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KENYA SOIL SURVEY PROJECT

A PRELIMINARY EVALUATION OF THE IRRIGATION SUITABILITY OF THE SOILS IN THE MANDERA-RAMU AREA

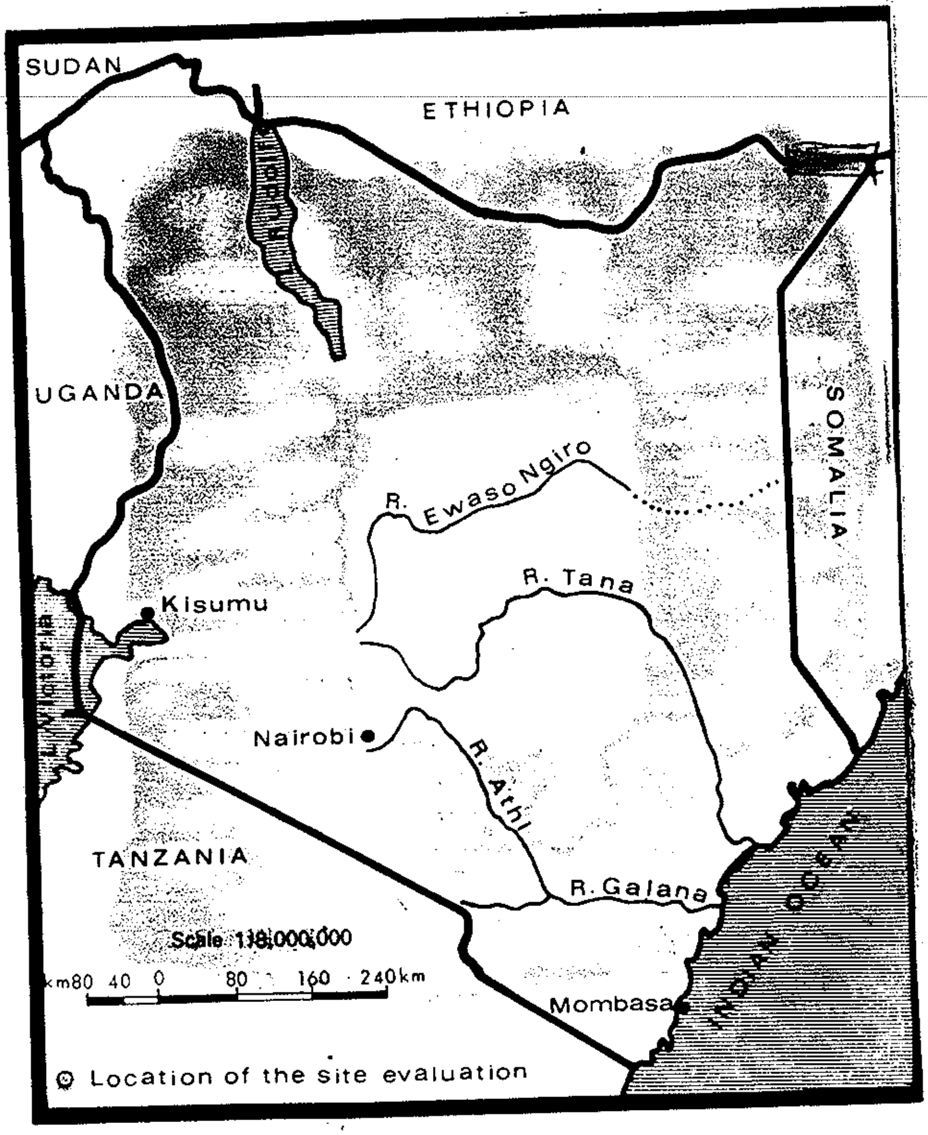
(North Eastern Province)

b y

W.G. Sombroek, H.M.H. Braun and J.M. Kibe

SITE EVALUATION

No: 10 Date: Sept., 1973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Nairobi
R. Athi
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R. Galana
INDIAN OCEAN
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Location of the site evaluation

Kenya Soil Survey Project
S178/OW/WGS/HMHB/JMK - 10/9/73
Site evaluation no. 10.

A PRELIMINARY EVALUATION OF THE IRRIGATION SUITABILITY OF THE SOILS IN THE MANDERA-RAMU AREA

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1. INTRODUCTION

At the request of the Land and Farm Management Division of the Ministry of Agriculture, a site evaluation of the soil and water conditions of the Daua valley in Mandera District was carried out, from 6th to 13th of April 1973.

Special attention was to be given to an area just downstream of Mandera town, an area halfway between Mandera and Ramu (Hareri), and one at Ramu town of beyond (Dimtu). These areas are under consideration for irrigated agriculture under the Ministry's programme of development of minor irrigation schemes. More specifically, they should serve for the settling of the groups of destitutes in the area, now living largely in famine relief camps. The data gathered should help the Ministry of Agriculture to assess preliminarily the feasibility of the proposed schemes.

In view of the vague indications given on the siting of these schemes, and the fact that some of the sites proved to be already occupied by private irrigation farms (Ramu), it was decided to produce a photo interpretation map for the whole floodplain area of Mandera - Ramu. This would allow the Ministry of Agriculture to select alternative development sites, depending on the acreage of the sites, the irrigation suitability of its soils and the availability of the land.

The study of aerial photographs revealed that, next to the floodplains hitherto considered for irrigation, there are several stretches of low terrace land near Mandera and Ramu that might be also considered for irrigation with Daua river water. Patches of flat and clayey higher terrace land similarly seemed interesting for irrigation, using ground or run-off water from nearby hills. It was therefore decided to show the physiographic units over a relatively broad stretch, thus including the terrace lands. For completeness sake, also the configuration of the various uplands within this stretch are given. They determine the accessability of the lower lands, and may help to obtain an estimate of the flood characteristics of the alluvial fans of the main tributaries.

The aerial photographs studied have a scale of approx. 1:55.500 and were flown by R.A.F. in 1967. Much of the information on physical conditions in the area given below and on the accompanying map is derived from the Atlas of Kenya and the geological report of the area (Joubert 1960) accompanied by a map at 1:125.000.

It should be stressed that the present mapping and evaluation is a very preliminary one, based on aerial photo interpretation, a few field observations (surface, augerholes, profile pits) and only some laboratory data of collected soil 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

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field and the laboratory, of the water holding and transmitting properties of the various soils.

The field party was accompanied continously by Mr. R. Storer, Project Manager of the FAO/FFHC Project for Development of Minor Irrigation Schemes, and part-time by the D.A.O. Mr. Bett and the topographic surveyor Mr. Mutete. Valuable information and hospitality was given by the D.C. Mr. Kasaka, the D.O. of Ramu Mr. Ambuka, the Officer-in-Charge of the Police Department Mr. Maina and Father John of the Mandera Catholic Mission.

2. ENVIRONMENTAL CONDITIONS

The Mandera-Ramu area is located at 4°.00'N and between 41°.00' and 42°.00' E. Its general altitude is about 500m in the western part and about 300 m in the eastern part. The Daua river valley, forming the boundary with Ethiopia, crosses the area in a West to East, direction, the valley floor being at 300-200 m altitude (slope 0.8-0.9 m/km). The river has built up a relatively narrow band of recent floodplain, on the Kenyan side varying in width from about 200 to 1500m.

The recent floodplain is banded by an older floodplain and several terraces. The uplands and interior plains are crossed by several ephemeral streams with associated alluvial fans.

The climate is arid which can be illustrated with some meteorological data of the year 1965 for Mandera (EAMD 1966):

Annual mean maximum temperature		34.3°C	(31.6 to 37.1 monthly range)
" " minimum	"	21.9°C	(19.4 to 23.9 " ")
" " relative humidity	at 06.00h	72%	(60 to 93 " ")
" " " "	" 12.00h	46%	(32 to 67 " ")

Total annual rainfall in 1965: 283 mm.

