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SOILS AND AGRICULTURE

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LAND USE & AGRICULTURAL CONSULTANTS
6, ELSTREE [illegible] BOREHAMWOOD
HERTS, ENGLAND

SIR M. MACDONALD & PARTNERS
CONSULTING ENGINEERS
HANOVER HOUSE, 73, HIGH HOLBORN
LONDON, W.C.1.

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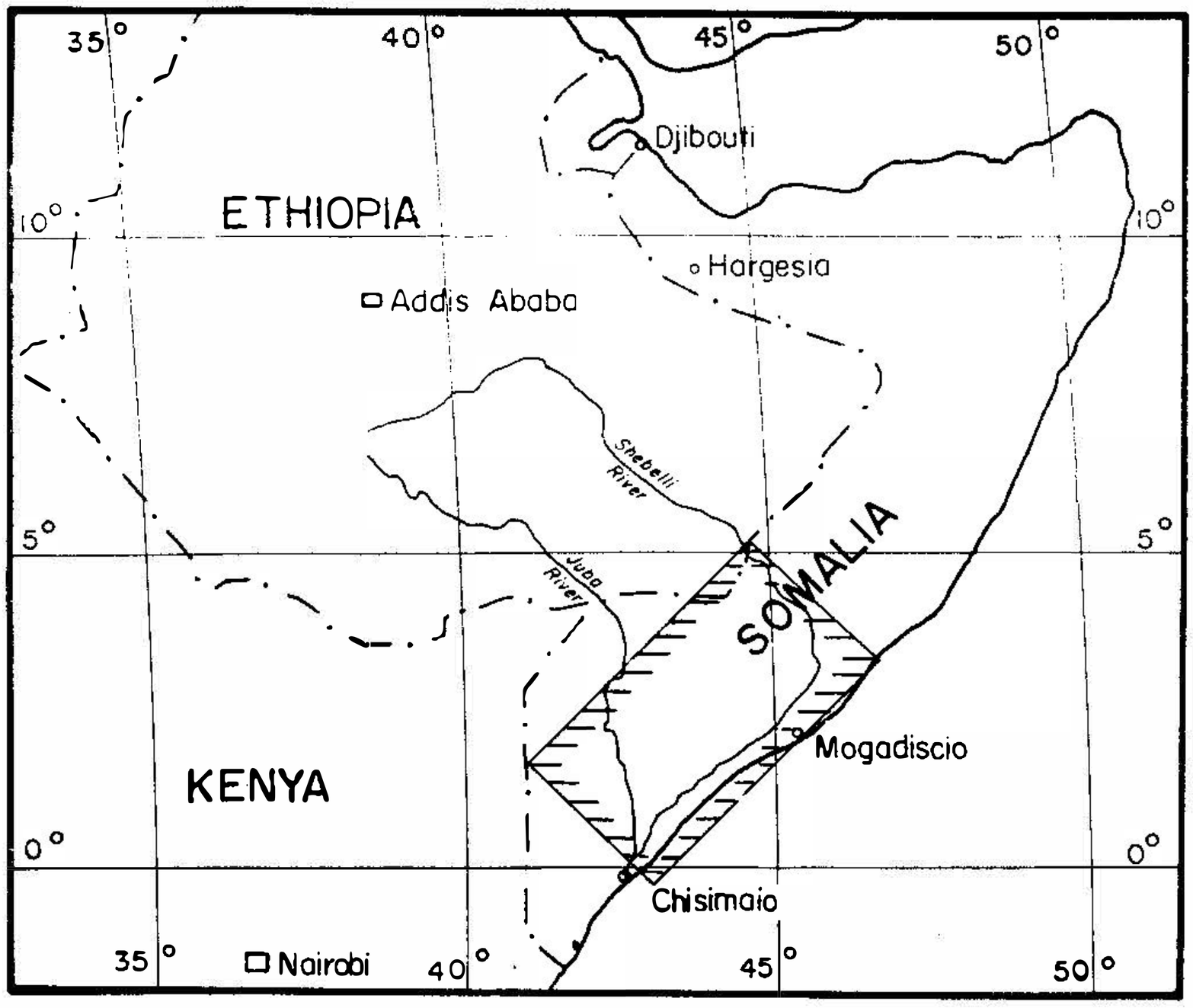
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GLOSSARY OF LOCAL TERMS

'Azienda'	Farm or concession holding.
'Der'	The rainy season October-November.
'Faf'	The farming or pasture areas inundated by flood flows.
'Far'	A natural channel from the river to lower ground in the flood plain used for inundation watering.
'Gu'	The rainy season April-June.
'Hagai'	The season of coastal showers July-August.
'Jambo'	A short handled hoe used for traditional hand tillage.
'Uebi'	(= Wadi) A non-perennial stream.



SCALE : 1:1,000,000

Kilometres 10 0 10 20 30 40 50 60 70 80 90 100 Kilometres

SOMALI REPUBLIC & UNITED NATIONS DEVELOPMENT PROGRAMME

THE WATER CONTROL AND MANAGEMENT OF THE SHEBELLI RIVER

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

LOCATION MAP

SCALE
1:1,000,000

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CHAPTER 1

SOIL AND SURVEY METHODS

1.1 Review of Previous Survey Reports

Various surveys have been carried out to assess the potential of the Juba and Shebelli Rivers. However, only a few have been studied, as the reports written under the Italian Administration were not available. The following gives a brief summary of the most important reports.

a) Inter-River Economic Exploration (ICA 1961)

This report is mainly concerned with the soils of the Juba River and the dry land area between the Shebelli and Juba Rivers. Only a very brief and small exploratory survey was carried out in the Lower Shebelli and in the Uanle-Afgoi-Middle Shebelli area.

The land class classification used is based on the Bureau of Reclamation U. S. D. I.

The Lower Shebelli River Area

Two main soil types were found in the Lower Shebelli:

(i) The dark grey soils, which occupy most of the area, were classified as a Low Humic Gley - Solonetz intergrade. The soils were not considered suitable for irrigation due to their poor physical structure - highly saline-alkali nature and very slow permeability rates. They were considered possibly suitable for paddy rice.

(ii) The dark greyish brown soils occupying the better drained positions in long narrow belts along the river were placed in the slight to moderate saline/alkali alluvial class. Being more permeable than the dark grey soils, it appeared that the soils could be easily reclaimed for irrigation by leaching and drainage.

The Uanle Uen - Middle Shebelli River Area

No information is available for the soils along the Shebelli River. The conclusions described above are based on two observations. It was not possible to confirm these findings during the present survey as the area was continuously flooded. A few samples were taken along passable roads. These will be discussed in Chapter 4.

b) Preliminary Study on the Waters of Somalia (Doxiadis, Ionides, 1962)

This report is a preliminary study, which formed the basis for the survey carried out by UNDP/SF Agriculture and Water Surveys. The report makes little mention of the soils as it is a general study mainly concerned with hydrology and irrigation. One of the most important aspects considered is the irrigation development of the Bulo Mererta area for seasonal crops.

c) Reconnaissance Soil Survey - Bulo Mererta (U.S. AID 1964)

A reconnaissance soil survey was carried out in the Bulo Mererta area and adjacent lands in 1961. A total of 60,000 ha, was investigated of which 11,000 ha. lies in the central part of the Bulo Mererta scheme. 16 sites were described and analysed in this locality (Site Nos. 1, 2, 3, 4, 5, 6, 8, 9, 11, 13, 16, 17, 18, 25, 26 and 27).

A brief summary of this survey is given below. For the chemical data, the report itself should be consulted.

(i) The soils are of alluvial origin and consist of various depositional layers.

(ii) The soils are generally heavy. The clay content varies between 58 and 82 per cent throughout the profile. There is a small area with different soils approximately 2.4 km east of Gero.

(iii) The soil depth varies between 0.70 m (near Scingani) to more than 2.5 m. The depth and stratifications vary near former river channels.

(iv) There is generally no visible evidence of poor internal drainage, except that the subsoils between Gero and Coriolei are very heavy. It has been noticed that water is ponded for long periods, but this could be due to other factors.

(v) The physical properties of the soils are good.

(vi) All soil profiles gave a strong reaction with dilute acid in all horizons ,. indicating the presence of free carbonate.

(vii) The pH is neutral to mildly alkaline and varies between 7.1 and 7.9. The total salt determinations show that the surface horizons in general have no, or only a slight salt hazard. The subsoil horizons have mainly a slight or moderate salt hazard. The impression may be influenced by the fact that thick horizons were bulk sampled. There is no sodium hazard in the area.

The analysis of calcium carbonate contents show an average of 21.9 per cent for the surface horizons and 22.3 per cent for all samples. No concentration was observed at specific depths.

d) Reconnaissance Soil Survey of the Afgoi Experimental Station (U.S.A.I.D. 1964)

A reconnaissance Soil Survey was carried out in 1962. Nine sites were investigated in approximately 400 ha.

'The surface horizons are generally quite uniform, but the depth of these horizons is variable. Textures are medium heavy to heavy, and drainage appears to be good. None of the surface horizons have a salt hazard. Sub-surface horizons are either non-saline or have a medium salt hazard. No sodium hazard existed in the profile. All horizons show a strong reaction with dilute hydrochloric acid.'

e) Irrigation Development (F. M. Tileston, 1964)

This report describes in more detail the results of the survey carried out by the Agriculture and Water Survey Project.

Observations were made of farming areas adjacent to the Experimental Farm at Afgoi. No problems were found in the irrigated area immediately to the south though this area has been irrigated for more than eight years. Salinity and waterlogging were not problems, although infiltration was observed to be very slow.

Observations were made at Johar sugar estate where salinity occurs in some of the irrigated areas. The soils there are not similar to those of the Afgoi Experimental Station, but might indicate what will occur after prolonged irrigation. The sugar estate management allows salt affected areas to lie fallow for 8-10 years for reclamation to occur by natural leaching. Some of the areas are then recultivated and good crops grow under improved crop husbandry and irrigation management. Field drainage experiments were started in 1958 but no results are as yet available.

General observations in the plantations indicate that the drainage and salinity problems are associated with the lack of surface drainage. Soils absorb the water very slowly and high water tables were not detectable. (During the present survey it was noticed that a high water table is present particularly near the main canal).

Permeability values obtained for Johar range from 1.25 cm/hour to 2.00 cm/hour. These values appear high.

f) UNDP/SF Agricultural and Water Surveys (FAO 1968)

The survey was at the reconnaissance level to provide a soil inventory for a large area and only a small amount of work was carried out along the Shebelli River.

During the survey 19 landforms were identified, of which some were sub-divided on the basis of geological parent material or formational processes, topography, soil depth and erosion. The soils in association with each landform were classified into 10 Great Soil Groups according to their morphology, physical and chemical characteristics. Some soils were only provisionally classified.

The flood plain of the Shebelli River was sub-divided into six geomorphic units:

(i) Flood plain Cover
(ii) Flood plain Meander
(iii) Flood plain Channel Remnant
(iv) Flood plain Slackwater
(v) Flood plain Levee
(vi) Flood plain Active

The two areas surveyed in detail during the present project contain the Flood plain Meander and with small areas of the Flood plain Channel Remnant units all other units were recognised during the reconnaissance survey executed during the present project to identify areas for future development.

Several areas are named as Active Flood plain, but only very limited areas are flooded, except in exceptional flood years such as 1961 and 1968. These flooded areas are due to breakage of the river banks when the river is at a very high level and are not typical of active flood plains.

The soils considered to have the greatest potential for irrigation are the soils of Goluen, Johar, Gofca and Shebelli which occur in theFlood plain Slackwater unit. These are fine textured soils, with a good water holding capacity and they are non-saline and generally easily managed.

The land suitability index distinguishes five classes:

A. Lands suitable for cultivation.

B. Lands marginally suitable for cultivation.

C. Lands unsuitable for cultivation but having a fair to limited potential for grazing.

D. Landforms unsuitable for cultivation but with a limited potential for grazing.

E. Landforms unsuitable for cultivation and having virtually no potential for grazing.

The soils were classified for cultivation accordingly:

1. No serious limitation.

2. Main limitations include erosion, low water holding capacity, poor natural fertility, the existence of salt and sodium hazards.

3. The main limitations are high salt or sodium hazard.

4. Unsuitable, rugged terrain with little soil cover, sandy coastal tracts on level to undulating plains with little or no soil cover.

g) Relasione sulle Missiori in Somalia per lo Studio dei Terreni dei Comprensoie di Genale e Bulo Merertа (Agroloni, 1966)

This report is concerned with the Genale and Bulo Merertа districts. The area studied covers approximately 715 square km of young alluvial soils and the soil classification was based on the texture of the top horizon. A soil map was prepared for both districts. The clay soils are dominant in both districts; the silty soils occur only in isolated areas. Loamy soils also are present in approximately the centre of the Genale area, and sandy soils occur along the edge of the dunes. The report stated that banana yields are limited by salinity but this conflicts with the findings of other surveys which show that the top soil is generally non-saline down to 100 cm although a medium salt hazard may occur below this depth.

1.2 Soil Survey Procedure

On the basis of the Agriculture and Water Surveys Soils report and a brief engineering and soils reconnaissance executed in December 1967 and January 1968, areas for feasibility study for a 3000 ha. controlled irrigation scheme near Afgoi and a 10,000 ha. flood irrigation scheme near Balad, were selected. Besides soils and engineering considerations, possible difficulties over land tenure, especially with regard to redevelopment of abandoned station concessions in Genale and Bulo Mererta, were taken into consideration in the selection of these areas. The previous reports by Ionides (1962), Agriculture and Water Survey (1966) and subsequently the report of the World Bank/FAO Project Identification Mission (1968), all favoured development in the unused and abandoned areas at Genale and Bulo Mererta where soils are of the same type as in the area selected for the controlled irrigation study at Afgoi and are predominantly land class 1 and 2.

The semi-detailed soil survey of the Afgoi Mordile and Balad areas was carried out between March and August 1968.

The survey specifications were 7 observations per square km for the Afgoi Mordile controlled irrigation scheme and 2 observations per square km for the Balad flood scheme.

In the Mordile area 109 routine sites and in the Balad area 102 routine sites were sampled and 475 and 443 samples respectively were sent to Hunting Technical Services' laboratory in the U.K. for chemical and physical analysis.

Pits were sited at representative locations on the basis of photo-interpretation and field inspection in an attempt to cover all soil series occurring within the areas.

Sites were investigated to a depth of 2 m. All pits and auger sites were sampled at fixed depths of 0-50 cm, 50-100 cm and 100-150 cm, unless horizons were discernible. Such fixed depths in the Vertisols correspond approximately to the major horizons. When there were stratifications they were bulk sampled except where the individual layers were thick enough to be sampled separately.

A preliminary survey analysis of the air photography for the two project areas was made and the observed boundaries were checked along traces and tracks in the field.

Where no soil changes were obvious the sites were placed at regular intervals, otherwise the sites were located where a soil change was expected. All distances between the observation sites were recorded on a mileometer to facilitate their transfer to the base maps. After the field work a second photo-interpretation was carried out when all soil information from the field and laboratory was assembled.

Areas for future development were investigated after a careful study of the mosaics and in consultation with the engineers who are concerned with the irrigability of the lands. The areas were delineated on the aerial photographs and boundaries were transferred to the mosaics. All areas, between Belet Uen and Avai were visited except where floodwater was standing, observation bores and pits made and samples were taken for analysis. It was not possible to make detailed soil maps for each individual area, as funds were not available and time did not permit more detailed work. Each area is discussed separately and recommendations are given in Chapter 4.

Observations were also made in the irrigation schemes of Genale and Johar since these areas have a reasonably long history of irrigation. These observations enabled the Contractor to assess the probable effects of irrigation on similar soils present in areas selected for development.

1.3 Use of Aerial Photographs

For an area where base maps are not available, aerial photographs and mosaics are essential for use as field base maps for location purposes. The aerial photographs used were taken in 1962 at a scale of 1:30,000 which is small for a detailed soil survey. The quality was rather poor. Scale differences in the runs and between the runs were common. Changes in land marks, which have taken place since the area was photographed, made location in the field difficult. The mosaics were studied in conjunction with the aerial photographs to obtain an overall impression of the area.

Due to the uniformity of the Afgoi-Mordile area air photo-interpretation proved to be of limited value. More identifiable features occurred on the photographs in the Balad area. The following elements were recognised during the photo-interpretation:

Relief

On the Balad area it was possible to delineate minor relief by tone differences. The former river levees showed as light grey, whilst slight depressions were dark grey. The rest of the area was very flat and topographic changes could not easily delineated without additional field observations. Correlation between soil types and topography was often possible.

Vegetation

The use of vegetation for photo-interpretation was limited by the fact that many species gave similar patterns on the photographs although growing on different soil types.

Land-Use

Land use in the Balad area proved to be of assistance in delineating the slight depressions. This was particularly important in the area south of the village of Gululei. The local farmers cultivate these depressions when the height of the flood-water in the river is sufficient to flood them by way of a flood canal. Crops and cultivation patterns in the Afgoi-Mordile area were of no help in photo-interpretation.

1. 4 Chemical Analysis of Soils

Methods of Analysis

The soil samples were air-dried and lightly ground by hand to pass a two milimetre sieve.

A subsample was ground in a mechanical mortar to pass a 0.5 mm sieve. The 0.5mm sample was used for the determination of organic carbon, total nitrogen, total phosphorus, total potassium and total carbonate.

All other determinations were done on the less than 2 mm material.

Particle size analysis

40 g. of soil were dispersed by shaking overnight with 20 ml of five per cent sodium hexametaphosphate solution and 150 ml of water. The suspension was then transferred to a one litre cylinder, made up to volume and stirred. A Bouyoucos hydrometer, calibrated in grams of soil per litre at 20°C, was used to take readings of the density of the suspension at various settling times:

(i) 46 seconds - coarse silt, silt plus clay

(ii) 5 hours - clay

The density readings were corrected for temperature variations and the dispersing agent content.

The soil suspension was then washed through an 80 mesh (0.2 mm) sieve and the coarse sand fraction weighed after drying.

Exchangeable Cations

10 g. of soil were leached with 200 ml of neutral normal ammonium chloride. The leachate was made up to 200 ml and an aliquot analysed by atomic absorption spectroscopy for sodium, calcium and magnesium and by emission flame photometry for potassium.

pH

A glass electrode was used for the determination of the pH of the saturated soil paste.

Saturation Extract

200 g. of soil were mixed with water until the saturated paste was obtained.

The paste was then subjected to suction to obtain the saturation extract. The saturation extract was analysed as follows:-

Electrical Conductivity (EC)

The EC was measured using a conductivity bridge.

Soluble Sodium

Measured by atomic absorption spectroscopy.

Soluble Potassium

Measured by emission flame photometry.

Soluble Magnesium and Calcium

Measured by atomic absorption spectroscopy using strontium chloride as a releasing agent.

Organic carbon

The Walkley-Black method was used.

20 g. of soil were oxidised with an excess of potassium dichromate in the presence of sulphuric and phosphoric acids. The excess dichromate was titrated against standard ferrous ammonium sulphate using barium diphenylamine sulphonate as indicator.

Total Nitrogen

The Kjeldahl method was used. One gram of soil digested with concentrated sulphuric acid using a catalyst mixture of potassium sulphate, copper sulphate and selenium. The digest was then made alkali, the ammonia steam distilled into boric acid and titrated against standard acid.

Gypsum Content

The soluble calcium in the filtrate from a 1:5 soil-water suspension was measured using atomic absorption spectroscopy. If a saturated gypsum solution was obtained using a 1:5 suspension then the rest was repeated using a 1:10 or 1:50 soil-water suspension.

The difference between this value and the soluble calcium found in the saturation extract was used to calculate the gypsum content.

Total Carbonate

The amount of carbon dioxide released by the action of hydrochloric acid was measured using a calcimeter.

Cation Exchange Capacity

The soil was saturated with sodium by leaching with sodium acetate and the sodium displaced by ammonium acetate. The amount of displaced sodium was measured using atomic absorption spectroscopy.

1.5 Physical Analysis of Soils

pF Determinations

Soil samples were collected in the field using a special coring device. The cores were saturated with water then placed in the porous plate apparatus and subjected to a pressure of 7.6 cm mercury (0.1 atmos.). When the sample and the pressure were in equilibrium, water ceased to flow from the pressure chamber. The sample was then removed and weighed to determine the moisture content.

The experiment was repeated at two more pressures (25.4 cm mercury and 76 cm mercury; 1/3 and 1 atmospheres).

The samples were then removed to the high pressure chamber and the soil moisture content determined when in equilibriun with pressures of 3, 5 and 15 atmospheres.

Bulk Density

The weight and volume of dry soil in the core was determined and the bulk density calculated.

Hydraulic Conductivity

The core samples were saturated with water and then a constant (10 cm) head of water was applied. The amount of water passing through the core in a given time was measured, after steady state conditions were reached. The results were expressed in cm/hour.

1.6 Map Compilation

a) Soil Mapping

The soil boundaries were first determined where possible on the aerial photographs. Where aerial photo-interpretation gave no indication as to where the soil boundaries were situated, then they were interpolated between the sites. The soil boundaries were then transferred by means of a Sketchmaster from enlarged overlays of the photographs to the base maps.

Each soil type is identified by a specific symbol, complexes are mapped where necessary.

b) Land Class Maps

Land class boundaries were determined by procedures similar to those applied to the soil maps, and the soil class boundaries are used where land and soil class coincide. This is particularly important in the case of the old river levees.

Where available a profile diagram showing the textural classes and the salinity status of the profile is placed at each individual site with the appropriate land class symbol.

2°00'

42°00'

Bardera

River Juba

1°00'

42°00'

Gelib

Avai

Brava

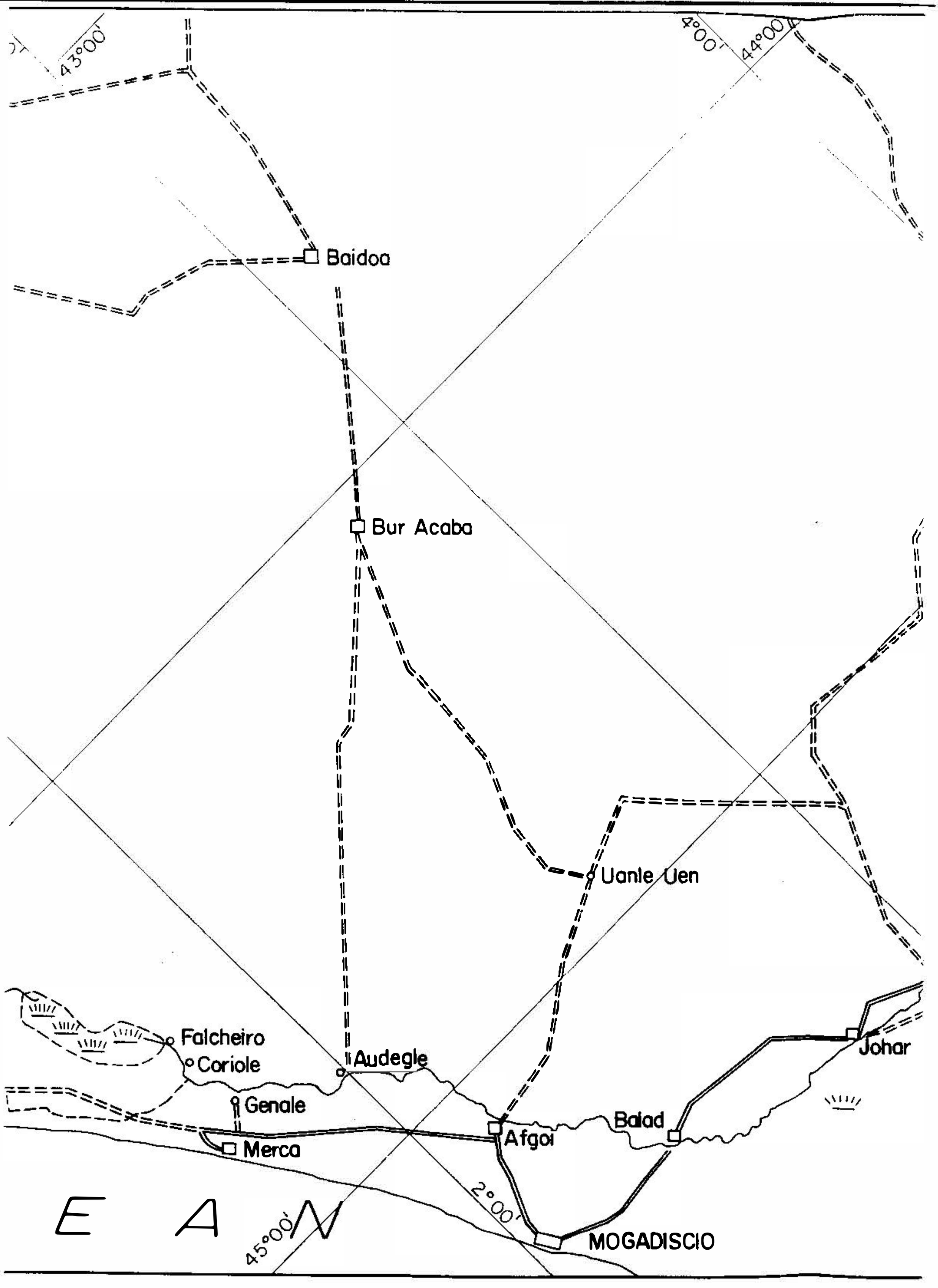
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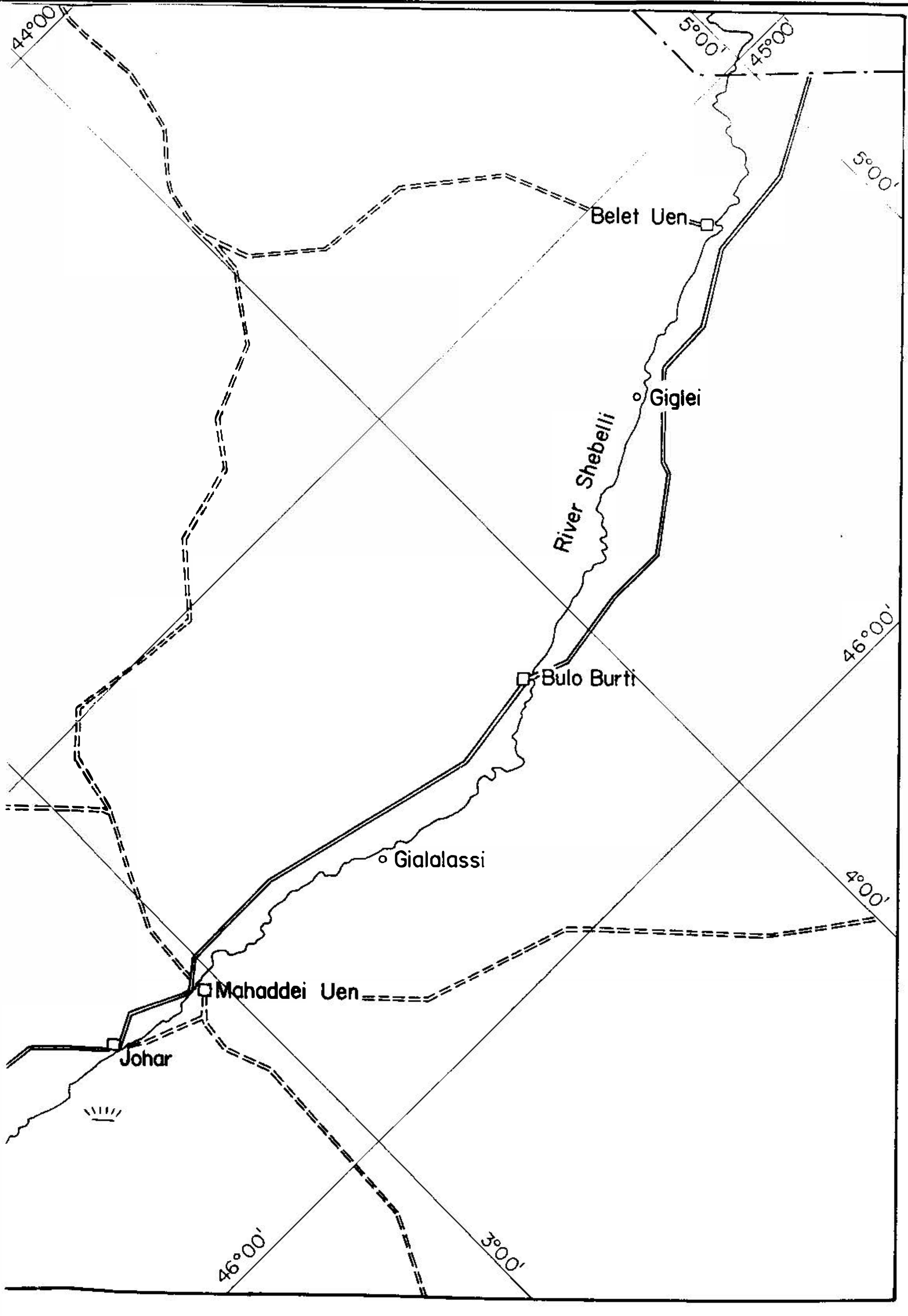
43°00'

INDIAN

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43°00'
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Baidoa
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Uanle Uen
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Audegle
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Johar
2°00'
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MOGADISCIO
E A


44°00'
5°00'
45°00'
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Belet Uen
Giglei
River Shebelli
Bulo Burti
46°00'
Gialalassi
4°00'
Mahaddei Uen
Johar
46°00'
3°00'

CHAPTER 2

SOILS PEDOLOGY

2.1 Parent Material

The area consists entirely of deep alluvial deposits overlying rocks of Miocene age. These alluvial deposits contain considerable amounts of calcium carbonate and gypsum, derived from the weathered parent material in the catchment area. The present land surface is formed by coarse-textured levee remnants surrounding hollows filled with finer textured material. The soil profiles consist of successions of depositional layers, and several stages of deposition were recognised during the survey. The River Shebelli formerly flowed further inland, where its abandoned courses are readily discernible on the aerial photographs. During changes in sea level during the Pleistocene the river assumed its present course south of the Mahaddei Uen area. The older alluvium along the former courses occupies the higher ground to the north and it underlies the younger alluvium in the Afgoi-Mordile area and in the Balad area, although mostly at a depth greater than the observation site depth of two metres. The soils of part of the Balad area however, are developed from the older alluvium. In Balad there is a well-marked boundary between the old and recent alluvium, running more or less east-west. In the east an abandoned river channel of the recent phase has cut into the older alluvium. Formerly there would have been a slight terrace bluff along this boundary but this has now been reduced by erosion over most of the area. The land surface slopes down from the levees of the river to depressions on either side, before rising again to the older alluvium in the north (Balad) or to the dunes in the south (Afgoi-Mordile).

After its change of course, the river as far as the topography permitted, deposited alluvium on its flood plain, the sediments being coarser near the river and becoming finer textured away from it. The river bed built up gradually at the same time and depressions developed away from the river. These sediments constitute the first stage of recent alluvial deposition.

In the second stage of deposition a change in river regime occurred in which swampy conditions prevailed in the depressions. Fine material, very dark grey or black in colour and containing many shells and shell fragments, was deposited in the depressions. This has not been found along the higher ground of present and former river channels. In the deepest parts of the depressions, the layer is thick and may be overlain by two or more metres of more recent alluvial material. Towards the dunes, the dark layers are comparatively thin, 5 to 10 cms, and occur at shallow depth.

A further change in regime followed the second stage and these blackish sediments were covered by brown medium and fine textured sediments which were deposited by seasonal flow of the river. The thickness of this upper layer is in places relatively uniform, but elsewhere these medium textured soils may be thin and overlie finer textured deposits of the same age. Close to the river, and further inland, the soils are darker but lack the blackish sub-surface horizon.

Due to the complexity of the alluvial plain, the clay deposits may overlie coarse and/or moderately coarse textured substrata. The river modified its channel frequently during the deposition of the recent alluvium and some of the former river courses are still visible but generally they are eroded. Remnants of levees are found in both project areas and consist of layers of different textures. The sand fraction contains a high percentage of more or less coarse-grained quartz and its origin is partly aeolian and partly alluvial.

It is suggested that the horizons recognised within the two metre investigation depth are depositional rather than pedogenic, although some pedogenic action has taken place in the downward movement of clay. The soils in general are of an AC horizon type.

It is thought that the clay minerals are predominantly of the expanding lattice type. Mottles occur frequently in the soil profiles, particularly in the brown soils. It is thought that these are predominantly fossil in origin as the water table is at depth.

2.2 Soil Forming Processes

The project areas in general are flat to very gently sloping or very gently undulating. Rainfall averages 450 to 500 mm per annum. Water percolation in dry soil is fast and then slows down to 0.4 cm per hour. It penetrates deeply in to the profiles and appreciable quantities of water flow down the cracks. Leaching will be possible, especially in the medium textured brown soils.

In some profiles there is some evidence of downward movement of clay and salt, though the rainfall alone is not sufficient to leach the salts below 2 m.

The main soil forming process at present would seem to be related to the swelling and shrinking properties of the clay type. The clay soils are self-mulching, but this process is probably limited to the top 50 cm, although there is some evidence that it may extend to 100 cm in some cases. Marked cracking occurs to 50 cm depth, but appreciable cracking extends to 100 cm.

Gilgai formation and associated sink-holes occur in both areas. Slight gilgai formation occurs at various sites with the best developed gilgai in a depressed site in the south-east corner of the Afgoi area. Sink-holes are very common features, especially in the recent alluvium.

The coarse to medium textured levee soils do not crack. Being on higher levels than their surroundings it is likely that some rainfall runs off, reducing potential leaching. As a result they have rather high salinities.

2.3 Physical Characteristics of the Soil

a) Texture

Texture varies in the flood plain from the coarse to medium textured levee soils (Entisols) to the medium to fine textured Vertisols. Textures may change abruptly throughout the profile and stratifications occur in both the subsurface and subsoil. These stratifications were bulk sampled when the layers were too thin to justify individual sampling, (less than 15 cm).

Most of the soils possess medium to high clay percentages although low clay contents are found in the levee soils. The clay content varies from 0 to 74 per cent. There is an increase in clay content in the subsoil of some profiles. No proper clay skins were recognised and it is not certain whether clay illuviation has occurred or not. It is probable that most variations in clay percentage within the profile are due to differences in deposition.

b) Colour

The top horizon of the soils in both project areas are of four main colours in two hues, 7.5YR and 10YR. The estimation of precise colours is important as it is a critical factor in the soil classification. It was often difficult to estimate the colour exactly under different weather conditions. This applies especially when colours are intergrades in chromas and values which are classification criteria at subgroup level. However, no differences in agricultural potential exist between the subgroups.

The soils with 7.5YR hue occur throughout the Afgoi-Mordile area and as a narrow strip along the river in the Balad area. It appears that these soils are formed from more recent alluvium than the very dark grey brown and the dark grey brown soils. The 7.5YR colours are found both in depressional and water-shedding sites. The latter have predominantly 7.5YR 4/4 soil colours and the receiving sites have 7.5YR 3/2 to 7.5YR 4/4 soil colours. No differentiation is made here at subgroup level, as most colours are intergrades. The profiles may have uniform colours throughout but often a black (7.5YR 2/0) horizon occurs between 40 and 200 cm. 10YR hues are common in the third and fourth horizons.

The soils of the older alluvium have uniform 10YR hues. These hues occur also in the more recent alluvium of both project areas. The 10YR hue occurs both in receiving and in shedding sites, but the dark grey brown and dark brown colours are more dominant on the shedding sites. The dark grey (10YR 4/1) is typical for low lying areas in the Balad region. These dark grey soils occur only rarely, in small isolated localities in the Afgoi-Mordile area.

All soil colours in the descriptions are for moist soils.

c) Structure

Vertisols

The high degree of swelling and shrinking of the clay soils as a result of bi-annual wetting and drying cycles is the main factor controlling structure. The swelling and shrinking and the inter-mixing of surface material with lower horizons is called homo-genisation or soil circulation. This churning effect is likely to be limited to the depth of greatest cracking (approximately 50 cm).

During the rains and under irrigation the clay expands and dessication of the top soil during the dry season results in shrinkage and the formation of deep vertical cracks. During this period the majority of the Vertisols develop a granular mulch, which is of agricultural significance. The Udic Chromustert (hue 7.5YR) especially possesses a moderately deep well developed granular surface mulch. The practical advantage of a surface mulch is that it provides a fine seed bed through which water will move freely and enables a rapid development of the initial root system. During the survey it was noticed that the local population always avoided cultivating soils which have a hard surface crust. An attempt has been made to differentiate the mulch and the crust at phase level, although it was difficult to map at a large scale. Impurities in mapping must be expected.

