded water from the river and had a more or less sedimentary function, thus not only providing some new sediments but also providing more or less regularly water to certain areas. Now, many of these river channels tend to erode and form, specially in the middle and northern part of the surveyed area, steeply incised and in some places deep and wide erosion gullies. It is expected that this erosion hazard has the tendency to move gradually more southwards.

(c) the vegetation. Because water of the Kerio river is entering large parts of the area more occasionally than before (see (a) above) and because of the presence of deep erosion gullies (see (b) above) which results in a deeper subsoil drainage, extensive areas are much more dry than they used to be. As a consequence much of the formerly dense vegetation (mainly of Salvadora persica?) on the river levee land (unit F1) on both sides of the Dead river has died off.

(d) the condition of the topsoils. Because of the drier conditions and as a consequence the partial disappearance of vegetation the micro-aggregated topsoil particles in saline areas are easily transported by wind. They accumulate at the lee side of vegetation remnants, etc. thus forming low and very low dunes. It is expected that the accumulation of this saline, wind blown soil material will continue and in the course of time will also extend to other areas.

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The above mentioned changes obscure the differences in physiography and consequently make a photo interpretation difficult. Moreover, during the fieldwork it appeared that the transitions between river levee land and river basin land are not only very gradual but also very irregular. The boundaries indicated on the map in the floodplain land are therefore only indicative and do not represent sharp transitions between the distinguished mapping units.

3.2.2. River levee land (unit F1)

River levee land is found on both sides of recent and former riverbeds. It is characterised by the presence of no other vegetation than many dead trees (Salvadora persica), which gives the area a sinister appearance. This dead "forest" and the many steeply incised, branching gullies make the area almost impassable. Only along the Kerio river patches with aforrest of mainly Accacia tortilis is found.

The soils of this unit are predominantly very deep (more than 250 cm), brown (10YR 5/3)* to dark yellowish brown (10YR 4/4) and calcareous and micaceous throughout. Very locally, mainly in the surroungings of the hilly rock outcrops rock may be encountered in the subsoil within 250 cm.

The texture ranges in general from sandy clay to sandy clay loam, but in many places 1 to 30 cm thick layers of medium to coarse sand or loamy medium to fine sand are found at variable depth. These sand layers cause the soils to have a very high horizontal permeability. Near incised erosion gullies in several places potholes were found that must have been formed because the coarse sand in the subsoil was washed away, thus forming a sort of a tunnel. When the tops of these "tunnels" collapse a round or elongated hole of sometimes more than 150 cm depth and 50 to 100 cm width is formed.

Soil samples collected during the site evaluation indicate that some soils of this unit have an ECe (electric conductivity of the saturation extract) between 4 and 5.2 mmhos/cm and an E.S.P. (exchangeable sodium percentage) of less than 10. This classifies these soils as saline-nonalkali** (U.S. Dept. of Agriculture Handbook 60; Richards, 1954). Probably salinity occurs only spotwise, because other analysed profiles proved to be nonsaline-nonalkali.

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* colour moist; notation according to the Munsell Soil Colour Charts.

** saline soils contain a high percentage of soluble salts. This makes the uptake of water and nutrients difficult or impossible, resulting in restricted plant growth and crop production.
alkali soils contain a high percentage of sodium. Upon leaching this results in dispersion of the soil, sealing of the pores and often a sharp rise of the pH. Such conditions are adverse to root development and crop production as a whole.

Soils of this unit are not suitable for irrigated agriculture because:

1. they have a very high horizontal permeability, due to the presence in many places of thick sandy layers. This sand layers cause considerable water losses, not only in irrigated fields, but also in irrigation channels and ditches that would transport the irrigation water to the fields (unless lined, which is very expensive).

2. the presence of many erosion gullies make the construction of irrigation channels and ditches difficult and very expensive.

3. the soils are partly saline - nonalkali. The saline areas probably occur spotwise and location of the nonsaline areas would require an accurate, detailed soil survey and the analysis in the laboratory of many soil samples.

3.2.3. River basin land (unit Fb)

River basin land is found in relatively low-lying areas, scattered over the whole floodplain of the Kerio valley. After rain showers or in periods of high discharges of the Kerio river, water can accumulate here and flood the river basin land for a variable period.

The vegetation in the river basin land consists in the dry season mainly of a very open bush with very little groundcover of herbs.

The soils are mostly very deep (more than 250 cm). Only at the foot of the lava flows (unit L..) and near the alluvial fans (unit Al) soils are locally less deep. Soils are mostly brown to dark brown (10YR 4/3 - 10YR 3/3), strongly calcareous and micaceous. The texture ranges from clay to very fine sandy clay loam and locally to silty clay loam or even siltloam. In places these soils are stratified with 2 to 15 cm thick layers of medium fine sandy loam to loamy m edium sand.

The soil samples in the laboratory analysed give the impression that the basin lands belonging to the sedimentation system of the Dead river have a chemical composition that differs from that of the basin lands of the present Kerio river. There are indications (to be sure a detailed soil survey has to be carried out and many more samples have to be analysed), that the basin lands west of the Dead river, and those near Merulina hill and south of Lotubai hill are at least partly and maybe predominantly saline-nonalkali in the topsoil (ECe up to 12 mmhos/cm and E.S.P. upto 10%) and saline-alkali in the subsoil (ECe up to 12 mmhos/cm and E.S.P. up to 40). A possible explanation for the salinity and alkalinity could be the occasional water logging, caused by the relatively low position of the soils and resulting in accummulation of salts in the soil.

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Samples of two profiles in river basin land near the Kerio river were all low in salts and sodium, the EC (electic conductivity) in a 1:1 suspenstion always being less than 1.0, mostly even less than 0.5 mmhos/cm. This could mean that the river basin land near the Kerio river are mostly nonsaline and nonalkali, probably because they are younger than those of the Dead river system.

Until further, more detailed, investigations are carried out the river basin lands at the foot of the lava flows, north of Merulina hill and south of Lotubai hill must be considered not suitable for irrigated agriculture, because of the presence of saline-alkali soils.

The river basin land near the Kerio river is probably suitable for irrigated agriculture, because:

(a) there are indications that most of the soils are nonsaline and nonalkali.

(b) the texture of the soils is favourable and the workability is probably good.

(c) the permeability and water holding capacity seems favourable (there was however no time to carry out measurements)

(d) in the subsoil layers of loamy sand or sandy loam are found, which make subsoil drainage possible.

3.2.4. River basin land covered by alluvial fan material (unit Fba)

This unit is found in only one area in the northern part of the map. The area is covered with an open bush vegetation with very little ground cover of some herbs.

Soils are very much comparable with those of the other basin lands at the foot of the lava flows (see 3.2.3.), but are covered by 10 to 70 cm. thick layer of brown to yellowish brown (10YR 5/3 - 10YR 4/4), calcareous, micaceous material deposited by an alluvial fan. Closest to the alluvial fan this cover is thickest (70 cm) and has the lightest texture (loamy sand). To the north and northwest the cover becomes gradually thinner(up to appr. 10 cm) and less sandy (very fine sandy loam).

One sample of a fine sandy loam top proved to be saline - non-alkali (ECe 12.0 mmhos/cm; E.S.P. 8%).

Soils of this unit are not suitable for irrigated agriculture, because they have probably predominantly a saline-nonalkali top and a saline-alkali subsoil.

3.2.5. Undifferentiated floodplain land (basin and levee; Unit Fu)

Some areas of the floodplain are partly or completely covered with wind blown material, the presence of which obscure the original

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image of levee land and basin land on the aerial photographs. This makes a separation of both units impossible without a detailed ground survey.

Apart from the wind blown cover the soils are composed of those described under the levee land (3.2.2.) and the basin land (3.2.3.). A sub-division was made according to differences in wind-blown deposits.

Undifferentiated floodplain land (basin and levee) with scattered, 30 cm to 1 m high, wind-blown hummocks of calcareous sand to sandy clay (unit FU1)

This unit is found in three, rather big sections in the northern part of the investigated area. The soils are covered with an open bush with very little ground cover of some herbs. Locally however, a "forest" of dead trees (Salvadora persica) is found.

The wind-blown hummocks vary in texture from medium sand to sandy clay. The first ones are mainly found close to the lava flows and are nonsaline-nonalkali, the latter ones are located more in the centre of the floodplain and are probably predominantly saline - alkali. One sample of a wind-blown hummock, consisting of sandy loam, had an ECe of 15.5 m mmhos/cm and an E.S.P. of 27.6%. Salinity and/or alkalinity of wind-blown, fine textured material is normal, because it is normally associated with micro-aggregated clay.

Soils of this unit are considered non-suitable for irrigated agriculture because of the high risk of salinity and alkalinity.

Undifferentiated floodplain land (basin and levee) with scattered, 50 cm. to 2 m high, wind-blown hummocks and sheets of wind-blown, calcareous sand (Unit FU2)

These soils are found east of Merulina hill and west of Namortungai hill. The area is covered mainly with a very open bush, with very little groundcover during the dry season.

The hummocks are 50 cm to 2 m high, 50 to several hundreds of metres apart and consist of calcareous, medium sand.

The sheets of sand cover most of the area, are 10 to 100 cm thick and consist also of calcareous, medium sand.

Soils of this unit are not suitable for irrigated agriculture for reasons mentioned under 3.2.2. and 3.2.3. and because of the presence of the cover of wind-blown sands.

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3.3. Soils of the alluvial fans (units A..)

Alluvial fans are found in the area of the lava flows and in the transition to the floodplain. They are covered with some very scattered herbs and shrubs. During and after rain showers, most of the water falling on the lava flows is transported via the alluvial fams to the floodplain. Most areas dip with a slope of 1 to 2% towards the floodplain and are dissected by shallow gullies at irregular distances.

Two mapping units are distinguished (Unit Al and Unit Als). Both have basically the same soils, but the latter is covered with sheets of wind-blown sand.

The soils consist of brown (10YR 5/3 - 10YR 5/4), calcareous sand. An A-horizon is mostly absent or very vague. The texture ranges from loamy medium to coarse sand with gravelly layers (mainly upstreams) to very fine sandy loam, stratified with sandy layers close to the floodplain. The subsoil consists of rock, which starts in general between 50 cm and 150 cm below the surface.

The soils are very permeable and have a low water holding capacity.

Soils of unit AlS are similar to the ones described above, but are covered with 10 to 60 cm of wind-blown, calcareous, medium sand.

Soils of both units (Al and AlS) are not suitable for irrigated agriculture, because:

(a) permeability is very high
(b) water holding capacity is low
(c) the risk that irrigation devices are washed away during and after rainstorms is high.

3.4. Soils of the lava flows (unit L..)

The area with lava flows are situated 5 to 40 m above the floodplain. They are subdivided according to differences in topography and the presence of sand dunes. In dry periods all areas carry very little vegetation and have a very barren appearance.

The soils of unit L1 have an undulating to gently undulating topography (slopes up to 8%) and are mostly less than 40 cm deep over rock. They are dark yellowish brown (10YR 4/4) in colour and mostly very calcareous. An A horizon is virtually absent, but the surface is covered by numerous gravels of 1 to 10 cm diameter (desert pavement). Striking is also the presence of 5 to 15 mm thick, very calcareous, "spongy" top layer, which is full of tiny gas bubbles.

The texture ranges from coarse sandy loam to medium sandy clay loam.

Soils of unit L1 are not suitable for irrigated agriculture because:

(a) the soils are shallow and consequently have a very low water-holding capacity.

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(b) the topography is unfavourable

(c) the areas are too high above the floodplain

Soils of unit L1S are similar to those of unit L1, but have scattered sand dunes. These dunes are 1 to 4 m high and cover 20 to 50% of the area. They consist of brown (10YR 5/3), calcareous, medium sand, which is partly stabilised. In most parts a 10 to 50 cm thick layer of loose, shifting sand is found on top of stabilized sand.

Soils of unit L1S are not suitable for irrigated agriculture, for the same reasons as L1. The presence of the dunes would be an additional serious limitation.

Soils of unit L2 have a rolling to hilly topography (slopes up to 25%). Soils are in general less than 20 to 30 cm deep and stony and in many places rock outcrops occur.

The soils of this unit are not suitable for irrigated agriculture because:

(a) soils are too shallow, too stony and too rocky

(b) the topography is unfavourable

3.5. Miscellaneous

Grouped under this heading are two units. One unit (M1) is found in the surroundings of Namortungai hill. In this area a 10 to 40 cm thick layer of predominantly stabilised, brown (10YR 5/3), calcareous, wind-blown, medium sand ("coversand") is deposited. In places this sand is accummulated into scattered, 1 to 6 m high, partly stabilized, calcareous sand dunes.

The above mentioned sands are in most places found over undifferentiated floodplain land (basin and levee). Locally however, the sand is found over rock and over gravelly material that very much looks like a remnant of an old river terrace.

The second unit (M2) concerns rock outcrops and rocky hills in the floodplain and rocky hills in the lava flow area. The rock outcrops in the floodplain vary in height from 2 m to 50 m (estimated). The hills in the lava area are higher and reach up to 100 or 150 m.

3.6. Conclusions and recommendations

Conclusions

1. The investigated area is divided into river levee land, river basin land, alluvial fans, lava flows and miscellaneous land types. Due to the unpredictable amount of water, carried by the Kerio river and the unfavourable soil conditions the possibilities for irrigated agriculture are very limited and restricted to probably only small areas in the river basin land.

2. The soils of the lava flows (unit L1, L1S and L2) are not suitable, mainly because they are too shallow.

3. The soils of the alluvial fans (unit A1 and A1S) are not suitable, because they are too sandy and have therefore a too low water holding capacity and excessive permeability.

4. Soils of the river levee land (unit F1) are predominantly not suitable because:
   (a) they have a too high horizontal permeability, due to the presence of thick sandy layers, which would cause considerable water losses in irrigated fields and in irrigation channels.
   (b) the presence of many, steeply incised and often deep and wide erosion gullies which make the construction of irrigation channels difficult and very expensive.
   (c) saline parts occur, though probably only potwise. Location of the non-saline areas requires a detailed survey and the analyses of many soil samples.

5. (a) Soils of the river basin land. Until further, more detailed, investigations are carried out, soils of the river basin land (unit Fb) at the foot of the lava flows, north of Merulina hill and south of Lotubai hill, must be considered not suitable for irrigated agriculture, because of the presence of saline-alkali soils.
   (b) Soils of the river basin land (unit Fb) near the Kerio river are probably suitable for irrigated agriculture because texture, permeability and drainage possibilities are favourable. Moreover there are indications that most of the soils are nonsaline-nonalkali.

Recommendations

1. Before any irrigation is started, a detailed soil survey, combined with the analysis of many soil samples, should be carried out, in order to establish accurately the boundaries between salt affected and non salt affected areas.

2. Such a survey will be greatly facilitated and be more accurate, if aerial photographs of scale 1:10.000 or 1:20.000 will become available.

3. Regular river discharge measurements should be carried out near Lokori, in order to obtain reliable estimates of the amounts of water available for irrigation and other purposes during the various seasons.

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4. If irrigated agriculture is to remain successful, soil salinity must be controlled. It is therefore essential to provide an adequate drainage system, so that salts accumulating in the topsoil can be leached.

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