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# KENYA SOIL SURVEY PROJECT

## A PRELIMINARY EVALUATION OF THE IRRIGATION SUITABILITY OF THE LANDS IN THE PRE-DELTA TANA FLOODPLAIN.

(Marembo - Garsen)

by

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SITE EVALUATION

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Contents:

1. INTRODUCTION

At the request of the Land and Farm Management Division of the Ministry of Agriculture, a site evaluation was carried out of the soil conditions of the Tana floodplain in the stretch just above the apex of the Tana delta, from 17th to 19th of August 1973.

In first instance attention was to be focussed on the soil conditions of the three minor irrigation schemes in the area (Wema, Hewani, Kulesa, each with about 25 ha presently under development) and their immediate surroundings, in connection with plans for their expansion. At the same time, however, interest was expressed by technical officers of FAO/HCDA (Horticultural Crop Development Authority) for large-scale irrigation development in the area. This development would be in the sphere of commercial vegetable and fruit tree growing, in view of the favourable road connection with Malindi and Mombasa. Therefore the whole floodplain in the stretch Marembo-Garsen, as well as some of the adjacent low terrace lands, was taken into consideration.

Existence of good-quality aerial photographs 1:50.00 of R.A.F. 1969 allowed for the preparation of a preliminary map on the physiography of the area (see maplet attached), on which the location of the minor irrigation schemes is identified.

It should be stressed that the present mapping and suitability evaluation is a very preliminary one, based on aerial photo-interpretation, a few field observations (surface, augerings, profile pits), and laboratory data on only a few collected soil and water samples. For any large-scale irrigation development a a full-fledged feasibility study would be needed which on its turn should be preceded by a proper semi-detailed soil survey. Such a soil survey, preferably carried out with the help of recent large-scale aerial photographs, should include measurements, both in the field and the laboratory, of the waterholding and transmitting properties of the various soils and their substratum.

2. ENVIRONMENTAL CONDITIONS

The Marembo-Garsen area is located at about 2°. 10'S and 40°. 10'E. Its altitude is about 10m or less. Geologically the area consists of Quaternary sediments, varying from fluviatile to marine, but no published detailed maps exist in this respect. The Tana floodplain proper is banded by extensive terrace lands, only a few metres above flood level. Flooding takes place twice a year, in May-June and November-December, till an average depth of 1-2 feet. From the physiography it is apparent that the main river channel, which is of the meandering type, has shifted its course to the east side in the course of time.

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The climate is at the narrow transition zone from semi-arid (upstream) to sub-humid (downstream). Mean annual rainfall would be about 550 mm, with peaks of about 75 mm per month in April-May and November-December, and rather erratic amounts in-between (EAMD averages for Garsen town are quoted as: January 10 mm, February 5, March 50, April 90, May 65, June 45, August 20, September 25, October 65, November 70, December 80 mm). Temperatures are high throughout the year (mean maximum 32°C, mean minimum 23°C). The mean potential evaporation (Eo, Penman) would be about 2300 mm per year, 200-220 mm in each of the months October to March inclusive, 170-190 mm in-between (averages taken from Woodhead 1968).

The area belongs to the ecological zone IV, of which the natural vegetation would be Acacia-rich dry forms of woodland and bushland vegetation. The terrace lands indeed contain low forest, thicket or bushed grassland. The floodplain is covered with tall grasses and herbs, with only patches of riverine forest or swamp forest. Indications are that formerly all of the floodplain was covered by such forests.

Agricultural occupation is restricted to subsistence farming on the higher parts of the floodplain by the local population (Pokomo tribe). Some rice and maize is grown on-the-floods at intermediate levels. Extensive grazing is the main use of the terrace lands; in times of drought cattle are moved to the lush grasslands of the lower floodplain parts. Reportedly a rice scheme existed in th these lower parts some 50-60 years ago, connected with the main river channel by a feeder canal. The reasons for its abandonment are not clear.

3. WATER RESOURCES AND REQUIREMENTS:

The prevailing climatic conditions make the utilization of surface or ground water imperative for any cropping. This may be done by conserving floodwater, and has reportedly been tried-out at small scale. The vagaries of flooding would however not permit to take this as a basis for any substantial arable cropping. Moreover, any flooding is certainly to diminish (further) in the near future, because of the construction of dams in the upper Tana and the use of Tana water for major irrigation schemes upstream.

For any substantial crop growing in the area, irrigation development is necessary. It is estimated that 150-180 mm per month would be needed. The Tana river is the obvious source of irrigation water. The present day dry-season flow is in the order of 80m³/sec (30m³/sec once in ten years, cf. hydrological data on Lahza -20 Km upstream of Marembo- and Garissa town, as reported by Ilaco, 1973), sufficient for many thousands of ha's. After the development of large-scale irrigation in the Bura-Hola area, the dry-season flow will however be substantially lower.