Cracking may reach 150 cm at the end of the dry season, but in general cracking is limited to 100 cm with a maximum development in the top 50 cm. The cracks not only vary in width and depth, but they also vary in intensity. As cracking in clay soils has an important effect on water penetration, aeration and moisture loss, cracking may be expressed by the number of cracks per unit area of surface soil or per unit volume of an horizon. However, it was difficult to observe surface cracking patterns due to the concealing effect of the mulch.

In general a pattern of very fine cracks is agriculturally undesirable, as they are likely to become sealed by fine crumbs from the surface mulch. The high initial intake rate of the infiltration tests shows the great influence of well developed cracks.

Cracking progressively increases in depth and width during the dry season and where the classification of the 7th Approximation is used such a seasonal variation in width of cracks may be sufficient to differentiate the soil class. An important criterion for the separation of Vertisols from Entisols is the presence of cracks wider than 1 cm.

The Entisols in both project areas have only poorly developed cracks.

The surface horizon roughly corresponds with the depth of most intensive cracks which extends to approximately 50 cm. The coarse cracks separate large, coarse, weakly developed prismatic blocks, which break down into a moderate, medium, subangular blocky structure. Occasionally a weak fine platy structure is found between 30 and 50 cm. Weakly developed slickensides may occur at the base of this horizon.

The second and third horizons have a moderate, medium, angular blocky structure or are massive. Cracks usually extend into the second horizon and occassionally into the third. The cracking intensity is much less there than in the surface horizon. Medium and large well developed slickensides are common features. These slickensides may vary from a few centimetres to several metres in length. A secondary, weakly developed wedge structure may be present.

The fourth horizon is similar to the overlying horizon, but the structure varies between a very weakly and a moderate, medium, angular structure. Some profiles in the more recent alluvium show a very well pronounced structure. The peds are surounded by weakly developed pressure faces, which absorb water very slowly. If the ped becomes moist inside, it then breaks open. Moist peds have a friable consistence.

It must be realised that the cracking behaviour will be drastically modified under permanent irrigation, though cracking between periods of irrigation will still take place and will play a significant part in the entry of water.

Entisols

The coarse/medium textured levee soils are weakly structured and cracking is only weakly developed. Structure is normally a weak fine to weak medium sub-angular blocky.

d) Soil Consistence

The consistence of the soil depends mainly upon the texture, structure and moisture status when sampled. Soils which are very hard when dry may be friable when moist and very sticky and plastic when saturated with water. In general it was found that the better the degree of structure and the smaller the size of the individual peds, the less hard was the consistence. Most Vertisols had peds which when dry were hard or very hard and when moist were friable. The Entisols were more variable in their characteristic consistence, depending upon the texture of the individual horizons.

e) Gypsum and Carbonate

Gypsum occurs in the subsurface horizons and subsoil, but no association was found between the amounts of gypsum and the different soil series. Gypsum commonly occurs in the subsurface and subsoil of the Saruda soils, which are developed from the old alluvium in the Balad area. Large quantities of gypsum are found especially in the subsoils of the Upper Shebelli.

Gypsum is in two forms:

a) fine to very fine crystals and,

b) fairly large lenticular crystals with dull faces.

The latter occur mainly in the subsoil, except in the Upper Shebelli where lenticular gypsum crystals may be found as near as 50 cm to the surface.

Calcium carbonate is found in four different forms:-

a) Small hard, round whitish concretions usually up to 0.2 cm in diameter, are found both in Entisols and Vertisols, occurring throughout the profile.

b) Medium hard, round whitish concretions up to 0.6 cm in diameter occurring only in a few profiles at between 80 and 150 cm depth.

c) Very small crystals occurring as streaks or distributed through the soil profiles. In certain profiles the calcium carbonate occurs in fairly fine crystalline form through the soil matrix.

d) Very hard dark grey concretions usually up to 0.5 cm in diameter. These dark grey concretions are only found in few profiles in the two project areas. They occur commonly on the surface and throughout the profile in the Upper Shebelli.

f) Hydraulic Conductivity

Hydraulic conductivity rates have been determined on undisturbed core samples of the various horizons of 15 pits from 10 soil mapping units. Samples were taken from several pits of the most important series, GL 1b21 and Sr 211. The tests were carried out on 14 Vertisols and only one Entisol as the hydraulic conductivity is of greater importance in the Vertisols.

Samples were taken by a coring device. Two samples of each horizon were taken; one vertical and one horizontal to obtain information on possible lateral movement.

Hydraulic conductivity tests determined in the laboratory have certain disadvantages, i.e. major cracking and structure are not taken into consideration. However, in the land classification both the profile investigations and the results from the laboratory are taken into account.

It is extremely difficult to achieve reliable results on permeabilities of cracking clay soils measured both in the field and in the laboratory. In the field the initial water intake goes mainly through the cracks. Permeability is also affected by salinity, alkalinity and texture.

The following hydraulic conductivity classes are recognised:-

Class	Hydraulic Conductivity		Description
1	1	cm/hour	fast
2	0.64 - 1.0	"	moderate
3	0.33 - 0.63	"	moderately slow
4	0.13 - 0.32	"	slow
5	0.13	"	very slow

The hydraulic conductivity varies greatly, both in the different pits and in each horizon. However, it can be said that uniform coarse/medium textured soils have no permeability problems, but stratifications may be a limitation. The Udic Chromusterts have high to slightly reduced hydraulic conductivities although the soils with 10YR hue seem to be less permeable than the 7.5YR hue soils. Pit H 255 shows very high rates and this is probably due to the high salinity status in the subsoil.

The Udorthentic Chromustert (recent alluvium) shows moderately slow hydraulic conductivities in the surface soil and relatively high in the subsoil. This subsoil has a medium salt hazard and a favourable structure. (See Pit H 25).

The Udorthentic Chromusterts (older alluvium) tend to possess lower hydraulic conductivities than the Udorthentic Chromusterts (recent alluvium) and some profiles are only slowly permeable to water.

Pit H 60 has a slow permeability and this is probably due to the medium high sodium content.

In general the soils in both project areas do not have irrigation drainage problems except for the Udorthentic Chromusterts, which need careful management under irrigation as their hydraulic conductivities are low.

It is only below 100 cm that permeability has a bearing on area drainage problems, but if class 1 permeabilities are only of the order of 1 cm per hour, if drains are required, they will be costly since they will require close spacing

High vertical and high horizontal permeabilities occur together and low values, when they occur, are persistent in both the vertical and horizontal directions. The vertical rates are on the whole similar to the horizontal ones which is unusual in alluvial soils.

Table 2.1 gives the values obtained for hydraulic conductivities of individual series and the associated land class.

Soils which are relatively permeable and have initial good infiltration rates, may alter after several years under irrigation. Soil changes which occur under irrigation may be due to the mechanical compaction during cultivation or changes in the physical properties due to alterations in the chemistry of the soil. In this respect the quality of the applied irrigation water is of vital importance.

TABLE 2.1 Hydraulic Conductivity of Individual Series

Pit Number Soil Series	Sample No.	Depth in cm	Hydraulic conductivity cm per hour	Land Class
H 61	61/ 27[1)]	40- 70	16.15	1
C 131	61/ 28		19.46	
	61/ 30	70- 95	6.46	
	61/ 31		6.46	
	61/ 33	95-130	3.44	
	61/ 34		5.98	
	61/ 36	130-200	7.34	
	61/ 37		1.94	
H 21	21/123	0- 40	0.26	2s
G 1a21	21/124		0.32	
	21/126	40- 95	0.60	
	21/127		2.26	
	21/129	95-125	0.65	
	21/130		1.36	
	21/132	125-150	2.97	
	21/133		0.90	
	21/135	150-185	2.78	
	21/136		0.07	
H 268	268/ 54	50-110	8.82	2ps
Gl 1a21	268/ 55		1.10	
	268/ 57	110-160	1.30	
	268/ 58		5.40	
	268/ 60	160-200	5.38	
	268/ 61		1.97	

1) The first and second value of each horizon show the vertical and horizontal hydraulic conductivity respectively.

Pit Number Soil Series	Sample No.	Depth in cm	Hyeraulic conductivity cm per hour	Land Class
H 251	251/ 1V	0- 50	13.46	3s
Gl 1a31	251/ 2		13.46	
	251/ 3	50- 95		
	251/ 4			
	251/ 6	95-130	5.38	
	251/ 7		8.82	
	251/ 9	130-200	5.05	
	252/ 10		5.38	
H 26	26/111	0- 60	1.36	2s
Gl 1b21	26/112		5.98	
	26/114	60-120	0.13	
	26/115		1.42	
	26/117	120-140	0.81	
	26/118		0.26	
	26/120	140-200	0.81	
	26/121		2.40	
H 98	98/138	0- 45	2.52	1
Gl 1b21	98/139		3.23	
	98/141	45- 95	1.19	
	98/142		2.84	
	98/144	95-135	0.22	
	98/145		1.03	
	98/147	135-200	1.55	
	98/148		0.41	
H 255	255/ 15	43- 97	1.23	4sg(2)
Gl 1b21	255/ 16		2.20	
	255/ 18	97-130	7.34	
	255/ 19		13.46	
	255/ 21	130-180	19.46	
	255/ 22		19.46	

Pit Number Soil Series	Sample No.	Depth in cm	Hydraulic conductivity cm per hour	Land Class
H 270	270/ 63	0- 50	2.20	2sg
Gl 1b21	270/ 64		5.77	
	270/ 66	50-105	1.94	
	270/ 67		1.55	
	270/ 69	105-140	0.77	
	270/ 70		1.33	
	270/ 72	140-200	2.32	
	270/ 73		1.16	
H 347	347(2p)H	0- 60	16.15	1
Gl 1b31	347(1p)V		4.85	
	347(2p)H	70- 85	24.10	
	347(2p)V		0.48	
	347(3p)V	85-145	3.44	
	347(3p)H		2.24	
H 25	25/ 99	0- 40	0.45	3s
Gl 221	25/100		0.35	
	25/102	40-100	0.32	
	25/103		0.90	
	25/105	100-135	0.52	
	25/106		1.20	
	25/108	135-170	2.83	
	25/109		1.74	
H 60	60/ 42	40- 90	0.67	4pas
Gl 311	60/ 43		0.60	
	60/ 45	90-140	0.03*	
	60/ 46		1.62	
	60/ 48	140-200	0.26	
	60/ 49		1.55	

* Denotes soils with irrigation/drainage problems.

Pit Number Soil Series	Sample No.	Depth in cm	Hydraulic conductivity cm per hour	Land Class
H 192	192/ 87	0- 30	7.02	3ps
Sr 211	192/ 88		2.78	
	192/ 90	30- 80	1.23	
	192/ 91		2.71	
	192/ 93	80-130	0.19	
	192/ 94		0.16*	
H 183	183/ 75	0- 50	1.16	2ps
Sr 211	183/ 76		2.56	
	183/ 78	50-100	0.15*	
	183/ 79		0.52	
	183/ 81	100-150	0.84	
	183/ 82		0.31	
	183/ 83	150-200	2.40	
	183/ 85		7.02	
H 195	195/162	0- 35	3.44	4ps
Sr 211	195/163		1.26	
	195/165	35- 90	0.16*	
	195/166		1.10	
	195/168	90-140	0.15*	
	195/169		0.07*	
H 148	148/150	0- 50	1.49	2ps
Sc 111	148/151		1.10	
	148/153	50- 90	0.97	
	148/154		2.58	
	148/156	90-140	0.78	
	148/157		0.30	
	148/159	140-200	2.10	
	148/160		0.48	

* Denotes soils with irrigation/drainage problems.

2.4 Soil Moisture Characteristics

The range of soil moisture which is of interest to the agricultural user is the "available water content" or AWC.

The AWC is defined as the moisture held by the soil between field capacity (FC) and the permanent wilting point. (WP).

The field capacity is the highest moisture content of freely drained soil and the wilting point is the lowest possible moisture content for plant survival.

Under practical conditions the field capacity of a soil is normally reached some two days after the soil has been completely saturated with water either by rainfall or irrigation, and downward flow of water by gravitational pull has virtually ceased. In the laboratory various workers have simulated the field capacity of soil by using tensions of 0:1 or 0:3 of an atmosphere. There is still a certain amount of controversy as to the particular tension to use. Our experience in other projects has indicated that for coarse textured soils the best approximation is given by the 0:1 atmosphere tension and for the medium and fine textured soils the 0:3 atmosphere tension.

It is generally agreed by most soil scientists that the 15 atmosphere tension is a good measure of the wilting point.

The amount of water held in a soil at different tensions depends upon many factors, including its colloidal properties, the degree and amount of aggregation and the soil particle size distribution.

The moisture content of the soil is calculated on a dry weight basis but for many purposes it is more useful to know the moisture content by volume of the soil.

It must be recognised that all the water held by a soil is not equally available for plant growth and in the lower moisture ranges the plant has to exert considerable energy to obtain moisture. Thus the shape of the soil moisture tension curve is important.

Undisturbed core samples were collected from the principal horizons of the various soil series and measurements made of soil moisture retention against tensions of 0.1, 0.3, 1.0, 3.0, 5.0 and 15.0 atmospheres.

Table 2.2 illustrates the moisture holding characteristics of the major soil groups on a dry weight and a volume basis.

For controlled irrigation conditions the available water content was calculated as the difference between the moisture held at 0.3 and 15 atmosphere tensions, whereas for the flood scheme where only a single irrigation is contemplated the available water content was calculated as the difference between the 0.1 and 15 atmosphere tension.

TABLE 2.2 Soil Moisture Determinations

Pit No. and Series	Sample No.	Depth in cm	Bulk Density	% moisture on dry weight basis at pressures						Texture	Total Available Moisture		
				0.1	0.3	1	3	5	15		Dry Weight %	Volume %	Depth per layer
H 61	23	0-40	1.20	37.4	27.1	22.4	20.4	20.4	16.9	SiCL	20.5	24.6	9.8
C 131	26	40-70	1.26	37.9	26.9	22.2	19.4	19.4	16.1	SiCL	21.7	27.6	8.3
	29	70-95	1.26	40.1	25.1	23.7	22.6	20.1	11.4	SiL	24.6	28.3	7.1
	32	95-130	1.32	38.1	27.1	25.7	21.4	19.2	17.9	CL	21.8	27.5	9.6
	35	130-200	1.38	35.8	28.3	27.2	24.9	24.0	21.4	C	28.1	36.1	25.2
H 268	50	0-50	1.06	42.7	31.4	28.0	26.5	24.3	22.4	C	19.0	21.6	10.8
Gl 1a21	53	50-110	1.29	42.5	33.3	31.1	28.7	25.9	24.6	C	17.9	23.1	13.9
	56	110-160	1.30	35.5	29.9	29.2	25.9	25.9	22.5	C	13.0	16.9	8.5
	59	160-200	1.18	48.9	39.4	37.9	31.5	30.9	27.1	CL	21.8	25.7	10.3
H 251	1	0-50	1.21	37.6	27.5	23.6	21.5	21.4	17.0	C	20.6	24.9	12.5
Gl 1a31	2	50-95	1.50	38.3	28.5	24.9	22.3	21.6	17.1	CL	21.2	31.8	14.3
	5	95-130	1.30	38.7	25.5	24.4	17.7	16.8	15.6	L	23.1	30.0	10.5
	8	130-200	1.61	44.4	32.0	30.1	21.9	18.6	17.1	CL	27.3	44.0	30.8
H 21	122	0-40	1.22	49.2	40.8	38.3	31.5	29.7	29.8	CL	19.4	24.6	9.8
Gl 1b21	125	40-95	1.28	48.0	40.6	38.4	32.8	32.3	29.8	CL	18.2	23.3	12.8
	128	95-125	1.32	48.1	40.9	38.4	34.1	32.3	28.0	CL	20.1	26.5	8.0
	131	125-150	1.18	50.3	43.2	41.1	35.2	35.1	33.0	C	17.3	20.4	3.1
	134	150-185	1.44	41.3	35.5	34.3	28.5	28.5	23.6	C	17.7	25.5	6.9

TABLE 2. 2 (Continued)

Pit No. and Series	Sample No.	Depth in cm	Bulk Density	% moisture on dry weight basis at pressures						Texture	Total Available Moisture		
				0.1	0.3	1	3	5	15		Dry Weight %	Volume %	Depth per layer
H 26	110	0- 60	1.30	44.7	35.8	35.9	31.2	30.9	28.3	C	16.4	21.3	12.8
Gl 1b21	113	60-120	1.40	43.9	39.1	37.4	34.4	31.2	29.9	C	14.0	19.6	11.8
	116	120-140	1.24	42.6	39.4	38.1	28.0	25.8	24.2	C	18.4	22.8	4.6
	119	140-200	1.29	39.3	33.1	30.9	22.8	22.3	22.2	SiL	17.1	22.1	12.3
H 98	137	0- 45	1.22	40.1	32.2	29.9	23.6	22.7	21.4	SiL	18.7	22.8	10.3
Gl 1b21	140	45- 95	1.33	40.7	33.9	31.7	26.2	24.5	21.9	C	18.8	25.0	12.5
	143	95-135	1.40	39.5	34.5	32.4	27.7	25.3	25.2	C	-	-	-
	146	135-200	1.69	40.6	33.1	31.2	26.5	22.8	22.1	C	18.5	31.3	20.3
H 255	11	0- 45	1.18	41.0	29.8	25.8	24.5	21.6	20.4	C	20.6	24.3	10.9
	14	45- 97	1.27	45.0	35.4	32.1	30.5	28.1	24.3	C	20.7	26.3	13.7
	17	97-130	1.34	42.9	33.6	32.1	29.5	28.5	25.1	CL	17.8	23.9	9.9
	20	130-180	1.21	48.0	41.4	40.4	39.5	38.6	38.4	C	9.6	11.6	5.8
H 270	62	0- 50	1.24	45.6	36.8	34.6	30.7	28.1	27.2	CL	18.4	22.8	11.4
Gl 1b21	65	50-105	1.25	45.3	37.2	33.8	29.6	29.2	26.6	C	18.7	23.3	12.8
	68	105-140	1.43	39.3	34.1	32.3	29.7	29.0	26.0	C	13.3	19.0	6.7
	71	140-200	1.34	40.1	33.2	31.2	28.5	28.2	24.7	C	15.4	20.6	12.4

TABLE 2.2 (Continued)

Pit No. and Series	Sample No.	Depth in cm	Bulk Density	% moisture on dry weight basis at pressures						Texture	Total Available Moisture		
				0.1	0.3	1	3	5	15		Dry Weight %	Volume %	Depth per layer
H 347	1	0- 60	1.46	39.1	36.2	35.3	30.8	30.3	30.1	C	9.0	13.2	7.9
Gl 1b31	2	70- 85	1.21	37.3	26.0	16.9	15.9	13.8	12.1	SL	25.2	30.5	4.6
	3	85-145	1.27	37.3	27.0	20.7	8.8	7.9	6.9	SiL	30.4	38.6	23.2
H 25	98	0- 40	1.31	45.8	38.2	35.2	29.9	29.5	27.9	SiL	17.9	23.5	9.4
Gl 221	101	40-100	1.39	44.8	38.1	36.1	31.3	29.1	29.3	C	15.5	21.6	13.0
	104	100-135	1.36	45.4	40.3	38.9	34.1	32.2	30.4	C	15.0	20.4	7.1
	107	135-170	1.21	46.2	40.1	38.8	30.9	30.7	28.6	C	17.6	21.3	7.5
H 60	38	0- 40	1.41	40.2	31.8	28.4	27.7	25.7	22.7	C	17.5	24.7	9.9
Gl 311	41	40- 90	1.39	46.1	36.6	33.1	29.8	29.2	24.1	C	22.0	30.6	15.3
	44	90-140	1.62	38.6	34.2	33.1	32.0	29.6	28.6	C	10.0	16.2	8.1
	47	140-200	1.85	43.2	36.5	35.6	33.9	31.3	29.7	C	13.5	25.1	15.1
H 192	86	0- 30	1.26	37.4	24.4	21.7	17.9	16.2	13.4	CL	24.0	30.2	9.1
Sr 211	89	30- 80	1.39	37.4	29.1	27.4	22.2	21.4	19.0	C	18.4	25.6	12.8
	92	80-130	1.45	35.0	29.2	26.7	22.5	22.2	18.4	C	18.6	24.1	12.1
H 183	74	0- 50	1.29	45.0	36.8	34.0	29.5	28.2	27.1	C	17.9	24.8	12.4
Sr 211	77	50-100	1.44	40.4	35.5	33.2	30.6	30.0	25.3	C	15.1	21.8	10.9
	80	100-150	1.43	42.4	37.6	35.5	31.5	29.8	28.9	C	13.5	19.3	9.7
	83	150-200	1.20	46.8	38.6	35.9	33.5	32.1	37.7	C	9.1	11.0	5.5

TABLE 2.2 (Continued)

Pit No. and Series	Sample No.	Depth in cm	Bulk Density	% moisture on dry weight basis at pressures						Texture	Total Available Moisture		
				0.1	0.3	1	3	5	15		Dry Weight %	Volume %	Depth per layer
H 195	161	0- 35	1.32	37.0	28.8	26.9	23.2	21.8	18.6	C	18.4	24.3	8.5
Sr 211	164	35- 90	1.42	39.4	32.9	30.4	26.6	25.7	23.0	C	16.4	23.2	12.8
	167	90-140	1.40	39.0	33.4	31.7	28.7	26.1	21.9	C	17.1	23.9	12.0
H 148	149	0- 50	1.23	39.5	30.5	28.2	22.9	20.8	19.9	C	19.6	24.1	12.1
Sc 111	152	50- 90	1.38	37.9	31.2	29.2	25.2	23.3	19.9	C	18.0	24.8	9.9
	155	90-140	1.47	35.6	31.8	30.5	28.3	25.0	21.8	C	13.8	20.3	10.2
	158	140-200	1.23	41.7	30.9	28.8	24.9	22.6	19.7	C	22.0	27.1	16.3

2.5 Chemical Characteristics of the Soil

Salinity

Electrical conductivity determinations were carried out on approximately half of the routine sites and on most samples from the reconnaissance survey. The results were expressed as electrical conductivities of the saturation extract in mmhos/cm at 25°C.

There is a general increase in salt content with depth. This applies in particular to the Udorthentic Chromusterts and the low-lying Pellusterts. However, the general salinity status of the soil does not limit the choice of crops, except in parts of the Balad area. Having regard to the hydraulic conductivities leaching will be possible under controlled irrigation, but there may be a gradual salt increase in the soils of the flood scheme as only one watering will be given and leaching will be minimal.

Soils in the Upper Shebelli area show very high EC's throughout the profile.

Soil salinity varies widely over short distances. The majority of inspected and analysed sites have no saline surface horizons and conductivities only rarely exceed the critical value of 4 mmhos/cm.

Leaching

Where excessive amounts of salt interfere with the growth of crops, the salinity in the rooting zone has to be reduced to acceptable levels by leaching. As already stated high salt concentrations do not occur in the topsoil, but it is essential to avoid a salinity build up in the underlying horizons.

Leaching at present is not necessary but if leaching is required in the future, the leaching requirements can be calculated. The depth of water that must be leached through and below the rooting zone to control the salinity levels for specific crops has been described by the U.S. Salinity Laboratory staff (1954). The leaching requirement is calculated by:

$$LR = \frac{D_{dw}}{D_{iw}} = \frac{EC_{iw}}{EC_{dw}}$$

where the leaching requirement (LR) is expressed as the ratio of the EC of the applied irrigation water to the EC of the drainage water (EC_{iw}) and it is equal to the ratio of the corresponding depth of drainage $\frac{(EC_{iw})}{(EC_{dw})}$ water to that of the irrigation water $\frac{(D_{dw})}{D_{iw}}$. Since values of EC_{dw} cannot be determined it is necessary to substitute another value for this expression in the formula (Allison, 1964). Satisfactory yields are obtained if the salinity (EC_{dw}) at the base of the root zone is the same as the value of the salinity throughout the root zone at which a yield reduction of fifty per cent is experienced. Because the salinity at the base of the root zone is approximately twice that in the zone above it, in which the roots grow, the resulting yield becomes about eighty per cent of the optimum obtainable in salt free soil under good conditions of irrigation and crop management, e. g. the EC's in the root zone for a fifty per cent reduction in yield of sorghum is given as 12 mmhos/cm (Bernstein 1964). If the EC_{iw} is 1.0 mmho/cm, the LR is then 1/12 = 0.08 or 8 per cent, and in these circumstances there would be no salt accumulation and approximately 80 per cent of optimum yields would be obtained.

It is probable that under controlled irrigation conditions such an LR will be met by normal irrigation losses. Higher LR's will be required for the less salt tolerant crops such as cotton, rice and groundnuts.

Drainage

The present water table is deep, probably at 15 metres and more and it is doubtful if the water table will rise under irrigation provided proper management if practised. It is believed that the LR which will be added to the water table will be removed by natural drainage.

It is essential that the Afgoi Experimental Station makes and monitors a survey of the water table in the farm because this forms one of the most important parts of drainage investigations. The principal reasons for a rise in water table would be seepage and leaks from canals and farm laterals and excess of irrigation applications.

In some parts of the Johar sugar estate and in some parts of the Genale concessions a high water table has developed with associated salinity problems. The high water table (80 cm) occurs near the main canals and near basins where water is stored. Lateral movement from these sources is probably the main cause of the high water table, because it does not occur in other parts of the schemes which have also been irrigated for over 40 years.

Field drainage experiments at Johar started in 1958, but were discontinued and no information could be obtained during the present survey.

It can be stated that there are no drainage problems at present in the project areas.

Total Carbonate and Gypsum

The distribution of visible calcium carbonate and gypsum has been described in section 2.3(e). The values obtained from the analyses show that the total carbonate remains rather constant throughout the profile and that little variation occurs within the different strata. A comparison between the soil series of the distribution of carbonate down the profile did not reveal any significant trends. The values of individual strata range from 6 to 31 per cent with the largest number occurring between 15 and 25 per cent.

Gypsum contents vary between nil and 35 per cent, with the highest values occurring in the soils of the Upper Shebelli and on the older alluvium. There is a general trend for the values to increase down the profile although some profiles show constant levels below the top horizon.

pH Paste

The pH ranges between 7.3 and 8.2 with the majority of values between 7.5 and 8.0 and does not show a simple relationship with exchangeable sodium percentage. The values are affected by the presence

of gypsum and other soluble salts. The pH of soil with a considerable amount of gypsum seldom exceeds 8.0 regardless of the ESP (See pit H 445).

Nitrogen

Only the surface horizons of series pits were analysed for nitrogen. The values obtained are low and range between 0.04 to 0.11 per cent.

Organic Carbon

Only the surface horizons of series were analysed for organic carbon. The values are low and range from 0.35 to 1.06 per cent.

Available Phosphorus

Available phosphorus was determined on the topsoil samples of all series profiles.

In most cases the soils were low or marginal in their available phosphorus reserves and response to phosphatic fertilisers is expected.

The ranges used for interpretation purposes were:

P in ppm	
Less than 5	Response to fertiliser very likely.
5 to 10	Response probable.
Greater than 10	Response unlikely.

General Fertility

The soils are low in nitrogen and phosphorus and crops should respond to fertiliser applications. It is unlikely that potassium will be a limiting factor unless large quantities of phosphorus fertilisers are applied.

Selected soil analyses are given with type sizes descriptions in Appendix XVI of Volume IV / V A.

2.6 Soil Classification

(a) Classification

The soil classification is based on the 'Soil Classification, A Comprehensive System, 7th Approximation', U.S. Department of Agriculture 1960 and the supplements to this classification of June 1964 and March 1967 (Table 2.3).

The classification used deviates from the one used by the International Co-operation Administration (1961) and Lockwood Survey Co-operation Limited (1968). However, all soils described and mapped are accommodated in the new classification wherever possible. The classification should be regarded as tentative until more is known about the soils. This refers especially to the soils in the reconnaissance area.

Entisols and Vertisols were found in the project areas between Avai and Gialalassi. The Aridisols were dominant in the Gialalassi-Belet Uen reach, although Entisols and Vertisols do occur. The soils of the areas for future development and their classification are discussed in Chapter 4.

(b) Description of the Soil Mapping Units

(i) Channel Remnant

ENTISOLS

Typic Usthorthents (C)

These soils occur as narrow, relatively high-lying ridges or as isolated patches scattered throughout the two project areas and they are intermixed with the Vertisols. The soils are situated on former levees. Most of the levee soils are eroded and are not discernible on the aerial photographs. Most of these soils intergrade into the Vertisols, but it was not possible to separate then and they are therefore mapped with the latter, as they have more of the diagnostic properties of the Vertisols than of the Entisols.

The levee soils are all mapped as an Entisol complex or in an Entisol/Vertisol complex due to their wide variation in properties over a short distance, but each individual site has a notation showing its soil series separately. In the case of single observations which are not mappable, they are left as impurities in the relevant Vertisol series.

These soils were provisionally mapped as Brown-Sub-Arid soils by Lockwood (1968).

The substrata in alluvial plains are considered of importance and three groups are introduced on the basis of texture:

a. Coarse/medium textures throughout the profile down to 1.5 m.

b. Coarse/medium textures overlying fine texture down to 1.5 m.

c. Coarse/medium textures overlying stratifications down to 1.5 m.

The soil series were separated on an Electrical Conductivity of less than or more than 4 mmhos/cm in the top 50 cm.

C 111 A coarse/medium textured Typic Ustorthent with EC's of less than 4 mmhos/cm. They are generally non-saline and non-alkali in the top 100 cm. A medium or high salt hazard is present in some profiles. There is no sodium hazard, except for pit H 24, which has a medium sodium hazard between 95 and 165 cm. For series analyses see pit H 24.

C 121 A coarse/medium textured Typic Ustorthent (overlying fine texture) with EC's of less than 4 mmhos/cm. Generally they are non-saline and non-alkali in the top 100 cm, but a medium or high salt hazard is present in some profiles.

The depth of fine textured substrata varies greatly. The criteria used in this classification is when the layer occurs within 1.5 m. There appears to be no sodium hazard in any profile. For series analyses see pit No. H 91.

C 131 A coarse/medium textured Typic Ustorthent overlying stratifications with EC's of less than 4 mmhos/cm. They are generally non-saline and non-alkali in the top 50 cm, but they may have a medium or high salt hazard. The depth where the stratifications are situated varies greatly within the fixed depth of 1.5 m. It appears that the fine textured layers show an increase in total salts and that they are a limiting factor for water movement. For series analyses see pit No. H 61.

Most of the levee soils are provisionally placed in irrigation land use classes 3 & 4. However, pockets of Class 6 may be present. The evidence is that leaching will occur under irrigation.

The levee soils in the Afgoi-Mordile area are classified differently from those in the Balad flood scheme. Apart from the fact that the Ustorthents in the latter are probably not commandable, their moisture retention capacities will not be sufficient to produce a good crop under a one flood irrigation system. In local practice none of the coarser textured soils are used for cultivation.

The rooting depth of the natural vegetation on these soils is comparatively shallow compared with the Vertisols. The general rooting depth is down to 80 cm but roots occasionally go down to 190 cm. The stratifications do not seem to be an obstacle to root development, except where a very coarse textured layer over 25 cm thick occurs.

(ii) Floodplain Meander

VERTISOLS

Chromustert (recent alluvial)

These soils occur in both areas and are mapped either in a unit or complex, or occur as impurities in other units. Approximately three-quarters of the area belong to this mapping unit, intermixed with the levee soils.

It was considered important to have a subdivision, based on colour, (7.5 YR and 10 YR) in the Udic Chromustert subgroup. The 7.5 YR hue soils are thought to be developed on more recent alluvium than the 10 YR soils; they are better structured and have a better developed friable, granular mulch compared with the latter.

Soil series are separated on EC's of less and more than 4 mmhos/cm in the top soil.

For further information on the salinity status in the profile it is necessary to consult the land classification map.

Classes have been used to differentiate different textural profiles and each mapping unit is divided into three groups, based on their substrata.

Udic Chromustert: Hue 10YR

Gl 1a11 Medium to fine textured Udic Chromusterts overlying coarse/medium textured alluvium. EC's less than 4 mmhos/cm. The depth of the different substrata varies, but it normally lies between 50 cm and 100 cm.

These soils occur only in complex mapping units and as impurities near old river levees. It was not possible to distinguish these soils on the aerial photographs or in the field on a topographical basis.

They are mainly non-saline and non-alkali throughout the profile.

Root distribution in clay loams or clays which overlie coarser textured horizons depends on the depth of the fine textured surface horizon. In coarse textured surface horizons the root distribution is concentrated in the top 20 cm. These soils are suitable for all adapted crops and some are used under rainfed cultivation. The depth of the fine textured material may be a limitation in the flood scheme. For series analyses see pit No. H 19.

Gl 1a21 Medium or fine textured Udic Chromusterts overlying fine textured subsoil with EC's less than 4 mmhos/cm.

These soils occur both on water shedding and receiving sites in the southern part of the Afgoi-Mordile area and south of the old river channels in the Balad scheme. They are mapped separately and in complexes, especially in the flood scheme.

They are non-saline to medium saline (EC's of 4-8 mmhos/cm) throughout the profile, but no sodium hazard is present. Structure, surface mulch, gilgai and sink holes are less well developed than in Unit Gl 1b21. Gilgai and sink holes are often absent. The natural rooting depth is approximately 1.3 m but may extend down to 2.0 m. These soils are generally classed as 2 and 3 lands and are at present partly used under rainfed cultivation. For series analyses see pit No. H 31 and H 268.

Gl 1a31 A medium/fine textured Udic Chromustert: overlying stratifications with EC's less than 4 mmhos/cm.

This soil occurs in general as an impurity in other units or in complexes. It is an intergrade between Vertisols and Entisols, and is closer in characteristics to the Vertisols.

The soils are in general non-saline to medium saline to below 50 cm, but a high salinity hazard may occur. No sodium hazard has been recognised. The stratifications may be a limitation to root development and water movement. These soils are in general classified as 2 and 3 lands. They are at present partly used under rainfed cultivation.

For series analyses see pit No. H 22 and H 251.

Udic Chromustert: Hue 7.5YR

Gl 1b11 A medium to fine textured Udic Chromustert overlying coarse/medium textures with EC's less than 4 mmhos/cm. The depth at which the generally moderately coarse texture occurs is between 70 and 110 cm.

This series is mapped in the Afgoi-Mordile area although the boundaries are not accurately defined and are therefore shown as a dotted line on the soil maps. They occur also as impurities and in complexes. They are normally found close to old river levees.

The salinity status varies considerably. The top 50 cm is non-saline and non-alkali but below this depth a medium salt hazard may occur. One site exhibited a very large EC, but this was an exception. No sodium hazard is recognised. Root development is good, but is limited to the fine textured surface horizon when it overlies sands and loamy sands.

These soils are classified as 1 and 2 lands and are very suitable for controlled irrigation provided the coarse substrate material is not too near the surface. This will also be a limitation in the flood scheme. They are little used under rainfed cultivation.

Samples from two pits of this series were analysed, - H 251 and H 347 is an intergrade between series Gl 1b11 and Gl 1b31.

Gl 1b21 A porous medium to fine textured Udic Chromustert overlying fine textured subsoils with EC's less than 4 mmhos/cm. The clay and silt content varies considerably not only in the profile, but also between locations.

This series is mapped and covers a large area in the Afgoi-Mordile area, and it also covers a small strip behind the present levees of the Shebelli River in the Balad area. It occurs also in a complex in the latter area.

The soils are non-saline down to 100 cm and may have a medium and/or occasionally a high salt hazard below this depth. High ESP's do not occur and there is no sodium hazard. Structure and the surface mulch are better developed than the Gl 1a21 soils. Sink holes are very common throughout this mapping unit. Mottles occur in the profile, but it is believed that they are not due to presently active pedogenic processes.

The soils are classified as 1, 2 and 3 lands in the Afgoi-Mordile area and as class 1 and 2 lands in the Flood Scheme. They are intensively used under rainfed cultivation and they are highly suitable for irrigation. For series analyses see pits H 255, H 270, H 26 and H 98.

Several pits were selected for series analyses as this soil covers most of the area between Balad and Coriolei and it is considered to be the most suitable soil for irrigation. The analyses show that the soils of this unit in the Afgoi-Mordile area contain considerably more gypsum than those of the Balad area.

Gl 1b31 A medium to fine textured Udic Chromustert overlying stratified alluvium with EC's less than 4 mmhos/cm.