The average annual rainfall at Mandera amounts to 257 mm (29 years; EAMD 1972). Over the period 1958-1970 the maximum was 643 mm (1968) and the minimum 149 mm (1969). The rainfall is erratically distributed over the two rainy seasons March to May and October to December. In other months rainfall of any significance occurs only very rarely. Some relevant data concerning the rainy seasons over the 1958-1970 period are given below:

	March-May	October-December
minimum rainfall	73 mm	34 mm
maximum "	297 mm	220 mm
average "	174 mm	113 mm

The average annual potential evaporation (E_0) at Mandera is 2677 mm (Woodhead 1968) with a monthly distribution as follows:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
233	234	257	210	213	222	223	234	238	205	193	215

With a potential evaporation of 680 and 613 mm in the respective rainy seasons it is seen that even during rainy seasons with maximum precipitation, the excess of evaporation over rainfall is large.

Parts of the younger floodplain contain riverine woodland, in which the Doumpalm (Hyphaene coriacea) often dominates. Most of the lands are covered with bushed grassland (desert scrub) in which Acacia reficiens is often prominent. Rainfed farming by the local population (Somali) is restricted to some patches of terrace land where the apparently very favourable soil conditions (unit Tld of map) allow occasional cropping of millet. Locally, farming-on-the floods is practised (river edge at Hareri), while irrigation by pumping of riverwater has recently started (Ramu). Extensive grazing (by cattle, sheep, goats, camels) is in fact the very predominant use of the various land units.

The different land units in the area and their characteristic features are described systematically in the legend and the schematic cross-section of the map, to which reference may be made.

3. WATER RESOURCES AND REQUIREMENTS

The Daua river receives most of its water from the Ethiopian Highlands. At the end of the main dry season the discharge at Mandera drops usually to zero; then only a few pools in the riverbed contain surface water. Combined with water from shallow dug-outs in the sandy river bed filling, this can serve only for domestic, livestock and wildlife purposes. Irrigation can therefore be practised only during the rainy season(s). Only last year water level recording started, near Mandera township. In the periods August 1972 to December 1972 and May 1973 to August 1973 the water level varied between about 0.5 and 1.5m, while during the other months (19th Jan to 20th May 1973, 4 months!) the river was dry. Scanning the data recording sheets available at the MoA Water Development Division and assuming a width of the flat river bed of 25m and an average water velocity of 1m/sec, the total flow may have varied between 15 and 25m^3/sec during most of the flow period (May to December). The potential evapotranspiration (Ep) under normal conditions is smaller than the Eo (see 2). In the case of the arid north of Kenya with relatively small irrigated areas, heat advection will occur and it does not seem unreasonable to assume the Ep to be 40% higher than the calculated Eo. Thus the mean annual potential evapotranspiration would be in the region of 3750 mm (or 315 mm/month) with a monthly maximum of 360 mm in March and a minimum of 260 mm in November.

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The water requirement (in l/sec ha) can be calculated with the following formula:

$$W.R. = E_p \times \frac{1}{IE} \times 3.85 \times 0.001$$

with: W.R. = water requirement in l/sec ha

E_p = potential evapotranspiration in mm/month

IE = irrigation efficiency = $\frac{\text{water used by plants}}{\text{water pumped or diverted}}$

Example: E_p = 315 mm IE = 0.5

W.R. = 315 x 2 x 3.85 x 0.001 = 2.4 l/sec ha

For a scheme of 1000 ha with day and night water delivery 2.4 m^3/sec would be needed. In the case of day delivery only either a storage of 2.4 x 12 x 3600 = 100,000 m^3 must be constructed with a continuous diversion of 2.4 m^3/sec, or a day-time diversion of 4.8 m^3/sec would be needed.

A rainy season river discharge of 15 m^3/sec would therefore allow the irrigation of 6000 hectates maximally, i.e. not considering other uses like domestic water supply and watering of cattle and wildlife. By international agreement half of the water should be available for the Ethiopian side of the river. Though the discharge data are scant it seems that the envisaged irrigation of 1000 ha on the Kenyan side is possible and does not jeopardize other uses of the river water.

The quality of the river water is supposedly good but no laboratory data are available. A sample of pool water taken at the end of the dry season, showed an electrical conductivity (EC) of 0.41 mmho/cm, a sodium adsorption ration (SAR) of 0.4 and residual sodium carbonate content (RSC) of 0.0 meq/l. The last two factors are very favourable - no alkali hazard -, but the salinity hazard should be medium (Richards 1954). The flowing river water, during the rainy season, may however have a lower salinity.

No data could be obtained on the sediment content of the flowing water.

A permanent ground water level occurs at about 40 m depth below the level of the upper terrace land. Both Mandera and Ramu towns draw from this groundwater for their centralised domestic water supply. The water is slightly brackish. The quantity is restricted, reportedly no continuous pumping can take place at the end of the dry seasons. It is not unlikely (cf. Joubert 1960, pages 56-57) that at the transition between the uplands and the alluvial fans of the main ephemeral tributaries of the Daua substantial ground-water reserves exist, which might be used for cattle watering or even irrigation, but actual survey is lacking.

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4. LAND RESOURCES FOR IRRIGATION DEVELOPMENT

4.1. The younger floodplain lands (Mandera, Ramu and Dimtu areas)

These lands appear to have a pattern of active river levees and river basin lands, at about 4 and 3 m respectively above the dry river bed. The transition between these sub units is very gradual and not well identifiable on the aerial photographs 1:55.000, hence the boundary line is drawn interruptedly everywhere on the map.

No coherent information was obtained on the nature of flooding. In general, frequency, length and depth of any flooding seems smaller at Mandera than at Dimtu, upstream.

The levee lands (F1 unit) seem to have a fairly regularly flat surface, but have a dense coverage of Doum palm, the stumps of which are difficult to uproot. Some parts, directly along the river bed, are at lower level and with a less regular surface (apparently recently re-worked sediments). Tender grasses prevail as ground cover.

The surface soil is fine sandy to loamy; it shows no cracking, and sealing or crusting are negligable. The soil profile itself has a good internal drainage. It shows a rapid alternation of sedimentary layers of different textures, though predominantly fine sandy to fine loamy; medium to coarse sandy or stiff clayey layers seem exceptional. Characteristically the sand fraction is fine to very fine, the silt percentages are very high (often more than 30%), and primary minerals, notably shiny mica flakes, abound. The colours vary from dark brown to (dark) reddish brown or yellowish red, with little or no mottling. The structure is subangular blocky to massive and the porosity is fair. The consistence is usually soft and very friable. All layers contain high percentage of free lime (2 to 15% in analysed samples), but no gypsum (traces only). There are no surface or profile features of salinity, which is confirmed by laboratory data (EC of 1:2.5 suspension is 1-3 mmho/cm), while alkaliness is uncommon (ESP usually <5%, sometimes >15%).

Water holding and transmitting properties seem favorable on the the average. An infiltration test (near profile 22-4) with six repetitions showed that 10 cm water needed, on the average, 95 minutes and 130 minutes, for dry and wet run respectively, to infiltrate. The measurements indicate that no special problems are to be expected during irrigation of this soil. It should be emphasized that the above data have indicative value only and should not be used for calculations of the layout (e.g. the length-of-run) of the irrigation plan.

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The moisture storage capacity in the various layers should be fair at least, and the transitions between the layers are not as abrupt usually as to impede deep rooting. The hydraulic conductivity of the subsoil will be all right, at least in the sandy to loamy layers. Subsoil drainage should normally be possible. This is of paramount importance, since the groundwater level should be kept low to prevent salt accumulation in the rootzone, also in view of the expected strong capillary rise.

Considering all these aspects, it can be concluded that the levee lands are well suited for irrigation. Any levelling that may be required will not be harmful to the soil conditions. Clearing costs are however high and great attention has to be given to periodic leaching of any accumulated salts of the irrigation water and to keeping the ground water level low (deeper than 2 m).

The basin lands (Fb unit) have in places a regularly flat surface but in others are characterized by interrupted gullies or sinkholes. The vegetation is less dense and tall, consisting often of shrubs (Salvadora persica, Sesbania sp.a.o.) and scattered tall trees (Acacia tortilis). Doumpalms are infrequent; sometimes low Phoenix reclinata palms take their place. The ground coverage consist usually of dense tender grasses.

The surface soil, though usually clayey, shows no sealing or substantial cracking.

The soil profile has a moderate to poor internal drainage. It shows sedimentary layering with a predominance of fine loamy to clayey layers, though sandy layers are not rare; homogeneously silty clay profiles - proper backswamp soils - occur as well. The sand fraction is again characteristically fine to very fine, silt percentages are high and mica flakes abundant. The colours are (reddish) brown to dark brown, the heavy layers often showing substantial mottling. The structure is mostly subangular to angular blocky and the porosity is fair. Clayey layers have a very hard consistence when dry and are firm to very firm when moist. All layers contain very high percentages of free lime (4 to 25%), but gypsum is absent. As in the case of the levee soils, no apparent features of salinity were found (EC values <3 mmho/cm for the few samples) while alkali layers seem to be exceptional (ESP <5% usually). The deeper subsoil however may consist of strongly saline - alkali loamy to clayey layers that are probably of an earlier deposition period (Fa material, see below).

Water holding and transimitting properties are largely unfavourable. Moisture storage of individual layers will on the average be higher than in the Fl unit, but transitions are more pronounced and abrupt - restricting root penetration - and percolation may be very slow through the clayey layers.

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On a site where during a trial irrigation difficulties were experienced in getting the water infiltrated, a test showed that while the surface infiltration in the loamy topsoil was all right, the sub surface clayey layer had a low percolation rate (160 - 370 minutes for 10 cm. water).

Also the horizontal hydraulic conductivity of the subsoil will often be very slow. A laboratory test on three ringsamples from a heavy clay subsoil showed initial hydraulic conductivity of 3.2, 1.8 and 1.0 cm/day respectively which is very slow; after 6 days it had dropped even to 0.9, 0.8 and 0.3 cm/day respectively.

The mentioned physical properties imply that subsoil drainage is not well possible and that as a whole the Fb unit will be definitely more liable to deterioration through salinisation and alkalinisation. The very poor condition of the soils of unit Fa - which sedimentologically are similar to the Fb soils - indicate how serious deterioration may become. Considering the above factors, as well as the poorer tilth where the surface is clayey, and the often irregular micro topography, the unit as a whole is only moderately suitable for irrigation. In places however the soils will be unsuitable for most crops very soon after the start of a scheme. Even rice growing would soon be impossible where the subsoil is saline.

4.2. The older floodplain lands (Dimtu and Hareri areas)

These lands (unit Fa of map) are extensively flat. They are at a level just above flooding, but standing rain water may cause swampy conditions after heavy rains. There is no apparent pattern of former levees and basinlands, nor do they have any micro relief. The coverage of the land is an open grassland, locally with scattered trees of one species only, namely Acacia seyal.

The surface soil shows locally some crusting, but does not crack substantially. The soil profile has a poor internal drainage. The textures are clayey to fine loamy (clay, silty clay, silty loam) and are characterised by high percentages of silt and very fine sand, strongly micaceous. The colours are reddish brown mainly. Structure and porosity are presumably poor (no profile pit was examined). The consistency is firm when moist, hard when dry. All layers contain high percentages of free lime (15-25% in the lab.) partly in visible patches, while no gypsum was observed. The peculiar vegetative cover and the crusty surface point to strong salinity. This was confirmed by both field and laboratory measurements of salinity (20-35 mmho/cm), while also sodium proved to be in excess (ESP 10-30%). Water holding capacity may be all right in view of the prevailing textures, but the water transmission properties (infiltration and percolation rates, hydraulic conductivity of the subsoil) are undoubtedly poor. They are likely to become even worse once the excessive salinity-at these levels very harmful to crop growth - would be leached, because the excessive sodium would then cause further structure decline. The soils are therefore essentially unsuitable for irrigated agriculture.

4.3. The alluvial fan lands (Hareri and Ramu areas)

Where occurring near the entrance of the major ephemeral tributaries into the Daua floodplains, these lands have a pattern of levees and basin lands, the latter at slightly lower level. The over-all slope of these fan lands seems less than 1%.

The levee lands (Ftl unit) normally show some mesorelief of shallow gullies (1-2m deep, about 200 m apart). The vegetation consists of wooded grassland. The soil surface does not seal crack or crust; locally loose sand accumulations occur. The soil profile, well drained, consists quite homogenously of yellowish red fine sandy loams. In contrast to the levee soils of the Daua river, the percentages of the very fine sand and silt fractions are fair only (20 and 25% respectively), and mica flakes are totally absent. Structure and porosity are presumably fair to good and the consistence is soft when dry and very friable whem moist. The free lime content is high (15%), gypsum is nearly absent. There are no signs of salinity or alkaliness, and the lab. data concur (EC 1-3 mmho/cm, ESP 5%). A field test showed the moisture holding capacity to be quite fair. Internal drainage (percolation, hydraulic conductivity) is favourable, while capillary rise should not be excessively high in view of the textures. Hazards for the harmful accumulation of salts or sodium are therefore very low. Infiltration rates may however be on the high side for gravity irrigation.

In conclusion, the alluvial-fan levee lands at the mouths of the tributaries seem moderately well suited for irrigated crop growing.

The levee land further upstream, where bushed grassland prevails, the meso relief of gullies usually is more pronounced, and the textures may be still sandier, is tentatively qualified as marginally suitable.

The alluvial fan basin land parts (Ftb unit) at the mouths of the tributaries are either homogeneously flat or show a pattern of gullies or elongated sinkholes (0.5 deep, 1.5m wide, 5-20m apart). The vegetative cover is usually an open woodland of various species (but few or no Doumpalms). The surface soil shows usually no sealing or crusting, but cracking may occur. The soil profile, moderately well to imperfectly drained, has predominantly loamy to clayey textures (loam, clay loam, clay or heavy clay) with less high silt percentages than in the Fb unit and without micas. Textural changes seem also more gradual, both vertically in the profile and in horizontal

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direction. Soil colours seem predominantly yellowish red. Clayey layers may have a poor consistency. The free lime content is very high (about 20%); gypsum was not observed. Field conclusions as to the absence of salinity and alkaliness were confirmed in the lab. on a topsoil and a subsoil sample respectively (EC about 1 mmho, ESP<10%). The moisture holding capacity should be quite high, the infiltration rates moderate to slow. The internal drainage (percolation rate and horizontal hydraulic conductivity of the subsoil) will however be fair at best. A large ringsample of one clayey layer of the subsoil, at 150 cm depth, showed a hydraulic conductivity of less than 0.5 cm/day.

In view of the latter it will be rather difficult to prevent ultimate salinization at prolonged irrigation, but probably less to than in the case of the Fb unit.

Tentatively the unit is qualified as moderately well suited for irrigation of most crops, but actual augerings and lab. analytical data on which this is based are even fewer than in the case of the Fb unit.

4.4. The terrace lands

Among the various terrace lands (units T_1, T_{1d}, Tt, T_2; see legend of the map) there are two units that are of potential interest for irrigation development, if water can be commanded to their respective sites.

Large stretches of the low-terrace unit (T_2) may receive irrigation water by pumping from the riverbed; the height difference is about 10m. The description of the soil ("fine loamy soils, very calcareous, yellowish brown") is derived from surface observations and indications by Joubert (loc. cit) only; the colours and surface crusting do suggest salinity and/or alkalinity. The mesorelief of the unit is moreover often somewhat irregular, through past erosion. Provissionally this unit is therefore indicated as only marginally suitable for irrigation.

The mudflat parts (unit T_{1d}) within the sandy upper terrace will become of interest if substantial amounts of good-quality ground water would be found in the upland area. These patches, slightly depressed (0.5m or so) within the main terrace lands, are extensively flat, without any meso-or micro relief. They are either grasscovered (with some low Doum palms) or used for rainfed farming (millet). The surface soil shows no sealing, crusting or cracking. The profile consists homogenously of dark red sandy clays to more than 150 cm depth, the predominant sand fraction being medium to fine. The consistence in dry condition is only slightly hard, except for the subsoil (at about 150cm) where a hard horizon seems to be present, with calcium carbonate concretions and powdery free lime. Some free lime is however present as from the surface (1-4%). Field indications that salinity and alkalinity are absent were confirmed in the laboratory (EC$<$1 mmho/cm, ESP$<$5%). The homogeneously dark red colour indicates that the internal drainage is favourable, and the moisture holding capacity should be high.

In view of the above, the unit will be well-suited, nearly ideally, for irrigated agriculture, if water can be found.

5. COMPARISON OF THE VARIOUS LANDS AND SCHEME SITES

For the immediate future, interest will centre on the utilization of Daua river water for gravity irrigation of the younger floodplain units (Fl, Fb) and on nearby parts of alluvial fan lands (Ftl, Ftb).

The Fl parts of the younger floodplain, well suited, are located right alongside the river bed, hence water supply will be easy. Clearing costs are however very high. The Fb unit, qualified as moderately well (to marginally) suited, will probably have to form part and parcel of any organised scheme, like those near Mandera. Water supply will be easy but a different management will be required with notably much attention to deep drainage, and a more restricted choice of crops. In view of such drainage, knowledge on the exact location of any slowly permeable and possible saline/alkali subsoil layers is at least as important as the variation in topsoil textures.

If drainage is forgotten or carried out haphazardly then there is a great chance that within 5 or 10 years the terrains, especially the Fb unit, will turn to similar waste land as the Fa unit (such rapid deterioration under irrigation has also occurred on similar sediments in Northern Nigerian floodplains, under even less extreme climatic conditions).

The association of alluvial fan levee land (Ftl) and basin land (Ftb) of the lower tributaries e.g. that near Hareri, both moderately well suited, should be seriously considered for an irrigation scheme, especially since salinization/alkalinisation seems less a hazard here than in the case of the younger floodplain. Some engineering costs will however be involved in the re-routing of flushy run-off through the various gullies crossing the terrains.

It is likely that the alluvial fan soils will also require different fertilizing from those of the younger floodplain, in view of the completely different primary mineral composition. A few analytical data on easily available plant nutrients (Mehlich analysis) point to higher values for both P and K in the younger floodplain soils (0.7 and 0.4 m.e. K, 12 and 16 ppm P, for clayey and loamy floodplain soils respectively; 0.50 and 0.15 m.e. K, 10 and 8ppm P, for clayey and loamy topsoil of the alluvial fan units). Nitrogen will be required probably equally, also in view of the generally low percentages of organic matter (0.3%C; N values 0.05% or lower).

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4. A systematic survey programme for the location of any ground water reserves in the uplands and interior plains should be carried out, taking into account geologic indications (cf. Joubert 1960)

5. Regular river discharge measurements should be carried out at both Mandera and Ramu, in order to obtain reliable estimate of the amounts of water available for irrigation and other purposes during the various seasons.

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Richards, L.A.(ed) 1954 "Diagnosis and Improvement of Saline and Alkali soils" USDA. Department of Agriculture. Agriculture Hand book 60. Washington D.C.

Woodhead T. (1968) "Studies of potential evaporation in Kenya". East African Agriculture and Forestry Research Organization, Nairobi.

The older floodplain soils are evidently unsuitable for any irrigation development. The proposed Dimtu scheme would be located on these soils (and/or narrow stretches of younger floodplain). An area directly west of Kalalyo, not yet occupied by local farmers, may be a suitable alternative.

6. CONCLUSION AND RECOMMENDATIONS

It is concluded that:-

1. The Daua younger floodplain lands have very fine sandy, loamy or clayey and very calcareous soils without substantial presentday salinity or alkalinity (units Fl and Fb). They are mostly well to moderately well suited for irrigation development, but great attention should be given to deep drainage, especially for the basin land parts (Fb unit), to prevent harmful salinization/alkalinization within a few years.
2. The downstream parts of the alluvial fan lands of the main tributaries of the Daua have also fine sandy, loamy to clayey and very calcareous soils with no presentday salinity or alkalinity (units Ftl, Ftb). They are also moderately well suited for irrigation, though the hazard of harmful accumulation of salts or alkali seems lower. Particular attention should be given to canalisation of the occasional flush flooding.
3. In view of the different nature of the sediments, the management of the younger floodplain soils, will have to be different, both as regards water and chemical fertilizers, from that of the alluvial fan soils.
4. The soils of the older floodplain are clayey to fine loamy and are strongly saline and alkali (unit Fa). They are unsuitable for irrigation.

It is recommended that:-

1. For any irrigation area to be selected after taking into account the above conclusions, both a topographic survey and a semi-detailed soil survey will be required prior to the preparation of a detailed lay-out of the scheme. Such a soil survey should not only define better the boundary between the various units, notably Fl and Fb, but also map the variations in properties of the deeper subsoil and the substratum.
2. Any of these surveys will be greatly facilitated and be more accurate if aerial photographs of scale 1:10.000/20,000 will become available.
3. It seems worthwhile to pay attention the topographical and soil conditions of the lower terrace land (unit T2), in order to determine its irrigation potential.

GROSS IRRIGABLE LAND OF THE DAWA VALLEY BETWEEN DIMTU AND MANDERA

(Based on photo interpretation map 1:55,500 of Site Evaluation Report No.10 Kenya Soil Survey (Sombroek et al 1973), with additional photo-interpretation for the Ethiopian Side in 1977).

Mapping Unit	Kenyan Side	Ethiopian Side	Total ha.	Suitability rating
F1	3920	3930	7850	well suited
Fb	1620	3850	5470	moderately well to marginally suited
Fa	1320	950	2270	non-suited (unless reclaimed)
Ft1	6020	6220	12240	moderately well to marginally suited*
Ftb	1040	1420	2460	moderately well suited
T2	3470	1350	4820	marginally suited, if water commandable
Tid[1]	1410	-	1410	well suited**

* but largely not commandable from the main river, and with flash flood hazard

** not commandable from the rivers, but possibily from ground water resources.

N.B. Map with photo-interpretation units also on Ethiopian side in SE report in Library, Kenya Soil Survey.

Gross Irrigable Land at the Dawa valley between Dintu and Mandera

(Based on photo interpretation map 1:55500 of ~~KSS~~ [Kenya Soil Survey] Site Evaluation Report no 10 E (Sombroek et al 1973), with additional photo interpretation for the Ethiopian side in [illegible])

Mapping Unit	Kenyan side	Ethiopian side	Total ha	Suitability rating
Fl	3920	3930	7850	well suited*
Fb	1620	3850	5470	moderately well to marginally suited
F	1320	950	2270	non-suited (unless reclaimed)
Ftl	6020	6220	12240	moderately well to marginally suited
Ftb	1040	1420	2460	moderately well suited
T2	3470	1350	4820	marginally suited, if water commandable
Tid	1410	—	1410	well suited**, ~~but not commandable from river~~

*) but largely not commandable from the main river, and with flash flood hazard

**) ~~but~~ not commandable from the river but possibly from groundwater resources

Remarks
Sombroek