For minor irrigation schemes pumping at several sites from the river bed may not be too costly. For substantial irrigation development, however, it will for reasons of economy be necessary to supply the water by gravity. This would imply the construction of a diversion dam further upstream, e.g. at Sailoni, with a feeder canal leading from there straight to the irrigation scheme.

The quality of the Tana water for irrigation is excellent, like upstream (Acres/Ilaco 1967, Vol. II). A low-flow sample taken during the site evaluation proved to have low salinity, alkalinity and bicarbonate hazards (EC 185 micromho/cm, SAR of about 1.6 and RSC of 0.02 me/l; cf. Richards et al 1954).

The ground water in the area occurs rather shallow and is reportedly quite brackish (verbal information, Water Development Department and local). In the floodplain its level varies between 4 and 7 m depth, on the terrace lands it would occur at 30 m depth or so. Two samples of groundwater in the floodplain were tested on their quality. One sample, below a river levee part, had only medium salinity hazard and low alkali or bicarbonate hazard. The other, howewer taken from ground water below a basin land part and probably more representative for the area as a whole, proved to have high salinity hazard, low to medium alkali hazard and high bicarbonate hazard (EC 1250 micromho/cm, SAR 10.0, RSC 7.5 me/l. The implications of the presence of such an unfavourable ground water at relatively shallow depth for the lay-out of an irrigation scheme is discussed in ch. 6.

## 4. LAND AND SOIL RESOURCES

### 4.1. The floodplain lands

The floodplain of the Tana river in the Marembo-Garsen area consists of two main physiographic units, being river levee lands and river basin lands.

4.1.a. The normal river levee land (unit Fl of the maplet) is just above present-day normal flooding. The macro-relief is flat, but there are meso-relief differences of 0.5 m or less over distances of 20-50 m or so. The soils consist of micaceous (very) fine sands to loams, probably till several metres depth. The topsoil is brown, with a fair organic matter content and a favourable structure (moderately subangular blocky). The subsoil, mainly dark yellowish brown and with mottles of reddish yellow, still maintains a distinct sedimentary stratification. The soils are noncalcareous, non-saline and non-alkali till at least 2 m depth. Chemically the soils are moderately rich only (CEC 5-20 me/100 g soil, V 80% or more), and no immediate nutrient deficiency is to be expected, though nitrogen fertilizing would be useful (one topsoil sample showed N 0.2%, P 530 (!) ppm and K 2.4 me% as easily available nutrients). Tillage is easy. The infiltration rates will be rather high on the average, and the moisture storage fair only.

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Root penetration will be somewhat hampered by occasional abrupt transitions to clayey or very sandy layers. The levee lands contain the villages in the area, and most of the terrains are already in use for seasonal subsistence cropping, like maize. Locally, fruit trees like mango have been planted, and do well. The original vegetation, presentday occurring only in patches, consists of riverine forest, rather high (10-15 m) and of varied species composition.

In some parts (unit Fli) the meso-relief is quite irregular, the land being in fact composed of, or re-worked to, a pointbar complex.

4.1.b. The normal river basin land (unit Fb of maplet) is extensively flat, without any appreciable meso- or micro relief. The land is flooded two times a year, till 30-50 cm. depth. The soils consist of heavy clay till 2-3m depth or more; therebelow stratified fine sandy to loamy micaceous sediments occur. The topsoil is very dark grey brown, with a fair organic matter content (one sample 1.7%C); it has a favourable structure (crumbly, or subangular blocky composed of fine granules), and crack deeply and strongly when dry.
The subsoil is grey brown and slightly mottled, with a fair structure (medium prismatic to angular blocky) and a firm though not very firm consistence. Porosity seems appreciable till only about 100 cm depth. Till about 150 cm the soils are non-calcareous, non-saline and non-alkali; therebelow a slight salinity and slight alkaliness occurs, in the presence of some soft free lime (ECe 5-8 mmho/cm, ESP 10-25%, $CaCO_3$ 1%). Chemically the soils are quite rich (CEC 40 me/100 g soil throughout the profile; V 70% or more) and no immediate nutrient deficiencies are to be expected, although nitrogen fertilizing would be beneficial for several crops (one topsoil sample showed N 0.2%, P 35 ppm and K 0.6 m.e.% as easily available nutrient).