The depth of the surface layer over the stratifications varies between 40 and 90 cm.

These soils occur mainly as impurities in other mapping units and in a complex. A very small number of Gl 1b31 are recognised during the survey.

A medium salt hazard may occur below 50 cm. The stratifications may be a limitation to root development and water movement.

Gl 1b31 soils are classified as dry 2 and 3 lands depending on soil depth and salinity. They are very suitable for irrigated crops.

Pit H 347 is situated in the Afgoi Experimental Station. For series see pit H 347 and pit H 29. The former, as already mentioned, is an intergrade between Gl 1b11 and Gl 1b31. These soils are little used under rainfed cultivation.

Udorthentic Chromustert

Gl 211 A medium to fine textured Udorthentic Chromustert overlying coarse and moderately coarse textures with EC's less than 4 mmhos/cm.

These soils are only very occasionally found near old eroded levees and therefore they are not mapped and occur as impurities in other mapping units. No series analyses were made. They appear to be non-saline throughout the profile and no sodium hazard has been recognised. The shallow topsoil of between 40 cm and 100 cm may be a limitation in the flood scheme. They are not used at present under rainfed cultivation.

Gl 221 A medium to fine textured Udorthentic Chromustert overlying fine textures with EC's less than 4 mmhos/cm. Textures and the salinity status varies from site to site.

These soils occur as mapping units in the Afgoi-Mordile area and in a complex in the Balad area. Their salinity values in the profile varies from low to medium. No sodium hazard has been found. Rooting depth is generally limited to 100 cm although roots may occasionally go down to 150 cm. The soils on the higher grounds have a semi-hard to hard surface crust and do not have well developed cracks, while other soils in this series possess a moderately well developed surface mulch. Only the soils with a surface mulch are used under rainfed cultivation. They seem to be less saline. In one site only there was a moderate salt hazard in the surface horizon.

Gl 221 soils are generally classified as classes 2 and 3 lands. For series analyses see pit H 25.

Pellusterts

Udorthentic Pellustert

Gl 311 A medium to fine textured Udorthentic Pellustert overlying fine textures with EC's less than 4 mmhos/cm. These soils are not mapped as they only occur as isolated patches in depressions in the Afgoi-Mordile area.

They are heavy clays, are non porous and impermeable and are medium to highly saline below 45 cm. They may have a medium sodium hazard below 90 cm. Root development is restricted. They are classified as 4 and 6 lands.

The local population do not cultivate these soils. For series analyses see pit H 27 and H 60.

Chromusert (old alluvial)

These soils only occur north of the old river channel in the Balad area. They have been developed in the old alluvial deposits and occupy a large proportion of the northern part of the area. They are found both in water receiving and shedding sites, and a sub division can be made at subgroup level.

Udic Chromustert

The Udic Chromusterts are situated on the shedding sites. They occur separately in mapping units and in a complex.

Sr 111 A medium fine textured Udic Chromerstert overlying fine texture with EC's less than 4 mmhos/cm. The sub-soil usually has low to medium salt hazards, but high salinities may be present.

These soils occur expecially in the most northern part of the area and if they are commandable they are suitable or marginally suitable for irrigation. Most soils are classified as 2 and 3 lands. There is a medium salt hazard only in a few profiles. Small areas are at present under rainfed cultivation. Three observation sites have a medium salt hazard in the top 50 cm, but these sites were mapped as impurities. The surface consists of a hard crust or of a moderately well-developed surface mulch. For series analyses see pit No. H 186.

Udorthentic Chromustert

Sr 211 A medium to fine textured Udorthentic Chromustert overlying fine texture with EC's less than 4 mmhos/cm. They occur as a mapping unit north of the old river channel along the western boundary and in the northern part of the Balad area. They have higher EC's down the profile than the Udic Chromustert and they may have a medium to high salt hazard below 50 cm.

and especially below 100 cm. Medium sodium hazards may occur below 50 cm. Root development is, as in the Udic Chromustert, restricted to approximately 100 cm, but occasionally roots may go down to 150 cm. These soils are classified as 2, 3 and 4 lands. The surface has a moderately well-developed mulch. Sink holes and poorly developed gilgai forms are common. Only small areas are under rainfed cultivation, except north west of Galole near the flood canal. For series analysis see pits H 183 and H 195.

(iii) Floodplain Slackwater

VERTISOLS

Pellustert

These soils are developed in former river basins and occur mainly between the old river course and Gululei in the Balad area. They are only found in depressional sites and are mapped separately and also in complexes.

Udorthentic Pellustert

Sc 111 A medium to fine textured Udorthentic Pellustert overlying fine texture with EC's less than 4 mmhos/cm. The substrata however, may consist of medium textured soils. The area mapped covers a large depression in the centre of the northern part in the Balad area and a small area in the southern part. It also occurs in a complex with Sr 111 and Sr 211. The latter area is very uneven; the higher parts are occupied by the Udic Udorthentic Chromusterts and the receiving sites by the Udorthentic Pellusterts. The Pellusterts are intensively cultivated by the local population, who water the area by means of a flood canal. The soils are classified as classes 2 and 3. A medium salt hazard may occur below 50 cm. No sodium hazard is recognised. The surface has a moderately well-developed mulch.

For series analyses see pit H 148

TABLE 2.3 Soil Classification (based on Soil Classification, A Comprehensive System, 7th Approximation)

FLOOD PLAIN MEANDER

VERTISOLS

G1 CHROMUSTERT (Recent alluvial)

G1 1a Udic Chromustert: hue 10YR

G1 1a1	-	Medium/fine textures overlying coarse/medium textures down to 1.5 m.	
		G1 1a11	EC < 4 mmhos/cm.
G1 1a2	-	Medium/fine textures overlying fine texture down to 1.5 m.	
		G1 1a21	EC < 4 mmhos/cm.
		G1 1a22	EC > 4 mmhos/cm.
G1 1a3	-	Medium/fine textures overlying stratifications	
		G1 1a31	EC < 4 mmhos/cm.

G1 1b Udic Chromustert: hue 7.5YR

Gi 1b1	-	Medium/fine textures overlying coarse/medium textures down to 1.5 m.	
		G1 1b11	EC < 4 mmhos/cm.
G1 1b2	-	Medium/fine textures overlying fine texture down to 1.5 cm.	
		G1 1b21	EC < 4 mmhos/cm.
G1 1b3	-	Medium/fine textures overlying stratifications	
		G1 1b31	EC< 4 mmhos/cm.

Gl 2 Udorthentic Chromustert

Gl 21 - Medium/fine textures overlying coarse/medium textures down to 1.5 m.

Gl 211 EC < 4 mmhos/cm.

Gl 22 - Medium/fine textures over fine texture down to 1.5 m.

Gl 221 EC < 4 mmhos/cm.

Gl PELLUSTERT

Gl 3 Udorthentic Pellustert

Gl 31 - Medium/fine textures overlying fine texture down to 1.5 m.

Gl 311 EC < 4 mmhos/cm.

CHROMUSTERT (Old alluvial)

Sr 1 Udic Chromustert

Sr 11 - Medium/fine textures overlying fine texture down to 1.5 m.

Sr 111 EC < 4 mmhos/cm.

Sr 112 EC > 4 mmhos/cm.

Sr 2 Udorthentic Chromustert

Sr 21 - Medium/fine textures overlying fine texture down to 1.5 m.

Sr 211 EC < 4 mmhos/cm.

Sr 212 EC > 4 mmhos/cm.

FLOOD PLAIN SLACKWATER

VERTISOLS

Sc PELLUSTERT

Udorthentic Pellustert

Sc 11 - Medium/fine textures overlying fine texture down to 1.5 m.

Sc 111 EC < 4 mmhos/cm.

FLOOD PLAIN CHANNEL REMNANT

ENTISOLS

C USTORTHENT mapped as complex (Idamoun)

C1 Typic Ustorthent

C11 - Coarse/medium textures throughout the profile down to 1.5 m.

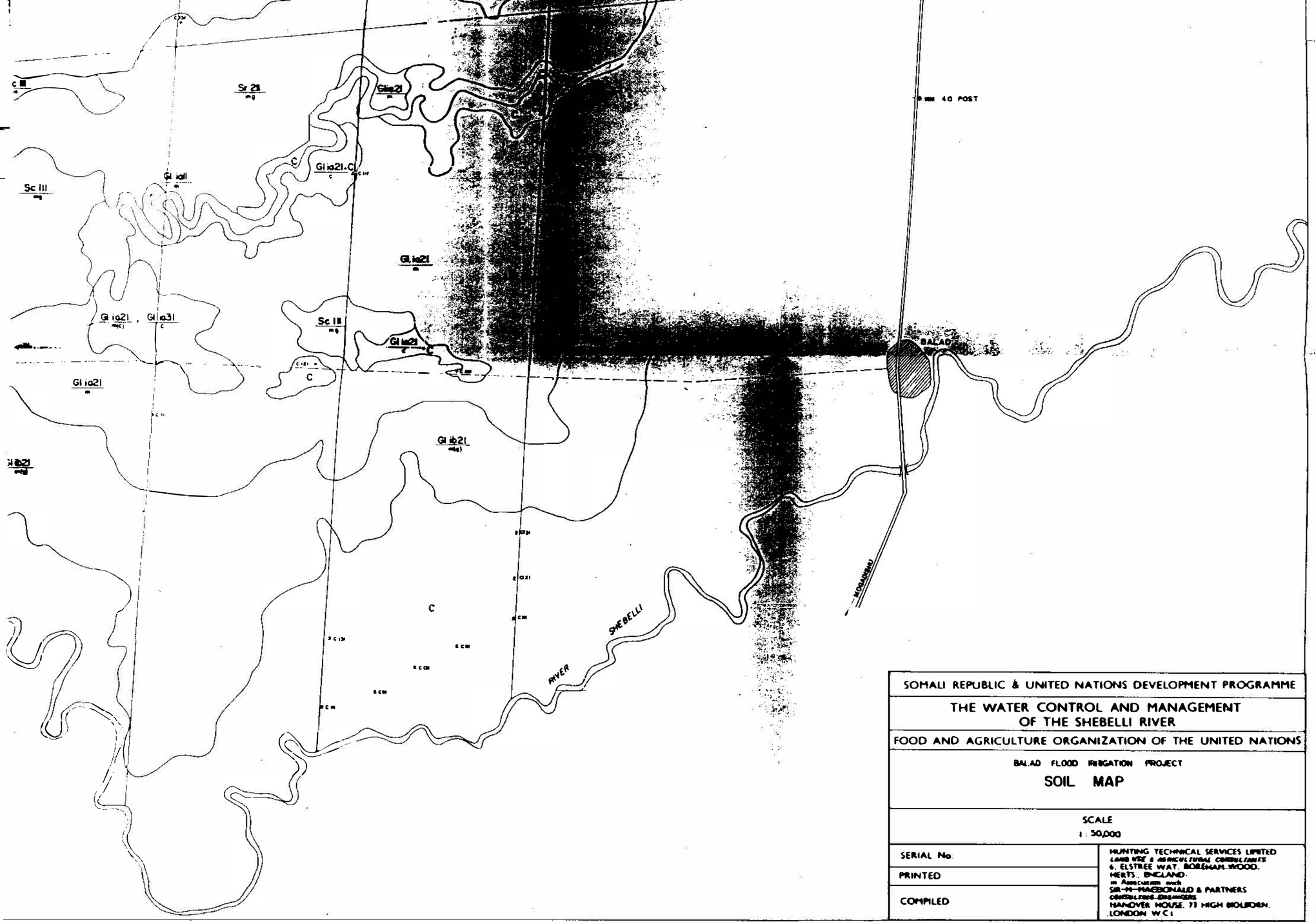
C111 EC < 4 mmhos/cm.

C12 - Coarse/medium textures overlying fine texture down to 1.5 m.

C121 EC < 4 mmhos/cm.

C13 - Coarse/medium textures overlying stratifications down to 1.5 m.

C131 EC < 4 mmhos/cm.



SOMALI REPUBLIC & UNITED NATIONS DEVELOPMENT PROGRAMME

THE WATER CONTROL AND MANAGEMENT OF THE SHEBELLI RIVER

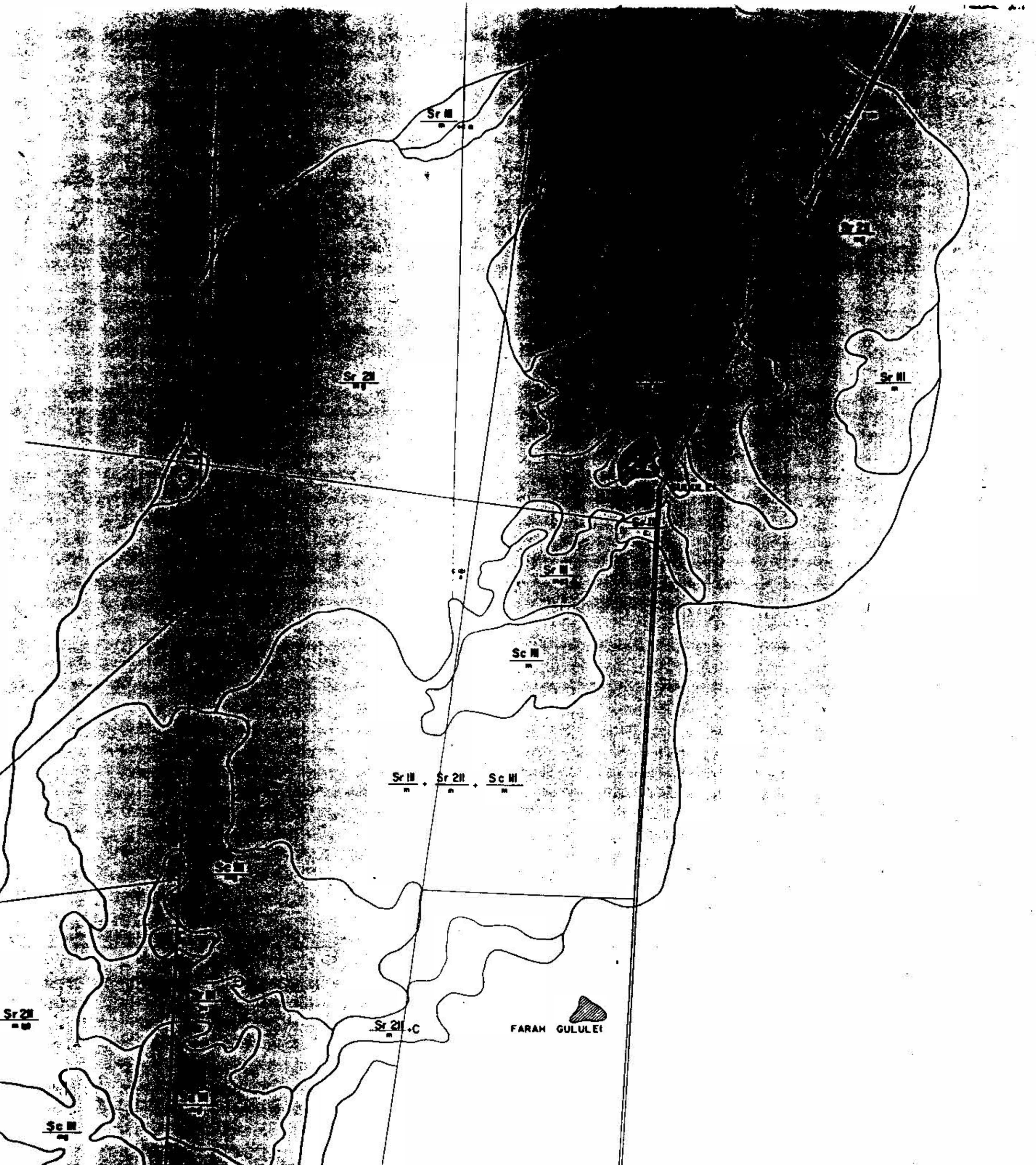
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

BALAD FLOOD IRRIGATION PROJECT

SOIL MAP

SCALE
1 : 50,000

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COMPILED	


Sr III
Sr III
Sr III
Sr III + Sr II + Sc III
Sr II
Sr II +C
FARAH GULULEI
Sc III

SOIL LEGEND

(Soil classification based on "Soil classification system - 7th Approximation)
(1960 and supplement 1967)

FLOODPLAIN MEANDER

VERTISOLS

Recent alluvium (Gilbert)

UDIC CHROMUSTERT; HUE 10 YR

Gl a 11 — Non-saline medium/fine textures overlying course/medium textures

Gl a 21 — Non-saline medium/fine textures overlying fine texture

Gl a 31 — Non-saline medium/fine textures overlying stratifications

UDIC CHROMUSTERT; HUE 7.5 YR

Gl b 11 — Non-saline medium/fine textures overlying course/medium textures

Gl b 21 — Non-saline medium/fine textures overlying fine texture

Gl b 31 — Non-saline medium/fine textures overlying stratifications

UDORTHENTIC CHROMUSTERT

Gl 2c — Non-saline medium/fine textures overlying fine texture

UDORTHENTIC PELLUSTERT

Gl 31 — Non-saline medium/fine textures overlying fine texture

Old alluvium (Sarvida)

UDIC CHROMUSTERT

Sr 111 — Non-saline medium/fine textures overlying fine texture

UDORTHENTIC CHROMUSTERT

Sr 21 — Non-saline medium/fine textures overlying fine texture

FLOODPLAIN SLACKWATER

VERTISOLS

UDORTHENTIC PELLUSTERT

SC 111 — Non-saline medium/fine textures overlying fine texture

FLOODPLAIN CHANNEL REMNANT (Levee Soils)

ENTISOLS C mapped as complex (Idamun)

TYPIC USTORTHENT

C 111 — Non-saline coarse/medium textures throughout the profile

C 121 — Non-saline course/medium textures overlying fine texture

C 131 — Non-saline course/medium textures soils overlying stratificotions

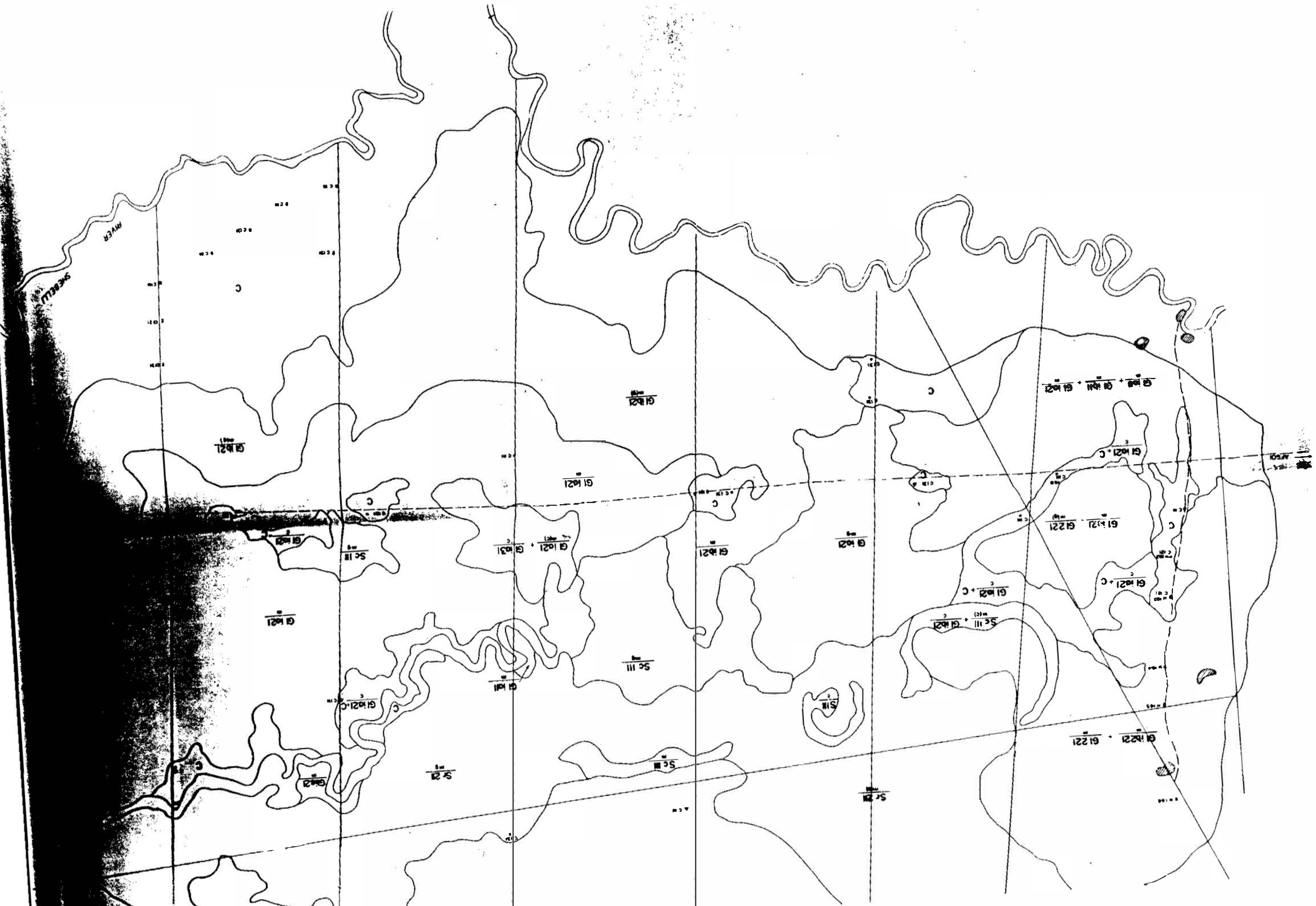
Soil phases
- m mulch
- c crust or massive surface
- g gilgai formation

LEGEND

- Soil Boundary
- Uncertain Boundary
- Surfaced Road
- Track
- Trace Lines

LOCATION OF SAMPLE SITES
- H123 2 metre sample site
- H124 2 metre observation site
- H125 2 metre sample site





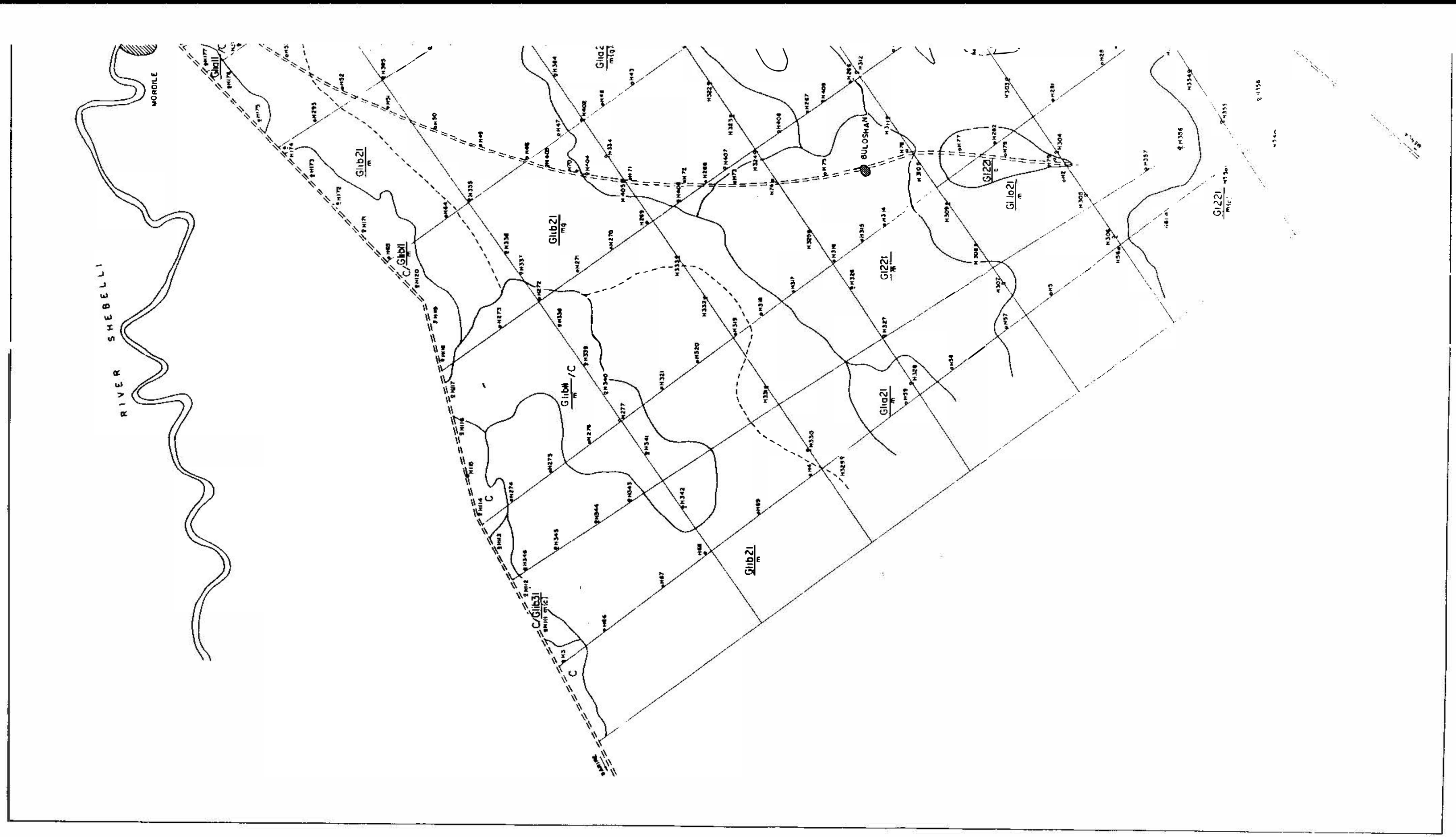
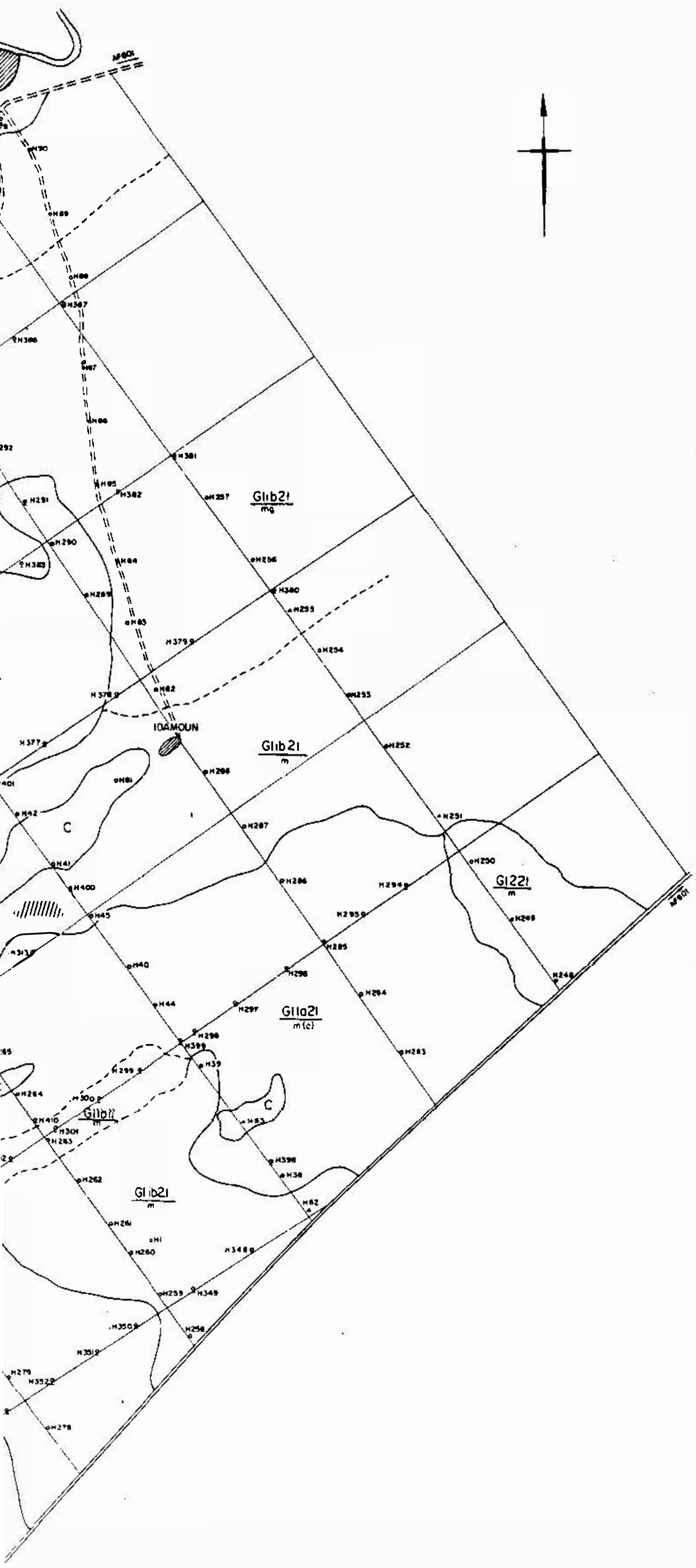

RIVER SHEBELI
MORDILE
BULOSHAN
C/Gilll/C
Gllb21/m
Gllb21/mg
C/Gllb1/m
Gllb1/m/C
Glla2/mg
Gll22/m
Gll2l/m
Gllb21/m
Gll2l/mg
Gllb21/m
C/Gllb31/mg
Gll2l/mg

Figure 2·2



SOIL LEGEND

(Soil classification based on Soil classification system 7th Approximation 1960 and supplement 1967)

FLOODPLAIN MEANDER

VERTISOLS

Recent alluvium (Golwein)

UDIC CHROMUSTERT; HUE 10 YR

Gl_{1a11} Non-saline medium/fine textures overlying coarse/medium textures

Gl_{1a21} Non-saline medium/fine textures overlying fine texture

Gl_{1a31} Non-saline medium/fine textures overlying stratifications

UDIC CHROMUSTERT; HUE 7 5 YR

Gl_{1b11} Non-saline medium/fine textures overlying coarse/medium textures

Gl_{1b21} Non-saline medium/fine textures overlying fine texture

Gl_{1b31} Non-saline medium/fine textures overlying stratifications

UDORTHENTIC CHROMUSTERT

Gl_{221} Non-saline medium/fine textures overlying fine texture

UDORTHENTIC PELLUSTERT

Gl_{311} Non-saline medium/fine textures overlying fine texture

Old alluvium (Saruda)

UDIC CHROMUSTERT

Sr_{1II} Non-saline medium/fine textures overlying fine texture

UDORTHENTIC CHROMUSTERT

Sr_{2II} Non-saline medium/fine textures overlying fine texture

FLOODPLAIN SLACKWATER

VERTISOLS

UDORTHENTIC PELLUSTERT

Sc_{1II} Non-saline medium/fine textures overlying fine texture

FLOODPLAIN CHANNEL REMNANT (Levee Soils)

ENTISOLS C mapped as complex (Idamun)

TYPIC USTORTHENT

C_{1II} Non-saline coarse/medium textures throughout the profile

C_{121} Non-saline coarse/medium textures overlying fine texture

C_{131} Non-saline coarse/medium textures soils overlying stratifications

Soil phases
- m mulch
- c crust or massive surface
- g gilgai formation

LEGEND

- Soil Boundary
- Uncertain Boundary
- Surfaced Road
- Track
- Track Lines

LOCATION OF SAMPLE SITES
- H123 2 metre sample site
- H124 2 metre observation site
- H125 2 metre sample site

SOMALI REPUBLIC & UNITED NATIONS DEVELOPMENT PROGRAMME

THE WATER CONTROL AND MANAGEMENT OF THE SHEBELLI RIVER

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

AFGO1 — MORDILE

SOIL MAP

SCALE 1 40,000

SERIAL No

PRINTED NOVEMBER 1963

COMPILED HUNTING TECHNICAL SERVICES LTD

HUNTING TECHNICAL SERVICES LIMITED
LAND USE & AGRICULTURAL CONSULTANTS
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LONDON W.C.1

CHAPTER 3

LAND CAPABILITY CLASSIFICATION

3.1 Specifications

The purpose of the survey was to produce a soil map and land capability map of the two project areas, Afgoi and Balad. Areas for future development along the Shebelli River have also been investigated. As the latter was only a reconnaissance survey, no detailed capability maps were prepared. The areas recommended for future development require detailed soil surveys to establish their full potential.

The specifications are based on the U.S. Bureau of Reclamation Standards, which are modified, where necessary, to suit the local conditions. Very little is known about the behaviour of irrigated soils in the Somali Republic and therefore the present criteria used may well be modified if and when more research data becomes available. It is of the utmost importance that the Afgoi Experimental Farm, or a Pilot Scheme in conjunction with the existing irrigation schemes, establishes a research programme on the behaviour of the Shebelli Soils under continuous and flood irrigation, for it may be found that the present class 3 land can be upgraded. Some class 4 land may also be upgraded. On the other hand the soils may be found to behave less well under field conditions than has been supposed in this report.

The main difference between the U.S. Bureau of Reclamation criteria and those used in the classification of the two project areas lies in the economic aspects. It is at present not possible to include all the economic factors in the land capability classification.

Two different land capability classifications for irrigated soils are prepared:

1) Controlled irrigation (Table 3.1)
2) Flood irrigation (Table 3.2)

In accord with local experience it is believed that the flood schemes require a slightly different classification criteria than to the controlled irrigation schemes. Textural considerations are given more weight in the flood scheme classification as the area will be irrigated only once a year.

3.2 Land Class Standards

The following is an outline of the definitions for each class and sub-class and a discussion of the criteria used in class limitations.

Class	Sub-Class	Soil Description
1 - ARABLE Soils with few or no limitations, highly suitable for irrigation.	-	A non-saline/non-alkali, sandy loam to friable clay soil. Well drained and well structured. Electrical conductivity and Exchangeable Sodium Percentage (ESP) limits are less than 4 mmhos/cm and less than 15 respectively, down to 150 cm. No limitations to root development; effective rooting depth is 100 cm. Little gilgai formation. It is expected that these lands have a relatively high repayment capacity.
2 - ARABLE Moderately suitable for irrigation. Soils with few limitations which reduce the choice of crops.		A well to moderately drained and well to moderately structured loamy sand to permeable clay. EC's less than 4 mmhos/cm in the top 100 cm and 4-8 mmhos/cm between 100 and 150 cm. ESP less than 15 down to 150 cm. Effective rooting depth at least 60 cm. Root development a little restricted. Moderate gilgai formation is accepted. These lands may have an intermediate repayment capacity.

Sub-Class	Soil Description
2 p	Meets all requirements of Class 1 except that water movement and root development are slightly impeded.
2 d	Meets all requirements of Class 1, with the exception of the effective rooting depth, which is between 60 and 100 cm.
2 g	Meets all requirements of Class 1, but the gilgai formation is moderately well developed.
2 s	Meets all requirements of Class 1, but has an EC of 4-8 mmhos/cm between 100 and 150 cm.
2 ps	Downgraded from Class 1 due to limitations in profile characteristics and an EC of 4-8 mmhos/cm between 100 and 150 cm.
2 sg	Downgraded from Class 1 due to moderate gilgai formation and salinity; EC of 4-8 mmhos/cm between 100 and 150 cm.
2 psg	Downgraded from Class 1 due to limitations in profile characteristics, salinity and micro-topography (gilgai).

Class	
3 - ARABLE Moderately to marginally suitable for irrigation. Soils with moderate limitation that reduce the choice of crops.	A moderately drained and moderately structured loamy sand to clay soil. EC's 4-8 mmhos/cm in top 50 cm and less than 8 mmhos/cm between 50 and 150 cm. ESP levels are less than 15

Sub-Class	Soil Description
	throughout the profile. Effective rooting depth is 60 cm and root development may be restricted. Moderate gilgai formation is permitted. These lands may have adequate repayment capacity under proper management.
3 s	Meets all requirements of Class 1, except for the higher EC levels, 4-8 mmhos/cm top 50 cm and less than 8 mmhos/cm between 50 and 150 cm.
3 ds	This soil has a minimum rooting depth of 60 cm. The salinity levels are 4-8 mmhos/cm in the top 50 cm and less than 8 mmhos/cm between 50 and 150 cm.
3 dp	This soil has a minimum rooting depth of 60 cm and has limitations in profile characteristics.
3 ps	This soil has limitations in profile characteristics and has EC's of 4-8 mmhos/cm in the top 50 cm and less than 8 mmhos/cm between 50 and 150 cm.
3 dps	This soil has limitations in profile characteristics and rooting depth and has EC's of less than 8 mmhos/cm between 50 and 150 cm.

Class	Sub-Class	Soil Description
	3 psg	This soil has limitations in profile characteristics, salinity and micro-relief which is moderately well developed.
4 - LIMITED ARABLE Soils with severe limitations which reduce the choice of crops.		A moderately to poorly drained and moderately to poorly structured loamy sand to clay. EC's mmhos/cm 8-12 in top 100 cm. ESP levels are 15-25 in the top 50 cm and less than 25 between 50 and 100 cm. Effective rooting depth is 50 cm. Root development moderately to severely restricted. Severe gilgai formation. These lands may have adequate repayment capacity if special studies have been carried out.
	4 a	ESP between 15 and 25 or less in top 50 cm and less than 25 between 50 and 100 cm.
	4 ps	This soil has limitations in profile characteristics and has EC levels of 8-12 mmhos/cm down to 100 cm.
	4 pas	This soil has limitations in profile characteristics; alkalinity and salinity as described above.
	4 dps	This soil has limitations in rooting depth, profile characteristics and salinity as described above.
	4 dpas	This soil has limitations in rooting depth, profile characteristics, alkalinity and salinity.

Class	Sub-Class	Soil Description
6 - NON-ARABLE Soils with severe limitations and at present unsuitable for irrigation. Could be used for pastures.		These soils are considered at present non-arable.
	6 pas	This soil has restrictions in profile characteristics, has limitations in alkalinity and salinity.
	6 t	This soil has topographical limitations.

(i) Criteria

a) Soil Rooting Depth (d)

The limiting layer is in general coarse textured, although occasionally a clay layer might be a limiting factor. The thickness of the layers varies between 1 cm to more than 50 cm. It was found that root development is restricted to the top 20 cm in coarse textured materials. If the thickness of the stratifications is less than 20 cm, there will be no restricted root development and the roots will go through the different textural layers. However, in some instances fine textured layers could form an impermeable barrier to roots. Class 2 in the flood scheme requires a slightly greater soil rooting depth than Class 2 in a controlled irrigation scheme.

b) Salinity, EC mmhos/cm (s)

The salinity levels of classes 1 and 2 for the top 100 cm is restricted to 4 mmhos. The subsoil of class 2 has EC's between 4-8 mmhos/cm and class 3 requires EC's of less than

8 throughout the profile. Class 4 has high EC levels, but the limits could be changed if more research data became available, especially as the salinity of the water of the Shebelli River itself is relatively high. The EC levels for both classifications are the same.

c) Exchangeable Sodium Percentage (a)

The alkali limits for classes 1, 2 and 3 are the same, the exchangeable sodium percentage levels are generally less than 15 per cent (ESP 15), whereas class 4 has ESP's of up to 25 in the top 100 cm. Sodium is at present not a serious hazard. No difference exists in the ESP limits for the two classifications.

d) Texture

Four textural classes are recognised and denoted on the map at which depth they occur.

1)	Very coarse (v)	Sands - Loamy sands
2)	Moderately coarse texture (l)	Sandy loam Fine sandy loam Very fine sandy loam Loam
3)	Moderately fine texture (m)	Silt loam Silt Clay loam Sandy clay loam Silty clay loam
4)	Very fine texture(h)	Silty clay Clay
5)	Stratifications (b)	

The main difference between the two land capability classifications lies in texture. The reason for taking clay loams to permeable clays in class 1 in the classification for the flood scheme is that only these are used under rain-fed or flood cultivation. The soils were in general moist to slightly moist at the end of the dry season. The coarser and some of the moderately fine textured soils were generally dry throughout the profile even at the start of the dry season. The rooting depth in clay soils is deeper than in the coarse textured soils.

e) Topography

Topographical limitations are of two kinds:-

1) Micro-relief - gilgai formation (g)
2) Micro-relief - former river courses (t)

It is considered that the intensity and the development of the gilgai formation is important in point of view of levelling. The former river channels are excluded for cultivation, but they could be used as drainage channels.

f) Profile Characteristics (p)

In view of the importance of cracking as an aid to water penetration, an attempt was made to record cracking patterns. The depth and the frequency of cracking over a width of 1 metre were recorded. The total area of the surface which is cracked is less significant than the relation between the frequency and size of cracks. A low frequency of wide cracks is preferable to a high frequency of fine cracks. Wide cracks are more permeable to irrigation water and less liable to be impeded by mulches.

A visual assessment of structure and the limiting layers are used in the land classification. All these factors could be a limitation to water movement and/or root development.

(ii) Mapping

A histogram showing the textural classes and the salinity status of the profile, where available is placed at each individual site with the appropriate land class symbol.

If for instance a soil is downgraded due to one severe limitation, and some minor limitations, it is shown with the following symbol: i.e. class 4 d(3) ps (2), means a class 4 soil with a depth limitation of class 3, class 4 limitations in profile characteristics and class 2 salinity class.

BLE 3.1 Land Classification for Controlled Irrigation Projects

		Class 1	Class 2	Class 3	Class 4	Class 6	SYMBOL *
imum soil th to erent texture ss		100 cm	60 cm	60 cm	50 cm	50 cm	d
	Depth in cm						
inity	0- 50	<4	<4	4-8	8-12	unlimited	
/	50-100	<4	<4	<8	8-12	unlimited	
mhos	100-150	<4	4-8	<8	unlimited	unlimited	s
	Depth in cm						
S. P.	0- 50	<15	<15	<15	15-25	unlimited	
	50-100	<15	<15	<15	>25	unlimited	
	100-150	<15	<15	<15	unlimited	unlimited	a
cture		sandy loam to friable clay	loamy sand to permeable clay	loamy sand to moderately permeable clay	loamy sand to clay	unlimited	b. stratifications v. very coarse texture l. moderately coarse texture m. moderately fine texture h. very fine texture
pography		little gilgai formation or no restriction.	moderate gilgai formation or no restriction.	moderate gilgai formation or moderate restriction.	severe gilgai or moderate restriction.	unlimited	g
ofile aracteristics		no limit to water movement or root development, well structured.	water movement and root development a little impeded. Well to moderately structured.	water movement and root development restriction moderately structured.	water movement and root development moderately to severely restricted. Moderately to poorly structured.	unlimited	p

'ABLE 3.2 Land Classification for Flood Scheme Projects

		Class 1	Class 2	Class 3	Class 4	Class 6	SYMBOL *
linimum soil epth in cm.		100	75	60	50	50	d
	Depth in cm						
alinity	0- 50	< 4	< 4	4-8	8-12	unlimited	s
C/	50-100	< 4	< 4	< 8	8-12		
mhos	100-150	< 4	4-8	< 8			
	Depth in cm						
.S.P.	0- 50	< 15	< 15	< 15	15-25	unlimited	a
	50-100	< 15	< 15	< 15	> 25		
	100-150	< 15	< 15	< 15			
exture		Clay loam permeable clay.	Clay loam moderately to permeable clay.	Sandy clay loam to moderately permeable clay	Loam to clay	unlimited	v. very coarse texture l. moderately coarse texture m. moderately fine texture h. very fine texture b. stratifications
opography		no restrictions	no restrictions	moderate restrictions	moderate restrictions	unlimited	t
rofile aracteristics		no limit to water movement or root development. Well structured.	water movement and root development a little impeded. Well to moderately structured.	water movement and root development moderately restricted. Moderately structured.	water movement and root development moderately to severely restricted. Moderately to poorly structured.	unlimited	p

LAND CLASSIFICATION LEGEND

(Land classes in accordance with U.S. Bureau of Reclamation Standards with criteria adjusted for Somali Conditions).

ARABLE

- Class 1 Highly suitable lands
- Class 2 Moderately suitable lands
- Class 3 Moderately to marginally suitable lands

LIMITED ARABLE

- Class 4 Special Use lands

NON ARABLE

- Class 6 Soils with severe limitations

Land sub-classes are shown on the map in areas of class 2,3,4 & 6 by the following subscripts:

- d Land downgraded due to depth limitation
- s Land downgraded due to salinity
- a Land downgraded due to alkalinity
- g Land downgraded due to gilgai formation
- t Land downgraded due to topographical limitations
- p Land downgraded due to profile limitations

Textural classes

- s Very coarse texture
  Moderately coarse texture
- m Moderately fine texture
- h Very fine texture
- b [illegible]ifications

LOCATION OF SAMPLE SITES

- H123 2 metre sample site
- H124 2 metre observation site
- H125 2 metre sample site

Note All sample sites are accompanied by a histogram showing the textural class(es) and salinity status of the profile. Observation sites only show the textural classes.



EC less than 4 mmhos/cm 25°

EC 4-7.9 mmhos/cm 25°

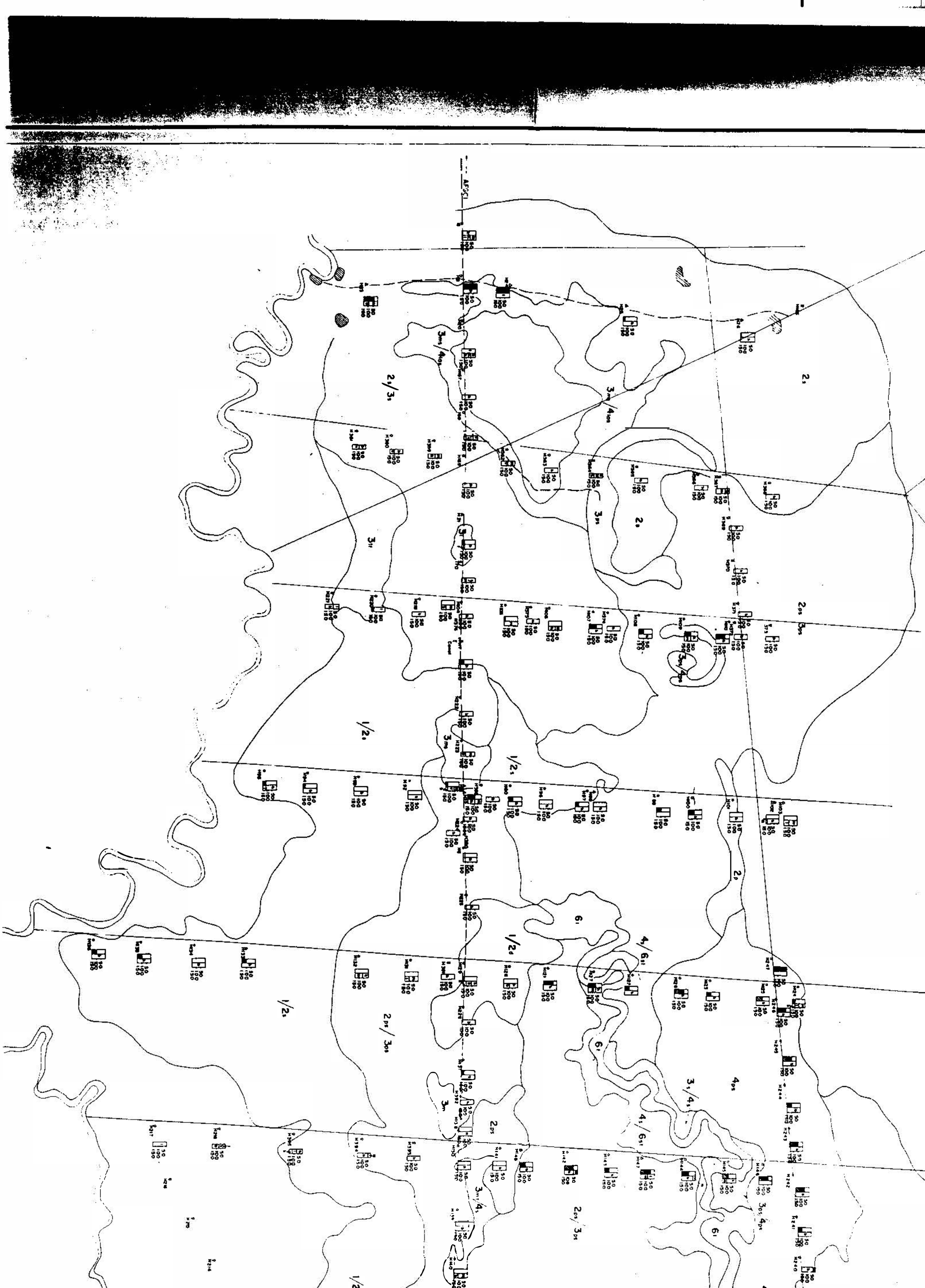
EC 8.0-12.0 " "

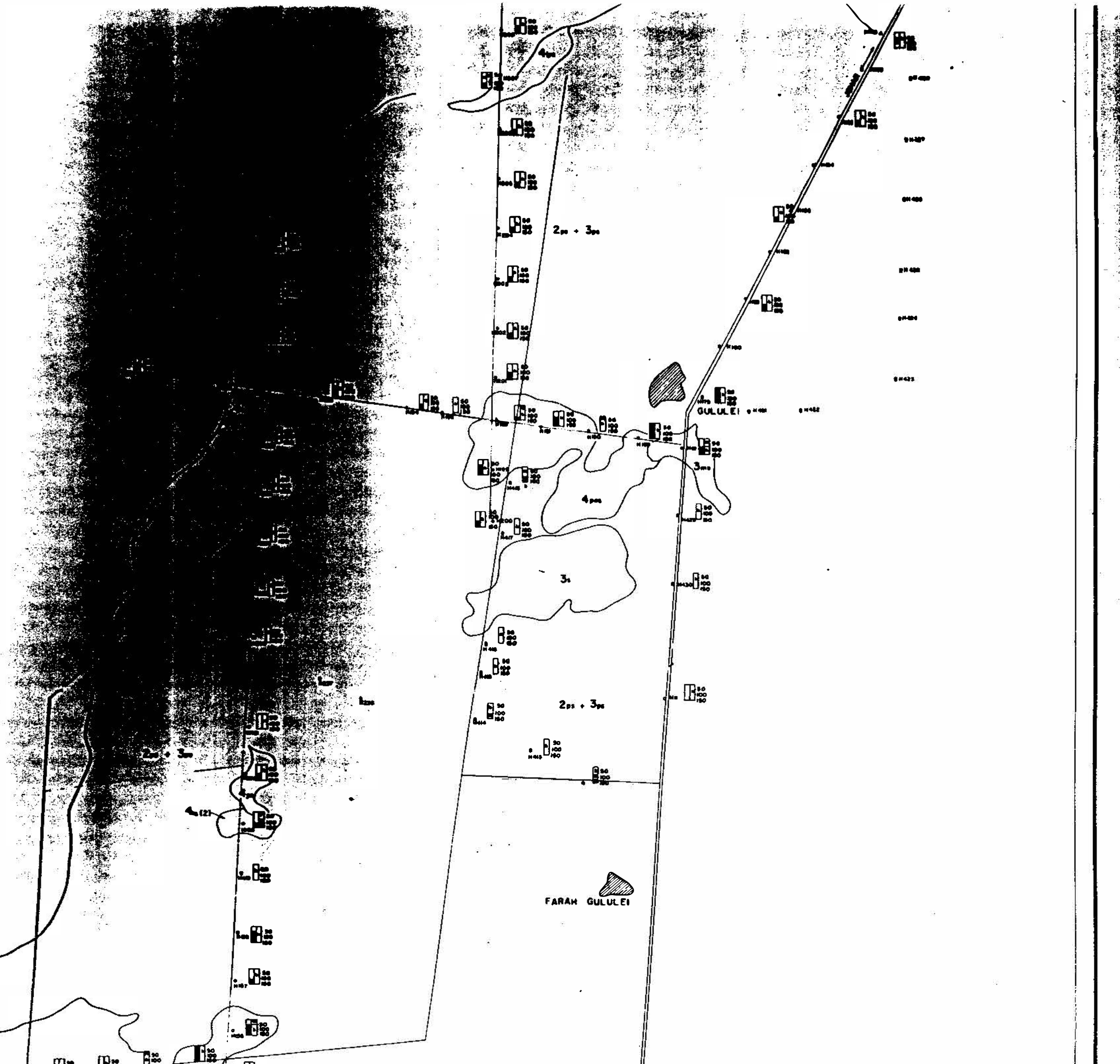
EC over 12.0 " "

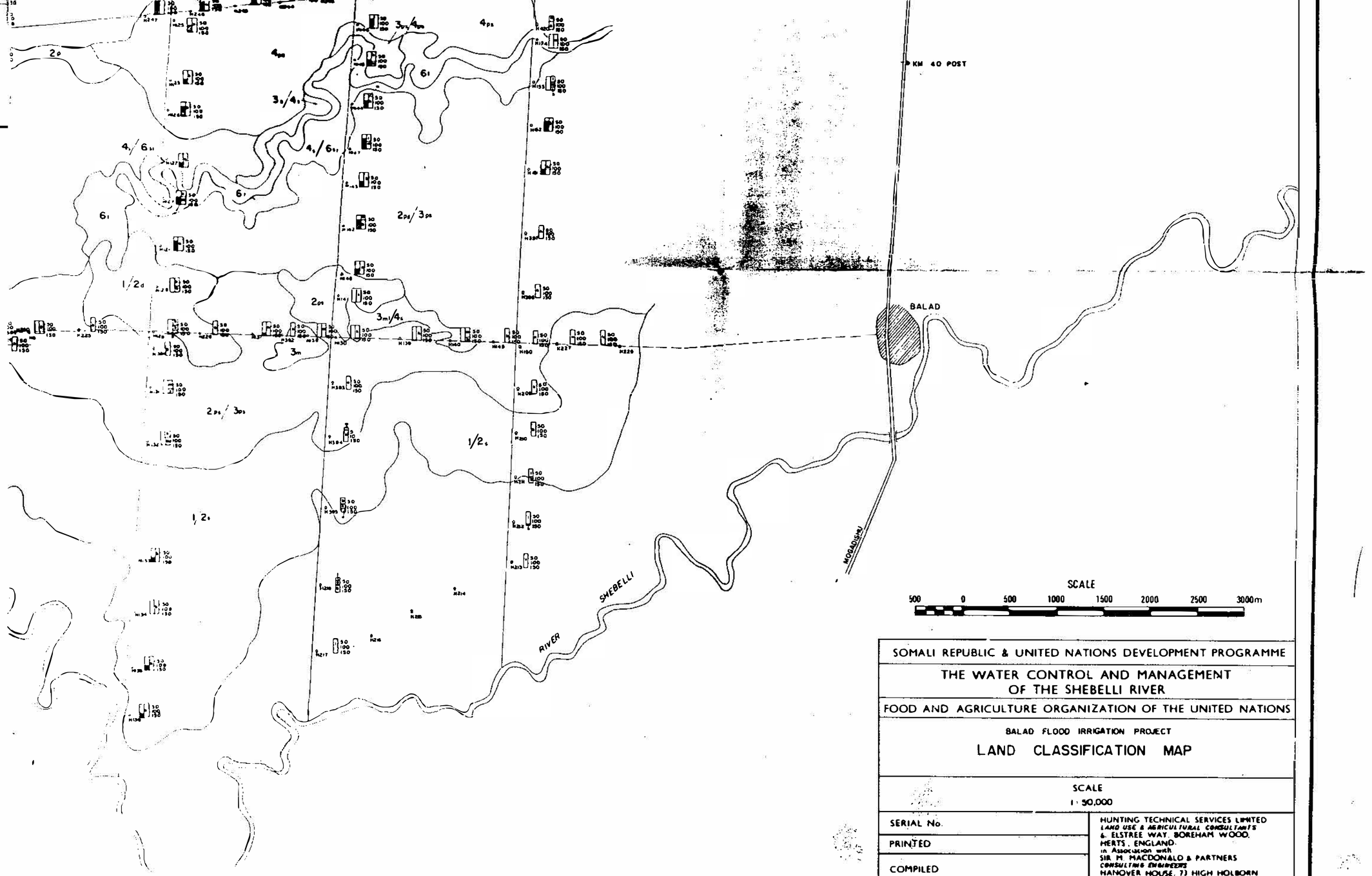


2ps + 3ps

4fc(2)




GULULEI
FARAH GULULEI



SOMALI REPUBLIC & UNITED NATIONS DEVELOPMENT PROGRAMME

THE WATER CONTROL AND MANAGEMENT OF THE SHEBELLI RIVER

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

BALAD FLOOD IRRIGATION PROJECT

LAND CLASSIFICATION MAP

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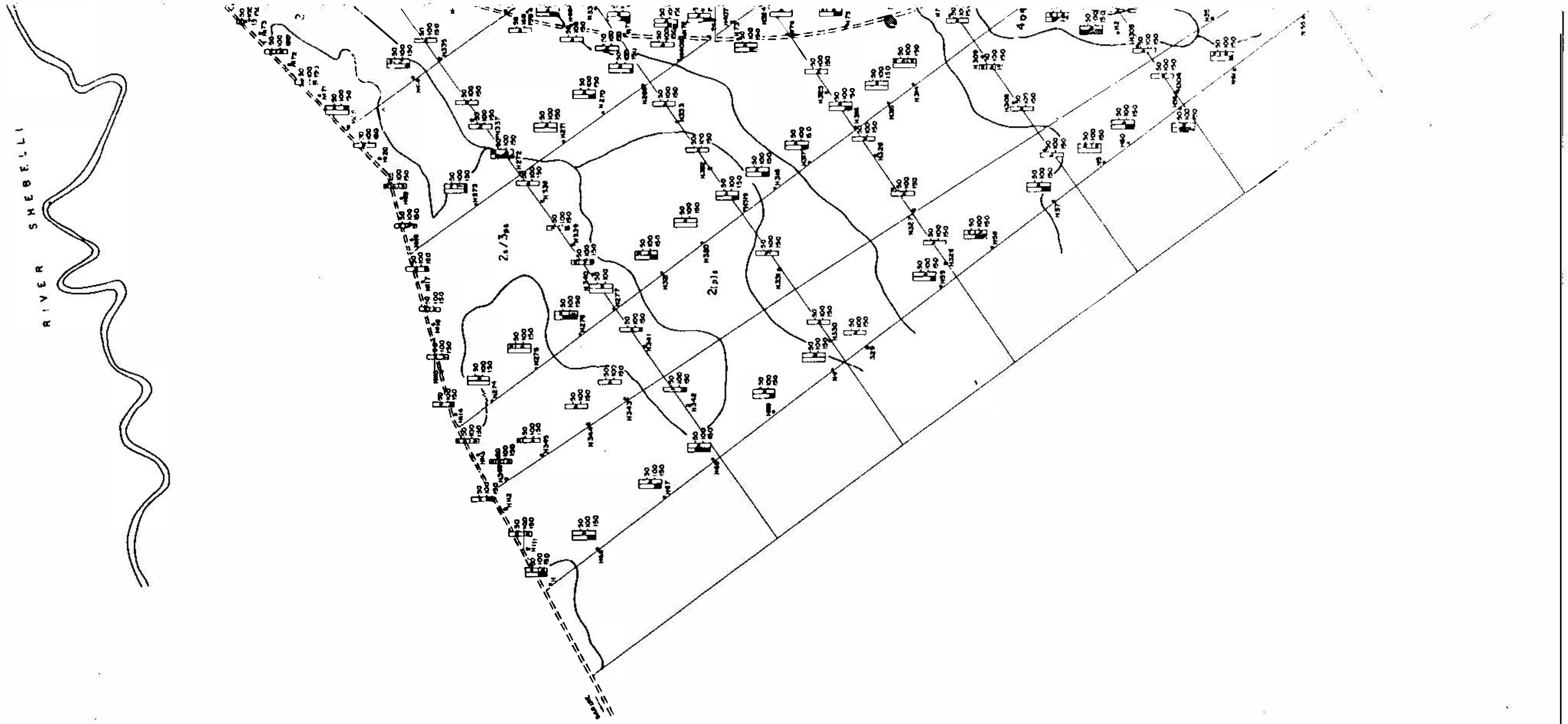
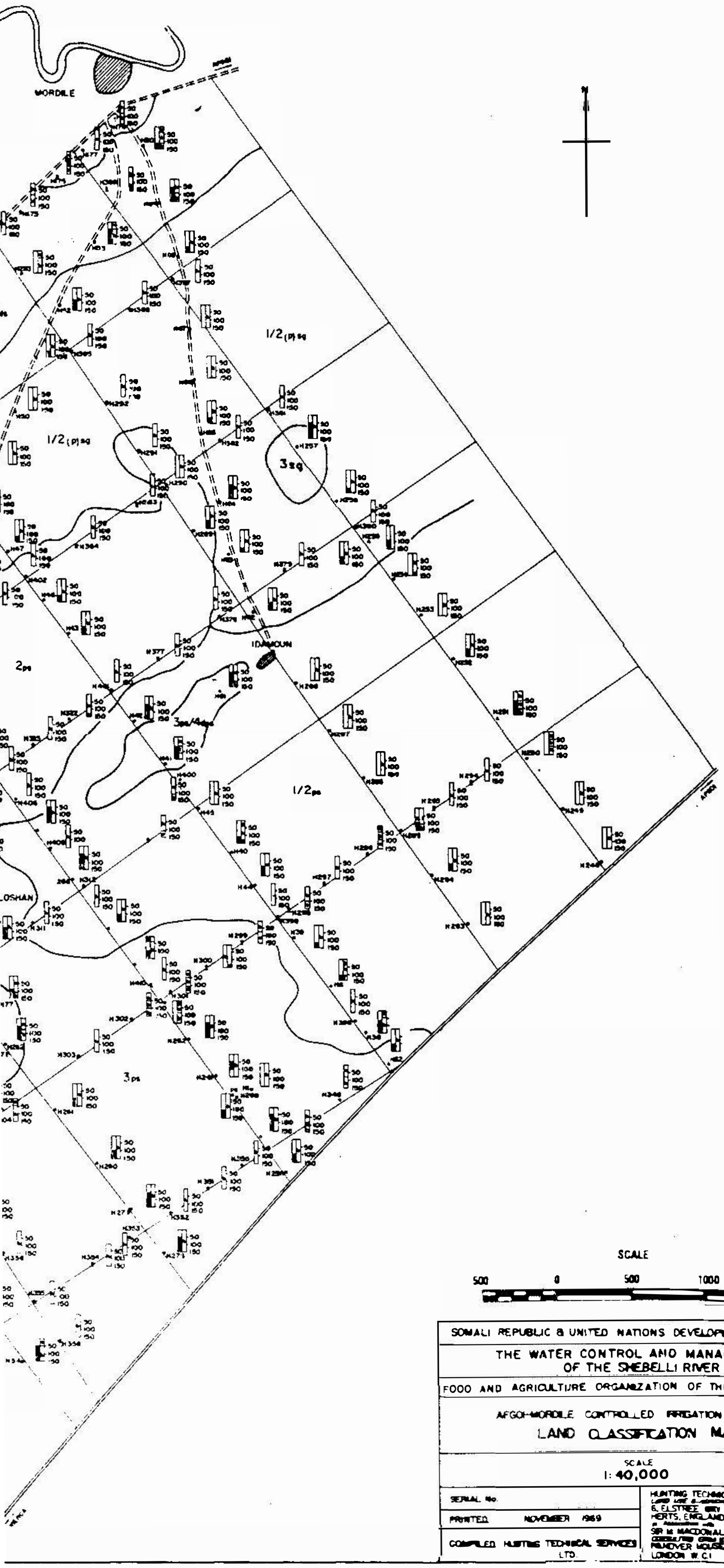

RIVER SHEBELLI

FIGURE 3·2



LAND CLASSIFICATION LEGEND

(Land classes in accordance with U.S. Bureau of Reclamation Standards with criteria adjusted for Somali Conditions).

ARABLE
- Class 1 Highly suitable lands
- Class 2 Moderately suitable lands
- Class 3 Moderately to marginally suitable lands

LIMITED ARABLE
- Class 4 Special Use lands

NON ARABLE
- Class 6 Soils with severe limitations

Land sub-classes are shown on the map in areas of class 2,3,4 & 6 by the following subscripts:

- d Land downgraded due to depth limitation
- s Land downgraded due to salinity
- a Land downgraded due to alkalinity
- g Land downgraded due to gilgai formation
- t Land downgraded due to topographical limitations
- p Land downgraded due to profile limitations

Textural classes

- v Very coarse texture
- l Moderately coarse texture
- m Moderately fine texture
- h Very fine texture
- b Stratifications

LOCATION OF SAMPLE SITES
- H123 2 metre sample site
- H124 2 metre observation site
- H125 2 metre sample site

Note: All sample sites are accompanied by a histogram showing the textural class(es) and salinity status of the profile. Observation sites only show the textural classes.

EC less than 4 mmhos/cm 25°

EC 4·79 mmhos/cm 25°

EC 8·0-12·0 " " "

EC over 12·0 " " "

LEGEND

Surfaced Road ==== Unsurfaced Road

Civil Limit

SCALE

500 0 500 1000 1500m

SOMALI REPUBLIC & UNITED NATIONS DEVELOPMENT PROGRAMME

THE WATER CONTROL AND MANAGEMENT OF THE SHEBELLI RIVER

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

AFGOI-MORDILE CONTROLLED IRRIGATION PROJECT

LAND CLASSIFICATION MAP

SCALE 1: 40,000

SERIAL No.

PRINTED NOVEMBER 1969

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LAND USE & AGRICULTURE CONSULTANTS
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in Association with
SIR M MACDONALD & PARTNERS
CONSULTING ENGINEERS
ANDOVER HOUSE, 73 HIGH HOLBORN LONDON W.C.1

CHAPTER-4

AREAS FOR FUTURE INVESTIGATIONS

The time and money available in the scope of this survey were not sufficient to investigate all areas in detail for future investigations. Lockwood's report is therefore considered as the basis for recommendations of future development. In addition to the soils formation given in Volume 3 (Agricultural and Water Survey, 1968) more investigations on the soils were carried out. Sir M. MacDonald and Partners provided information of irrigable areas. Careful studies of aerial photographs have been carried out in conjunction with the existing soil map.

The following gives a description of each area and their future recommendation.

4.1 Reconnaissance Survey: Belet Uen-Avai

Area 1. Belet Uen

A small area south of Belet Uen on the left bank has been investigated. Soils at two sites were examined and one site was sampled and the soils analysed. The topsoil consists of silty clay loam to clay loam with silty clay to clay subsoils. The moisture condition varies from moist to dry. Gley colours are common below 85 cm indicating poor drainage. Calcium carbonate and fine gypsum crystals are common in the profile and the soil reacts strongly to acid. The soil is very highly saline-alkaline and the land is classified as class 6. It is doubtful if the soil could be reclaimed by leaching. The soil was previously classified as a Solonetz (Bulo Scevelo). Reclassification was not made as only routine analyses were carried out.

The topography of the whole area is flat and gently sloping to the river. There is a small depression in the southern part of the area. Very small areas were cultivated at the time of investigations.

The sorghum looked very poor and was attacked by stemborers. Grazing is the main land use. The area is subject to flooding by run-off from the hills on the East side and the crops are damaged in years of heavy rainfall. There is some evidence of sheet and rill erosion.

Area 1 is not recommended for future development.

Area 2

The area is situated on the left bank approximately 30 km south of Belet Uen. Access is poor and there are only cattle tracks in the area. The general topography is flat, with little micro relief in the form of local depressions, and gently sloping to the river and to the East. It seems that the entire area is an old river terrace enclosed by the river and a former river course.

Land use consists mainly of grazing with small bunded areas of sorghum or other crops. The old river course in the east receives run-off water from the hills and is nearly all cultivated. The nomadic population is not interested in agriculture and might object to any type of agricultural scheme.

The soils have been previously mapped as Bulo Scevelo of the landform unit, Flood Plain Cover, which is not flooded by the river.

The surface is fairly even and consists of a very fine powdery mulch mainly caused by the trampling of livestock. This fine material is easily blown by the wind. The profiles consist of clay loam to clay topsoil with silty clay loam. Stratifications may occur. The colours vary from dark grey brown to dark brown. Fine calcium carbonate concretions occur throughout the profile and gypsum is common in the subsoil. The profiles were generally dry to slightly moist. Two sites were investigated and smpled. This soil is not suitable for irrigated agriculture due to the very high salinity and alkalinity and is therefore classified as class 6 as.

Area 2 is not recommended for future development.

Area 3

The area is situated at approximately 40 km north of Bulo Burti on the left bank. Access is very poor and there are only cattle tracks in the area. The population is small and consists of a very small number of nomads.

Approximately half of the area is subject to the influence of the wadis coming down from the eastern hills. The area is flat and gently sloping to the river with a slight rise near the river banks. One small depression occurs in the eastern part of the area, receiving run-off from the adjacent hills. Land use is mainly grazing with locally some areas of rainfed cultivation. As in the other areas bunding is practised. The aerial photographs of 1962 show more cultivation than exists at present. It may be that the cultivators have moved from the area to Bulo Burti or elsewhere.

The present river terrace is rather narrow on both sides of the river and material deposited by the wadis overlies the older terraces.

The soils were previously classified as Bulo Scevelo. The area could be divided into two units: the Bulo Scevelo area which is not subject to flooding, and the deposits brought down by the wadis. These differ considerably. On the wadi deposits the surface consists of a powdery mulch and sinkholes are common features. These sinkholes may differ from the sinkholes found in the Vertisols in that they are apparently an erosion feature. The profile examined had a reddish brown loam overlying sandy clay loam to clay loam at 100 cm. Kankars and fine calcium carbonate concretions are common throughout the dry profile.

One site was investigated and sampled.

The subsoil suffers from a high salt hazard, but exchangeable sodium percentages are low. This soil is classified as 4ps.

Area 3 is not recommended for future development, due to poor access and small population. These lands are only suitable for special use and high investment is necessary to protect the scheme from the run-off of the wadis.

Area 4

The area is located approximately 40 km north of Bulo Burti on the right bank. A reasonably good dirt road runs through the area, which is more densely populated than area 3.

The population consits mainly of migrant nomads who move from and to the riverine areas depending on the season.

Land use is mainly grazing but rainfed cultivation is also commonly practised. Tsetse fly is common.

The general topography is uneven due to old river courses which could be recognised on the aerial photographs.

It is difficult to say at present if the soils are suitable for irrigation due to the complex manner in which they occur and a detailed survey is recommended. They have been previously classified as Bulo Burti and Bulo Scevelo soils, but in this area the latter could be re-classified as Mahaddei Uen Complex, as described by Lockwood.

Two sample observations were made. The surface consisted of a powdery mulch with kankars and shell fragments. The topsoil material varies between silty clay loam and clay loam and the subsurface and sub-stratum materials are dominantly clay loam and clay. The colours of the Mahaddei Uen Complex are brown to dark grey brown and those of the Bulo Burti soils are dark brown. The latter soils contain kankars throughout the profile and fine and lenticular gypsum crystals occur below 50 cm. Both soils are dry and react strongly to acid. The Bulo Burti soils are classified as land class 4s, due to the high salinity status, and the Mahaddei Uen Complex as 6t due to topographic limitations. Exchangeable sodium percentages are low in both profiles.

Area 4 is not recommended for future development mainly due to topographic limitations.

Area 5

This area is situated approximately 15 km on the left bank north of Bulo Burti. No field inspection was made as no access to and in the area was possible. However a study of the aerial photographs was carried out and the area was observed to be very similar to area 3.

Area 5 is not recommended for future development for the same reasons as area 3.

Area 6

Area 6 is situated approximately 10 km south of Bulo Burti on the right bank $3^{0}45'N$, $45^{o}35'E$. Access to the area is good. The present population consists of nomads and the sedentary riverine population. Both practise rainfed cultivation. The riverine population cultivates sorghum, maize, vegetables, sesame and sugar cane along the river. Away from the river, sorghum, maize and occasionally cotton are grown but yields are very low.

The topography generally is flat and gently sloping with minor undulations in places due to former river channels.

The soils were previously classified as Arar Lugole, Bulo Burti, and Mobarech soils. Three sites were investigated and sampled. Large amounts of gypsum are found in the three profiles. The soils react strongly to acid. The investigated profiles are classified as 4ps (2), 4s and 6as respectively.

Area 6 is not recommended for development at present because of uncertainty about the effect of the high gypsum content or the behaviour of the soils under irrigation. If any future development is anticipated a semi-detailed soil survey should first be carried out and the economics of the project carefully examined.

Area 7

This area is situated approximately 30 km south of Bulo Burti on the right bank, 3°35'N, 45°35'E. Access to the area is good. The present population consists of nomads and the riverine people. Both pratise rainfed cultivation. The riverine people cultivate sorghum, maize, vegetables, sesame and sugar cane along the river. Away from the river very small areas of sorghum, maize and rarely cotton are grown, but yields are very low.

The topography is in general flat and gently undulating.

The soils were previously classified as Bulo Burti and Mobarech soils, but they could be better classified as Arar Lugole soils. They are deep to moderately deep dark brown (7.5YR 3/2) loam to sandy clay loam soils. Structure and cracks are poorly developed. Fine calcium carbonate concretions and fine and lenticular gypsum crystals are commonly found in the subsurface and subsoil and the soil reacts strongly to acid. The surface horizon may have high EC's, but in general the salinity levels are low. The subsurface and subsoil have medium to high salt hazards and medium sodium hazards.

The soil is at present only used for grazing. Three sites were investigated and sampled. These are classified as classes 2ps, 6as and 4ps respectively.

Area 7 is not recommended for development at present. If future development is to be considered the area should firstly have a semi-detailed soil survey.

Area 8

The area is located at approximately 10 km on the right bank south of Gialalassi, 3°20''N, 45°32'30''E. Access to the area is good. Moderately large areas of rainfed cultivation, maize and sorghum occur in area 8, although grazing is also common. Large areas, which have been cultivated in previous years are now fallow or abandoned and the natural vegetation is regenerating.

The topography is in general flat to very gently undulating.

The soils were previously classified as Bulo Togon. Two sites were investigated and sampled.
The soils are deep saline/alkaline, dark red (2.5YR 3/6) to dark brown (7.5YR 3/2). The surface has a soft broken raincrust over 2 to 3 cm of fine granular mulch. The profiles have a silty clay and/or clay surface horizon and silty clay and/or clay subsurface and subsoil material. Fine crystalline and lenticular gypsum is common below 20 cm. The soil has very high EC's and ESP's throughout the profile. Fine calcium carbonate concretions occur and the soil reacts strongly to acid.

These soils are classified as class 6as due to their high salinity and alkalinity.

It is stated in the Lockwood report that the Bulo Togon soil has a significant potential for agricultural development and irrigation. It will be necessary to investigate these soils in more detail if future development of this area is anticipated, as the recent figures show very high EC and ESP figures.

Area 8 is not recommended for future development.

Area 9

Area 9 is situated at approximately 25 km on the right bank, south of Gialalassi, 3°12'30"N, 45°32'30"E. This area has been partly used under flood irrigation in the past, but is at present abandoned.

Access to the area is good, if there is no flooding. Population is scarce. The topography is generally flat and slightly depressional.

The soil was previously classified by Lockwood as Bio Addo and Mobarech soil, but they are probably better classified as non-saline/non-alkaline Bulo Togon soils. Two sites were investigated

and sampled. The profile characteristics are similar to those for Bulo Togon soils. One site was very moist to wet due to recent flooding. Internal drainage is poor. ESP's and EC's are low. This area is provisionally classified as 3p and 4p due to poor internal drainage. The area could be developed in the future, providing adequate drainage is available and detailed soil studies are carried out.

Area 9 is recommended for future investigations.

Area 10

This area is located at approximately 15 km north of Mahaddei Uen on the right bank, $3^{o}7'30''N$, $45^{o}32'30''E$. Access to this area is good, but due to excessive flooding it was not possible to cover the major part of the area under these investigations. The population is scarce. Little cultivation was being carried out at the time of the survey as most lands were still flooded or too wet to cultivate. The main crops are sesame, maize and sorghum. Cotton has been grown in the past.

The topography is generally flat and slopes gently into a large, shallow depression.

The soils were previously classified as Bulo Togon, Mobarech and Bio Addo soils.

Three sample pbservations were made. The first two were in Bulo Togon soils and the latter in the Bio Addo soil. This profile is described in detail. One Bulo Togon soil was wet and stickly clay due to recent flooding. Internal drainage is poor. The Bulo Togon soils are non-saline/non-alkali soils, but the Bio Addo has high electrical conductivities below 60 cm and a medium sodium hazard in the subsoil. The soils would correspond to classes 4p, 1 and 6as respectively.

Area 10 is suitable both as a flood or controlled irrigation scheme, providing flood control measures could be taken. There are many flood canals in the area and it is essential to investigate the extent of these canals and the possibility of using these in the future development plans. The economics should also be carefully investigated and a detailed soil survey carried out.

Area 10 is recommended for future investigations.

Area 11

This area is located at approximately 5 km on the left bank north of Mahaddei Uen, 3°02'30"N, 45°32'30"E. Access to the area is poor but a small pump scheme has recently been established.

Part of the area was under water during the high floods, due to breakage of the river banks. These lands are cultivated by the population after the recession of the water. The main crops grown are vegetables, sesame, maize and sorghum.

The topography is generally sloping and slightly depressed.

The soils have been previously classified as Bio Addo and Johar soils.

No sample observations were carried out, but the soils are similar to those already investigated and to those in the Johar Irrigation Scheme. A detailed soil survey should be carried out.

Area 11 is recommended for future investigations.

Area 12

Area 12 is situated at approximately 5 km on the right bank north of Mahaddei Uen, 3°00'N, 45°2'E. Access is good and the inhabitants of Mahaddei Uen cultivate these lands. The topography is generally level, tending to depressional. Flood canals are common. Cultivation is common and yields are good. The main crops grown in this flood scheme are sesame, vegetables, maize and sorghum.

These soils were previously classified as Johar soils. One site was investigated and sampled.

The surface is slightly uneven and cracks and sinkholes are common features, when the soil is dried out. The profile consists of sandy clay, clay loam and clay surface and subsurface horizons and clay substrata. Colours vary between very dark grey brown and dark brown throughout the profile. EC's and ESP's vary not only in the profile but also at different sites. The profile investigated did not show any salt and sodium hazard.

A detailed soil survey is required before any development of this area is carried out.

Area 12 is recommended for future investigations.

Area 13

The area is situated at approximately 8 km south of Mahaddei Uen on the right bank, $2^{o}55'N$, $45^{o}32'E$. Access to this area is good. An abandoned controlled flood scheme covers a large part of the area. There is no proper reason given why this scheme is no longer in operation. Under a new development plan, this scheme could probably be enlarged and improved on the light of further detailed information.

The topography is generally flat and gently sloping to depressional lands near the river, which are used under flood irrigation. Main crops are sesame, vegetables, maize, sorghum and sugar cane.

The soils were previously classified as Mahaddei Uen soil Complex and Johar soils and are developed in alluvium of the Flood Plain Meander. This Mahaddei Uen soil is similar to the Johar soil and it is preferred to regard it as a variant of the latter. It is also developed in older alluvium than the soils in the depressional lands along the river, which are an integrade between the Bulo Togon and Johar soil. The river basins have been under water for a long period and it was not possible to cover the entire area during this survey.

Three sample observations were made. Two sites on older alluvium were classified as 2s and 3s. One on depressional lands near the river was poorly drained and many mottles were found below 90 cm. it was asigned to Land class 4ps(2). Full investigations are required before future development can be planned.

Area 13 is recommended for future investigations.

Area 14

The area is located approximately 2.5 km north of Johar on the right bank, $2^{o}47'30''N$, $45^{o}32'E$. Access to the area is good.

The topography in general is flat and gently sloping. A small experimental farm, under Chinese management is situated in the area and cultivates rice and tobacco.

Large tracts of these Johar soils are under rainfed cultivation. The main crops are sesame, vegetables and sugar cane along the river, maize and sorghum away from the river.

No sample observations were made, but based on findings of Lockwood's report it could be recommended for future development.

Area 14 is recommended for further investigations.

Area 15

The area is located approximately 5 km on the left bank north of Johar, $2^{o}48'N$, $45^{o}35'E$.

It was not possible to investigate this area on the ground, as large parts were under flood water, due to breakages of the river banks. The entire area is occupied by the Johar soils.

If future development is anticipated, flood control measures should be taken.

Area 15 is recommended for further investigations.

Areas 16 and 17

The areas are located between Johar and Balad on both river banks. The access to the areas is fairly good. The general topography is gently sloping to gently undulating. Large tracts are cultivated, either rainfed or under flooding. The main crops are sesame, vegetables, maize and sorghum.

The soils are rather complex and it was not possible to carry out a more detailed survey. Further complications lie in sociological, economic and engineering fields. A large number of co-operatives are situated in the areas.

A special survey is required for the Johar-Balad Reach, as it may have a good potential for irrigated crops.

The population is dense compared with all other areas and there is good access to the harbour in Mogadiscio.

One observation site was made in a depression which has been under water for several months. It is a non-saline / non-alkali dark brown clay, imperfectly drained.

Areas 16 and 17 are strongly recommended for further investigations.

Area 18

Area 18 is located between Afgoi ($2^{o}7'30''N$, $45^{o}10'E$) and Goluen ($1^{o}40'N$, $44^{o}35'E$) and the road Afgoi-Merca and the Shebelli River, but excludes all existing and operating concessions and the Mordile project area. Access to the area is good and the population is comparatively dense.

Sampling observations were made between Afgoi and Barire and in the Genale Concessions. The Bulo Mererta has been surveyed by Dr. Newton of the Afgoi Experimental Station. These results are discussed in Chapter 1. Observation sites made by Lockwood Corporation Ltd. were also taken into consideration.

The entire area is covered by the Goluen soil, which is developed in younger alluvium of the Shebelli River. The topography is gently sloping from the river to the Afgoi-Merca roads and rises slightly towards the dunes.

Large tracts of these soils are under rainfed cultivation and others are commanded by pump irrigation especially between Balad and Audegle. Controlled irrigation is practised in the Genale banana concession area. Lands near the river are watered by a large number of flood canals, but proper management is lacking and water losses are frequent. The main crops under rainfed cultivation are maize, sorghum, sesame and occasionally cotton.

The Goluen soil has in general a soft granular mulch and well developed cracks; sinkholes are common.

The profile consists of brown and dark brown clay loam to clay surface horizons and brown to dark brown clay subsurface horizons and subsoil. However in some cases coarser textured material may be overlain by finer textured material. Clay soils are intermixed with coarser textured soils that are developed in the old river levees. Slickensides are common features in the profiles, fine calcim carbonate concretions occur throughout the profile and the soil reacts strongly to acid. Common fine gypsum crystals may be present in the subsurface and subsoil. The Goluen soil is in general non-saline/non-alkali. The subsurface and subsoil may have medium or occasionally high salt hazards, but no sodium hazard is present. These lands are classified as 1, 2 and 3 lands and are the best suited for irrigated agriculture.

Further detailed investigations are necessary prior to future development. Priority should be given to re-establish and re-develop the abandoned concessions and the Bulo Mererta area, but a full appraisal is necessary prior development.

Area 18 is strongly recommended for further investigations.

Area 19

The area is located between Goluen (1°40'N, 44°35'E) and Avai (1°10'N. 43°42'30"E), the dunes in the south east and the swamps in the northwest.

The topography is generally flat and gently sloping to slightly undulating.

Land use is rainfed cultivation, the main crops being sesame, maize, sorghum and cotton; some groundnuts are also grown.

Access to the area is good, but large parts in the area could not be covered by these investigations because of extensive flooding. Population density is low.

The area is covered by four soils, the Avai, Goluen, Gofca and Ururgala soils. The Ururgala soil is developed in older alluvium of the Flood Plain Cover; the other three are developed in the alluvium of the Flood Plain Meander.

Five observations were made: two in the Goluen soil, two in the Gofca soil and one in the Avai soil. No observations were made in the Ururgala soil as the area was still flooded at the time of the survey.

The Goluen soil has already been described in detail and has been recommended for irrigated crops. Both sites examined in the Goluen soils were classified as class 2s lands.

The Gofca soil is well developed in alluvial material brought down by the Gofca which is probably a former course of the Shebelli River. It occurs in areas with an average annual rainfall of 300 to 400 mm. The surface has a soft broken raincrust over a medium granular mulch which obscures the cracking pattern. Shell fragments are common on the surface. Soil colours vary from dark grey to dark grey brown. The profile consists of clay material. Well developed slickensides and fine calcium carbonate concretions are common in the subsurface

and subsoil. Fine gypsum crystals may occur below 100 cm. Mottling is present at few imperfectly drained sites (see H 458). A medium or high salt hazard may occur in the subsoil, but no sodium hazard is found in any part of the profile.

The Gofca soil is suitable for irrigated crops. Water from the swamps may be used to irrigate not only this soil but also the Goluen, Avai and Ururgala soils. This proposal should be carefully investigated. The investigation sites studied were classified as 2p and 4ps.

The Avai soil is developed in alluvium deposits of the Shebelli River. It is a dark grey non-saline/non-alkali clay soil. It is found in areas with an average annual rainfall of 300 to 400 mm.

The surface has a soft broken raincrust over a medium granular mulch, which covers well developed large cracks, the extent of which depends on the moisture condition of the soil. Sink-holes are common and shell fragments are abundant. Slickensides are well developed in the subsurface and subsoil. Fine calcium carbonate concretions occur throughout the profile and a few fine gypsum crystals are found in the subsoil. A moderate salt hazard may occur in the subsurface and subsoil horizons, but sodium hazard is found in any part of the profile.

The Avai soils are suitable for irrigated crops. Site H 459 is classified as class 2s land.

No observations were made on the Urúrgala soils, but reference is given here to the results found during the survey carried out by Lockwood Corporation Limited.

The soil is a fine textured Vertisol, and is developed in older alluvium of the Shebelli River under average annual rainfall of 400 to 500 mm. The surface has a slight micro relief and a soft mulch. Sinkholes and cracks are common, depending on the moisture condition of the soil. The surface and subsurface horizons are non-saline, the subsoil has a moderate to very high salt hazard and a low to high

sodium hazard. This soil has some potential for crop production. The presence of salts in the subsoil detracts from its suitability for irrigation. Further investigations are necessary before any future development plans are made.

Area 19 is recommended for further investigations.

4.2 Conclusions

Future development of the areas which are recommended should not be carried out before adequate investigations are made. Detailed soil surveys, economic appraisals and engineering surveys should be made. As the amount of water in the Shebelli River is limited it is essential to determine accurately the areas which could be irrigated by the river.

Below is a list of the areas which deserve priority in further investigations prior to future development, when the amount of water for irrigation is known.

1) Re-development of the Bulo Mererta area.

   Advantages: Labour available; main canal and canal layout present; little bush clearance to be carried out; soils suitable for irrigated crops.

   Disadvantages: Re-allotment of land necessary.

2) Abandoned concessions in the Genale area and along the Shebelli River.

   Advantages: Canal layout present, labour available and soils suitable for irrigated crops.

   Disadvantages: Re-allotment of land necessary.

3) Area between Afgoi and Goluen.

   Advantages: Soils suitable for irrigated crops.

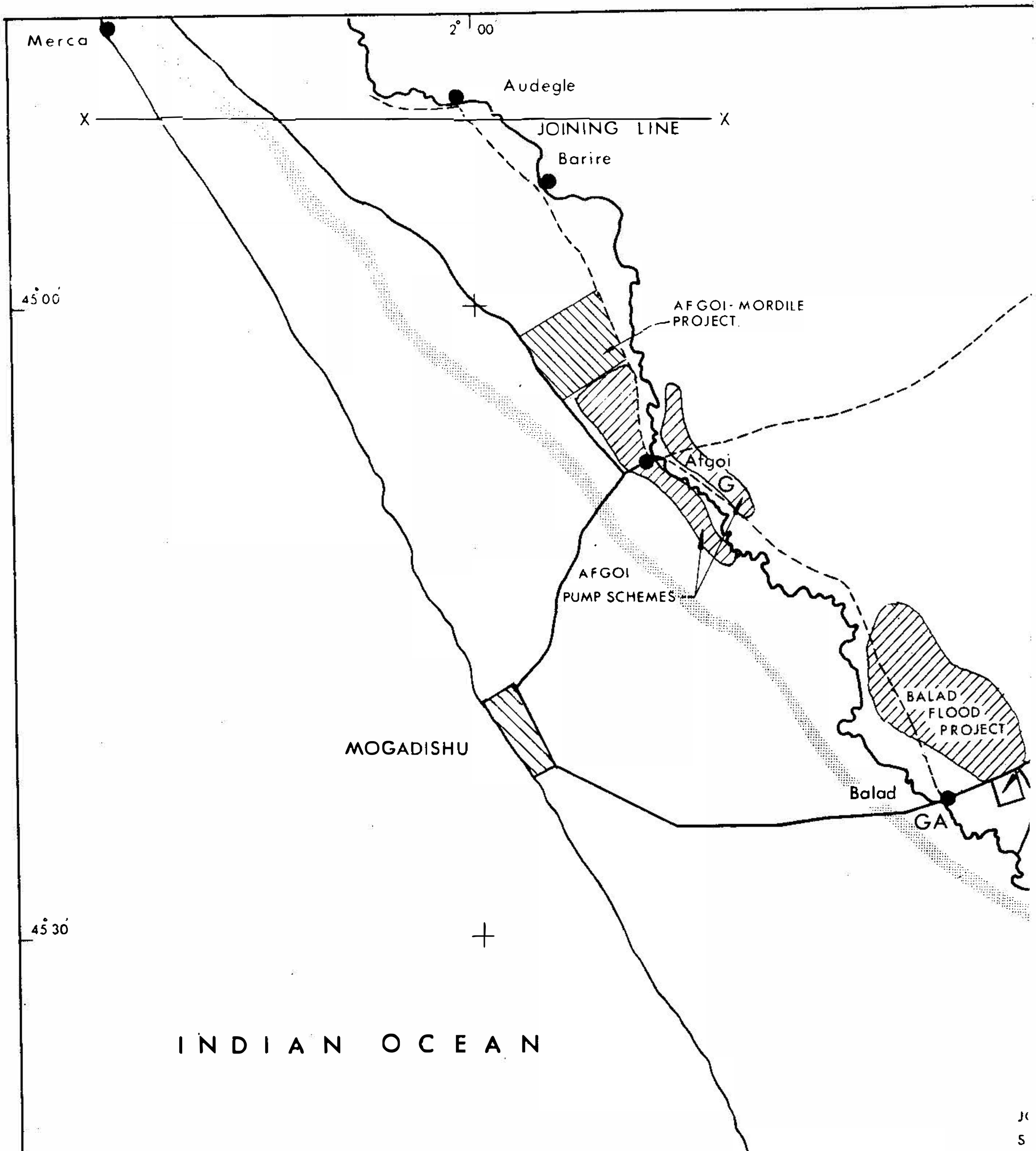
4) Area between Johar and Balad.

Advantages: Soils suitable for irrigated crops; labour available.

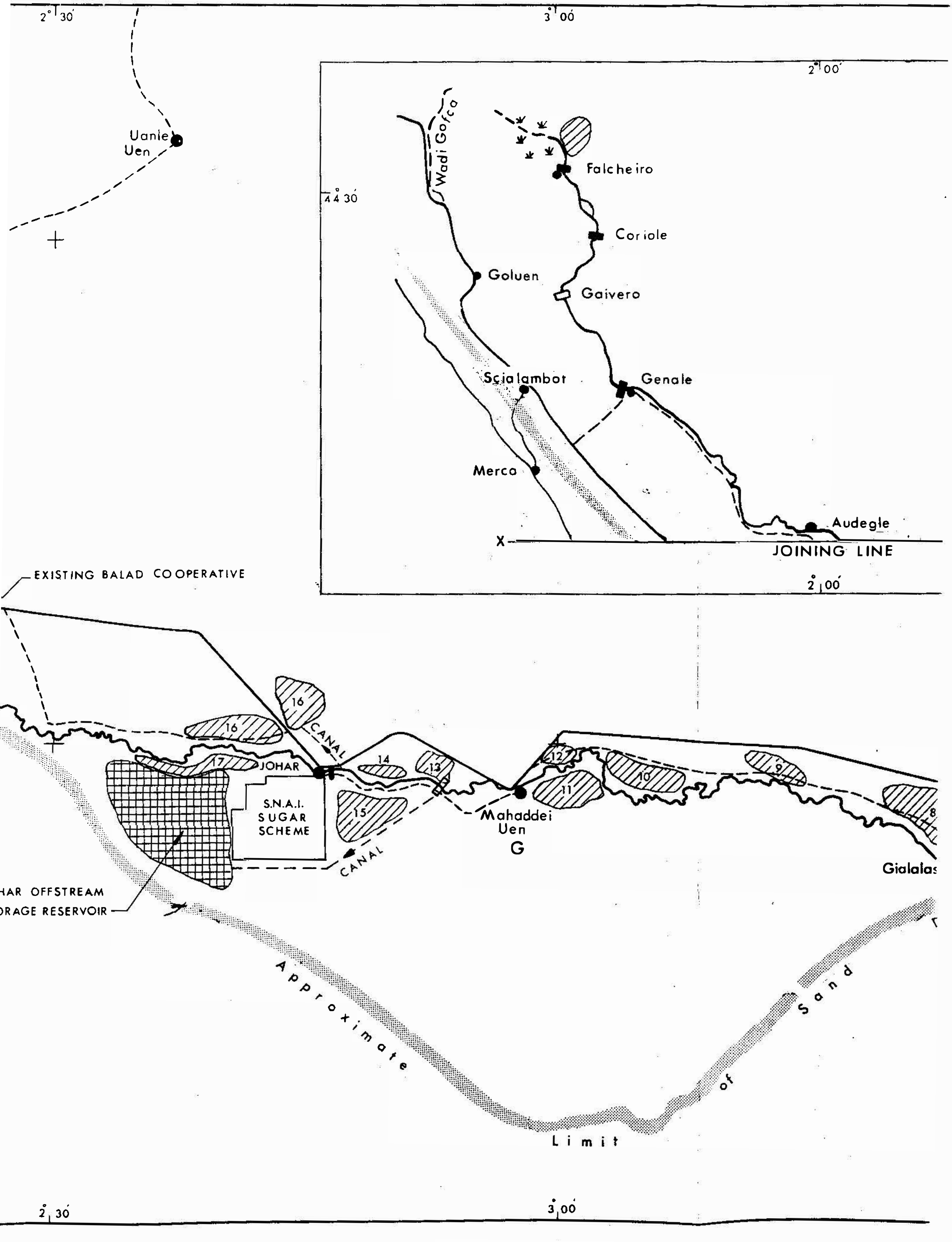
5) Area between Goluen and Avai.

Advantages: Water available from the swamps.

Disadvantages: Low population density.



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CHECKED		30.10.69
APPROVED		30.10.69


2° 30'
3° 00'
2° 00'
Uanle Uen
Wadi Gorca
4° 30'
Falcheiro
Coriole
Goluen
Gaivero
Scialambot
Genale
Merco
X
Audegle
JOINING LINE
2° 00'
EXISTING BALAD COOPERATIVE
16
16
CANAL
17
JOHAR
14
13
12
11
10
9
8
S.N.A.I.
SUGAR
SCHEME
15
CANAL
Mahaddei
Uen
G
Gialalas
HAR OFFSTREAM
ORAGE RESERVOIR
Approximate
Limit
of
Sand
2° 30'
3° 00'

3° 30'

4° 00'

2° 00'

44 30

Audegle

X

INING LINE

2 00

LEGEND

SURFACED ALL WEATHER ROAD.

DIRT DRY WEATHER ROAD.

DAM SITES INVESTIGATED.

FUTURE DEVELOPMENT AREAS INSPECTED.

POSSIBLE OFF STREAM STORAGE SITES. SURVEYED OR INVESTIGATED.

EXISTING RIVER GAUGES.

G---STAFF ONLY.

GA--STAFF PLUS AUTOMATIC RECOREDER

EXISTING BARRAGE OR WEIR

PROPOSED BARRAGE

Bugda Acable

BUGDA ACABLE OFFSTREAM STORAGE

ELO GEIBO DAM SITE

Bulo Burti

GA

Gialalassi

Dunes

Sand

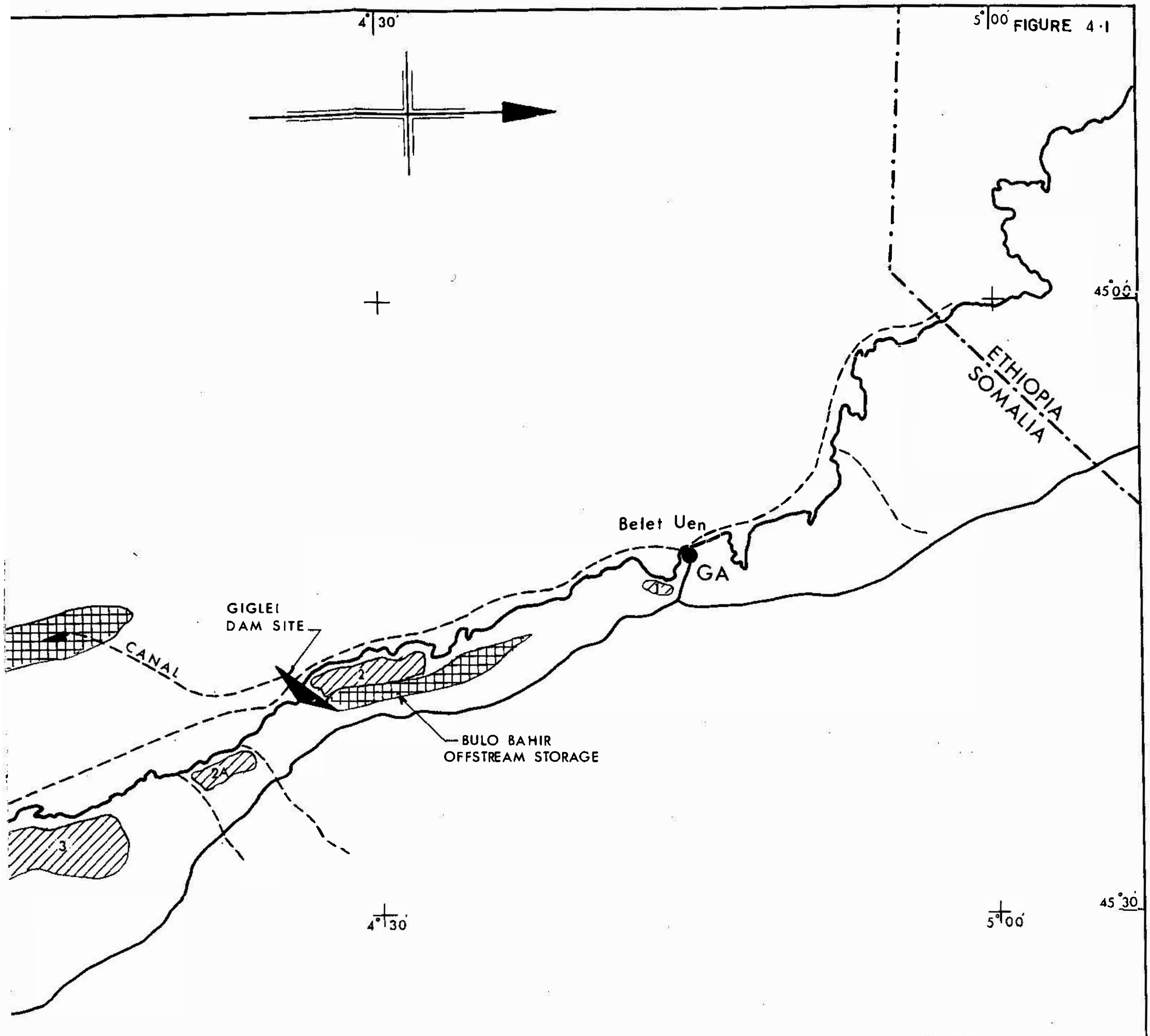
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Kilometres 5 0 5 10 15 20 25 30 35 40 45 50 kilometres

3° 30'

4° 00'

FIGURE 4·1



SOMALI REPUBLIC & UNITED NATIONS DEVELOPMENT PROGRAMME	
THE WATER CONTROL AND MANAGEMENT OF THE SHEBELLI RIVER	
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS	
FUTURE DEVELOPMENT AREAS AND STORAGE SITES INVESTIGATED	
SCALE AS SHOWN	
SERIAL No. SOM 28	HUNTING TECHNICAL SERVICES LIMITED *LAND USE & AGRICULTURAL CONSULTANTS* 6, ELSTREE WAY, BOREHAM WOOD. HERTS., ENGLAND. in Association with SIR M. MACDONALD & PARTNERS *CONSULTING ENGINEERS* HANOVER HOUSE, 73 HIGH HOLBORN, LONDON W.C.I.
PRINTED NOVEMBER 1969	
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CHAPTER 5

CLIMATE AND METHODS OF CALCULATING CROP WATER USE

5.1 Rainfall

The clirnate of the Shebelli Valley ranges from tropical semi-arid near the coast to tropical arid in the region of the Ethiopian border. Annual rainfall averages about 500 mm in the Johar, Balad, Afgoi, Genale areas and decreases northwards to about 200 mm at Belet Uen. Rainfall is very variable in amount from year to year and is mostly distributed in two distinct seasons associated with the passing of this inter tropical front. In the vicinity of Balad, Afgoi and Genale, these wet seasons occur in April to June, and October to December, locally called the 'Gu' and 'Der' seasons respectively. In addition, coastal showers locally called 'Hagai' rains occur during July and August, amounts being greatest near the coast. Hence Genale receives about three times and Afgoi about twice as much rain as Balad in these months. North of Johar, the rainy seasons are of shorter duration and rainfall in the 'Hagai' season is negligible. At Belet Uen, the 'Gu' rains occur in April-May and the 'Der' rains in October-November only. The seasonal precipitation for selected stations is shown in Table 5.1.

TABLE 5.1 Rainfall at Selected Stations in mms

Station	Years of Records	Mean Rainfall			Wettest	Driest
		'Gu' season	'Der' season	Annual		
Belet Uen	34	108	85	227	446	44
Bulo Burti	25	144	161	349	711	96
Mahaddei Uen	10	163	192	459	1171	226
Johar	40	206	209	497	1089	236
Balad	25	209	220	507	959	276
Afgoi	26	237	173	503	975	192
Genale	20	230	112	472	1045	149
Gelib (Alessandra)	20	304	183	586	944	415

The fact that rainfall is distributed in two seasons, the relatively small amounts of rain in these seasons and the great variability in rainfall from year to year place a severe limitation on crop production under rainland conditions of farming. An analysis of rainfall expectation for each of the two cropping seasons was made for selected stations. Probability graphs, Figure 5.1, were produced showing the accumulated precipitation during the seasons in relation to frequency of occurrence. The results indicated that stations having a mean annual rainfall of some 500 mm are likely to suffer a partial or complete failure of one raingrown crop due solely to inadequate rainfall as frequently as two years in five. Under such conditions, attempts to increase raingrown crop yields by means of costly inputs for mechanisation, fertiliser and pest and disease control are questionable.

5.2 Other Climatic Factors

Temperatures in the Shebelli Valley remain relatively uniform. The hottest periods are February-April and October-November. Mean monthly maximum and minimum temperatures for selected stations are shown in Table 5.2.

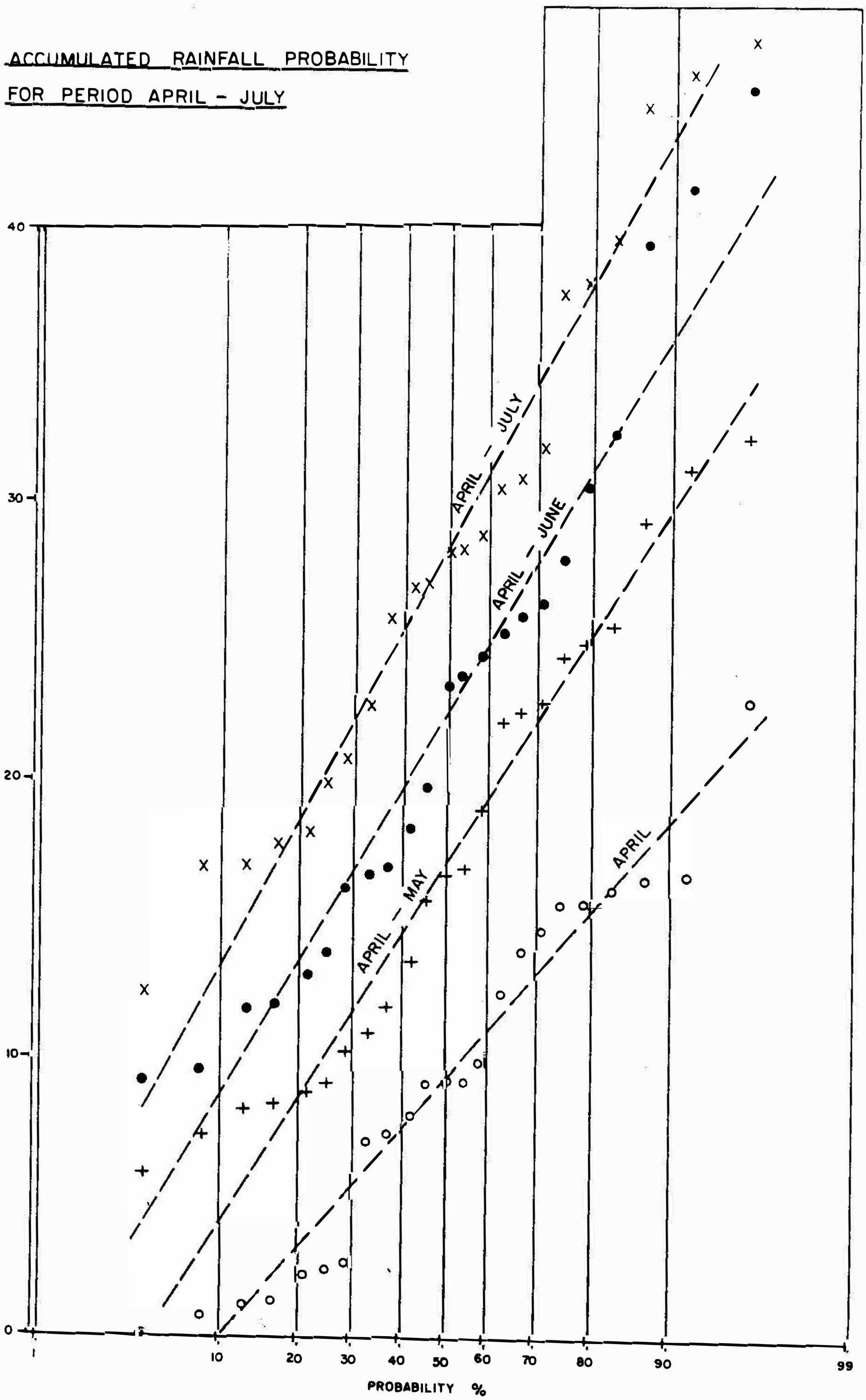
TABLE 5.2 Mean monthly maximum and minimum temperature for selected stations in °C

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Belet Uen												
Maximum	34.5	35.4	36.7	36.9	34.9	34.0	33.0	33.8	35.3	34.4	34.8	34.5
Minimum	22.0	22.0	23.4	23.9	23.4	22.8	22.6	21.6	22.7	22.6	22.3	22.3
Afgoi												
Maximum	33.7	33.4	34.8	34.1	31.7	30.5	28.4	30.1	31.1	32.0	31.9	32.5
Minimum	21.7	21.9	23.0	23.6	23.2	22.7	21.5	21.5	21.8	22.1	21.9	21.7
Gelib (Alessandra)												
Maximum	35.1	35.6	36.0	35.5	33.4	32.1	30.5	31.3	32.4	33.1	33.8	34.5
Minimum	22.2	21.8	22.4	23.1	23.0	21.4	20.6	20.3	20.4	21.5	22.1	21.9

Figure 5·1

ACCUMULATED RAINFALL PROBABILITY

FOR PERIOD APRIL - JULY



Relative humidity is highest near the coast and decreases further inland. Highest humidity occurs at the end of the 'Gu' rains and during the 'Hagai' season. Monthly mean humidity for selected stations is shown in Table 5. 3.

TABLE 5. 3 Monthly mean relative humidity (per cent) for selected stations

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Belet Uen	58	57	57	60	64	61	65	64	59	64	63	62
Afgoi	65	64	66	69	73	75	74	72	69	68	68	68
Gelib	68	67	66	72	78	78	77	75	72	73	76	74

The North-east Monsoon which blows from January to March and the South-west Monsoon from July to September have an ameliorating effect on the climate at these seasons. Previous records of wind speed are appreciably lower than those recorded at Afgoi during 1968 which are shown in Table 5. 4. The mean wind velocity during both monsoon seasons appears to be about 3. 5 m/sec. or 300 km/day at 2 m above ground level.

TABLE 5. 4 Monthly mean wind velocity at 2 m recorded at Afgoi during 1968

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Km/day	269	347	306	196	205	143	324	305	312	248	144	204
m/sec	3. 1	4. 0	3. 5	2. 3	2. 4	1. 7	3. 7	3. 5	3. 6	2. 9	1. 7	2. 4

Reliable records for Solar radiation were not available for the Shebelli Valley. Sunshine hours and Solar radiation using a Gunn Bellanni Distollometer were recorded at Afgoi during the period 1968 and these results are shown in Table 5. 5.

TABLE 5.5 Mean values of Solar radiation at Afgoi during 1968

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Mean daily Sunshine Hours	8.2	9.1	8.1	5.2	6.4	6.9	5.9	8.0	8.9	6.8	4.5	6.5
Mean daily radiation (Langleys)	580	611	575	470	484	511	481	533	575	522	409	425

The total sunshine recorded during the year was 2567 hours and the mean daily radiation was 516 Langleys. These may be compared with values of 3082 hours and 577 Langleys previously recorded for Mogadiscio.

5.3 The Estimation of Crop Irrigation Requirements

Where factual information is inadequate for the calculation of irrigation requirements for crops in a proposed rotation, it is necessary to estimate irrigation needs by reverting to meteorological data. The basic data on such factors as insolation, wind, temperature and humidity may be used to calculate an estimate of evaporation using any one of the various formulae which have been developed for this purpose. Alternatively, where reliable measurements of pan evaporation are available, these may be used directly as a basis for calculating crop water requirements. The available meteorological data in the Shebelli Valley area is very limited and until the inception of the present project, no reliable pan evaporation measurements had been made. Data from a meteorological station established during the course of the project at the Afgoi Research Station has been used for the estimation of evaporation.

The data from the Afgoi meteorological station comprising solar insolation, wind, temperature and humidity was used to obtain 5 day means which were then used to calculate evaporation using a method based upon that evolved by Penman. The original Penman formula for the estimation of open water evaporation (E_o) has been modified for use in East Africa

by Mc Culloch. This modified formula has been used with a further modification to the reflected radiation component (originally proposed by Penman in his paper on the Woburn Abbey trials) whereby the theoretical evaporation from a uniform turf sward may be estimated directly. This theoretical evaporation from turf (E_t) should in theory also apply to any other uniform and complete crop cover having similar surface characteristics.

Where cover is incomplete, as in the case of young growing crops and where surface conditions of reflectivity and roughness differ from those of the standard turf sward, an empirical crop factor (k) may be used to adjust the E_t value and the resulting evaporation from the crop surface under consideration is referred to as the crop evaporation (E_c).

The theoretical crop evaporation E_c assumes that the plants are able to draw their moisture supply from a soil where moisture stress is not a limiting factor. Numerous workers have shown that where moisture stress conditions exist in the soil, the crop may no longer be able to meet the water demands for the theoretical crop evaporation. When this condition arises, the plants wilt and evaporation then is at a much reduced rate due to the closing of the stomata. The point at which this loss of turgor occurs depends not only on the soil moisture stress which is a function of soil moisture content, but also on the magnitude of the crop evaporation demand. Thus a soil stress condition which would result in turgor loss, when the E_c was six millimetres per day, might have no effect on plant turgor with a smaller demand of 3 millimetres per day. Research by Denmead and Shaw demonstrated the effect of different values of crop evaporation demand on the turgor loss point measured in terms of soil suction. Using curves derived from those of Denmead and Shaw it is possible to apply a correction to the crop evaporation for the degree of soil moisture depletion when the moisture retention characteristics of the soil are known. The result provides an estimate of the actual evaporation from the growing crop (E_a).

The frequency of irrigation and the crop water requirement may be estimated using a mathematical model in which the above procedures are used to calculate a daily water balance. Effective rainfall is taken into account in the calculations. Whilst a soil at field capacity provides the optimum moisture conditions for crop growth, in practice other considerations prevent this condition being maintained. Moisture stresses up to about two atmospheres suction do not seriously affect crop yield and except during certain crucial stages of development, crop yield may not be seriously reduced if moisture stresses are permitted to rise to three or even four atmospheres suction before irrigation is applied. It is thus possible in the water balance model to use predetermined levels of moisture stress, which may be varied for different stages of growth to determine when irrigation water should be applied.

When the predetermined soil moisture deficit at which irrigation is necessary has been reached in the water balance model, an irrigation is assumed and the quantity of water required per unit area is determined.

The water applied should include not only that required to return the soil moisture content within the crop root zone to field capacity, but also to increase the depth of soil wetted to field capacity to provide reserves for future exploitation by the downward spread of roots of the crop. The sum of the two amounts is increased by an efficiency factor which makes allowance for losses due to evaporation during and immediately after the application of irrigation water to the field, surface run-off to drains and deep percolation below the root zone eventually to be exploited by crop roots at maturity. This efficiency factor has been taken as 85 per cent when less than the ultimate rooting depth of the crop has been wetted and 66 per cent after complete wetting of the zone of ultimate rooting.

The calculation described provides an estimate of the field irrigation requirements throughout the crop growing season. The estimate does not include losses from canals and water courses which must be added to obtain the full irrigation requirement at the headworks.

An alternative method of estimating crop water requirements is that developed by Blaney and Criddle. The method has the disadvantage that

the only climatic parameter used in the estimate is that of temperature. In a country such as Somalia where seasonal temperature variations are relatively small, estimates of crop water use show little variation between humid wet season and arid dry season conditions. Whilst the method is unsatisfactory in such circumstances for estimating short term crop water use, it does provide a reasonable estimate of use over the entire growing season of a crop. As such it can provide a check on the seasonal water use estimate using the more involved method described above. Where only seasonal consumptive use is required as in the case of rainfed or flood irrigated crops the Blaney and Criddle method is quite satisfactory and very much more simple to calculate.

The Blaney and Criddle estimate of consumptive use is derived from the formula

$$U = E\frac{tp}{100} \times K$$

when U is the seasonal consumptive use of the crop

t is the mean temperature in ^{o}F for each month of the growing season

p is the percentage of daytime hours for each month of the crop growing season and is a function of latitude

K is an empirical seasonal coefficient for the specific crop and resembles the K coefficients in the previously described method

Seasonal crop coefficients have been derived experimentally for a wide range of crops. Having derived the consumptive use value the irrigation requirement is obtained by deducting effective rainfall expectation for the crop season and any carry over of moisture reserves in the soil where this is applicable.

5.4 Availability and Quality of Irrigation Water

No storage facilities now exist along the river hence water supplies for irrigation purposes are both intermittent and unpredictable.

The River flow fluctuation at Belet Uen ranges from less than 10 cumecs to the 380 cumecs recorded in December 1961. In general the high flows in the 'Gu' flood which occurs from April to May are of short duration whilst in the 'Der' flood, during August to December, the high flows are usually sustained. The low flow period with the flow less than 10 cumecs is usually of about two months duration but can extend up to five months or in a good year last less than two weeks. The inflow to the river from the catchment in Somalia all occurs between Belet Uen abd Bulo Burti and accounted for approximately ten per cent of the total annual flow in 1968.

The natural topography of the riverain areas from Belet Uen to Mahaddei Uen results in flood flow self regulation being achieved. High flows are lost through overbank spillage and through the small primitive inundation canal systems. The artificial river control upstream of the weir of the Johar Sugar Estate (S. N. A. I.) causes high flood stage levels and this is not complemented by adequate flood bank maintenance so that spillage also occurs in the reach below Mahaddei Uen. Further spillage again takes place between Johar and Balad. In 1968, the largest record annual flow since records were taken in 1951, 70 per cent of the spillage took place between Gialalassi and Balad and a further 23 per cent in the Audegle - Genale reach of the river.

Examination of analysis results for river water samples taken by the Afgoi Research Station and further analyses made during the course of the present project indicated that water quality is good. No salinity hazard would arise from use of river water for irrigation of crops except during the first flush of the 'Gu' season flood. At this time high salts content occurs but does not last for more than ten days. To avoid crop damage if river water is used for irrigation during April, regular conductivity analyses should be carried out and no water should be abstracted when salt content is above the accepted maximum tolerance for the crops.

CHAPTER 6

PRESENT AGRICULTURE

6.1 Rainfed Agriculture

Extensive areas of this type of agriculture are found around all the main settlements along the Shebelli River downstream of Bulo Burti. Upstream of Bulo Burti rainfall quickly decreases to a level at which it will not usually support normal annual crop growth. Many of the people engaged in rainfed agriculture along the river are Bantu, although an increasing number of nomadic Somali have taken up settled arable agriculture in recent years. Farms are operated as family units with occasional hired labour at planting and harvest times and holding size, according to the Agriculture and Water Survey Report which covered the whole of the Shebelli and Jube Rivers and inter river area, varies between 1 ha and 100 ha with an average of 15 ha. A study of farms in an area west of Afgoi made during the present project showed holdings to vary between 0.1 and 5.7 ha with an average size of 2.3 ha and it is apparent that this is fairly typical of riverain holdings in the area downstream of Bulo Burti. Shifting cultivation is practised but there does not appear to be a regular or progressive movement in any of the areas examined.

a) Land Preparation

The traditional method of cultivation is still widely used. The soil is tilled with a 'jambo', a light-weight, short-shafted (70-90 cm in length) hoe with a blade of approximately 10 cm in width. Depth of cultivation is not more than 5-8 cm. As a water conservation measure, the loose surface is moved with a wooden tool, known as a 'kewawa', to form ridges enclosing square or rectangular patches of flat ground (known as 'mos' and of 4-10 sq. m in area) within which the crop is planted. Land preparation is usually carried out on a dry, cracked soil and much of the surface mulch or tilth is used in making the ridges.

In such conditions the seed-bed is completely free of weeds. Dry planting, in anticipation of the rains, is often practised.

Ox-cultivation in the vicinity of the river is precluded by the presence of the tsetse fly the vector of bovine trypanosomaisis in most areas. Machinery may be hired from the quasi-Government organisation O.N.A.T. (Organizzazione Nazionale Automezzi e Trattori). Although this organisation has made good progress in increasing the volume of its land preparation work since it began operating in 1963, the use of this service by the Somali farmer is very much restricted by the lack of ready cash and the absence of credit facilities. The uncertainty of dry-land cropping previously referred to make the provision of credit facilities for land preparation an extremely risky proposition and this factor may account for the lack of Government interest in this direction.

b) Cropping System

There are two recognised cropping seasons in rainfed agriculture:

(i) Planting in April-May during the 'Gu' rains.

(ii) Planting in October during the 'Der' rains.

The seasonal distribution and variability of rainfall have already been described in Chapter 5 where it was noted that the 'Gu' rains are generally more reliable and of longer duration, particularly in coastal areas which receive the 'Hagai' showers of July. Moreover during the growing season of crops planted at the beginning of the 'Gu' rains, rates of evaporation are much lower than during the growing season of crops planted in the 'Der' rains. Thus the chances of crop failure due to drought are generally much less in the 'Gu' season and it is for this reason that greater emphasis is placed on cropping at this time of year.

Maize is the major 'Gu' season crop under rainfed conditions along the Shebelli, being planted in April and harvested in July or early August. It is commonly interplanted with green gram (Phaseolus mung), cowpea (Vigna sinensis), sesame, local cherry-type tomatoes, pumpkin and

squash or gourds. Cotton may also be interplanted in the maize crop. Considerable areas of pure stand maize were observed in the 1968 'Gu' season; groundnuts, where grown, are usually planted in this season.

Sorghum is the major 'Der' season crop and, like maize, it is commonly interplanted. Sesame is also widely grown in this season, usually in pure stand.

In the Afgoi and Genale areas significant rainfall can occur during late June and July and in favourable years a crop of sesame is obtained which is planted in the maturing 'Gu' rains maize crop and harvested before the mid-October planting of the 'Der' season sorghum crop. Three crops in one year may thus be obtained in years of good well-distributed rainfall, as happened in 1968.

The cotton crop, although planted in the 'Gu' season is often left in the ground to grow through the following 'Der' season and this results in two harvesting periods, the first in August and September and the second in December, January and February.

No recognisable crop rotation is practised in rainfed agriculture at the present time. Production levels are generally very low and consequently the rate of decline in soil fertility is gradual.

c) Crops and Cultivation Methods

(i) Maize

Only the local variety of maize is grown and, until the recent mass selection programme and variety trials carried out at the Afgoi Research Station, very little effort had been made to develop or introduce improved varieties. Encouraging results have been obtained with mass selection of the local variety but seed is not yet available for general distribution to farmers. Some cob selection for seed is carried out by the farmers themselves but it does not appear to be general practice.

The local unimproved maize has a white flint-type grain but usually contains a sprinkling of coloured grains of varying shades of purple, red and yellow. The time taken from planting to maturity is approximately 120 days.

Maize is planted in rows, approximately 1 m apart, within the 'mos', the planting holes in the row are usually ½ m apart. 4-5 seeds are planted per hole and no thinning is carried out. Interplanting with other crops is usually carried out a few days after the maize has been planted.

The major factor limiting yields of maize, apart from moisture stress, is the stalkborer of which two main types appear to be present, namely Chilo spp. and Desamia spp. No attempt is made to control these pests.

Little information is available on the yields of maize obtained in the rainfed farming areas of the Shebelli flood plain. It is estimated, however, that overall average yields do not exceed 400-500 kg per ha. In 1963, according to the Agriculture and Water Survey Report, the average yield was 657 kg per ha in a year of favourable rainfall, but this relatively high yield must be considered along with years of virtual crop failure which are not uncommon. In the years of poor rainfall when grain production is likely to be negligible, maize may be harvested as a fodder crop and sold to cattle owners.

(ii) Sorghum

Three local 'varieties' of sorghum are recognised in the central part of Somalia, namely red, Aburas and white. Aburas is a mixture of red and white grained plants. The red and Aburas 'varieties' are widely grown along the Shebelli River but the white variety is rarely seen in this area. All three varieties have a similar growth habit (average height 8-9 feet) and panicle type which may be described as dense, tightly-packed, conical to oval in shape, and inverted (i.e. goose-necked).

Sorghum is usually planted irregularly with a spacing approximating to 1 m on the square; 4-6 seeds are planted per hole. Interplanting with other crops is commonly practised. The crop matures in approximately 120 days.

Harvesting is carried out by hand; the panicles are cut at the 'neck' and placed in storage pits in the ground. These pits are lined with stover and after filling, they are covered over with soil. Sorghum may be stored for up to 3 years by this method with relatively small losses. Maize cobs may also be stored in this way.

The sorghum stover is nearly all used for stock feed. At the time of grain maturity the stalks are still in a succulent condition and the feeding value, in terms of carbohydrates, appears to be quite high. After harvest the young tillers are often allowed to grow on and a small ratoon grain crop may be possible. If moisture is limiting and grain production seems unlikely, the ratoon growth is used as stock feed.

Sorghum is customarily planted in the 'Der' season in the riverain areas; the reason put forward for this season of planting is the fact that the much-preferred and often higher-priced maize crop can be grown successfully in most 'Gu' seasons but not in the 'Der'. Observations made in 1968 indicate that this may not be the only reason. Sorghum grown in the 'Gu' season of 1968 suffered badly from pest attacks including the sorghum midge and shoot fly. It is worth noting that in the main sorghum producing areas away from the river the crop is grown during the 'Gu' season.

The yields of sorghum obtained by farmers must vary tremendously from year to year and it is unlikely that the overall average yield exceeds 300-400 kg per ha. Moisture stress will inevitably occur at some period during crop growth in most years and this factor will have an adverse effect on crop yield. Other

major limiting factors include birds (Quelea quelea), stalkborers (Chilo spp. and Desamia spp.), loose smut (Sphacelotheca cruenta) and covered smut (Sphacelotheca sorghii). The farmer and his family spend many hours during the crop ripening period scaring away birds. No effort is made to control or reduce the effects of the other limiting factors. The practice of allowing ratoon growth means that high stalkborer populations are maintained through much of the dry season.

(iii) Sesame

After the staple food crops, maize and sorghum, the next in importance along the Shebelli river is undoubtedly sesame which is the country's main source of vegetable oil. There is only one variety or type of sesame in the area; this is a branched variety with a bushy appearance, growing to a height of 3-4 feet; it is white-flowered and the dehiscent capsules usually have 4 locules although occasional plants with 8-locule capsules may be found. Seed colour is variable, mainly white to yellowish brown but containing a sizeable proportion of brown to dark-brown seeds. Time taken from planting to harvest is approximately 90 days.

Pure stand sesame is normally sown in holes with 5-15 seeds per hole; spacing is irregular but holes are usually 0.5-1.0 m apart. No thinning is carried out but in effect the 3 or 5 move vigorous plants in each hole smother the remainder in the early stages of crop growth.

Sesame is usually planted towards the end of the rains to avoid wet conditions during the period of most rapid vegetative growth, flowering and fruit development. If wet conditions do prevail over this period leaf diseases, bacterial leaf spot (Pseudomonas sesami) and Crecospera leaf spot, can have a serious adverse effect on yield and pest damage is likely to be greater. The major pest of sesame is the leaf roller (Antigastria catalalunalis) which retards the development of young shoots, causes young buds to fall off and damages developing capsules.

The crop is harvested when the lower capsules have begun to open and leaf fall is nearly complete. The main stem is cut a few inches above ground level and the plants are placed in stooks to dry out. Threshing usually takes place after about two weeks good weather drying. Because the capsules shatter very readily the threshing operation must be carried out near the stooks.

Yields of sesame in rainfed agriculture along the Shebelli average between 250-350 kg per ha under normal conditions. On the other hand sesame is often interplanted in a maturing maize or sorghum crop towards the end of the rains when the level of stored soil moisture is low and the risk of crop failure is high.

(iv) Cotton

Only a small acreage of this crop is grown along the Shebelli River at the present time. Efforts have been made in the last two years to expand the area under cotton to meet the demand of the new Balad textile factory but without any marked success. Imported seed of Acala and Carolina Queen varieties was distributed in a number of areas; however the application of insecticides to the crop was not effectively carried out due to inadequate extension effort and the performance of both varieties was far from satisfactory. Small areas of long staple cotton, which was widely grown until the late 1950's, are still grown, although occasionally mixed with medium staple varieties.

Rainfed cotton is planted early in the 'Gu' season i.e. April or May at a spacing of 1 m x 0.5 m. Up to a dozen undelinted seeds are planted per hole; thinning to 2-3 plants is carried out some 3-5 weeks after planting.

Insect pests cause extensive damage in the cotton crop and are largely responsible for the extremely low yields obtained by the Somali farmers. The most important cotton pests include pink bollworm (Platydera gossypiella), spiny bollworm (Earias spp.), American bollworm (Heliothis armigera), the stainers (Dysdercus cardinalis and Oxycaraenus hyalinipennis), aphids (Aphis gossypii) and jassids (Empoasca facialis). Little attempt is made to control these pests despite the existence of a plant protection service, within the Ministry of Agriculture. The disease known as 'blackarm' or 'bacterial blight' (Xanthomonas malvacearum) is widespread in Somali cotton and obviously has some adverse effect on yield.

Harvesting of both medium and long staple varieties usually takes place in August, September and early October. The 'Der' rains follow in late October and November and the cotton continues to grow. A second harvesting is then possible during late December, January and February. The cotton is often left in the ground until the land is required for another crop and this usually means that a new cotton crop is growing before the old crop has been removed. Such a practice favours the maintenance of high pest populations and constitutes the main reason for the serious pink bollworm problem which now exists. The Ministry of Agriculture has, under legislation passed in 1957, the power to define and enforce time limits for planting the cotton crop and to fix the last date for uprooting and burning the cotton stalks. These powers are not exercised and the opportunity for effecting some insect control is lost.

The cotton crop is ravaged by the lack of controlled insect pests and the extremely poor performance of the crop is not therefore surprising. Yields rarely exceed 500 kg per ha of seed cotton and the annual average is thought to lie between 300-400 kg per ha in the Shebelli Flood Plain.

(v) Cowpea (Vigna sinensis)

This crop is widely grown along the Shebelli River in both 'Gu' and 'Der' season. Customarily interplanted with maize or sorghum it appears to have considerable drought resistance and yields well in the dry conditions which prevail after the maize or sorghum have been harvested. Occasionally it is grown in pure stand but only in small plots.

Both green pods and mature seed are eaten by the people and it is an important source of protein for the farmers who do not keep livestock. Cowpeas are sold on the local markets.

(vi) Green gram (Phaseolus mungo)

This crop is widely grown in both 'Gu' and 'Der' seasons and is usually interplanted in maize or sorghum. During 1968 the crop seemed to suffer little from pests and diseases. It grows quickly and the time from planting to completion of harvesting is approximately 110 days. The Somali green gram is relatively large seeded and pods may be in excess of 12 cm in length. No information is available on the yields obtained by local farmers but in a trial carried at the Afgoi Research Station in the 1966 'Gu' season the local variety of green gram produced the outstanding yield of 1, 274 kg per ha under irrigation. Green gram is well liked by the local people and is a valuable source of vegetable protein.

(vii) Tomato

A local cherry-type of tomato is very popular in most areas under rainfed agriculture. This crop is usually interplanted in maize and sorghum and will produce yields on low rainfall. This variety seems to be remarkably resistant to pests and diseases which attack the large fruited exotic varieties. Considerable quantities are sold on the local markets.

(viii) Sweet Potato

This crop is of relatively minor importance and is not very much liked by the local people. It is grown on a small scale, usually interplanted. Small quantities are found on the local markets.

(ix) Pumpkin and Squash

These two cucurbits can be found in most fields inter-planted in maize, sorghum or sesame. They are grown mainly in the 'Der' season and, as they can be stored, provide a welcome variation in the diet during the dry season.

(x) Groundnuts

Groundnuts are not grown extensively in the Shebelli flood plain at the present time. Only six small plots were seen in 1968 and of the large numbers of farmers interviewed only a small number had tried to grow the crop in the past. Groundnuts were grown under irrigation by the Italian settlers during the 1930's and 1950's and the reasons why the crop has never become popular with the Somali farmers are not altogether clear, although the following factors may contribute to the lack of interest in the crop:

(i) The absence of any extension effort to introduce the crop to the farmers.

(ii) The poor performance of the crop in years of low rainfall.

(iii) Lack of marketing facilities.

(iv) High peak labour requirements.

(v) Crop losses due to bird damage, particularly the Ibis.

(xi) Miscellaneous Crops

Tobacco is grown in a number of areas along the Shebelli River in both 'Gu' and 'Der' seasons. It has a heavy-bodied leaf which is air-cured. The cured leaf is used for chewing and for making snuff. Production is usually sufficient to meet the local demand for tobacco of this type.

Pigeon pea (Cajanus cajan) has been observed growing in some areas but is not popular with the local people and is of little importance.

Chilli peppers are sometimes seen interplanted in maize or sorghum.

d) General Situation in Rainfed Agriculture

Rainfed agriculture in Somalia has been much neglected in the past and little real progress has been made in the introduction of improved methods of farming which could enable the farmer to obtain higher crop yields and thus raise his standard of living. Even simple methods of improving crop performance, such as timely planting, the use of good seed, proper spacing and crop sanitation etc., have yet to be adopted by the Somali farming community. Extension effort has obviously not been effective in the past and the immediate prospects for success in this field in the future are not bright. There is a serious lack of trained extension officers working in the Shebelli flood plain and the allocation of funds for agricultural extension work seems to have a low priority.

The high frequency of complete or partial crop failure due to drought in the rainfed farming areas does not encourage the introduction of new techniques which involve cash expenditure. It is for this reason that insecticides, fungicides and fertilisers are little used at the present time. Recent efforts to persuade farmers to apply insecticides to the cotton crop met with little success largely because farmers were not convinced that the increase in cash return would be sufficient to pay for the insecticide as well as giving extra profit.

The number of partial crop failures due to drought could be considerably reduced in two ways:

(i) By improving cultivation techniques to conserve the maximum amount of water in the soil.

(ii) By the introduction, or development within the country, of early-maturing drought-resistant crop varieties.

Little attempt has been made to investigate these possibilities. Supplies of improved seed are virtually non-existent with the exception of the imports of cotton seed made by the Agricultural Development Agency.

The frequency of crop failure due to drought precludes the introduction of costly sophisticated techniques which whilst giving improved returns in good years could be disastrous when rainfall is inadequate.

6.2 Pre-sowing Inundation

This type of irrigation is widely practised in convenient low lying areas along the Shebelli River from Belet Uen to south of Falcheiro. It is possible to irrigate by gravity because much of the valley lies below the level of the river which is contained by relatively high levees. In many parts small hand-dug dykes are constructed by the farmers to carry water to the adjacent fields. Crude control of the quantities flowing out by these dykes is maintained by placing sticks, grass or other barriers in the channel at the offtake from the river. A number of larger canals with properly constructed headworks and control structures were built during the Italian Trusteeship of the 1950's and these supply water for flooding areas more distant from the river. Such canals are found at Belet Uen, Buriole, Balad, Barire and Falcheiro.

In some areas, particularly around Gialalassi and Mahaddei Uen, use is made of the 'wild flooding' resulting from overbank spillage. Where this occurs, small canals and bunds may be constructed by the local farmers to obtain a more efficient distribution of water and to increase the area receiving floodwater.

a) Land Preparation

The small farmer usually commences land preparation around the middle of August and may continue until early October. The traditional tool, the 'jambo' is used to clear weed growth off the land and to prepare the bunds surrounding the fields and 'Hods'. Canal maintenance and reconstruction is also carried out at this time. The size of a ''hod' on these farms is rarely more than 0.1 ha.

In the large areas of inundation flooding, situated near to O.N.A.T. machinery pools, land preparation operations are being increasingly carried out by tractor. Ploughing to a depth of approximately 15-20 cm is followed by discing and finally bund construction may also be undertaken mechanically, however levelling is carried out. The size of 'hod' may be larger than 1 ha on flat land but is usually about 0.5 ha.

b) Irrigation Practice

It is normally only possible to abstract water from the river for inundation irrigation at high river flows which occur reliably from September through to December and also periodically in April, May and June. At the present time inundation irrigation is largely confined to the former period ('Der' season) and little use appears to be made of the water available in some years during the high river flows occurring in April, May and June.

The application of water to the land, by a system of small furrows, does not usually begin until early October, although in most years the river has risen sufficiently to allow water to be abstracted at the beginning of September. The amount of water applied is quite arbitrary

and varies considerably - standing water may be held on the land for periods varying between 3-4 days and 3-4 weeks. Because of the rather poor control of the quantities of water applied, optimum conditions are rarely achieved and average crop yields are only slightly better than those obtained in rainfed agriculture. The application of excess water is unavoidable in a system of inundation irrigation if large areas of land are to be covered in the absence of any provision for drainage of the surplus water. Since the areas which have been developed for this type of irrigation are low lying they are difficult to drain. The lack of proper drainage results in temporary waterlogging which may be prolonged in years of heavy 'Der' season rainfall. Where waterlogging is severe planting is often delayed until after the 'Der' rains have ended.

c) Cropping System

The most important crop grown at present under inundation flooding conditions is sesame. This crop will produce acceptable yields using only stored soil moisture (i.e. with no additional rainfall) which accounts for its popularity in areas where late availability of flood water and poor surface drainage result in a delay in planting until after the 'Der' rains of October and November have ended. Sesame is often interplanted with such crops as cow-peas, green gram, squash and pumpkin. Where early planting is possible, maize is commonly planted, even though the chances of failure are high; sorghum is also widely grown. Very little cotton is grown in the areas of inundation irrigation and groundnuts are conspicuous by their absence.

Rain grown crops are produced during the 'Gu' season as in the dryland farming areas. Monocropping with sesame appears to be a common practice in areas which are subject to waterlogging in the 'Der' rains and consequently are not fit to plant until mid-December.

d) Co-operative Societies

Co-operatives in the strict sense of the term are practically non-existent at the present. A number of farming organisations termed co-operatives are to be found along the Shebelli Valley which are based on the system of pre-sowing inundation irrigation. The origin and organisation of these 'co-operatives' is rather unique in that the finance required for the initial operations was provided in each case by an individual or group of individuals usually merchants. The individuals who provide money in this way are generally urban dwellers with surplus capital which they wish to invest in agriculture and at the same time help some of their relatives and friends by providing employment. The people who actually work on the farm obtain shares in the enterprise through their labour input. Distribution of profits at the end of the season is on a share basis.

6.3 Controlled Irrigation

a) Types of Controlled Irrigation

Gravity-fed controlled irrigation systems, made possible by the installation of control structures on the river, are to be found at Johar and in the Genale area. In the latter area river levels are maintained by three barrages, situated at Genale, Coriole and Falcheiro. Furrow irrigation is practised for all crops except bananas which are flood irrigated in a system of square basins or small beds.

Irrigation by the use of pumps is carried out in a number of areas along the river. The largest concentration of pumps is to be found in and around Afgoi where more than 50 small pump schemes are operating at the present time. Furrow irrigation is usual for all crops.

Estates growing perennial crops and using gravity-fed irrigation systems frequently possess pumps which are utilised to provide supplementary water, either from groundwater or surface reservoirs during the periods of low river flows. In the Genale area river water may not be available for up to 3 or more months during the dry 'Gilal' season.

b) Cropping

The crops grown under controlled irrigation at the present time are mainly perennial. Sugar cane is grown at Johar whilst Genale and Afgoi are the major centres of banana production on the Shebelli. Small plantations of grapefruit, limes and lemons are found in the three main areas of controlled irrigation and limited areas of paw-paw, coconuts, guava and mango are also grown.

The area of annual crops grown under controlled irrigation is very small and is mainly restricted to vegetable crops and maize. The main area of vegetable production is around Afgoi which is nearest to the major market of Mogadiscio. Vegetables produced include onions, tomatoes, carrots, cucumbers, lettuce, endive, peppers, cabbage, beetroot, beans, spinach, broccoli etc.

The Italian banana estates grew substantial areas of cotton and groundnuts under controlled irrigation until the early 1960's. At the present time estate production of these crops is negligible. There are a number of reasons for this decline in popularity the most important of which include:

i) Poor yields of both the above crops were being obtained due to the failure to make use of modern techniques and they produced insufficient returns to meet the rising labour costs.

ii) Shortage of labour at the critical periods of weeding and harvesting was a recurring problem.

iii) At about the same time returns from banana production increased considerably due mainly to the introduction of the Poyo variety and improved growing techniques.

The resultant specialisation in banana production was not, therefore, surprising. The difficulties now arising in the banana industry due to the closure of the Suez Canal and the uncertainties associated with the subsidised Italian market after the end of 1969 is causing estate owners to consider diversifying production once again.

The Johar Sugar Estate also produced considerable quantities of cotton and groundnuts under controlled irrigation until it became necessary to expand the area under cane to enable an increase in production to meet the rising domestic demand for this commodity.

c) Crops

i) Bananas

The banana is the most economically important crop grown in Somalia: exports to Italy accounting for 40 per cent of the total value of the country's exports. The crop is still mainly grown on estates owned or managed by Italians but there has been increasing Somali participation in recent years. There are approximately 6,000 ha under bananas in the Genale area and some 300-400 ha around Afgoi (the area may have declined somewhat since these estimates were made).

The local Juba variety was grown by all estates until the introduction of the Poyo variety from Ivory Coast in 1958-59. Many estates are now growing Poyo which is much more suited to commercial production than the local variety. It is less susceptible to damage during handling and transportation because of its tougher skin and appears to be more resistant to pests and

diseases in the field. Poyo is also producing higher yields than the Juba variety under the more intensive conditions of management of the present day.

Land preparation for the banana crop begins with ploughing to a depth of 50 cm - until recently the depth was usually 75 cm, but this was found to be lifting infertile sub-soil to the surface. Such deep ploughing gives good weed control and also ensures a good depth of well-aerated soil for the bananas to exploit. A single discing operation may follow on the heavier soils or where weed growth has begun. Furrows are then constructed at approximately 25 m intervals and bunding is carried out to divide the field into a large number of small basins, 25 m x 25 m in size. This basin system of irrigation has the advantage of not requiring constant levelling between successive crops.

The planting material used by the farmers may be either setts or suckers which are planted in the basin in holes. The optimum plant spacing for the Poyo variety has been shown in a recent Afgoi Research Station trial to be 2 m x 2 m and whilst this is commonly used on estates occasional farmers use 2 m x 3 m spacing. In the past the local Juba variety was grown at 3 m x 3 m or 4 m x 4 m spacing.

In the early stages of crop growth weed control between rows is maintained by mechanical discing with hand weeding within the row. As yet little use is made of herbicides.

Pruning or removal or young suckers is carried out at approximately 3-monthly intervals to allow only one stem to mature per stool at each time of harvesting.

Planting is usually carried out during the 'Der' rains and this season has a number of advantages. The crop has a low water requirement during the following dry season when weed control measures are also likely to be most effective.

The crop reaches peak water requirements in the 'Gu' rains and ground cover by the banana foliage is then almost complete thus tending to smother the inevitable weed growth. Also the dry conditions following planting encourage good root development in the young crop.

No information is available on the amounts of water applied to the banana crop and no attempts have been made to determine experimentally the water requirements of the crop in Shebelli flood plain conditions. However, the average irrigation interval is said to be 15-20 days although this obviously varies considerably depending upon rainfall, stage of crop growth and soil type. It is estimated that water is applied to a depth of 10-15 cm at each application. A basin system of irrigation is used, requiring considerable labour for the earthing-up and breaking of bunds; applications of water by this method cannot be made accurately and it was noted that there is a strong tendency to over-irrigate.

Soil salinity has led to the abandonment of considerable areas of land on the banana estates in the Genale area. Most of these areas have relatively heavy soils resulting in a rise in the water table over the years. The lack of drainage is thought to be largely responsible for the increase in soil salinity, whilst the use of saline water at low river flows has probably been an important contributory factor. Most estates cease irrigating for several days at the beginning of the rise in river flows occurring at the end of the dry season when the water is particularly saline. This is the only precaution taken to avoid increasing soil salinity.

During the dry season river flows may cease entirely at Genale and pumped groundwater or water stored in surface reservoirs has to be used to enable the banana crop to survive. The average period for using these alternative sources of water is about 60 days with a maximum period of over 100 days.

Fertilisers are now being used to an increasing extent on the banana crop. Applications of a compound fertiliser (N. P. K.) 10:5:20 were usual at rates up to 800 or 900 kg per ha per 3 year cycle but no experimental evidence has been discovered to support the economics of such high applications. Urea has also been used in considerable quantities by some estates in recent years. In a fertiliser trial carried out at the Afgoi Research Station applications of urea at rates up to 10 gm per stool every two months equivalent to 450 kg per ha over 3 years produced a very good response, although phosphate and potash had little effect.

Sigatoka disease (Cercospora musae) is the major field disease of bananas in Somalia. It becomes severe during the rainy seasons and control is achieved by the aerial application of a fungicidal oil as and when required. Banana rot (Gleosporium musarum and others) which develops during shipment to Italy has become a serious problem since the closure of the Suez Canal doubled the time taken for the journey from Somalia to 24 days. To date no serious pest problems are evident in the banana crop but Banana Borer (Cosmopolites sordidus) and the burrowing nematode (Radolphoulus similis) are becoming increasingly prevalent.

The first bunches of bananas are harvested approximately 9 months after the planting of the suckers. Harvesting continues over 3-4 years. The average yield of hands of bananas of the Poyo variety is estimated by S. A. C. A. at 230 quintals per ha per annum over the cropping cycle, whilst on the better managed estates 300 quintals per ha per annum are obtained.

After the 3-4 year cropping cycle the land is usually fallowed for at least two years. During this fallow period one or two crops of rainfed sunhemp (Crotolaria spp.) may be grown and ploughed in as a green manure. The need for a long fallow period is attributed by many estates to the decline in soil fertility which occurs during

the relatively short 3-4 year cropping period. However, in a report written in 1952 (U. N. T. A. P. The Trust Territory of Somaliland under Italian Administration) reference is made to the rotting of the stools of bananas in the 3rd and 4th years, caused by eelworm (Mauginia musae penso), as being the major reason for the short cropping cycle and the need for a long period to control eelworm populations. Another important benefit which might accrue from including a long fallow would be the leaching of salts by rainfall which had accumulated in the top soil during irrigation.

ii) Sugar Cane

There is only one sugar producing enterprise in Somalia, the Johar Sugar Estate (S. N. A. I.) which is situated on the Shebelli River some 90 km north west of Mogadiscio. It was established in the early 1920's by an Italian, the Duca di Abruzzi. Sugar has always been the main crop although until the early 1960's considerable areas of cotton and groundnuts were grown. The area under sugar during the late 1950's and until 1963 was approximately 2,000 ha. An expansion programme in both the field and factory was begun in 1963 with the object of making Somalia self-sufficient in sugar. By the end of 1969 some 6,000 ha of land will be under sugar cane. Over 95 per cent of the area is planted with the South African variety NCO 310.

Land preparation involves the ploughing of land to a depth of 45-50 cm using a Rome plough; this is followed by two disc-harrowings and a ridging operation. Ridges are 1.70 m apart.

Before planting all cane is heat treated as a precaution against virus diseases and 'Aretan' is applied to prevent fungal attack. Aldrin is occasionally used where termites are likely to cause damage. The cane setts which have 2-3 nodes, are placed in the furrows by hand. At the time the cane is planted,

gram seeds (Phaseolus mungo) are broadcast over the whole area and irrigation water applied. The legume quickly becomes established and shades out many of the slower growing weed species - it is particularly effective in controlling the serious nut grass (Cyperus spp.) problem in the early stages of cane growth. There are two main seasons for planting cane - May and June, and September and October. In the more favourable years gram will produce two crops as it is planted in a rainy season, matures and shatters in the following dry season and a volunteer seed crop is produced in the following rainy season. If re-growth of the cover crop is good no cultivations for weed control may be necessary. Where the initial establishment of gram is unsatisfactory inter-row cultivation is carried out by tractor as customarily in the ratoon cane. Weed control is necessary for 5-6 months by which time the leaf canopy closes. As yet herbicides are little used.

Two cultivations are carried out in one operation at the beginning of a ratoon crop immediately after harvest. The ridges are cut to a 30 cm top by two blades which turn the soil from the sides of the ridges into the furrow. A ripper is attached to the same tool bar which passes along the centre of the furrow penetrating to a depth of 50-60 cm. Weed control in the ratoon crop is maintained by inter-row cultivations by tractor and hand weeding within the row.

The application of water to sugar cane at Johar is by the accepted furrow system. No attempt has been made to calculate the crop water requirement or to measure the quantities applied. Irrigation practices are all based on experience. Estimates of rates of application are between 600 cu. m. and 1,200 cu. m. per ha depending on age of cane. The irrigation interval in dry conditions may vary between 30-35 days on heavier soils and 14-20 days on lighter soils.

In the last 10-15 years some 800 ha of land in close proximity to the factory have been abandoned due to soil salinity and this constitutes a considerable loss to the estate. Salinity problems occurred because the water table was allowed to rise, in many areas to within less than 0.5 m from the soil surface. The rise in the water table was obviously due to canal seepage, poor irrigation practices and the completely inadequate provision for drainage. Other areas of the estate are threatened by increasing salinity but the basic cause is now understood. The installation of pumps and the construction of new canals for the purpose of drainage is going ahead and it is hoped that the problem of salinity increase can be arrested.

A daily check on river water quality is maintained by laboratory staff at Johar and irrigation is stopped if the salt content of the water exceeds 700 p.p.m. of NaCl and providing the state of the crop permits. This limit is not necessarily adhered to in dry years when the philosophy that salt water is better than no water, persists. Water from surface reservoirs may be used to supplement river water in years of low flow. The river rarely dries up completely at Johar but at low flows the amount of water capable of abstraction is often considerably less than estate requirement and yields are reduced at the succeeding harvest.

The present estate fertiliser practice is to apply 4 quintals of urea (60 per cent N) per ha per crop, which is usually given in split dressings of equal amounts. The first application is made approximately 45 days after planting and the second application 150 days after planting (similarly for ratoon crop but after harvest). The total application may be increased to 5 quintals without affecting sugar content. Although soil analyses indicate that the soils tend to have low levels of potash no responses have been obtained to applications of potash or phosphate fertilisers.

There are no serious pests or diseases present at Johar which cause significant losses in cane yield. The main insect pests found include stem borers, leaf miner and mealy bug and the most common disease is red rot which is a secondary fungal attack in stems damaged by stalkborers. Ratoon stunting virus is suspected but its presence has not yet been confirmed.

It is usual practice to burn the cane before harvest. The cane is cut mainly by hand, however machines have been used with some success. Yields of plant cane cut at 12-13 months are of the order of 120 tons per ha on new land, 100 tons per ha on old land, and 70 tons per ha on saline areas. Overall average yield on the estate is now over 75 tons of cane per ha per annum. At this level of yield 6,000 ha will produce 450,000 tons of cane, which will occupy the factory for a grinding season of 230 days approximately. Daily grinding capacity of the factory is 2,000 tons. The sugar extraction rate averages about 10.5 per cent.

iii) Grapefruit

This crop has attracted considerable interest in the past few years and proposals for large scale development of grapefruit production have been drawn up both by E.C.M. representatives and by an F.A.O. expert working for the Agricultural Development Agency. In a report by Electro-conault (Stazione di Multiplicazione Vegetale) published in 1967 proposals were drawn up for the establishment of a seed farm which would include a large propagation unit for grapefruit. It is generally accepted that quality grapefruit can be produced in the Shebelli flood plain and that the crop has good future prospects as an export crop. Exports of

over 200 tons per annum were well received on the Italian market but this trade ceased with the closure of the Suez Canal and has not yet been revived.

In the Genale area there are approximately 200 ha of mature grapefruit trees, the Johar Sugar Estate has 50 ha and there are small plantations at Afgoi and in other areas of controlled irrigation. The original planting material was introduced from Italy and consisted of seeded varieties. Small importations of planting material of the Marsh Seedless variety were made in the late 1950's so that trees of this variety at Genale and Johar are just beginning to come into full production.

The rootstock used for nearly all Somali grapefruit has been sour orange. A few trees at Johar have rough lemon root-stock but as they are not yet producing fruit no comparison with the sour orange is valid.

Spacing of trees planted in the past varied between 6.0 m x 6.0 m and 6.0 m x 10.0 m spacing; it has recently become standard practice to plant at 10.0 x 10.0 m spacings. Transplanting is usually carried out at the beginning of either the 'Gu' or the 'Der' rains. The depth of planting holes varies considerably.

Grapefruit is nearly always interplanted in the first three or four years after transplanting, usually with maize and vegetables, and this helps to control weed growth. In the mature plantations an occasional light disc harrowing between rows and hand weeding within rows are carried out to control weed growth.

A system of furrow irrigation is used for grapefruit. The quantities of water applied to the crop are not measured but are determined arbitrarily according to the experience of the farmer. The estimated requirement of the mature grapefruit plantation during dry weather is an irrigation every 25 days applying 1,200-1,500 cu.m. per ha.

The grapefruit is generally regarded as being a crop with a low salt tolerance. Some evidence of toxicity symptons, typical of the response to soil salinity were observed, but were not as widespread as might be expected. This may be explained by the fact that most of the grapefruit has so far been planted on the lighter, more freely draining soils. None of the estates which were visited undertook any pruning of grapefruit trees nor were fertilisers applied.

Grafted trees, one year old at transplanting, produce the first fruits in 5-6 years. Full production is achieved by about the 12th year. The profitable life of a tree in the Shebelli flood plain with present standards of crop husbandry is estimated at 30-35 years. Yields of grapefruit from mature trees average between 100-150 kg per tree per annum produced mainly in two seasons - July to August, and December and January. Such yields are produced without the use of insecticides, but only 50 per cent of the fruits are suitable for export. Major pests in Somalia include the purple scale (Lepidosaphes beckii), rust mite (Phyllocoptura oleivora), citrus codling moth (Argyroploce leucotreta), citrus thrips (Scirtothrips citri), the long-tailed mealy bug (Pseudococcus adonidum) and citrus aphids. Recommendations for the control of citrus pests have been made by the Afgoi Research Station, but until export markets are opened up the use of insecticides is uneconomic.

iv) Limes and Lemons

A number of small plantations of both limes and lemons and many isolated trees are to be found along the river. They grow well despite the fact that irrigation is carried out very irregularly in most cases. Both limes and lemons are available in the markets throughout the year.

The origin of the varieties of the limes and lemons now grown was probably Italy. The quality of the limes is excellent, they are very fleshy and juicy, have a thin skin and contain few seeds. Thus they are well suited to commercial lime juice production. The lemons, on the other hand, are rather small, unattractive fruits, but nevertheless juicy, with good flavour, seedless and thin-skinned. They are satisfactory only for the local market.

v) Paw-Paw (Carica papaya)

This crop grown extremely well on the Shebelli flood plain soils under controlled irrigation. Limited areas are grown in Afgoi and Genale and they supply considerable quantities of fruit which are sold on the fresh-fruit market in Mogadiscio. Attempts were made to produce papain in the 1950's but they were unsuccessful due to lack of markets.

vi) Coconuts

A few small plantations of coconuts are to be found at Genale and occasional trees elsewhere along the river. The majority of nuts are sold in the green unripe state ('dafu'). Yields have been estimated at 70 nuts per tree per annum (Agriculture and Water Surveys Report) but 20-30 nuts per tree per annum would appear to be more realistic.

Coconut production for direct consumption is a very profitable business but once this demand has been satisfied irrigated coconuts are unlikely to be profitable.

vii) Guava

This fruit is very popular in the Johar area where a number of small plantations are found. In several plots trees were dying-off, probably due to increasing salinity of the soil.

viii) Avocado

This crop is said to have an export potential to European markets. A range of types were planted at the Johar Estate in 1958 and all are now producing fruit of reasonable quality. Grafted trees planted at the Afgoi Research Station in 1965 have made remarkable growth but are not yet bearing fruit. These two trial plots indicate that avocados can be grown successfully along the Shebelli and may prove economic at some future date.

d) General Situation in Areas of Controlled Irrigation

There is an air of despondency amongst banana farmers at the present time. The main source of their problems has been the closure of the Suez Canal, which resulted in higher freight rates coupled with serious losses due to banana hand rot, caused by the increased time taken from Somalia to Italy. Consequently, profit margins have been drastically reduced.

In the Genale area canal maintenance has been very much neglected in recent years and the distribution of water has become extremely inefficient. Large capital outlay will be required for canal dredging, renovation and renewal of control structures in the future. Such capital outlay can only be justified if maximum use is made of the land which the canals serve. There are many thousands of hectares of good irrigable land in the Genale area which are served by the canal systems, but which are not being farmed. No effort has been made in recent years to bring this land 'under the plough' and into production. A large part of these unused areas are in Italian-owned concessions and their reversion to the state may involve political difficulties and the payment of compensation. Nevertheless the wastage of a valuable resource should be questioned.

Similarly, in the Afgoi area there are several pump schemes which became derelict when the Italian concession owners returned to Italy soon after independence and which are now almost returned to natural bush. These areas could be reclaimed.

The Bulo Mererta canal, which is situated south of the Genale irrigated area, was constructed in 1957 and was designed to serve an area of at least 20,000 ha of land with good soils. The tremendous potential of this development has never been realised. Very little controlled irrigation is carried out from this canal although the area of inundation flooding before planting is considerable near the river. This sad state of affairs appears to have been largely due to lack of extension effort in teaching the people the methods of irrigated agriculture and in demonstrating the benefits, and also due to inability to enforce the necessary settler discipline. The main obstacle in the way of developing the Bulo Mererta canal now appears to be the fact that the settlers have established claims to much of the land and to persuade them to accept reorganisation at this stage is impossible in the present political climate.

6.4 Livestock

A sample survey of livestock in and adjacent to the Shebelli Valley was made during the course of the Agriculture and Water Surveys. The Shebelly Valley is subdivided into the Upper Shebelli Valley extending from the Ethiopian Border to Bulo Burti including the adjacent Mudugh Plain and Central Upland Plain regions and the Shebelli Flood Plain extending from Bulo Burti to Avai with the adjacent Elevated Plain and coastal dune regions. The present stocking rates of these areas indicated by the survey results are shown in Table 6.1.

TABLE 6.1 Present Livestock Rates in the Shebelli Valley and Adjacent Areas

Type of Animal	Region	Animals per sq. km.	Stocking Capacity sq. km.
Cattle	Central Upland Plain	3.2	8.0
	Upper Shebelli	3.2	5.3
	Mudugh Plain	3.1	5.7
	Elevated Plain	9.0	23.6
	Shebelli Flood Plain	10.4	32.0
	Coastal Dunes	8.1	11.4
Camels	Central Upland Plain	3.8	Unknown
	Upper Shebelli	4.5	"
	Mudugh Plain	4.3	"
	Elevated Plain	1.6	"
	Shebelli Flood Plain	4.7	"
	Coastal Dunes	3.6	"
Sheep & Goats	Central Upland Plain	7.7	"
	Upper Shebelli	25.1	"
	Mudugh Plain	24.3	"
	Elevated Plain	1.8	"
	Shebelli Flood Plain	10.3	"
	Coastal Dunes	26.8	"

The table shows the marked increase in the numbers of cattle in the lower part of the Shebelli Valley where high rainfall results in increased availability of grazing and where dry season water supplies are more assured. Sheep, goats and camels on the other hand are relatively uniformly distributed throughout the area. An estimate of the potential carrying capacity of the existing grazing in terms of cattle was made during the same survey. The figures are shown in Table 6.1 and the potential for increase in the Shebelli Flood Plain and adjacent Elevated Plain region is very marked and it is evident that factors other than availability of grazing are effective in limiting the numbers of cattle.

Livestock are to a very large extent owned by nomadic graziers and few animals are kept by the settled cultivators who live generally in villages within relatively easy reach of the river. The herding of stock in close proximity to the river whilst providing fairly sure year round supplies of drinking water for both animal and human consumption greatly increases the risk of trypanosoniasis infection of cattle. This is probably the main reason for the derth of animals kept by the settled peoples of the area. Even those settled farmers who do own cattle frequently graze them away from the village because of the fly menace.

The main problem facing the nomadic grazier at present is the limited availability of drinking water during dry weather. Animals are usually grazed near a water supply until this becomes exhausted, they then have to be moved a considerable distance to another water source. Water supplies are generally from wells or from surface storage tanks or 'Uars' in which run-off from surrounding areas is collected during the rains. During the later part of the dry season when the danger from tsetse fly is reduced, livestock are brought back to watering places on the river. The limited number of watering points away from the river results in acute over-grazing of the adjacent range whilst large areas remain under-utilised. Provision of an increased number of 'uars' and wells has so far done little to alleviate the area of overgrazed range.

Although the nomadic people have a long tradition of livestock husbandry and the quality of the local cattle is good, there has been little success so far in the introduction of improved methods of management in the livestock industry. Market outlets for beef, camels, sheep and goats have been developed with a substantial export trade to the Arabian Gulf States as well as considerable cattle movements over the Kenya border. Unfortunately the latter trade has been uncontrolled until very recent times and results in a considerable loss of potential export revenue to the country.

The present markets for livestock have not been selective for quality. As a result a large proportion of cattle exports have been immature males. This is reflected in the present preponderance of females in the herds and there is a likelihood that this will result in a fall off in breeding rate in the immediate future. During 1969 an attempt was made to introduce buying by weight at the Kismayu canning factory. If successful this may result in a fundamental change in the livestock industry if a premium can be placed on well finished mature animals, the sale of immature beasts should decline. Moreover the possibility of establishing finishing lots on which mature animals off the range are fattened before marketing is opened up.

Major cattle diseases include trypanosomaisis, rinderpest, bovine pleuropneumonia and anthrax. Veterinary services have in the past been inadequate and the problems of large widespread herds, coupled with poor to non-existent communications and the lack of education among the nomadic people makes the establishment of satisfactory veterinary facilities extremely difficult. Currently a programme for innoculation to eradicate rinderpest is underway and a gradual expansion of veterinary facilities is planned. The establishment of a Government Training School for Animal Health Assistants will provide the staff for this expansion but any such programme involving such a vast area must be aimed at long term rather than short term benefits.

The best method of improving the utilisation of available grazing in the Shebelli Valley and adjacent areas would appear to be a more strict control of cattle watering places coupled with a carefully planned increase in the number of wells and 'uars'. By controlling the number of animals using a series of watering points and restricting the period during which an individual well or 'uar' is used, a system of rotational grazing should be possible. By such means overgrazing could be eliminated and the dry season grazing areas extended. The introduction of such controls are certain to cause difficulties over traditional water rights and customs but until such control is established other measures to increase livestock production in Somalia are unlikely to prove wholly successful. The rearing of cattle on open range is and will continue to be the most economic method of providing stock for fattening in Somalia. Regardless of the specific livestock husbandry methods which may be introduced for subsequent finishing of beef animals for market, any particular system will depend upon the continued supply of suitable animals by the range graziers.

The next logical step concerns the establishment of buying and holding centres at strategic points to which the graziers will bring their animals for sale. These centres could also provide veterinary facilities for the graziers herds, in addition the introduction of such centres would largely eliminate the difficult communications problems for the provision of vaccination and other veterinary services, including services to the grazier. Animals purchased at the centres could be classified and held until ready for dispatch to finishing lots or market.

Fattening of cattle on seasonally flooded areas adjacent to the river would appear practicable during the dry season provided the tsetse fly problem could be overcome by clearing of infested bush. Animals purchased off the range at the end of the rains are likely to be in prime condition. The utilisation of crop residues for fattening of cattle is worthy of consideration.

CHAPTER 7

SOCIO-AGRO-ECONOMIC SURVEY OF RAINFED AGRICULTURE IN THE AFGOI AREA

7.1 Population in the Survey Area

In order to assess existing production in the area selected for the controlled irrigation feasibility study and in order to investigate the labour inputs of rainland farmers, a socio-economic survey was carried out in villages within, and adjacent to the Afgoi-Mordile Project area.

Permanent settlement in the Afgoi-Mordile Project area proper consists of two villages, Idamoun and Bulo Shan. These villages lie away from the roads bordering the Project Area to the North and the South. A number of other villages lie near the Afgoi-Merca road, but outside the project area these include Booro, Buslow, Daarta, Feda Musse and Rahole. Villages found to the north and north west of the project area, on the banks of the Shebelli River are Merere, Mordile, Rakaileh Zabed and Beled al Amin. Temporary nomadic settlements are also found in the locality. It was not possible to carry out a full census on all of the permanent settlements; however a detailed census was taken of the populations of Idamoun, Bulo Shan and Mordile. The results of these surveys are shown in Table 7.1.

TABLE 7.1 Population of Villages within or adjacent to the Afgoi-Mordile Project Area

Village	Total No. House-holds	Total Population	Total Adult Male	Total Adult Female	Total Children	Average Population Household
Mordile	63	235	58	77	100	3.7
Idamoun	39	195	44	46	105	5.0
Bulo Shan	9	28	9	9	10	3.1

The population of other villages in the area can be assessed from the household counts made in every village by the Afgoi Municipal Administration shown in Table 7.2.

TABLE 7.2 Population Statistics of Villages in and around the Afgoi-Mordile Project Area from 1966 Census

Village	Administrative Area	No. Households
Beled al Amin	Afgoi	99
Booro	"	8
Buslow	"	31
Daarta	"	30
Idamoun	"	30
Merere	"	248
Mordile	"	57
Rakaileh	"	22
Zabed	"	115
Feda Musse	Merca)	55
Rahole	")	
Total		695

These figures were originally tabulated in 1966 for taxation purposes and should be corrected for any subsequent changes. The differences between these figures and those obtained in the sample village survey reflect the fact that the earlier data refers to taxation. It would appear reasonable to estimate the total number of households in these villages as being of the order of 800.

7.2 Survey Methods and Reliability of Results

The socio-economic study investigated present rainfed agriculture practices in the project area. The largest settlement in the project area is Idamoun, and for the purpose of the investigation this was taken as a

representative village. A total of 45 farmers were interviewed. A sample of farmers were also interviewed from other villages lying inside or adjacent to the project area in order to ascertain whether the findings in Idamoun were generally applicable. These villages were Booro (3 interviews), Bulo Shan (4), Merere (7), Mordile (4). Thus 63 farmers in all were successfully interviewed, of these seven were widows or single women.

Farmers were interviewed specifically with regard to the year ending March 1969, according to a questionnaire which included questions on:

Family.

Farm size.

Family labour.

Hired labour.

Machinery hire.

Crops grown in the 'Gu', 'Hagai' and 'Der' seasons, with details of area, yields and sales or disposal of these crops.

Livestock owned and details of income from livestock.

Sources of income apart from the private holding.

Family expenditure.

Major problems concerning the current farming system.

The system of agriculture which has evolved in this area enables the settlers to survive in a very harsh environment. Many problems face the farmer and he generally concentrates only on the present. Consideration of events in the past of the future is to him irrelevant, as both are entirely outside his control. Thus many of the farmers interviewed found it hard to appreciate the aims of such an investigation and to think in terms of the farming year as a whole. Throughout the investigations farmers were asked to give quantitative details of their enterprise, which for most proved to be a totally alien exercise. This factor, coupled with the single-minded concentration on the present implied that although those interviewed generally answered questions to the best of their ability, there were many apparently simple questions to which they genuinely did not know the answers.

Furthermore, people living in small rural communities are instictively wary of strangers, and are reluctant to give any details which could be used to their disadvantage, particularly with regard to tax assessment. Every effort was made in this investigation to allay such suspicions and major inconsistencies in the answers given by any farmer were generally easily corrected.

A number of the above factors impose limitations on the understanding of local agriculture which can be gained from such an investigation, therefore some degree of speculation must enter into the interpretation of the results.

7.3 Farm Distribution and Land Tenure

Land cultivated by any one farmer may consist of more than one holding. Land close to the villages tends to be at a higher premium and thus it may be that a farmer will have a small holding close to the village in addition to a larger holding further away. This is especially the case in Mordile, where holdings are very fragmented. In Idamoun village 10 of the 45 farmers interviewed cultivated two separate holdings. Holdings are not necessarily close to the farmers' village, and many farmers, especially in Merere, have a walk of one hour to their holdings. On the other hand those who live in settlements such as Idamoun in the main cultivated part of the project area are obliged to fetch water from the river.

Many farmers also mentioned other rights to plots which they hold but which have either fallen out of cultivation of have never been cultivated and would appear, to the outside observer, as unclaimed bush. Land is traditionally held on a tribal basis, and every member of the tribe has the right to cultivate land within his sub-tribe area. In the case of the Afgoi project area the land is held by the Hintire tribe who belong to the Hawige group of tribes. Thus the majority of farmers in the project are Hintire, but with abundant potential arable land available, some members of other tribes have been allowed

to take holdings in the area. In exchange for this privilege the outsider has to conform to the customs of the host tribe and to share group responsibilities.

Cultivation rights to individual plots of land are inherited through the male line, and brothers may continue to farm the inherited holdings collectively, or one may remain to cultivate the farm while the others find employment elsewhere. Women also hold cultivation rights to land in the Afgoi area. Land sales may occur, though they are rare, but renting is more common.

The redistribution of land essential to irrigation development will incur claims for compensation from many more people than are apparently using the land at present, and for much larger areas than are currently under cultivation. Consideration should be given to these problems and to formulation of appropriate changes in the land tenure legislation.

7.4 Farm Size

The local units of area measurement are the 'Jibal' and the 'Darab'. Five 'Jibal' are said to equal one 'Darab', and as a guide four 'darabs' are normally taken to be roughly equivalent to one hectare. These units are highly variable, and it was found that no reliance can be placed on local estimates of farm size. The cultivated farms of those interviewed were visited wherever possible, but the limited time available for the investigation meant that it was not always possible to visit out-lying holdings.

The area of the farms visited was calculated from paced measurements, and while this method only gives approximate results, it represents a considerable improvement over the estimates given by the farmer. 74 holdings were measured in this way from a total of 92 holdings cultivated by the farmers intervewed.

The average area cultivated by an individual farmer can only be quoted with a reasonable degree of confidence for Idamoun, where 52 of the total 56 holdings were measured. Random measurements coupled with empirical estimates on the farms around other villages indicate that these holdings are of a similar range of sizes.

At Idamoun the average area cultivated per farmer was 2.3 hectares. The smallest holdings were less than 0.2 ha and the largest area cultivated as one enterprise was 5.7 ha. Within the overall survey the smallest plots measured, at Mordile, were about 0.1 ha.

7.5 Crop Yields

The customary cropping pattern in the area is maize in the 'Gu' season, which is interplanted with sesame shortly before harvesting. The sesame crop is dependant on the 'Hagai' rains in July and August. The usual crop grown in the 'Der' season is sorghum, but maize may also be cultivated in this season. Other crops which are interplanted with these principal crops include soya and castor. Vegetables such as water melons and tomatoes are also grown, although frequently they are self seeded. Papaya is grown both on the holdings and in the village.

Farmers were questioned on the yields they had achieved in the past year; whilst the results were of value it is emphasised that it was not possible to check on the answers given. Local measurements of grain are entirely volumetric and the main unit used is the 'quintal'. This unit has been generally found to represent a weight of 94-96 kilogrammes; smaller quantities of grain are measured in 'sus', one 'sus' being approximately equal to 1.5 kg.

The consolidated yield figures for the main crops shown in Table 7.3 must be considered in the light of these limitations and those already mentioned in connection with the measurement of area. Average yields are derived only from those plots which were physically measured.

Yields of beans were sometimes quoted in shell at other times shelled, thus no average figure can be obtained. Failures were common during the year under consideration, and a fairly typical yield would appear to be under 4 quintals per hectare of shelled beans.

TABLE 7.3 Approximate Yields of crops and proportion of crop failures in 1968/69

		Measured Holdings				All Holdings		
Crop	Season	Total Area ha.	Total Production quintals	Average Yield Q/Ha.	No. Measured Farms	Total No. Farms	No. Failures	% Failures
Maize	Gu	122	493	4	71	91	27	34
	Der	30	92	3	34	39	11	35
Sesame	Hagai	70	52	0.75	49	55	20	36
	Der	11	14	1.25	10	11	3	27
Sorghum	Der	85	354	4	49	57	1	

The year under investigation was generally considered to be a 'poor year' in terms of grain yield, especially in the 'Gu' season. However, rainfall records show that 'Gu' rainfall was well up to the average, moreover the 'Der' rains exceeded the average.

Other reasons attributed to low yields were disease and insect attack, as well as bird damage.

7.6 Crop Sales

Crops produced within a radius of 20-25 km of Afgoi are normally solt to merchants in Afgoi town but smaller quantities may be sold to local shopkeepers, or bartered for goods. In the course of the investigation farmers were asked to quote the prices per quintal which they received for their produce; these are shown in Table 7.4.

The variation in prices from the immediate post-harvest period compared with prices later in the year was considerable. The cost of motor transport of produce from villages lying within the survey area to Afgoi Town is normally Shs. 2 per quintal.

TABLE 7.4 Average Prices Obtained for Crops in 1968-69

Crop	Season	Price/Q So. Sh.	No. of Transactions
Maize	Gu	39	26
Maize	Der	55	5
Sesame	Hagai	168	12
Sorghum	Der	37	20
Beans		61	5

7.7 Availability of Labour and Inputs

Farm work is normally done by the farmer, assisted by his family. His wife will provide help for almost all activities when required, but her participation is generally confined to periods of peak labour demand, such as weeding and harvesting, particularly if she has young children to care for. The labour provided by women in villages away from the river such as Idamoun and Bulo Shan is restricted because they are fully employed in fetching water from the river during dry periods. Children over the age of about 14 also provide assistance on the farm.

The seasonal nature of this farming system results in critical periods of peak labour demand for cultivations, weeding and harvesting. At such times the farmer may require additional labour; he may be able to call on the services of relations in exchange for food or in return for his assistance when required. A system of communal labour is sometimes adopted, known as 'Gop', in which the farmer provides a feast for a number of villagers on the understanding that they provide him with a day's labour.

The most common system for those that can afford it, is to hire labour. Of the 63 farmers interviewed 41 had hired labour at some time during the past year. Full time hired labour i.e. landless people, is not available locally but due to the unpredictable climatic conditions many farmers have to seek work to supplement the farm incomes and consequently there exists a pool of labour available for hire.

Labour is hired on a day to day basis, and the normal rate paid is So. Shs. 2.50 plus some food for work between 6 am. and midday. This system enables the labourer to work on his own farm during the afternoon. If he is hired for the full day the usual rate is So. Shs. 5.00 with food. On a piece-work basis or at very busy times, the rate of pay may be appreciably higher.

7.8 Machinery Hire

Of the farmers interviewed 31 had hired private contractors for ploughing between the 'Gilal' of 1968 and the 'Gu' rains of 1969. The equipment is hired from private contractors, and the normal rate is Shs. 25 per hour. High rates are charged for bush clearance. Frequently, the farmer has to borrow money to pay the contractor and he may be unable to repay this debt for a considerable period of time particularly if the harvest is poor. There is a strong desire among the farmers for the provision of machinery and credit facilities. It is apparent that traditional tools are inefficient and inevitably limit the area which can be cultivated by the family unit.

7.9 Livestock

Few settled farmers in the Afgoi area earn any significant income from livestock. Cattle may be bought after a good harvest as an insurance against difficult times in the future; they are frequently kept by a paid pastoralist outside the Afgoi area. Herds may be returned to the villages during the 'Gilal' season or when they are in milk. A minority of farmers keep their cattle near the village where they are tended by members of the family, often on a labour sharing system.

Milk is mainly consumed by the family, but any surplus to requirement is sold. The price per litre may vary from over Shs. 1.00 during the 'Gilal" season to less than Shs. 0.30 when milk is plentiful. Few animals are sold, except in times of need.

Somali farmers are traditionally reticent in giving details about their livestock and the figures quoted during the course of interviews may be somewhat low. Of the 63 farmers consulted 23 stated that they owned cattle, the number owned varying from 1 to 28, but generally being less than 5.

Goats are kept in and around the villages, where they scavenge for food.

Most families own poultry which run free in the village. Eggs are generally consumed by the family and those surplus to requirement are sold, normally at a price of Sh. 0.15 to 0.20. Poultry meat periodically supplements the largely carbohydrate diet of the farmer and his family.

7.10 Farm Income and Family Expenditure

The income achieved by a farmer from his holding is governed largely by factors outside his control. Crop failure is frequent, and when it occurs the farmer not only has to find money from elsewhere until his next crop is harvested, but also he may have to sell his crop immediately after harvest when prices are lowest. Farmers who have the most secure incomes are those who are prepared to work hard and cultivate a large holding.

One such farmer in Idamoun cultivated with his son a total of 5.7 ha. He had two wives and two children, but receives no help on the farm from them. One cow was kept near the village, and provided milk for family consumption, in addition to 30 head of poultry. Total farm output for the year was estimated to be:

Maize	23 quintals
Sesame	2 quintals
Sorghum	15 quintals

The farmer sold part of this produce, as and when cash was needed, and the remainder was consumed by the family or kept in store. A family of this size consumes about 3 kg of grain per day, which over the year

amounts to approximately 11 quintals. One quintal of sesame was also retained for household use.

A theoretical cash budget, at typical prices, for this farmer over the 1968-69 cropping year is shown in Table 7.5.

TABLE 7.5 Income and Expenditure for a Higher than Average Holding

Item	Expenditure Shs.	Income Shs.
Hired labour - 120 days @ Shs. 2.50	300	
Sale of 18 quintals Maize @ Shs.45		810
Sale of 9 quintals Sorghum @ Shs. 37		333
Sale of 1 quintal Sesame @Shs.168		168
Sale of eggs - say		100
Net cash Income	1111	
	1411	1411

Sale of maize and sorghum by-products could increase this net cash income to over Shs. 1200 per year. This however represents the highest level of income from farming among the farmers interviewed and still only provides some Shs. 100 per month for household expenditure for a family of six. An average annual income of Shs. 800 per year would be more typical of the average farmer in the area. Frequently a farmer cannot harvest enough grain for his family requirements over the year. Borrowing is frequent, both of grain and cash, and when the lender is a relation, as is generally the case, no interest is paid. Cash is usually only borrowed to meet large debts which must be paid at a specified time, such as contractors charges and wage payments. However some people, especially single women and older farmers depend very heavily on regular cash loans or gifts from relations working in the towns.

At periods of peak labour demand work on other holdings is readily available, but not necessarily at the other times of year. Not infrequently

those employers of labour interviewed could not justify their expenditure on labour on the strength of their farm income. In fact these farmers were supporting themselves, and were helping to support those who worked for them, on money originating from some outside non-farm source. The incomes of the dry land farmers of the area are thus being partially subsidised from non-agricultural incomes.

A few of the more enterprising farmers may leave their village during the dry season and seek work in Afgoi or Mogadiscio. Other seasonal work which supplements agricultural earnings includes the making of traditional Somali stools, hut building and the cutting and collection of hut-building materials.

The farmers interviewed found it difficult to estimate their expenditure over the year as a whole. During the early stages of the investigation it was found that the only way to gain any idea of family expenditure was to question farmers in detail on the items they purchased the last time that they went shopping, and then to extrapolate this information over the whole year. It must be remembered that the farmer will vary his expenditure strictly according to the amount of cash, or produce for exchange, that he has at any time. A total of 17 farmers supplied information on expenditure.

Families living in the villages which have a shop, such as Merere and Mordile normally buy their supplies each day. However those living in the villages which do not have shops are obliged to visit either Afgoi, Merere or Mordile. The interval between visits to shops normally varies between 4 and 14 days.

A family consisting of 3 adults and 4 children might require to purchase the following for two weeks household supplies:

		Shs.
Sesame oil	3 litres	15.00
Sugar	3 kg	7.20
Coffee	1 kg	1.80
Coffee beans		2.00
Tea	½ kg	1.50
Ginger		1.00
Salt		0.30
Soap		1.30
Paraffin	2 litres	2.00
Matches		0.30
		32.40

Meat would be bought if money were available; typically about 3 kg at Sh. 2 per kg. Alternatively meat might be bought by cutting down on items such as tea and coffee. It is probable that not all the items featured on the above list would be bought on each shopping trip, and the monthly family shopping bill is likely to be of the order of Shs. 65.

This example represents a family consuming home grown grain and obtaining an average cash income from the holding, which is supplemented by cash earnings from employment with other farmers. In a bad season expenditure could fall to a very low level, or debts might be incurred with the shopkeeper.

7.11 Suitability of Farmers for Settlement Projects

The pattern of dry-land farming found in the area represents the traditional way of life of the Hintire people. Today the lure of the allegedly higher standard of living and amenities available in the towns is causing many of the younger generation to leave the land. Thus it is increasingly the old and the more conservative minded who are found engaged in rainland agriculture.

The people interviewed were generally enthusiastic about the prospect for development of an irrigation scheme. Any development which would really

improve their standard of living would be welcomed, provided the scheme was fully explained in the initial stages. It was apparent that these people would much prefer to improve their income by continuing with agriculture than by having to uproot themselves and move into an alien town environment.

Understandably very few of those interviewed appreciated the changes that a settlement irrigation project would involve, particularly with regard to land redistribution. Most farmers are unlikely to give up their present holdings without being sure of personal gain in the future. It would therefore seem very important to inform the local people what an irrigation scheme would involve, and what advantages would accrue to the farmers on such a scheme before the implementation of any such project.

CHAPTER 8

IRRIGATION DEVELOPMENT

8.1 Vegetation and Bush Clearance

Areas suitable for irrigation development in the Shebelli Valley are presently covered by bush to a greater or lesser extent. In order to assess the bush clearance problem in areas selected for detailed study a straightforward classification of the existing vegetation was made by means of observations along survey traces supplemented by aerial photo-interpretation. The following four classes based on bush density were used:

Class I — Land at present under cultivation carrying only a few shade trees principally Dobera glabra known locally as the 'garas' tree, the density of these trees rarely exceeds 5 or 6 per ha. and including recently abandoned land.

Class II — Land cultivated in the fairly recent past but with considerable regeneration although open spaces still common and constituting approximately 50 per cent of area in this class. Vegetation consists mainly of Acacia nilotica, Acacia nubica, Dobera glabra and various Commiphora spp., Few trees exceed 4 m in height.

Class III — Bush in dense patches with occasional open spaces constituting approximately 25 per cent of area. Vegetation is more varied than in Class II and the largest trees are over 6 m in height. The following are the more important tree and shrub species present: Acacia nilotica, Acacia nubica, Acacia bussei, Acacia seyal, Commiphora spp., Cordia gharaf, Dobera glabra, Grewia spp., Dichrostachys glomerata, Euphorbia spp., Salvadoria persica.

Class IV Heavy bush which it is not possible to walk through, very few open spaces. Vegetation consists largely of dense Dichrostachys glomerata thicket with occasional trees of the Acacia spp. particularly A. nilotica, and Dobera glabra. All the species listed under Class III do occur in small areas. The Dichrostachys glomerata thicket is composed of large numbers of small trees about 3-4 m in height and as such will not be difficult to clear.

Mechanised methods of bush clearance must be used if the development of projects is to proceed at an acceptable rate. The use of hand labour or chemicals for the destruction of the bush is considered to be far too time-consuming. Mechanical bush clearance could be undertaken by local contractors. At the present time two contractors carry out bush clearance work in the Middle Shebelli flood plain. Crawler tractors with a dozer-blade attachment for the initial uprooting of the bush are customarily used. The dozer-blade is not considered very satisfactory, since a considerable amount of top-soil must inevitably be moved during the operation. A front mounted rock rake is a much more efficient tool and its use results in the minimum disturbance of the surface soil. This implement is recommended for bush clearance and the contractor should be obliged to conform to this specification in order that soil disturbance and subsequent levelling costs are kept to a minimum.

The raking operation will push the uprooted vegetation into windrows at least 100 m apart for burning after an appropriate lapse of time.

The removal of roots remaining after the initial bush clearance operation is at present carried out by a rear mounted rake or ripper, which is not altogether satisfactory, since a considerable amount of hand labour is required to tidy up the field afterwards. A far more efficient tool is the root plough - a heavy V-shaped, horizontal blade which is pulled at a predetermined depth by a crawler tractor. Efforts should be made to persuade the contractor to use this tool in order to minimise problems and breakages in later ploughing operations.

The final operation in bush clearance involves the collection and burning of debris including pieces of broken branches and roots remaining on the land, this operation must be carried out by hand, and requires to be completed before any land levelling is attempted.

Limited information on machinery performance under local conditions and on current contractor rates was obtained from the quasi-Government organisation, O. N. A. T. (a profit making enterprise) which operates Russian equipment.

The tractors used by O. N. A. T. for bush clearance are the Russian model S. 100 which have 100 h. p. engines which appeared to be rather underpowered. Whilst it was not possible to obtain any precise data for the uprooting and windrowing operations it was estimated that these two operations ranged between 4 and 10 hours per ha. depending upon bush density. It is believed that the use of a front-mounted rock-rake with cab guard instead of the dozer blade could reduce the number of tractor hours required by as much as 20 per cent.

The overall average charge quoted by O. N. A. T. for the initial bush clearance operation was Shs. 300 per ha. However, in a contract with the Johar Sugar Estate involving clearance of 700 ha of land, which would have been largely placed in clearance classes III and IV, the charge levied was Shs. 270 per ha. It would seem safe to assume that for extensive clearance for future development projects a further reduction in price could be negotiated.

The S. 100 tractor is also used for the ripping operation and this requires between 3-4 hrs per ha. The rates charged for this operation by O. N. A. T. range between Shs. 180 and 220 per ha.

It may be concluded that the average cost of mechanised bush clearance by O. N. A. T. will be of the order of Shs. 500 per hectare. This is a comparatively high figure, but it appears to be quite realistic in terms of the existing equipment and present level of supervision in Somalia as illustrated by two examples of bush clearance costs supplied by other agencies.

The felling and windrowing of bush on the German Dairy Farm Project near Afgoi cost between Shs. 300-500 per ha, whilst U.S.A.I.D. costs for bush clearance on two projects in the same area ranged between Shs. 600 -1,000 per ha.

Given more suitable equipment and assuming an adequate level of supervision, an improved work output could be achieved. Bush clearance studies in the Sudan and elsewhere under comparable conditions indicate that the following rates of work for the various bush densities could be readily achieved:

Class I	No mechanical clearance required
Class II	$2\frac{1}{2}$ hours per ha.
Class III	5 hours per ha.
Class IV	4 hours per ha.

Root ploughing in classes II, II and IV is estimated to require a further 2 hours per ha although if larger tractors (235 hp) were used, bush raking, windrowing and root ploughing would be possible in a single operation.

The prevailing hire charge for large caterpillar tractors (235 H.P.) is Shs. 52 per hour and based on the above outputs, clearance costs would range from Shs. 300 to 400 per ha cleared depending on the proportions of the various bush densities encountered.

8.2 Crops Suitable for Flood Irrigation Development

Cropping under flood irrigation is necessarily restricted to the 'Der' season, since the quantity of water required can only be reliably abstracted from the river during the months of September, October and November. The high river flows necessary for flood irrigation by gravity flow occur only spasmodically over the period April to August and, consequently, it is not possible to make use of the water which is available at this time for flood irrigation of annual crops on an organised scheme.

During the high flows which occur from September through to the end of November river water quality is usually at its best and carries a relatively small silt load.

Flood irrigation will be restricted to a single, heavy, pre-planting application of water. Crop yields produced on soil moisture alone are not likely to be very high and it is important therefore that maximum benefit should be obtained from rainfall. This is made possible during the 'Der' season by the fact that the high river flows begin at least six weeks before the usual onset of the 'Der' rains in mid-October.

Although rainfed cropping would be possible during the 'Gu' season the need for timely preparation of land for the following 'Der' season crops would severely restrict the growing season possible for 'Gu' planting.

The flood irrigation regime precludes the cultivation of perennial crops. The following annual crops were considered for inclusion in a cropping pattern for flood irrigation.

(i) Cotton

Cotton is well suited to flood irrigation having good drought resistance due largely to the growth habit of the rooting system, which is both deep and also extensive laterally. It is grown successfully on moisture stored in the soil profile in the effective root zone after a pre-planting irrigation in South Yemen and in the Rufiji basin in Tanzania. There seems no reason why good results should not be obtained on Shebelli soils where supplementary rainfall occurs in most years.

There is a local market for medium staple cotton. The Balad Textile factory, which became operational in 1968, will eventually require 1,500 tons of lint per year. At present production levels less than one-third of this demand can be met from within the country.

A suitable cotton variety can be expected to produce a moderate yield on stored soil moisture alone, whilst in years of above average rainfall yields could exceed 2,000 kg per ha of seed cotton.

(ii) Groundnuts

This crop has some potential as an export crop, in addition to limited markets within Somalia. Groundnut oil production for the local market must avoid upsetting the markets for sesame oil, which provides the main source of income for many traditional farmers.

Groundnuts have been successfully grown under controlled irrigation on Shebelli soils. Yields obtained at the Afgoi Research Station were as high as 4, 500 kg per ha. of unshelled nuts in one exceptional trial, whilst yields obtained by the Italian estates during the 1950's averaged over 1500 kg per ha. Unfortunately, there is no recorded information on the performance of the crop grown under flood irrigation or rainfed conditions, nevertheless it is certain that the crop will produce satisfactory yields under flood irrigation. Groundnuts have a relatively low water requirement and are able to withstand drought conditions over limited periods with no serious reduction in yield. Experience in the Sudan has shown that groundnuts can be grown successfully on heavy soils with little more additional moisture than that which is held in the soil after a heavy pre-planting irrigation. Two Sudan varieties which were imported as Sudan I and Sudan II, have been tested at the Afgoi Research Station and have given good results with controlled irrigation yielding over 2, 000 kg per ha.

(iii) Sesame

The price paid on the local market for sesame during 1968 was about Sh. 1.70 per kg. Although yields are rarely exceeding 500 kg per ha. sesame can be a profitable crop at this price level for farmers using minimum mechanical cultivation and hired labour.

Sesame is the most widely grown and the most successful crop in the existing areas of flood irrigation and it has the advantage of being a crop with which all the prospective settlers are familiar.

The local variety produces reasonable yields on stored soil moisture alone and is often planted well after the rains have finished. Planting can therefore be delayed with no serious effect on yield. Sesame has a relatively low labour requirement except at harvesting; this factor is most important in a flood scheme in which labour peaks are unavoidable.

(iv) Sorghum

This crop may be included in the cropping pattern with the object of achieving self-sufficiency in the staple food crop. Production surplus to family requirements can be sold. Sorghum is regarded as a dual purpose crop since the stover provides an important feed for cattle during the early part of the dry 'Gilal' season.

Initially a local variety will have to be grown since exotic varieties already tested, although superior to the local varieties in terms of yield, have unacceptable grain characteristics. Sorghum, like sesame, has a low labour requirement and the threshing operation can be carried out over a long period.

(v) Maize

Maize is not noted for its drought resistance and the chances of crop failure are high. The prospects for the crop might be improved by growing a short term variety maturing in 90-100 days but the local variety (120 days) is the only variety available at present. The market prospects for this crop are not attractive.

(vi) Safflower

This crop is well suited to growing under flood irrigation conditions having useful drought resistance properties. It was only recently introduced into Somalia by the Afgoi Research Station and acceptable yields of around 2,000 kg per ha have been obtained in trial plots. No serious limiting factors have been observed to date.

Unfortunately it is impossible at the present time to recommend this crop because of the lack of marketing information. Further testing under commercial field conditions should be carried out.

(vii) Sunflower

Sunflower is not grown at present in Somalia, but small areas planted at the Afgoi Research Station have given encouraging results. There appear to be no serious pest or disease problems. Bird damage could be a limiting factor. The crop has fair drought resistance and it could be grown successfully under flood irrigation. However, further experience of sunflower cultivation is required before it can be safely recommended for inclusion in a project. The prospects of procuring an export market appear to be favourable.

(viii) Soya Beans

This crop was considered because variety trials at the Afgoi Research Station had shown that soya could be produced in the Shebelli flood plain. Trials included some dwarf varieties which have a low water requirement and are therefore suitable for growing under flood irrigation conditions. However, following an investigation of the likely profitability of growing this crop for export it was concluded that it would be uneconomic.

(ix) Castor

Castor was grown commercially on Italian concessions in the 1930's and evidence of this is still to be seen by the abundance of 'wild' castor plants growing in the proximity of the concessions. Castor cultivation was halted during the war years and has never been revived. Trials with imported varieties at the Afgoi Research Station have been reasonably successful, the best variety yielding 1190 kg/ha in the 1967 'Der' season under controlled irrigation when no insect pests were noted. As insect pests are usually the most serious limiting factor of castor yields, the crop may have considerable potential on Shebelli soils.

The crop warrants further investigation, since it could be grown under flood irrigation, but it cannot be recommended on the basis of the current amount of information which is available.

(x) Leguminous Food Crops

The leguminous food crops considered included green gram, cowpea, pigeon pea and French beans. Local markets for these crops are restricted and they appear to be satisfied by present production. Export markets must be developed before any large expansion of pulse crops can take place.

The recommended cropping pattern for a system of flood irrigation is as follows:

Year 1	Cotton	
Year 2	½ Sorghum	½ Sesame
Year 3	Groundnuts	

Subject to further experimentation to confirm yield potentials and providing satisfactory markets can be found, safflower, sunflower and castor might be considered for inclusion in the rotation at some future date. It is considered desirable for one of these crops to substitute for sorghum included in the proposed rotation. Although the farmer would no longer be self-sufficient in his staple food grain, he would achieve an appreciably higher cash income and could purchase sorghum from rainland producers.

It is believed that soil fertility can be maintained at this level of cropping intensity since yields are not expected to be particularly high. The irrigation water will also contain considerable amounts of silt rich in potash and phosphate, which will tend to maintain fertility.

Soil salinity problems should not occur with the system of irrigation proposed, since it can only be carried out at high river flows when water quality is good.

Soil variation does occur in terms of the occurrence of salinity, but the differences within a possible flood irrigation basin do not appear sufficiently great to warrant special cropping patterns, since none of the crops recommended are especially sensitive to salinity. Each application of irrigation water will result in appreciable leaching of salts so that in the young stages of growth the topsoil will be relatively free of salts.

The presence of an impermeable layer has been detected in some profiles, which may give rise to a temporary or semi-permanent water table; it is possible this will have some adverse effects on crops in this event and when such areas are sufficiently well-defined a modified cropping pattern may be introduced in the future.

8.3 Cultivation Methods for Flood Irrigation Crops

Land preparation will be essentially similar for all crops and will consist of a single deep ploughing operation to a depth of 25-30 cm. A chisel plough is considered to be the most suitable implement for opening up the soil for flood irrigation, but it does not destroy weed growth as effectively as the conventional mould-board plough. Since in the 'Gu' rains profilic weed growth will occur in most years, a disc plough may be required. A careful watch should be kept on the soil profile in order to avoid the formation of a plough-pan. If a pan is formed, a ripping operation will be necessary. It is essential under a system of flood irrigation that pan formation is avoided.

After ploughing, the basins will be flooded and water will be allowed to remain on the land until the required amount infiltrated has taken place. Surface water remaining after this time will be drained away and planting will proceed as soon as the land has dried out sufficiently. The following cultivation practices are recommended for the selected crops.

Cotton

It is not possible, with the limited amount of information available, to make any definite recommendation regarding the specific variety of

medium staple cotton which should be grown. Field trials under typical flood irrigation conditions including a wide range of varieties will be necessary to enable the selection to be made.

Planting will be carried out by hand on flat ground. An inter-row spacing of 1 m and a within-row spacing of 30 cm is provisionally recommended; such a spacing gives a seed rate of approximately 30 kg per ha using undelinted seed. It would be advantageous if acid-treated (delinted) seed could be used allowing a reduction in seed rate of 15 kg per ha. Acid-treated seed is preferred because it has an enhanced viability - the 'floaters' or bad seed having been removed during the acid treatment; it also has the advantage of more rapid germination due to the effect of the acid on the seed-coat. Furthermore delinted seed facilitates better control of seed borne and seedling diseases due to the effects of the acid and to the fact that fungicides can be more efficiently applied to the seed. With only a single application of water prior to planting, it is important that optimum establishment of the crop is achieved at the first planting.

It is alleged that seed stored in the humid coastal climate loses its viability within 5-7 months to such an extent that it is not worth planting. If these claims are verified, facilities may have to be provided to store the seed inland under a more favourable environment.

Following germination, infilling of gaps should be carried out as soon as they become apparent. Thinning to one or two plants per hole should take place 2-3 weeks after planting, giving a theoretical plant population of between 33,000 and 66,000 per ha. Some hand weeding can be carried out simultaneously in these two operations.

Weeding of the crop will also be carried out by hand using the local 'jambo'. Weed growth should be kept to a minimum in view of the importance of moisture conservation, particularly in the early stages of crop growth. During the weeding operation a surface soil mulch should be worked up to reduce evaporation losses from the soil.

Significant responses to the application of nitrogenous fertilisers can be expected on these soils. The application of 100 kg per ha of nitrogen as a top dressing is likely to give an economic response. However, the timing of application will depend on the occurrence of rainfall which is required to wash the fertiliser into the soil. If a predetermined time of application is prescribed, in dry years the fertiliser may remain on the soil surface for long periods. In view of this uncertainty, an application of 50 kg of nitrogen per ha to be applied between 40-70 days after planting only when rainfall is likely to occur is recommended.

The success of the cotton crop will depend to a large extent on the effectiveness of insect control measures. The major cotton pests are listed below:-

Platyedra gossypiella	Pink bollworm
Earias biplaga E. insulara	Spiny bollworm
Dysdercus cardinalis	Stainer
Oxycaraenus hyalinipennis	Stainer
Syagrus rugiceps	Leaf-eating Coleoptra
Empoasca facialis	Jassid
Heliothis armigera	American bollworm
Aphis gossypii	Aphids

No entomological study of the relative importance of the above pests has been carried out, but observations made during 1968 on local rain grown cotton to which no insecticide had been applied indicated that the most serious pests were pink, spiny and American bollworm stainers.

The first step towards reducing the incidence of insect pest must be the enforcement by the authorities of the legislation on the uprooting and burning of cotton stalks after harvest to ensure a closed season and thus prevent the carry-over of large insect populations from one season to the next. The recommended sequence of cropping which should also apply to surrounding areas,

provides for the completion of cotton planting by the end of October and that uprooting and burning operations should be finalised by the end of April. This measure would have the greatest effect on pink bollworm populations which are not readily controlled by any other means.

There is no evidence of valid research work having been carried out in Somalia on the use of insecticides, however the results obtained in other countries with a similar range of pest species can be applied. A DDT/Sevin mixture has been used effectively in Kenya under similar conditions and there is no reason to suppose that it will not prove successful in Somalia. The rates of application recommended are 1.5 kg of 100 per cent DDT per ha and 15 kg of 85 per cent Sevin per ha. The number of applications required will depend upon the vigour of crop growth and potential yield. If crop growth is limited by moisture stress, which may occur in some years, fewer applications of insecticide will be required than in years of ample rainfall and vigorous crop growth. A maximum of seven applications and a minimum of four applications is the likely range. In such conditions a routine spray regime cannot be laid down and the timing of applications of insecticide should be determined by field inspection.

The application of insecticide will be undertaken by hand using mechanical knapsack sprayers. This operation should be carried out under the supervision of the Plant Protection Service of the Ministry of Agriculture who should also be responsible for the supply of insecticides and the maintenance of the spray equipment. A supply of clean water for mixing with the insecticides is essential to the smooth operation of spray equipment.

Harvesting of the cotton crop will begin towards the end of December and continue until late February. Picking and grading of the cotton should be undertaken in the field in one operation by the use of two containers for separate grades.

As soon as harvesting has been completed the cotton plants should be uprooted and burnt.

There is very little information available locally on yields of seed cotton grown under flood irrigation or rain grown conditions, with adequate pest control measures. The estimates of potential yields, therefore, have to depend upon the yield data on the crop when grown under controlled irrigation. At the Afgoi Research Station in one variety trial, yields exceeded 3,000 kg per ha under controlled irrigation. It is considered that given adequate pest control measures and assuming reasonable rainfall during the latter half of October and November, yields could reach this level under flood irrigation conditions. However, since rainfall is extremely variable average yields are unlikely to be much above 1,500 kg per ha.

Groundnut

The Afgoi Research Station has carried out a number of variety trials under controlled irrigation in recent years. In the one trial two varieties from the Sudan produced favourable yields. These varieties are known locally as Sudan I and Sudan II. The Sudan I variety, though not as high-yielding as Sudan II is a shorter term crop and is probably better suited to flood irrigation conditions in which moisture may be a limiting factor in the later stages of crop growth. This variety can be recommended initially but further trials should be carried out to confirm the most suitable variety.

It is anticipated that planting will be carried out on flat ground by hand. Spacing should be wider than that used under controlled irrigation, that is to say an inter-row spacing of 1 m and a within-row spacing of 15 cm.

Kernels are preferable for planting since they will germinate more quickly than unshelled seed. A fungicidal seed dressing should be applied immediately before planting. Two seeds per hole are recommended and at the above spacing this will require a seed rate of 90-100 kg per ha.

Weeding of the crop will be carried out by hand using the local 'jambo', during this operation some of the soil tilth or mulch should be moved into the rows to produce a small ridge. This operation will reduce moisture losses from the soil around the plant as well as providing a loose tilth for the 'pegs' (gymophores) to penetrate. Effective weed control is essential if competition for moisture is to be avoided.

Responses to nitrogenous fertilisers have been obtained but usually when applied in the early stages of crop growth. Since there is little possibility of any rainfall until 3-4 weeks after planting, the application of nitrogenous fertilisers is likely to be ineffective until such times as the crop will have begun 'to fix' atmospheric nitrogen, therefore no fertiliser applications are recommended for this crop.

Yields of groundnuts grown under flood irrigated conditions will inevitably prove variable depending upon the rainfall during the later stages of crop growth. An average yield of 1,200 kg per ha should be possible with a maximum of 2,000 kg per ha and a minimum of 800 kg per ha. These yield estimates are based upon yields obtained under controlled irrigation.

Harvesting of groundnuts will require the use of tractors to loosen the nuts in the soil. This will be carried out using a tractor-mounted blade cutting just below the nuts. For stripping the nuts from the haulm a simple hand operated machine developed in the Sudan may be used if hand stripping proves impracticable.

The crop should be marketed in-shell. The groundnut haulm is a valuable stock feed and could either be fed in situ after harvest or carted off the field to the animals. The former is preferable so that advantage is taken of the manure.

Sesame

The local variety is recommended since no exotic varieties have been tried in Somalia, and its performance compares very favourably with varieties grown in other parts of East Africa.

This crop will follow cotton, groundnuts and sorghum since it is able to germinate in a drier scil and is therefore more readily established. Sesame produces comparatively better results than any of the other three above crops on stored soil moisture alone. Planting will be carried out by hand in rows 1 m apart with a within-row spacing of 20 cm. At 5-10 seeds per hole the seed rate will be approximately 6-8 kg per ha. The crop should be thinned to 2-3 plants per hole some three weeks after planting.

Weeding will be carried out by hand similar to other crops grown under flood irrigated conditions.

The most important pest of sesame is the leaf roller, Antigastria catalulunalis, which may require control measures in some years. A single application of DDT is considered to be adequate to control this pest, however until the economics of such an application have been established it cannot be firmly recommended.

Harvesting should take place when leaf fall is almost complete and the lower capsules have begun to open. The traditional method of cutting the plants, tying them in bundles and placing them in stooks should be followed. Threshing should take place some two weeks after cutting. The remaining dried stalks should then be burnt.

Sorghum

This crop may be regarded as a dual purpose crop being grown for both grain and stock feed. The local variety is recommended. Some exotic varieties have been tried but they have proved to be little better than the local variety in terms of grain yield and none possess grain quality which is acceptable to the local people.

Planting will follow cotton and groundnuts. The inter-row spacing should be 1 m with a within-row spacing of 30 cm between planting holes. Four to six seeds should be planted in each hole and this will give a seed rate of about 12 kg per ha. Thinning is not normally required.

Weeding will be carried out by hand with the aim of maintaining a minimum level of weed growth until some 60 days after planting.

Harvesting should take place when the grain has hardened about 120 days after planting; the traditional method of harvesting will be followed, the panicle being cut from the stalk which is then used for stock feed. After harvest the sorghum area may be grazed when some ratoon growth has occurred.

8.4 Crops for Controlled Irrigation Development

The major crops at present grown in the middle Shebelli flood plain under controlled irrigation are sugar cane and bananas. Both are perennial crops requiring irrigation throughout the year. Any increase in the area under perennial crops is limited by the availability of water during the dry 'Gilal' season when the river may virtually cease to flow for periods of up to 4 months. Alternative sources of water, from groundwater and upstream reservoirs, for supplementary irrigation has been investigated. Groundwater is limited in availability and is likely to prove expensive, particularly as the pumping installations will only be effectively required to operate for some 2-3 months each year. Onstream storage sites on the Shebelli River in Somalia are not particularly favourable and construction costs of such reservoirs would be high resulting in stored water being relatively expensive. Offstream storage is a more attractive proposition but the limited quantity of water which could be stored would only permit a comparatively small extension of perennial crops; on the other hand a very considerable extension of annual crops could be developed using offstream storage to supplement river flows in December and January so extending the 'Der' cropping season. Thus on grounds of water availability, the cultivation of annual crops in future development projects appears to be more attractive than expansion of perennial crops.

Other factors must be mentioned in relation to the exclusion of sugar cane and bananas from the recommended cropping system. Expansion of sugar cane was ruled out because the Johar Sugar Estate is capable of meeting domestic demand for the next 10 years and the high capital investment required to establish a new sugar estate is hardly likely to be forthcoming for production for the export markets bearing in mind current sugar prices. The banana crop was also ruled out on economic grounds. At the present time, bananas, soldto Italy, contribute more than 40 per cent of the value of total exports from Somalia. There is an obvious need for diversification of agricultural production to reduce the degree of dependence on this crop, particularly in view of possible future uncertainties in the Italian market. Italy pays a preferential price for Somali bananas and the Agreement by which the present price is fixed expires at the end of 1969. If the agreement is not renewed Somali bananas will have to compete with bananas produced in West African countries where costs (and hence prices) are much lower - they have no irrigation costs and transport costs to Europe are lower than from Somalia in view of the fact that the Suez Canal remains closed. Increased production efficiency could enable the Somali banana crop to compete on free European markets, but this is not likely to be achieved until some applied research has been carried out to demonstrate the extent to which maximum returns can be obtained. In view of the rather bleak marketing outlook for Somali bananas in present circumstances, the crop has not been included in the proposed cropping system.

Another perennial crop, grapefruit, is provoking considerable interest in Somalia at the present time and was considered as a possible crop. Although a small export of 200 tons per year was marketed in Italy before the closure of the Suez Canal, grapefruit production is still very much in its infancy in Somalia. A comprehensive programme of applied research is necessary before the crop can be confidently recommended for large scale development. Grapefruit grown for the export market must be of high quality and this can only be attained with the proper varieties and assuming sound husbandry practices.

The development of controlled irrigation on the Shebelli River is principally based on estate production of perennial crops; consequently such crops received first consideration. Annual crops, including cotton, groundnuts and maize, were grown by the Italian estates until the early 1960's when production was discontinued because of difficulties associated with the supply of labour and, more important, on account of the failure to recognise and solve the technical problems limiting yields. Recent work at the Afgoi Research Station, which was established in 1964, has shown that profitable yields of a number of annual crops can be obtained provided sound agronomic practices are followed. So far no attempt has been made to translate the trial plot results onto a field scale. The selection of crops for the Afgoi project has, therefore, been largely based on the results of field experiments carried out on the Research Station.

Having obtained the yield potential of the range of possible crops from experimental results, an economic assessment of their relative profitability in relation to potential markets was carried out. On the basis of this preliminary assessment rice and cotton appeared to be the most promising crops and, consequently, they receive major emphasis in the cropping system. A brief outline of the reasons underlying the selection of these crops is discussed below.

Rice

Milled rice imports into Somalia over the last 5 years have fluctuated between 25-35,000 tons annually and there is every indication that they will increase in the future. At the present time virtually no rice is produced in the country. It was not surprising, therefore, that the expansion of local rice production has been accorded a high priority by Government and by F.A.O. officials of the Grain Marketing Project and the Agricultural Development Agency. The need to improve the country's balance of payments situation by the production of rice for import substitution is obvious. Thus from an economic viewpoint rice should play a major role in the cropping system.

Variety trials at the Afgoi Research Station have indicated two American varieties of dryland or upland rice giving yields of 2000-3000 kg per ha, whilst at Johar introduced Chinese varieties of paddy rice are reputed to have yielded 4000-5000 kg per ha when transplanted. Despite the higher yields of paddy rice, dryland rice is considered the most suitable for this project. The latter requires appreciably less water and can be more easily accommodated into a rotation with other crops. Large quantities of water would be required to grow paddy rice on the Afgoi soils, which have high infiltration rates, and it is doubtful whether the higher yields would offset the greatly increased pumping costs and the additional costs involved in transplanting.

The variety of dryland rice favoured by the Research Station is that known as Dawn which was imported from the U. S. A. in 1965. Another U. S. A. variety, Saturn, has also given good results at Afgoi. Both varieties require approximately 120 days from planting to harvest. Milling percentages were 62. 2 per cent for Dawn and 63. 3 per cent for Saturn. There is apparently little to choose between the varieties in terms of palatability. Seed of both varieties is immediately available.

Cotton

A sound market for this crop exists locally. The recently completed textile factory at Balad, which became operational in 1969, will eventually have an intake of 1, 500 tons of lint per year. At present production levels less than one-third of this demand can be met from within the country. An assured supply for the full factory requirement of cotton is of immediate importance if the factory is to be used to the best advantage. Efforts to stimulate cotton production in the rainfed farming areas during the past two or three years have met with little success and the prospects of increased supplies from this source do not appear to be bright, especially in view of the lack of a competent extension service. Cotton production on an organised irrigation scheme could ensure a regular supply of cotton for the textile factory.

Medium staple cotton is preferred by the factory on account of its lower price differential and the fact that medium staple is suited for the production of a cheap and relatively low quality cloth for the internal market. Production of this type of cotton has only taken place in recent years with introducted seed of an Acala strain and Carolina Queen varieties. Both varieties have performed reasonably well in trials at the Afgoi Research Station, where it was possible to exercise adequate insect control. Yields of over 2, 500 kg/ha seed cotton have been obtained under irrigation but, unfortunately, no information is available on such important varietal characteristics as ginning out-turn and lint quality.

Both dryland rice and medium staple cotton constitute the crops which are better suited to growing in the 'Der' season. Other crops were considered for the 'Gu' season with the object of double cropping on a proportion of the area and thus obtaining greater returns on investment. Groundnuts appeared to be the most suitable crop for the 'Gu' season, being easily fitted into a sound rotation with rice and cotton and having a good production potential. Yields obtained at the Afgoi Research Station were recorded as 4, 500 kg per ha of unshelled nuts in one exceptional trial, whilst yields obtained by Italian estates during the 1950's averaged over 1, 500 kg per ha. Few production problems have been reported. However, the marketing prospects for groundnuts are not nearly as assured as for cotton and rice and this is the main reason why the crop is regarded as being of only secondary importance in the cropping system proposed.

Other annual crops which were considered for inclusion in the cropping system were maize, safflower, sesame, soya beans, sunflower, castor and a number of leguminous food crops. None of these crops could be recommended on the basis of present yield projections and in the absence of reliable information on potential markets.

A wide range of vegetable crops are grown successfully and the local markets are well supplied for most of the year. On the other hand onions provide a notable exception in that imports are running in excess of 5,000 tons per year. Excellent results have been achieved with this crop at the Afgoi Research Station and planting on a limited scale would prove profitable assuming the continuation of the present price of Sh. 1 per kg. Yields of 12,500 kg/ha have been obtained at the Research Station.

The selected crops for extensive cultivation - rice, cotton and groundnuts - have been accommodated in the following rotation which extends over a 2-year cycle:-

1.	Rice	'Der' season, planting in September.
2.	Groundnut	'Gu' season, planting in April.
3.	Cotton	'Der' season, planting in September.
4.	Fallow	'Gu' season.

A number of general advantages apply to 'Der' season cropping:

a) River water of good quality is usually available at the beginning of the 'Der' season. This is not so at the beginning of the 'Gu' season (i.e. April) when river flow may be extremely limited or even non-existent and when the higher flows do occur at this time the water is apt to prove saline and carrying a heavy silt load.

b) Land preparation, planting and weeding operations can normally be carried out with few difficulties during the early part of the 'Der' season, but this is not so in the 'Gu' season when heavy rainfall in April and May can interfere with these operations causing considerable delays.

c) Ideal harvesting conditions are most likely to occur from mid-December onwards for the 'Der' season crops but rainfall in July and early August could cause difficulties for the harvest of 'Gu' season crops, as well as having an adverse effect on quality of produce in some years.

d) At the time of 'Gu' season planting and during early weeding operations, a period of peak labour requirement, temperatures and humidities are at their highest and the worst working conditions of the year prevail. Climatic conditions at the beginning of the 'Der' season are more conducive to hard manual labour in the field.

Apart from the general advantages listed above, specific advantages associated with the 'Der' season cropping of both rice and cotton apply.

In the case of the rice crop poor pollination often results when grown in the 'Gu' season and this is thought to be due to the high winds of the S. W. monsoon which occur in May, June and July. If planted in the early 'Der' season flowering occurs at a time of low windspeeds and this problem is avoided. Bird damage is likely to be a relevant factor limiting rice yields; recent observations indicate that this problem is less serious with 'Der' season cropping.

The 'Der' season is better suited for cotton growing than the 'Gu' season, largely on account of climatic differences. Lower temperatures in September give better conditions for germination and establishment of the cotton crop than the warmer weather in April. Observations made locally and experience elsewhere indicate that the incidence of pests and diseases is lower in the 'Der' season than in the more humid and overcast conditions of the 'Gu' and 'Hagai' seasons. Lastly the greater number of sunshine hours occurring in the latter part of the 'Der' season should give better results than the more cloudy 'Gu' and 'Hagai' seasons.

There is overwhelming evidence in favour of growing the two main crops in the 'Der' season. However, some cropping is obviously also desirable in the 'Gu' season. If double cropping is to be practised, a short term crop must be grown in the 'Gu' season, since the commencement of planting is often not possible until mid-April and harvesting must be completed by mid-August to allow for time to carry out cultivation operations for the following 'Der' season crop. In order to meet this requirement a crop which matures in 100 days is necessary. Groundnuts was the crop selected.

Although better results would be achieved in the 'Der' season with this crop, for economic reasons already mentioned it has been included in the recommended cropping system as a 'Gu' season crop.

In the recommended rotation, cropping intensity is at a relatively high level, with double cropping in alternate years. In the absence of any experimental evidence on the long-term effects of continuous cropping with annual crops on Shebelli soils irrigated with river water, this recommendation was concluded after examining the available information on estate experience and on the existing peasant farming systems, together with data on the physical and chemical characteristics of the soil. Estate experience on the long term effects of continuous cultivation of perennial crops on Shebelli soils is rather variable. Continuous cropping with sugar cane has been practised on the Johar Sugar Estate on sound well-drained soils and satisfactory yields of cane are still being obtained after the lapse of more than 40 years. On the other hand a 2-3 year fallow period is usual between banana crops grown on land which has been cropped for a similar length of time, whilst in both bannna and sugar cane estates land has had to be completely abandoned because of increasing soil salinity in appreciably less than 40 years under cultivation.

The reasons for the inclusion of a 2-3 year fallow between banana crops is not difficult to understand. It is a shallow rooting crop with exacting nutrient requirements (until recently little use was made of fertilisers), and the fallow period is necessary to allow for soil nutrient replenisbment, particularly nitrogen. Being a perennial crop, a three year period is available for the build-up of pests and diseases which could have a detrimental effect on the succeeding crop if the fallow period were to be excluded.

An increase in soil salinity which results from the necessity to irrigate with the saline river water in the 'Gilal' season is a contributory factor to the need for a long term fallow between banana crops. Where an increase in soil salinity has led to the abandonment of areas on the banana and sugar estates, it has been principally due to a build-up in the water table caused by over-watering, underground seepage from canals

and reservoirs and inadequate fallow periods. A balanced rotation of annual crops will avoid most of these adverse factors which favour the inclusion of a fallow crop in perennial cropping. Although soil salinity will have to be carefully watched, the problem does not present such a serious threat with annual crops since they will normally be grown when high quality river water is available together with some supplementary rainfall. Moverover the quantity of water applied to the soil will be appreciably lower for annual crops than perennial crops, consequently the problem of water table build-up is less likely to occur. It may be concluded that, since irrigated perennial crops have ben successfully grown continuously on favourable soil types for over 40 years, satisfactory yields of annual crops can be maintained over a period in excess of 40 years with the recommended level of cropping intensity.

Some indication of the inherent fertility of the soils is evident by reference to local farming practice under rainfed agriculture. Although a modified forrn of shifting cultivation is practised, the cycle is a long one, soils are said to maintain productivity for at least 15 years growing two crops per year. With the recommended cropping intensity and higher anticipated yield levels, the application of fertilisers should be adequate to maintain yields over a long period. The possible effects of the recommended cropping intensity on the physical characteristics of the soil have been considered. The structure of the clay soils in the Shebelli Valley is generally stable and few problems are envisaged in the maintenance of this condition, although tractor movement on the soil must be restricted to a minimum if pan formation is to be avoided.

The order in which the crops are placed in the rotation was largely influenced by cultural requirements. The rice crop is preceded by a 'Gu' season fallow so that there is ample time for carrying out the more laborious land preparation operations, particularly land levelling. Cultivations in the 'Gu' season will be an effective method of controlling weed growth in the early stages of growth of the rice crop. It should be possible to plant

rice at the optimum time every year and thus make the best use of the available water. Rice is followed by the 'Gu' season groundnut crop which is grown on ridges. The groundnut harvesting operations are immediately followed by re-ridging for the cotton crop. The groundnut crop will theoretically add a certain amount of nitrogen to the soil which can be utilised by the succeeding cotton crop. The 'Gu' season fallow cotton is convenient in that it allows ample opportunity for the task of uprooting and burning the cotton stalks. Other advantages of the 'Gu' season fallow are that it allows moisture storage in the soil from the rains thus reducing the initial irrigation requirement of the rice crop and in years of high rainfall gives an opportunity for some leaching.

8.5 Cultivation Methods for Crops Recommended for Controlled Irrigation

Rice

Rice cultivation is very much in its infancy in Somalia and, consequently, there are no proven and accepted methods of cultivation. The recommendations made for this crop have been based on the results obtained in trial plots at the Afgoi Research Station, on personal observations made during 1968, and on experience with this crop elsewhere. Reference has already been made to the two ex-U.S.A. dryland rice varieties, Dawn and Saturn, which have been successfully grown in Somalia and are recommended for the project.

Land preparation for the dryland rice crop is likely to consist of four basic operations - ploughing, discing, levelling and harrowing. Chisel ploughing to a depth of 20-25 cm in the 'Gu' rains, sufficient to cover most weed growth, followed by a single discing should provide an adequate tilth for the land levelling operation. The crop will require a border irrigation system and the necessary low bunds should be constructed simultaneously with the land levelling operation. Fertiliser distribution, discing to produce a suitable tilth for sowing and seeding may be incorporated into one operation using wide level discs fitted with seed and fertiliser hoppers. A seed rate of 100 kg per ha is recommended.

A fungicidal seed dressing should be applied which, as well as controlling disease, will help to curb losses due to birds and rodents in the seed bed. Planting should commence in late August.

As soon as possible after drilling, irrigation should be made to ensure germination. