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A PRELIMINARY EVALUATION OF THE IRRIGATION
SUITABILITY OF THE LANDS IN THE MIDDLE-
LOWER TANA VALLEY

(Mbalambala-Garissa-Bura)

by

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(Mbalambala-Garissa-Bura)

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ACKNOWLEDGEMENTS

The report of the Soil Survey Project of the Ministry of Agriculture and the Commonwealth Development Corporation, the evaluations were carried out in the field conditions in the Tana valley in the stretch Mbalambala-Garissa-Bura. The field studies were carried out in two legs, 3 and 4 July 1973

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A PRELIMINARY EVALUATION OF THE IRRIGATION POTENTIALITY
 OF THE LANDS IN THE MIDDLE-LOWER TANA VALLEY
 (Mbalambala-Garissa-Bura)

W.G. Sombroek, J.P. Mbuvi, J.M. Kibe and H.W. Okwaro

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1.	<u>Introduction</u>

At the request of the Land and Farm Management Division of the Ministry of Agriculture and the North-Eastern Provincial Group Officer, site evaluations were carried out on the soil conditions in the Tana valley in the stretch Mbalambala-Garissa-Bura. The field studies were carried out in two legs, 5 and 6 July 1973

(Messrs Sombroek and Kibe), and 15 and 16 August 1973 (Messrs Sombroek, Mbuvi and Okwaro). The official reporting was delayed because of pressure of other works and the late availability of the laboratory data, and the long time required for the preparation of the map (two sheets; see appendix).

In the first instance, attention was to be focussed on the soil conditions of the minor irrigation schemes already planned or functioning in the area (Mbalambala, Samburu, 1st. Garissa self-help, Bura-east). Once at the sites it appeared that these schemes were not always located on the best sites, and that alternatives should be indicated. The field team was also confronted with a line of thought advocating that human settlement should move out of the floodplain onto the adjacent low valley sides, if only to avoid large-scale destruction of the riparian forest vegetation, which is the natural habitat and corridor for a number of important wildlife species. In contrast to the Lower Tana area proper (Bura-Galole, of Ilaco/Acres survey, 1967) and the Upper Tana proper (of Ilaco exploratory survey of 1971, Mwea detailed surveys, Kindaruma reconnaissance survey etc), no soil data exist on the intermediate stretch of the Tana catchment.

Both to facilitate the choice of alternative irrigation settlement and to present a first idea of the over-all soils pattern in the area, it was decided to present a preliminary photo interpretation map scale 1:100,000 of the whole stretch along the Middle - Lower Tana, using the existing small-scale aerial photographs. They are of scale 1:80,000 of 1963 or earlier and are of extremely poor quality (a.o. because it often concerns ends of flight runs). Fortunately most of the areas of the present irrigation schemes are also covered by photo's 1:20,000 of 1962, allowing for a more detailed presentation (see inserts of map).

It should be stressed that the present mapping and the irrigation suitability evaluation is a very preliminary one, based on aerial photointerpretation, a few field observations (surface, augerings, profile pits), and laboratory data on only a few soil and water samples. Any irrigation development in which substantial public money is involved should be preceded by a proper (semi-) detailed soil survey, next to a detailed topographical survey.

2. Environmental conditions:

The area is located between 38° 45'E - 40° 00'E and 0° 00' - 1° 15'S. Along the river, the stretch is about 200 km. long; across the river it covers about 40 km. Administratively, the area falls largely in the Tana River District of Coast Province, but for all practical

(Messrs Somprok and Kibe) and 15 and 16 August 1967 (Messrs Somprok and Kibe). The official reporting was delayed because of pressure of other work and the late availability of the laboratory data, and the long time required for the preparation of the map (two sheets; see appendix).

In the first instance, attention was to be focused on the soil conditions of the minor irrigation schemes already planned or functioning in the area (Mbalambala, Gumbur, Jaf, Gumbur self-help, Bura-east). Once at the site it appeared that these schemes were not always located on the best sites, and that alternatives should be indicated. The field team was also confronted with a line of thought advocating that human settlement should move out of the floodplain onto the adjacent low valley sides, if only to avoid large-scale destruction of the riparian forest vegetation, which is the natural habitat and corridor for a number of important wildlife species. In contrast to the lower Tana area proper (Bura-Galele, of Ilaco/Acres survey, 1967) and the Upper Tana proper (of Ilaco/Acres survey of 1971, lower detailed survey, Kinama reconnaissance survey etc.), no soil data exist on the intermediate stretch of the Tana catchment.

Both to facilitate the choice of alternative irrigation settlement and to present a first idea of the over-all soils pattern in the area, it was decided to present a preliminary photo interpretation map scale 1:100,000 of the whole stretch along the middle - lower Tana, using the existing small-scale aerial photographs. They are of scale 1:80,000 or 1:90,000 or earlier and are of extremely poor quality (e.g. because of often enormous areas of flight runs). Fortunately most of the areas of the present irrigation schemes are also covered by photo's 1:20,000 of 1962, allowing for a more detailed presentation (see inserts of map).

It should be stressed that the present mapping and the irrigation suitability evaluation is a very preliminary one, based on aerial photointerpretation, a few field observations (surveys, augurings, profile pits), and laboratory data on only a few soil and water samples. Any irrigation development in which substantial public money is involved should be preceded by a proper (semi-) detailed soil survey, next to a detailed topographical survey.

Environmental conditions

The area is located between 38° 45' E - 40° 00' E and 0° 00' - 1° 15' S. Along the river, the stretch is about 200 km long; across the river it covers about 40 km. Administratively, the area falls largely in the Tana River District of Coast Province, but for all practical

purposes it is orientated on the adjoining North-Eastern Province, and its capital Garissa in particular. The altitude is about 300 m in the upper part (Mbalambala), about 100 m in the lower part (Bura).

Geologically the area consists of Quaternary sediments, Mbalambala being near to the line of contact with the pre-Cambrian crystalline Basement rocks. At the valley sides there are several stretches with outcropping Late-Tertiary sediments (unit Tpl, "Pliocene marine sands and clays", of Matheson 1961, provisional geologic mapping), which are apparently strongly saline and alkali and therefore very liable to gully erosion (badlands). In most places however these sediments are smoothly capped by a veneer of Pleistocene sediments, of different ages and composition, viz. the "red sands" (unit Qr of Matheson, loc. cit), the "pale-brown loams/grey sandy clays" (unit Qg) or "black/grey cracking clays" (unit Qb).

Geomorphologically, the area outside the floodplain appears to consist of at least three plain levels (see legend of map, and ch. 3.3), largely coinciding with the above mentioned sedimentological grouping. The lowest level occurs only in the downstream part of the area ("old alluvial land" of Ilaco/Acres). The upstream and middle parts of the area have also substantial stretches of smoothly sloping valley sides. Adjacent to the floodplain, and often hardly separable from the alluvial fan land of the minor tributaries, there are relatively narrow stretches of low-terrace land ("middle terrace" of Ilaco/Acres, 1967). The floodplain itself has the characteristic levee land - basin land pattern of meandering rivers (though part of the so-called basin land, little or not below the level of the levees, may in fact be the result of an ancient lacustrine-like sedimentation phase). In the upper part of the area, just downstream from where the river breaks out of the Basement area onto the sedimentary plain, there is substantial recent splay formation, evidence of a more braiding river regime (probably induced by recently increased erosion in the upper catchment). All along the stretch, moreover, there are parts of river levee land that are incised and re-deposited at slightly lower level. Mostly it concerns narrow stretches only - not mapped separately - , but south of Bura they start to occupy sizeable expanses ("meander plain" of Ilaco/Acres).

The hydrological network is simple. Only the Tana is a perennial river; all tributaries are ephemeral, even the major ones of the Basement area at the extreme west. Whenever rains fall, however, their flooding is quite flashy due to a high run-off of melt loads.

reserved for the Bura-Hola major irrigation scheme further downstream). The quality of the Tana river water for irrigation is excellent (Ilaco/Acres 1967, Vol II), which was once more confirmed by a sample taken near Garissa town (EC = 177 micromho/cm, SAR 1.3, RSC 0.33 meq/l)

1. The flooding seasons are May-June and November-December. Between these times the groundwater level of the floodplain lands seems to vary between 1.50 and more than 5m. On the quality of this groundwater no data were found with Ilaco. Under the basin land parts it is probably saline, to a varying degree. A sample from Mbalambala area showed a high salinity hazard (EC.870 micromho/cm, but low sodium and bicarbonate hazards (SAR 2.65, RSC. 00 mg/l).

3. Land and soil resources.

3.1. The floodplain lands

The floodplain of the Tana river consists in this area essentially of only two physiographic units, the river levee lands and the river basin lands.

3.2. The normal river levee land (unit F1 of map) is mostly just above presentday normal flooding level. The macro-relief is flat, but there are often considerable meso-relief differences at relatively short distances (gradual or abrupt changes of 1-3 m over 50 m or so). Deserted river channels (oxbows), often partly filled-in with sediments, are also quite common. There is however little or no micro-relief.

The soil consists mainly of fine to very fine loamy sands to loams till several metres depth, with occasionally thin silty to clayey layers inter-spersed. The sediments contain characteristically a high percentage of mica flakes. The topsoil is dark (reddish) brown, with a fair to low organic matter content (0.3-0.9% C where sampled), a favourable structure (moderate fine subangular blocky) and little or no surface sealing/capping. The subsoil, mainly dark brown or yellowish brown, still maintains a distinct sedimentary stratification. The soils are slightly calcareous throughout (0.5 - 2.0% CaCO₃), and mostly non-saline and non-alkali (EC < 4mmho/cm, ESP about 5% where sampled); clayey layers may however have both some salinity and alkaliness. Chemically the soils are moderately rich (CEC 5-30 me/100g soil, V 80% or more) and no immediate nutrient deficiency is to be expected, apart from nitrogen (N 0.10-0.02%, P about 100 ppm, and K 0.50-0.10 me%; average of three samples). With the exception of the clay layers, the consistency of the soils is

The climate is semi-arid. Mean annual rainfall is 300-400 mm, with peaks in April and November-December. The pattern is however quite erratic over the years. Monthly averages are as given in the table below (from HAMD 1970):

Table with 12 columns for months (J, F, M, A, M, J, J, A, S, O, N, D) and 3 rows of data. Includes labels 'Average years' and 'Monthly averages (in mm)'. The data values are: Row 1: 300, 29, 10.5, 2.3, 25.3, 80.0, 7.6, 0.7, 1.4, 2.5, 2.6, 25.2, 29.3, 49.3; Row 2: 320, 39, 19.8, 6.1, 32.3, 64.2, 12.8, 2.3, 2.0, 6.1, 6.9, 22.6, 22.6, 62.9; Row 3: 443, 13, 17.3, 2.2, 21.7, 101.2, 22.1, 8.2, 7.2, 4.4, 7.9, 23.1, 102.8, 87.6.

Temperatures are high throughout the year: the monthly averages are between 20.5 and 30.3°C. The mean potential evaporation (Ho, Penman) is about 2375 mm per year, with little difference between the months (180-220 mm, cf. data for Garissa town of Woodhead, 1968). A large moisture deficit therefore exists throughout the year. The area consequently belongs to ecological potential zone V.

The over-all natural vegetation is a Commiphora-Acacia bushland (Atlas of Kenya 1970). There are however quite distinct differences in vegetation between the various physiographic dry-land units, while the floodplain may carry a quite luxuriant forest (cf. legend of map).

Wildlife is of regular though sparse occurrence on the drylands (gazelles, giraffes, cheetahs etc). The floodplain lands are however teeming with big-game animals like elephants, buffaloes and crocodiles; in time of extreme drought the Tana floodplain is a survival area for wildlife from very far away.

Land Use: In view of the prevailing climatic conditions, it is obvious that no rational agriculture is possible; extensive grazing is the only use of the drylands. Whenever water happens to be available (flooding, groundwater, irrigation), crop growth is very rapid and continuous throughout the year - the latter in contrast to e.g. the Nairobi area.

The population consists of Somali tribesmen at the northeastern side of the river and of Gama tribesmen at the southwestern side. Both have a nomadic way of life, herding cattle, goats and camels, but irrigated agriculture has rather suddenly grasped their enthusiasm.

The water supply for any irrigation should come from the Tana river. Its discharge is quite high, with a presentday dry-season flow of about 80m³/sec (see also in ten years, of Ilaco 1973), sufficient for many thousands of hectares (a substantial part of this is

reserved for the Bura-Hola major irrigation scheme further downstream). The quality of the Bura river water for irrigation is excellent (Lilac/Artes 1987, Vol. II), which was once more confirmed by a sample taken near Gortasa town (EC = 177 microhm/cm, SAR 1.3, RES 0.33 meq/l).

The flooding seasons are May-June and November-December. Between these times the groundwater level of the floodplain lands seems to vary between 1.50 and more than 5m. On the quality of this groundwater no data were found with Lilac. Under the basin land parts it is probably saline, to a varying degree. A sample from Mbalambala area showed a high salinity hazard (EC 870 microhm/cm, but low sodium and bicarbonate hazards) (SAR 2.55, RES. 00 meq/l).

Land and soil resources.

3.1. The floodplain lands

The floodplain of the Bura river consists in this area essentially of only two physiographic units, the river levee lands and the basin lands.

3.1.1. The normal river levee land (unit Fb of map) is mostly flat above present-day normal flooding level. The micro-relief is flat, but there are often considerable micro-relief differences at relatively short distances (gradual or abrupt changes of 1-3 m over 50 m or so). Deserted river channels (oxbows), often partly filled in with sediments, are also quite common. There is however little or no micro-relief.

The soil consists mainly of fine to very fine loamy sands to loams till several metres depth, with occasionally thin silty to clayey layers inter-spaced. The sediments contain characteristically a high percentage of mica flakes. The topsoil is dark (reddish) brown, with a fair to low organic matter content (0.5-0.9% where sampled), a favourable structure (moderate fine subangular blocky) and little or no surface sealing/capping. The subsoil, mainly dark brown or yellowish brown, still maintains a distinct sedimentary stratification. The soils are slightly calcareous throughout (0.5 - 2.0% CaCO₃), and mostly non-saline and non-alkali (EC < 100 microhm/cm, SAR about 25 where sampled); clayey layers may however have both some salinity and alkalinity. Generally the soils are moderately rich (CEC 2-30 meq/100g soil, V 80% or more) and no immediate nutrient deficiency is to be expected, apart from nitrogen (N 0.10-0.02%, P about 100 ppm, and K 0.50-0.10 meq; average of three samples).

With the exception of the clay layers, the consistency of the soils is

friable and soft to slightly hard.

Tillage is easy. Infiltration rates will be rather high on the average, and the moisture storage fair only. Field capacity of some samples of recently irrigated topsoil proved to be about 15 weight %. Assuming a bulk density of 1.4, this would imply an available moisture storage of about 11 mm per 10 cm depth. Unless stiff clayey layers happen to occur, the rooting will easily go to great depth, so that the total available moisture storage will be quite high. In view of the prevailing textures, the capillary rise in the soils can be substantial. A laboratory test showed a total rise of only 60 cm after three days, but with a then nearly steady speed of about 5 cm/24 hours.

The natural vegetation is a riverine forest, often quite high (30m or so) and consisting of quite a number of different species (Acacia eleator eleator, Acacia polyacantha, Diospyros corni and Ficus sp. seem quite common, while palms are relatively few).

Upstream, near Mbalambala, there is a stretch of splayey river levee land (unit Fls.). It is threaded by many shallow gullies, has apparently common flooding, and seems to have recent sandy spill-deposits over older levee and basin land deposits. The vegetation is a wooded grass-land rather than a forest or woodland.

3.1.1. The normal river basin land (unit Fb of map) is extensively flat, mostly only slightly below the level of the levee-land and only shallowly flooded if at all. In several places the land has a rather dense network of narrow gullies (about 3 m wide, 1m deep). Often a substantial micro-relief occurs (gilguy and/or cowfoetoes: 30-50 cm differences over 5-10m; sinkholes).

The soils consist predominantly of silty clay to heavy clay till considerable depth, 2-3m or more. The topsoil, where examined, was dark reddish brown with only a fair organic matter content (0.5-1.0 %). It may crack strongly, seal substantially (the latter when silty clays are concerned) and the structure seems mostly fair only (prismatic to angular blocky). The subsoil is brown to dark reddish brown, sometimes with some yellowish brown mottling. The consistency is mostly very firm when moist and very hard when dry. The soils are slightly to moderately calcareous throughout (0.5-4% CaCO₃ where sampled). More often than not they seem to be moderately saline and alkali from some depth onward (EC up to 10-15 microhm/cm and ESP up to 35% where sampled). Chemically the soils are quite rich (CEC 30-50 meq/100gr soil, V 80% or more) and nutrient deficiencies are unlikely, apart from nitrogen.

Tillage should be quite difficult, the rootability of the soils is restricted and the infiltration rates of the moist soil should be very low.

The water passage through the deeper subsoil, both vertically and horizontally, should be extremely slow.

The basin lands are covered with (bushed) grassland, bushland or even bush-thicket; the woody species never reaching much height.

In some parts low clay dunes appear scattered over the basin land (unit Fbd). The clayey soil of the basin land may have been over-spilled with some recent micaceous loamy to fine sandy sediments of substantial thickness (0.5m or so). This is particularly common in the upstream part, near Mbalambala. The sub unit concerned, splayey river basin land (unit Fbs) seems to have also a less thick clay layer, and it may also be less saline-alkali and compact in the subsoil. The vegetation, at least, is more regular and higher, consisting of a wooded bushland. The meso-relief of (splay-) gullies is however on the average more pronounced.

3.2. The low-terrace and alluvial fan lands.

The numerous ephemeral minor tributaries of the Tana river are accompanied by narrow bands of alluvial deposits, widening out into a fan when nearing the Tana floodplain. The unit concerned, alluvial fan and tributary floodplain land (unit Tf) is veined by many shallow drainage ways. Directly banding the floodplain there are also patches of regularly flat land, only a few metres above flooding: low-terrace lands (unit T).

Both units seem to have brown soils consisting of medium to coarse sandy loam, slightly calcareous and non saline - non alkali till about 80 cm depth, overlying a hardpan of moderately calcareous sandy clay loam, non saline but moderately alkali (EC < 5 mmho/cm, but ESP 25% where sampled). This hardpan is impenetrable for most roots and very slowly-permeable for water (one core sample having a hydraulic conductivity of 0.4 cm/24 hours). The chemical fertility of the rootable soil is fair only (CEC about 15 meq/100 g soil). Tillage should be easy, but infiltration rates are likely to be high and the total available water storage should be fair only.

The vegetation consists mainly of wooded-bushed grassland in the case of unit Tf and of wooded grassland (with common *Acacia tortilis*) in the case of unit T.

3.3. The sedimentary plains and valley sides

The regular valley sides (unit Ss) are smoothly and regularly lowering towards the floodplain with a slope of about 1m per 100 m(1%). They have little or no meso- or micro-relief.

Where examined, the topsoil consisted till about 40 cm depth of reddish brown coarse sandy clay loam, which was not calcareous, non-saline and non-alkali. The structure of this topsoil is rather poor (massive) and the surface sealing is strong. It overlies abruptly a hardpan of brown gravelly coarse sandy clay; it contained high percentages of both lime concretions and free lime (.10-20%) and was both moderately saline and alkali (ECe 6-14 mmho/cm, ESP 25-30%; Solodized Solonchaks). The chemical fertility of the topsoil was fairly high (CEC 30meq/100 g soil, V about 70%). Fertilizing can in first instance probably be restricted to nitrogen (N 0.07%, P 136 ppm and K 0.77 me%, for one sample).

Tillage should be frequent to avoid re-sealing, but will not be very difficult. Once the sealing crust is broken-up, then infiltration rates should be neither very high nor very low. Rootability will be restricted to only 40 cm, total available moisture storage is therefore quite limited (field capacity of five samples of irrigated soil was about 12 weight %, only about 40 mm available water may therefore be stored, assuming a bulk density of about 1.6 and half of this moisture kept below wilting point). The vegetation is a bushed grassland. On aerial photographs it often shows a vague dot pattern, connected with fossil and flattened termite mounds (see also below).

The irregular valley sides (unit Sb) are quite irregularly sloping and often actively eroding, both by sheetwash and gullying: "badlands". In most places the topsoil has been removed and the hard and very firm subsoil or substratum of gravelly clay is exposed. This clay appears to be strongly saline and strongly alkali, in the presence of lime concretions and free lime (samples from two sites were analysed and showed ECe 15-55 mmho/cm, ESP 35-50%, 2-15% CaCO₃).

The vegetative cover is very poor, consisting of low bushy grassland with many patches of completely bare ground.

The lower-level plain (unit Sp1) is on the average about 30 m above the level of the floodplain, with a very gentle slope of about 0.5% towards the latter. The plain has a variety of soils and vegetative covers, as shown amply by the semi-detailed soil survey of the Lower Tana, to which may be referred (Ilaco/Acres 1967 and Ilaco 1973, units S, O, GU and GA mostly).

The intermediate-level plain (unit Sp2) is about 60 m above floodplain level and seems more homogeneous. The terrains are level to broadly and very gently sloping. A shallow topsoil, about 20 cm thick on the average, consists of brown, medium to coarse sandy loam with an appreciable percentage of silt. It is non-calcareous, non-saline

The water passage through the deeper subsoil, both vertically and horizontally, should be extremely slow. The basin lands are covered with (bushes) grassland, plainland or even bush-thicket; the woody species never reaching much height. In some parts low clay dunes appear scattered over the basin land (unit Fbd). The clayey soil of the basin land may have been overlaid with some recent micaceous loam to like sandy sediments of substantial thickness (0.5m or so). This is particularly common in the upstream part, near Mchambala. The soil with concerned, grey clay basin land (unit Fbd) seems to have also a less thick clay layer, and it may also be less saline-alkali and compact in the subsoil. The vegetation, at least, is more regular and higher, consisting of a wooded plainland. The meso-relief or (spaly-) gullies is however on the average more pronounced.

3.2. The low-terrace and alluvial fan lands

The numerous ephemeral minor tributaries of the Tana river are accompanied by narrow bands of alluvial deposits, widening out into a fan when nearing the Tana floodplain. The soil concerned, alluvial fan and terrace floodplain land (unit T) is formed by many shallow drainage ways. Directly bordering the floodplain there are also patches of regularly flat land, only a few metres above flooding: low-terrace lands (unit T).

Both units seem to have brown soils consisting of medium to coarse sandy loam, slightly calcareous and non saline - non alkali till about 80 cm depth, overlying a horizon of moderately calcareous sandy clay loam, non saline but moderately alkali (ECe 5 mmho/cm, but ESP 25% where sampled). This horizon is impermeable for most roots and very slowly-permeable for water (one core sample having a hydraulic conductivity of 0.4 cm²/hour). The chemical fertility of the rootable soil at this only (CEC about 15 meq/100 g soil). Tillage should be easy, but infiltration rates are likely to be high and the total available water storage should be fair only.

The vegetation consists mainly of wooded-bush grassland in the case of unit T and of wooded grassland (with common Acacia tortilis) in the case of unit T.

3.3. The sedimentary plain and valley sides

The regular valley sides (unit Sa) are smooth and regularly lowering towards the floodplain with a slope of about 1m per 100m (1%). They have little or no meso- or micro-relief.

Where examined, the topsoil consisted of about 40 cm depth of reddish brown coarse sandy clay loam, which was not calcareous, non-saline and non-alkali. The structure of this topsoil is rather poor (massive) and the surface sealing is strong. It overlies strongly a hardpan of brown gravelly coarse sandy clay; it contained high percentages of both fine concretions and free lime (10-20%) and was both moderately saline and alkali (ECe 5-14 mmho/cm, ESP 25-30%). Solodized Solonchaks. The chemical fertility of the topsoil was fairly high (GR 30 mg/100 g soil, V about 10%). Fertilizing can be first instance probably be restricted to nitrogen (N 0.07%, P 135 ppm and K 0.77 mg, for one sample).

Illage should be frequent to avoid re-sealing, but will not be very difficult. Once the sealing starts it breaks up, then infiltration rates should be neither very high nor very low. Rootability will be restricted to only 40 cm total available moisture storage in the zone due to limited field capacity of five samples of 100 g soil was about 12 weight % only about 40 cm available water was therefore stored, assuming a bulk density of about 1.6 and half of this moisture kept below wilting point). The vegetation is a bushed grassland, on aerial photographs it often shows a vague dot pattern, connected with forest and flattened termite mounds (see also below).

The irregular valley sides (unit Sp) are quite irregularly sloping and often actively eroding, both by sheetwash and gullying "badlands". In most places the topsoil has been removed and the hard and very thin subsoil or substratum of gravelly clay is exposed. This clay appears to be strongly saline and strongly alkali, in the presence of lime concretions and free lime (samples from two sites were analysed and showed ECe 12-22 mmho/cm, ESP 25-30%, 2-15% CaO).

The vegetative cover is very poor, consisting of low bushy grassland with many patches of completely bare ground.

The lower-level plain (unit Sp1) is on the average about 30 m above the level of the floodplain, with a very gentle slope of about 0.2% towards the latter. The plain has a variety of soils and vegetative covers, as shown early by the semi-detailed soil survey of the lower zone, to which may be referred (Llaco/Acres 1967 and Llaco 1972, units S, G, U and G mostly).

The intermediate-level plain (unit Sp2) is about 60 m above floodplain level and seems more homogeneous. The terrain is level to broadly and very gently sloping. A shallow topsoil, about 20 cm thick on the average, consists of brown, medium to coarse sandy loam with an appreciable percentage of silt. It is non-calcareous, non-saline

and non-alkali but overlies a hardpan of grey-brown sandy clay loam to clay, slightly calcareous and non- or slightly saline but often moderately alkali (ECe 4-8 mmho/cm, ESP 12-25%, often high percentages of Mg: shallowly solodized Solonetz or Solod).

The topsoil is strongly sealing, the hardpan is impenetrable for roots and little permeable for water.

The vegetation is a bushed grassland, which characteristically shows a regular pattern of white dots (partly with a dark circle around it, or a dark centre) on aerial photographs. These dots represent the nearly completely flattened remnants of fossil termite mounds, the surfaces of which are bare due to very poor structure right from the soil surface.

Note: This mapping unit, together with unit Ss, is predominant in the whole area between Garissa, Wajir and Merti.

The higher-level plain (unit Sp3), situated 100 or more metres above floodplain level, is extensively flat and without meso and micro-relief. The soils are characteristically dark red, with textures gradually increasing with depth from coarse loamy sand/sandy loam to sandy clay loam or sandy clay (low silt percentages). The surface is hard because of a thin sealed layer, but below this the soil is friable throughout and quite porous. The soils do not contain any lime, salts or alkali; they are in fact rather acid (pH 5.0-5.5).

The easy and deep rooting of the soils and their low run-off allows the growth of a relatively luxurious vegetation: rather high bushland, with scattered trees of *Acacia tortilis* and *Delonix elata*.

Note: These soils, presumed to have formed during a Pleistocene period with high rainfall, are common on most of the higher parts of the sedimentary lands of semi-arid eastern Kenya (e.g. in the Wajir-Tarbaj area, east of Kitui, etc).

4. Irrigation suitabilities and acreages

The normal river levee lands (unit Fl) are not well suitable for large-scale mechanised irrigation of field crops like cotton, rice or sugarcane. This because of the irregular topography, the high costs of clearing of the forest, and the relatively high infiltration rates, which latter precludes gravity irrigation with a length-of-run that would be appropriate for field-crops (cf. Llaco/Acres 1967 classification of these lands as class 5, "non-irrigable, because of location and topography").

For minor irrigation schemes however, in particular when largely manual cropping of truckcrops (vegetables) and high-priced specials like asparagus and melons is envisaged, the above limitations are of

and non-alkali but over a horizon of grey-brown sandy clay loam to clay, slightly calcareous and non- or slightly saline but often moderately alkali (BSE 4-8 mho/cm, RSP 12-25), often high percentages of Mg; shallowly solidified dolomite or selenite).

The topsoil is strongly saline, the horizon is impermeable for roots and little permeable for water.

The vegetation is a bushed grassland, which characteristically shows a regular pattern of white dots (partly with a dark circle around it, or a dark centre) on aerial photographs. These dots represent the nearly completely flattened remnants of fossil ferrite nodules, the surfaces of which are bare due to very poor structure right from the soil surface.

Note: This mapping unit, together with unit 2a, is predominant in the whole area between Gortasec, Wajir and Merit.

The higher-level plain (unit 2b) is situated 100 or more metres above floodplain level, is extensively flat and without mounds and mounds. The soils are characteristically dark red, with textures gradually increasing with depth from coarse loamy sand/sandy loam to sandy clay loam or sandy clay (low salt percentages). The surface is hard because of a thin sealed layer, but below this the soil is friable throughout and quite porous. The soils do not contain any lime, salts or alkali; they are in fact rather acid (pH 5.0-5.5).

The easy and deep rooting of the soils and their low run-off allows the growth of a relatively luxuriant vegetation: rather high bushland with scattered trees of Acacia tortilis and Delonix elata.

Note: These soils, presumed to have formed during a Pleistocene period with high rainfall, are common on most of the higher parts of the semi-montane lands of semi-arid eastern Kenya (e.g. in the Wajir-Turkey area, east of Kitui, etc.).

Irrigation suitability and sources

The normal river levee lands (unit 2c) are not well suitable for large-scale mechanised irrigation of field crops like cotton, rice or sugarcane. This is because of the irregular topography, the high costs of clearing of the forest, and the relatively high infiltration rates, which latter produces gravity irrigation with a length-of-run that would be appropriate for field-crops (cf. Ilaco Acres 1967 classification of these lands as class 2, "non-irrigable", because of location and topography").

For minor irrigation schemes however, in particular when largely manual cropping of truckcrops (vegetables) and high-priced specialties like asparagus and melons is envisaged, the above limitations are of

minor importance. The soils can be considered well suitable for truckcrops/specials as mentioned, as well as for fruit trees and bananas, because of the easy and deep rooting conditions, the easy tillage, and the location of the land very near a permanent water source (i.e. the main river channel) from where pumping can take place. Overhead irrigation (sprinkling) seems indeed more feasible than furrow or basin irrigation, because of the relatively high infiltration rates and the uneven topography. Short length-of-run of the furrows would not be much of a disadvantage with truckcrops but high losses would occur along the feeder canals/ditches. This would contribute to a rising ground water table and together with the steady capillary rise in the soils might result in ultimate salinisation of the rooting zone. Any expansion of irrigation till more than a few hundred metres away from the river channel should count with a deep drainage canal, to offset any tendency to soil deterioration by such a salinisation from below. Any superficial salt accumulation because of under-irrigation can then easily be removed by periodic leaching.

The splayey river-levee land (Fls) with its more irregular meso-relief and presumably more stratified soils, is tentatively evaluated as only moderately suitable for truckcrops.

The normal river-basin lands (unit Fb) are not suitable for the growth of truckcrops because of difficult tillage and the poor rooting conditions. They are marginally suitable for fieldcrops (maize, sorghum, cotton, rice; see also Ilaco Acres report of 1967: class 3). Advantages are the regular flatness of most terrains and the low infiltration rates, allowing basin or furrow irrigation. Disadvantages are the difficult tillage, the shallow rooting, the frequency of gullies in many places, and especially the low hydraulic conductivity of the subsoil, which prevents any deep drainage. There is a definite hazard that the salinity/alkalinity of the soil will be increased to dangerous levels under sustained irrigation. Only by the excavation of quite deep major drainage canals - combined with surface drainage at the plots by means of furrows, ditches and/or cambered beds - an ultimate salinisation and further structure deterioration in the rooting zone may be avoided. These measures, as well as the necessary flood protection works, can only be carried out if a major mechanised scheme would be embarked upon and even then the feasibility seems marginal.

The splayey river basin lands (unit Fbs) may be moderately suited for field-crops, because of the presumed less thick clay layer and other factors.

The low dryland terrains directly alongside the floodplain (unit T and the lower parts of unit Tf) may be marginally suitable for irrigation, of both truckcrops and fieldcrops. The flatness of the

lands and the rather deep rooting conditions are favourable factors. The sandiness would however preclude gravity irrigation. The position of the lands in relation to the source of water (i.e. the low-water level in the main river channel), the occurrence of drainage gullies with their occasional torrential run-off from the higher lands, and the rather patchy occurrence of the land in general, make it necessary to carry out substantial topographic surveying and cost/benefit calculations before any scheme would be considered.

The regular valley sides (unit Ss) are also marginally suitable for irrigation of both truck and field crops. The topography of the terrains is favourable, but the effective rooting depth is rather limited; the frequency of water applications should therefore be high. The presumably fair infiltration rates, together with the shallowness of the hardpan, will probably allow for gravity irrigation. A build-up of salinity in the rooting zone can probably be avoided by the installation of a number of downslope drainage ditches. The major drawback for irrigation development is the position of the land in relation to the source of water. The construction of a feeder canal, with an intake at a diversion dam in the river bed further upstream, is mostly not feasible because of the interspersed nature of the very irregular Sb unit (unstable clays) and of the Tf stretches with their run-off problems. Pumping from the river bed all the way up the slope is possible (viz Brother Mario's farm) but it is doubtful whether it will ever be an economic proposition.

The irregular valley sides (Sb) are definitely unsuitable for any irrigation development, because of severe soil and topography limitations.

The lower-level plain (Sp1) as a whole is moderately to marginally suitable for large-scale irrigation of field crops (cf. Ilaco proposals of 1967 and 1973).

The intermediate-level, "dotted" plain (Sp2) and the higher-level, "red sand" plain (Sp1) are unsuitable for irrigated agriculture, not only because of their poor water commandability (too high above the river course) but also because of their soil properties (effective shallowness or high infiltration rates combined with low fertility).

A summary of the irrigation suitabilities and the acreages involved is given in the table below.

Mapping Unit	Suitability for irrigation (preliminary evaluation)	Gross area (in hectares)
F1	well suitable for truckerops/specials on minor schemes	5,800
F1s	- do -, moderately suitable	400

Mapping unit	Suitability for irrigation (preliminar evaluation)	Gross area (in hectares)
Fb	marginally suitable for field crops on larger schemes, floodcontrol necessary	3,200
Fbs	- do -, moderately suitable	600
T	marginally suitable for both field and truckercrops, on minor schemes.	1,200
Tf	- do -, but lower parts only, and run-off floodcontrol necessary	4,800
Ss	marginally suitable for both field and truckercrops, on minor or larger schemes	8,000
Sb	unsuitable	18,000
Sp1	moderately to marginally suitable for field crops on larger schemes	6,600
Sp2	unsuitable	15,000
Sp3	unsuitable	4,600

5. The various minor irrigation schemes

5.1. Introduction

The above sections give only a rough outline of the land resources and their irrigation suitability, averaged over a large area and based on only very few ground observations and laboratory data. In detail there are many possibilities for variations which may either refine or over-rule the above descriptions and evaluations. This can be established only by many more field observations and laboratory determinations, together with study of large-scale aerial photographs.

A partial coverage by such photos does exist but the material is quite old. This implies that quite some "natural" changes may have taken place in the meantime and that a number of new roads, settlements, etc. can not be traced. The photos moreover concern often a single run, covering only the central part of the floodplain (the purpose of flying them was apparently the charting of the main river bed). Nevertheless they were used to show the configuration of the above described mapping units in more detail, for most of the areas where the various minor irrigation schemes (planned or in execution) are located - see inserts of the map.

5.2. The Mbalambala irrigation scheme

Most of the lands of the Mbalambala area are of unit Fsb, splayey river basin land. On this particular site splay-gullying and-overwash

... and the rather deep rooting conditions are favourable factors. The sandstone would however provide gravity drainage. The position of the lands in relation to the source of water (the lower level) in the main river channel, the occurrence of drainage ditches with their occasional horizontal run-off from the higher lands, and the rather patchy occurrence of the land in general, make it necessary to carry out substantial topographic surveying and soil benefit calculations before any scheme would be considered.

The regular valley sides (unit Ss) are also marginally suitable for irrigation of both truck and field crops. The topography of the terrain is favourable, but the effective rooting depth is rather limited; the frequency of water applications should therefore be high. The generally high infiltration rates, together with the shallowness of the hardpan, will probably allow for gravity irrigation. A build-up of salinity in the rooting zone can probably be avoided by the installation of a number of drainage ditches. The major drawback for irrigation development is the position of the land in relation to the source of water. The construction of a feeder canal, with an intake at a diversion from the river bed further upstream, is mostly not feasible because of the interposition of the very irregular Sp unit (unsuitable clay) and of the T stretches with their run-off problems. Pumping from the river bed all the way up the slope is possible (see Brother Marjo's farm) but it is doubtful whether it will ever be an economic proposition.

The irregular valley sides (Sp) are definitely unsuitable for any irrigation development, because of severe soil and topography limitations. The lower-level plain (Sp1) as a whole is moderately to marginally suitable for large-scale irrigation of truckercrops (or, if also possible, of 1967 and 1974).

The intermediate-level "dotted" plain (Sp2) and the higher-level "ver" and "plain" (Sp1) are unsuitable for irrigated agriculture, not only because of their poor water commandability (too high above the river course) but also because of their soil properties (extensive shallowness or high infiltration rates combined with low fertility).

A summary of the irrigation suitability and the sources involved is given in the table below.

Mapping unit	Suitability for irrigation (preliminar evaluation)	Gross area (in hectares)
Tf	marginally suitable for truckercrops on minor schemes	4,800
Fbs	- do -, moderately suitable	600

Area (ha)	Soil suitability for irrigation (preliminary evaluation)	Remarks
000:2	marginally suitable for larger schemes, floodcontrol necessary	10
000	marginally suitable	10
000:1	marginally suitable for both field and floodcontrol, on minor schemes	10
000:4	marginally suitable for both field and floodcontrol necessary	10
000:8	marginally suitable for both field and floodcontrol, on minor or larger schemes	10
000:18	unsuitable	10
000:8	marginally to moderately suitable for field crops on larger schemes	10
000:15	unsuitable	10
000:4	unsuitable	10

5. The various minor irrigation schemes

5.1. Introduction

The above sections give only a rough outline of the land resources and their irrigation suitability, averaged over a large area and based on only very few ground observations and laboratory data. In detail there are many possibilities for variations which may either refine or over-ride the above descriptions and evaluations. This can be established only by many more field observations and laboratory determinations, together with study of large-scale aerial photographs.

A partial coverage by each photo does exist but the material is quite old. This implies that quite some "natural" changes may have taken place in the meantime and that a number of new roads, settlements, etc. can not be traced. The photos moreover concern often a single row covering only the central part of the floodplain (the purpose of flying them was apparently the clearing of the main river bed). Nevertheless they were used to show the configuration of the above described mapping units in more detail, for most of the areas where the various minor irrigation schemes (planned or in execution) are located - see inserts of the map.

5.2. The Mbalambala irrigation scheme

Most of the lands of the Mbalambala area are of unit Fb, especially river basin land. On this particular site special-irrigation and overwash

seem restricted. A soil pit dug in the centre of the scheme showed 1.5m heavy clay, without alkaliness or salinity. The fine sandy material occurring below the clay layer will allow deep drainage (necessary in view of the brackish ground water). Though directly west of the scheme a soil was found with moderate alkaliness throughout, it seems that the area as a whole is moderately suitable for irrigation, especially when fieldcrops would be grown (which is apparently the intention: famine relief food production). It is recommended to dig a sizeable drainage canal all alongside the dryland, with an outlet on the river further downstream, to drain away any seepage from high ground and to lower the general groundwater level.

The stretch of terrace land (T) between the headquarters of the present scheme and Mbalambala village itself seems homogeneous enough to be considered for future irrigation development.

5.3. Sankuri irrigation scheme

The terrains of the present Sankuri scheme are quite varied. They comprise a not-quite-flat remainder of terrace land (T) along the river, a narrow strip of levee land (Fl), and a part of basinland (Fb). Quite different irrigation and drainage practises would be required for each of them. The basin land in this stretch moreover consists of very heavy and compact clay. Where examined, the clay continued to great depth (3m) with a dense sandy clay loam below; alkaliness starts already at 20 cm depth, salinity at 80 cm.

It is recommended to move the scheme - for which only preliminary works have been carried out - to another site, e.g. the wide stretch of Fl land in the meander directly upstream.

5.4. The Garissa first self-help scheme

The land presently under irrigation belongs to the Fl unit. It is well suited for the growing of truckercrops/specials, as borne out by the first years' results. The first extension envisaged also falls largely on the same unit and should do equally well. It is however recommended to supply this extension with a deep drainage canal, emptying to the main river channel downstream. It is definitely not recommended to extend the scheme further towards the dryland onto the stretch of basin land (Fb). This is because of the unfavourable soil conditions (difficult tillage, difficult drainage, salinity/alkaliness - even if the laboratory data of the one examined profile do not show dangerous levels at present).

5.5. Nordin's gardens and MoA Garissa town scheme

Nordin, as a road construction firm active in the area, started its scheme in the first instance to supply its personnel with fresh vegetables. The chosen area, as well as that of the Ministry of Agriculture, are on F1 land. The schemes should do well; some low parts within Nordin's area (filled-in old river-channels) may give low yields, if only because of poor drainage. Sprinkling irrigation may be the most economical, though Nordin's trials with furrow irrigation seem promising as well.

Once again, it is recommended to have a deep drainage canal dug all along the dryland. Non-intercepted seepage from this dryland is likely to have a nefarious long-range effect on the subsoil conditions of the schemes, in view of the poor chemical properties of the sediments (Sb for a good part) through which any effluent water from the expanding town passes.

5.6. Catholic and Moslem Boys Centre schemes

The Catholic Boys Centre of Brother Mario is the earliest irrigation effort in the region and by now quite famous. It is located on the unit Ss, far from the river (about 25 m above the floodplain), from which nevertheless all water has to be pumped-up.

Though the soils are marginal (only about 40 cm. rootable layer) the enthusiasm and sustained efforts of Brother Mario have made the scheme of much demonstrative value. It is however not recommended to expand the scheme or to start another scheme on Ss land similarly far upslope, in view of the high development and recurrent expenditures involved.

The proposed site for the Moslem Boys Centre scheme is definitely unsuitable. The poor-quality Sb unit is involved. Though the topography at this particular site is fairly good, the laboratory results of soil samples taken show high values for salinity and alkalinity throughout the soil and a very low permeability.

A better site may be found southward, either on the stretch of Ss land adjoining the floodplain or on a stretch of F1 land south of Nordin's gardens.

5.7. Bura-east scheme

The site of this minor irrigation scheme is partly on F1 land, partly on Fb land. The latter is in this stretch rather dissected by gullies and seems to have often a cover of sandy material over the clay layer. The site therefore does not seem to be very well chosen; any extension should preferably be sought farther downstream, on the stretch

of F1 land sandwiched between the big westward bulging meander.

6. Conclusions and Recommendations

- The Tana floodplain in the stretch Mbalambala-Garissa-Bura consists of two main physiographic units, the relatively high lying river levee land with a forest cover, and the somewhat lower lying river basin land with mostly a bushed grassland cover.
- The river levee land (unit F1, about 5,500 ha.) having deep fine sandy to loamy soils with little or no salinity or alkaliness at present, is well suited for the growing of specials/truck crops.
- The river basin land (unit Fb, about 3,200 ha.), consisting of stiff clays often till great depth and saline/alkali from about 80 cm downward, is not suitable for the growing of truckcrops/specials, and is only marginally suitable for large-scale growing of fieldcrops.
- Some of the low-terrace and valley-side lands adjoining the floodplain (units T and Ss) seem to have sufficiently deep rooting and smooth topography to allow their irrigation, but the costs of water supply may be prohibitive.
- Some of the minor irrigation schemes being started in the area are better moved to a nearby locations with more favourable soil conditions than exist at the present sites.
- Detailed studies on soils, topography and substratum should be carried out prior to any significant scheme-expansion, preferably with the help of recent large-scale aerial photographs. Also, the changes in soil conditions at existing schemes should be monitored so as to signal in time any trend to deterioration, especially as regards salinity and structure decline through alkaliness.

7. References:

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5.5. Horizon's extension and Mba-Garissa town scheme

Horizon, as a road construction firm active in the area, started its scheme in the first instance to supply its personnel with fresh vegetables. The chosen area, as well as that of the Ministry of Agriculture, are on F1 land. The schemes should be well served by water from the old river-channels (filled in old river-channels) may give low yields, if only because of poor drainage. Sprinkling irrigation may be the most economical, though Horizon's trials with furrow irrigation seem promising as well.

Once again, it is recommended to have a deep drainage canal dug along the drainage. Non-intercepted seepage from this drain is likely to have a noticeable long-range effect on the soil conditions of the schemes, in view of the poor chemical properties of the sediments (Ss for a good part) through which any effluent water from the expanding town passes.

5.6. Catholic Boys Centre and Moslem Boys Centre schemes

The Catholic Boys Centre of Brother Marko is the earliest irrigation effort in the region and by now quite famous. It is located on the left bank of the river (about 25 m above the floodplain), from which nevertheless all water has to be pumped-up.

Through the soils are marginal (only about 40 cm rootable layer) the enthusiasm and sustained efforts of Brother Marko have made the scheme of much demonstrative value. It is however not recommended to expand the scheme or to start another scheme on the land already far up slope, in view of the high development and recurrent expenditures involved.

The proposed site for the Moslem Boys Centre scheme is definitely unsuitable. The poor-quality Ss with its involved. Through the topography at this particular site is fairly good, the laboratory results of soil samples taken show high values for salinity and alkalinity. A better site may be found southward, either on the stretch of Ss land adjoining the floodplain or on a stretch of F1 land south of Horizon's gardens.

5.7. Bura-est scheme

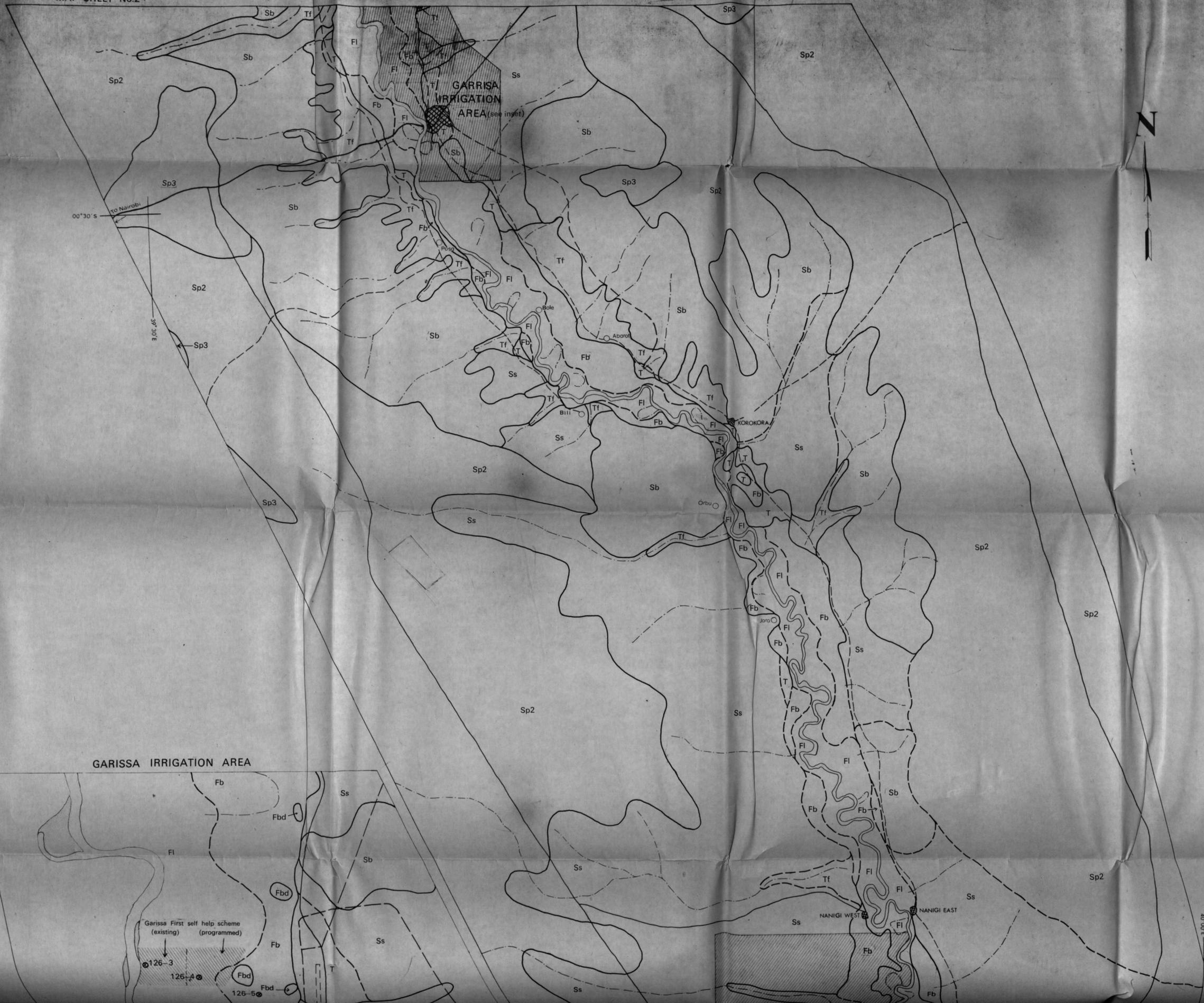
The site of this minor irrigation scheme is partly on F1 land, partly on Fb land. The latter is in this stretch rather dissected by gullies and seems to have often a cover of sandy material over the clay layer. The site therefore does not seem to be very well chosen; any extension should preferably be sought further downstream, on the stretch

PHOTO INTERPRETATION MAP OF THE PHYSIOGRAPHY OF THE MIDDLE-LOWER TANA VALLEY

(Mbalambale - Garissa - Bura)

MAP SHEET No.2

For location map see map sheet No.1

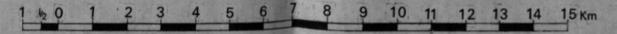




SCALE 1:22,000



SCALE 1:100,000



LEGEND

MAIN FLOODPLAIN

- Fi** River levee land. Relatively high lying, somewhat irregular meso-relief. Dark brown, micaceous, slightly calcareous, stratified fine sand to loam, mostly non-saline and non-alkali. Riserine forest or woodland.
- Fis** Splay river levee land. Relatively high lying, irregular meso-relief. Soils like unit Fi. Wooded grassland.
- Fb** River basin land. Relatively low lying, extensively flat. Dark reddish brown, slightly calcareous, cracking, silty clay to heavy clay, mostly moderately saline and moderately alkali. Topw about 80cm. Grassland, bushland or bush-thicket.
- Fbs** Splay river basin land. Relatively low lying, rather irregular meso-relief. Soils like unit Fb. Wooded bushland.
- Fbd** Low clay-dunes on river basin land.

LOW TERRACES AND ALLUVIAL FANS

- Tf** Alluvial fan and tributary floodplain land. Gently sloping but with many drainage ways. Mostly brown, slightly calcareous, loamy sand to sandy loam, about 80cm depth, non-saline and non-alkali, over hardpan of moderately calcareous sandy clay loam, non-saline but moderately alkali. Wooded-bush-grassland.
- T** Low terrace land. Flat, a few metres above flooding. Soils like Tf unit. Wooded grassland.

SEDIMENTARY PLAINS AND VALLEY SIDES

- Ss** Regular valley slopes. Gently sloping. Reddish brown sandy clay, loam, about 40 cm, non-saline and non-alkali, over hardpan of strongly calcareous sandy clay, moderately saline and moderately alkali. Bushed grassland.
- Sb** Irregular valley slopes. Irregularly sloping and often actively eroding. Hard subsoil of gravelly clay, strongly saline and strongly alkali, often exposed. Bushed grassland or bare ground.
- Sp1** Low level "black/grey-clay" plain. Extensively flat. Soils of varying colour, texture and salinity/alkalinity. Bushed grassland or bush land.
- Sp2** Intermediate level "dotted" plain. Flat to gently undulating. Brown sandy loam till about 20 cm depth, non-saline and non-alkali, over hardpan of slightly calcareous sandy clay loam to clay, non- or slightly saline and moderately alkali. Bushed grassland.

KEY

- main and secondary roads
- active river channels, with sand banks
- deserted river channels and ephemeral tributary streams
- villages or towns
- air strips
- irrigation areas