Tillage should be difficult but not extremely so. Rootability will be restricted to 100 cm or less. Initial infiltration rates should be fair, in view of the pronounced cracking. In the deeper subsoil however, the water passage both vertically and horizontally is likely to be very low (confirmed by lab. tests on some core samples: less than 1 cm/day hydraulic conductivity).

The basin lands are largely covered with a dense mat of tall grasses and herbs (Panicum meyerianum, Echinochloa haploclada). This is often burned and the fire each time takes off some of the patches of swamp forest that seem to compose the original vegetation. This forest is low (10 m or so), dense and seemingly rather restricted in species composition.

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Extensive grazing is the only significant use of the land. The three minor irrigation schemes (Hewani, Wema, Kulesa) are however located on parts of river basin land (see maplet).

In some parts ( unit Fbi) of the basin land, the presence of pondlike depressions or old river channels c.q. natural drainage channels causes the meso-relief to be rather irregular. These parts may also be deeper flooded and have a more marshy vegetation than the normal basin lands as described above.

Between the river basin and the river levee units there are often stretches of transitional lands (unit Fl-b). These stretches are usually quite narrow, but in the area immediately north and south of the Garsen-Witu road they seem to cover substantial acreage (200 ha). There the meso- relief is quite regular. A very dark grey clay to heavy clay topsoil seems to grade into fine sandy to loamy sediments at shallower depth than in the basin land proper, namely 150-200 cm depth or so. Scattered Borassus palms, towering high above the surface cover of tall grasses, herbs and some shrubs, may be a characteristic feature of these transitional soils.

4.2. The terrace lands

The flat terrains adjacent to the floodplain proper seem to consist of two main physiographic units, composing river terraces of different age. The lower terrace (unit T1) is situated about 2-3 m above flood level. It is extensively flat and without appreciable meso-or micro-relief. The soil consists of clay or heavy clay till undetermined depth. The topsoil is grey brown, slightly crusting, only slightly cracking and with a fairly good structure (moderate subangular blocky). At shallow depth however, often already at 20 cm, the consistence becomes very hard, associated with moderate salinity (ECe 8-15 mmho/cm) and moderate to very strong alkaliness (ESP 20 - 70%). The soil is slightly calcareous throughout (1 - 3%).

The vegetative cover is a thicket or dense bushland , with sparse grazing as the only land use.

The upper terrace (unit T2) is situated about 5 m above flooding. It is also flat, but has a considerable meso-relief of small pondlike depressions and degraded termite mounds (both diam. 10 m or so). There is also a micro-relief of shallow, partly interconnected gullies (cowfoetoes). The soil consists of sandy clay loam to clay till undetermined depth. A thin black topsoil, somewhat sealed, slightly cracking and non-calcareous, overlies a very hard subsoil which from 20-50 cm depth onwards is moderately saline (ECe 8-12 mmho/cm) and moderately to strongly alkali (ESP 20 - 50%), in the presence of only some free lime (1%).

The vegetative cover is a low forest or, where burned repeatedly, a wooded grassland. Only rarely some rainfed cropping takes place. ..../6

## 5. IRRIGATION SUITABILITY AND CROPS

Among the floodplain lands, the normal river levee land (unit Fl) is moderately well suited for irrigated agriculture. If gravity irrigation is foreseen then the land may locally need some levelling, but such land development would not be detrimental to soil conditions. In view of the prevailing water holding and-transmitting properties, it may however be preferable to apply the irrigation water by sprinkling. Irrigated horticultural crops (a.o. melons, asparagus) and fruit tree crops (a.o. mango) should do well on these lands. Their total acreage east of the river, in the stretch between Sailoni and the main road, is about 1100 ha; it should however be kept in mind that a good part is already in use for subsistence cropping.

Also the normal basin lands (unit Fb) seem moderately well suited for irrigation. They would not need any levelling and the water holding and transitting properties are better, at least in the upper part of the soil profile. The difficult tillage is however a disadvantage, as well as the somewhat restricted rooting and the difficult drainage (see below). Gravity irrigation with furrows or basins would be most suitable for these lands. Field crops like cotton, maize and sorghum should grow well. The same holds for most leafy vegetable crops and bananas, but for root crops and fruit trees the soils are less suited. Rice may well be grown; initially high water consumptions could be brought down by puddling of the subsoil, thoughh in that way the relatively favourable soil structure would be destroyed and the suitability for other crops diminished. Mechanised fodder or hay production-to cater for the cattle in the arid countryside upstream - might be a feasible proposition as well ( fodder or hay production without irrigation, on-the-floods only, may be feasible as well, since at this type of land use the presentday vagaries of flooding would not be too risky). The acreage of the basin lands east of the river, between Sailoni and the main road, is about 3900 ha. Downstream of the road this unit occupies several thousands of hectares more.

The transitional lands (unit Fl-b) combine the advantages of both main units, and can be qualified as well suited for irrigation. Their total acreage east of the river, between Sailoni and the main road, is however restricted: about 200 ha.

Mainly because of topographic limitations, the irregular river levee lands (unit Fli) and the irregular river basin lands (unit Fbi) are only marginally suited for irrigated agriculture.

Mainly because of the excessive alkaliness of the soils at shallow depth, the terrace lands (units T1 and T2) are unsuitable for irrigation development. Only expensive and time-consuming reclamation measures would improved these soils substantially.

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## 6. DRAINAGE REQUIREMENTS

Any irrigation development in the area has to pay much attention to drainage measurements.

To avoid flooding the terrains are to be protected by low dikes all-round (empoldering). Because of the associated seepage problems wherever these dikes cross over river levee land, substantial engineering works will be required. If no flood protection is foreseen, then obvious any floodwater has to be drained-off twice a year as soon as possible, to allow proper crop management.

Drainage is however also essential to avoid ultimate salinisation and/or alkalisation of the rooting zone, which would render the soils unsuitable for any crop growth. As mentioned before, the Tana river surface water is of excellent quality for irrigation, but the ground water may contain harmful concentrations of salts in general, and of sodium and bicarbonate in particular. Especially for the basin lands, where the presentday dry season ground water level is only 3-4 m, measures should be taken to avoid any substantial rise of this level, which would result in contact between this poor-quality water and the moisture of the rooting zone. Under irrigation there will always be excess water (over-irrigation, seepage from canals, flooding or heavy showers) which would induce such a rise, unless drainage is effectuated.

For the small tracks of basin land near the main river channel - where the present minor irrigation schemes are located - the drainage can probably be realised largely by speedy surface drainage (furrows, ditches, possibly cambered beds), with some collector drains till 1 m depth or so.

A substantial expansion of these minor schemes, however, or any major scheme, should count additionally with one or several deep drainage canals. They should be located in the central, lowest part of the Fb unit east of the river, and be at least 3-4 m deep so as to reach the more or less sandy substratum. The ground water can then be moved off though this layer with its supposedly adequate horizontal hydraulic conductivity. It may be necessary to install sizeable drainage pumps at the lower end of this canal (e.g. on the roadside).

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7. CONCLUSIONS AND RECOMMENDATIONS

1. Two main physiographic units exist in the Tana floodplain stretch between Marembo and Garsen, namely normal river levee lands (unit Fl) and normal river basin lands (unit Fb). The first has fine sand to loamy soils, the latter heavy clays; both are non-saline and non-alkali till 150 cm depth or more and can be qualified as moderately well suited for irrigated agriculture.

2. In any scheme of substantial acreage great attention will have to be paid to deep drainage, because of the necessity to keep the level of the brackish ground water sufficiently deep below the rooting zone.

3. The present minor irrigation schemes are well located and can be expanded further from the river if drainage measures are taken.

4. The low-terrace lands alongside the floodplain, although favourable from topographical point of view, are unsuitable for large-scale irrigation development because of the extremely high alkaliness of the soils at shallow depth.

5. Any major irrigation development in the floodplain should be preceded by a proper semi-detailed soil survey, which should include the mapping of the chemical and hydrological properties of the deeper subsoil and the substratum.

8. REFERENCES

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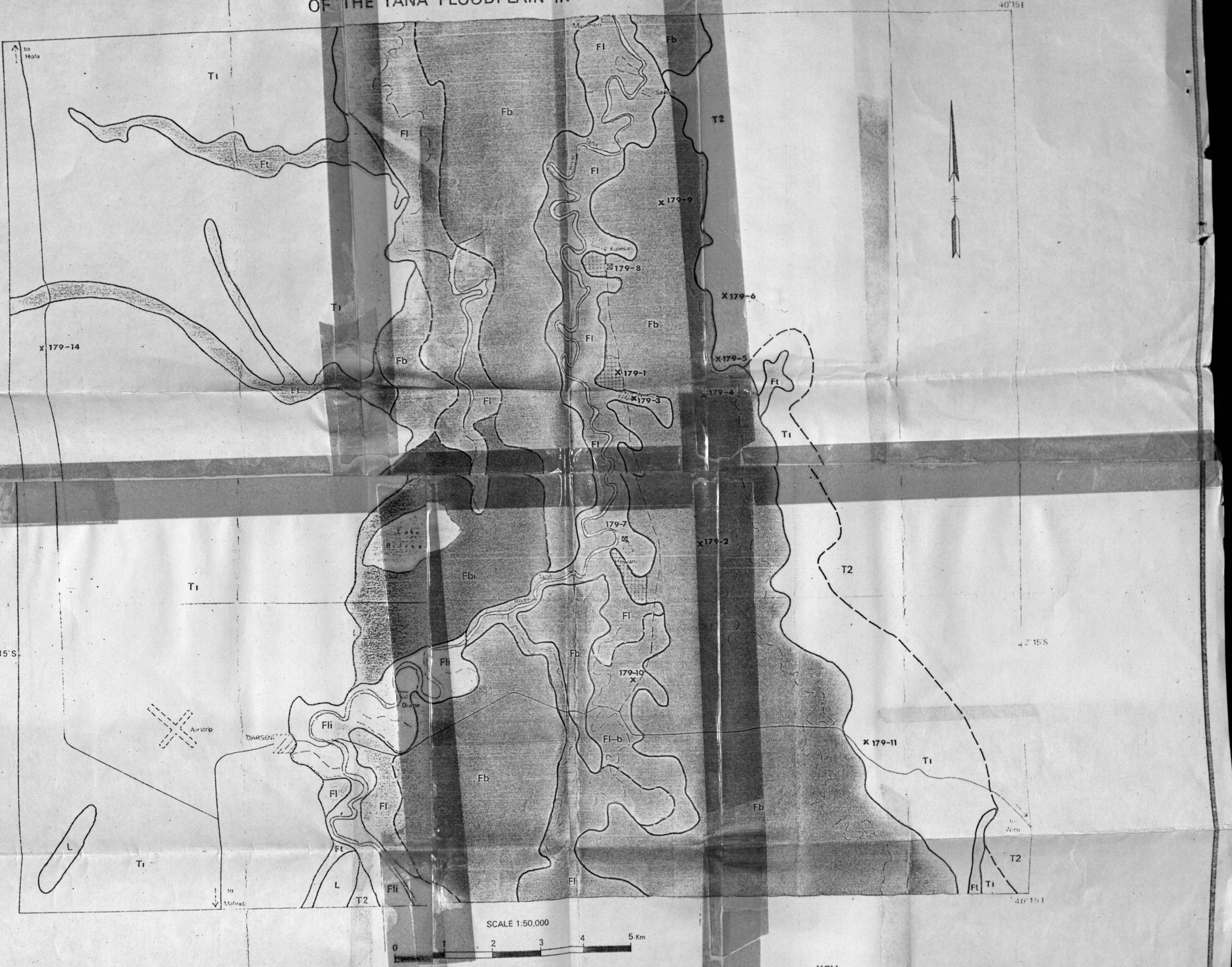
# PHOTO INTERPRETATION MAP OF THE PHYSIOGRAPHY OF THE TANA FLOODPLAIN IN THE PRE–DELTA AREA




## LEGEND

### FLOODPLAINS

| Fl | River levee land. Flat, but with some meso–relief; dark yellowish brown, stratified, micaceous, non–calcareous, fine sandy to loamy soils; non–saline and non–alkali; riverine forest or subsistence farming

| Fli | River levee land, irregular (point-bar complex). Like Fl, but with considerable meso–relief

| Fl-b | River levee–river basin transitional land. Flat; dark brown, non–calcareous, clay or heavy clay soils, non–saline and non–alkali, over micaceous fine sandy to loamy sediments; tall grassland, with scattered Borassus palms

| Fb | River basin land. Flat; grey brown, non–calcareous, heavy clay, non–saline or alkali above 1.5m depth; tall grassland, with patches of swamp forest

| Fbi | River basin land, irregular (depressional complex). Like Fb, but with irregular meso–relief of depressions and old river channels

| Ft | Tributary drainage ways. Clayey soils, probably strongly saline; swamp thicket

### TERRACES AND RIDGES

| T1 | Lower terrace land. Flat; grey, slightly calcareous, clay soil, moderately saline and moderately to strongly alkaline as from 20–50cm depth; thicket or dense bushland

| T2 | Upper terrace land. Flat, but with considerable meso–relief; grey brown, slightly to moderately calcareous, sandy clay loam to clay soils, moderately saline and to strongly alkaline as from 20–50 cm depth; low forest or wooded grassland

| L | Lagunar sand ridges. Gently undulating to flat, reddish sandy soils; forest or subsistence farming

### KEY

River channels, with Oxbows

Main and secondary roads

Villages

Minor irrigation scheme

X ⊠ Augerhole or soil pit with reference no

Boundary or tentative boundary of mapping unit


Prepared and drawn by the Kenya Soil Survey Project in Jan.1974.

To accompany site evaluation report Nº 15.

Refer to this map as CT/D/6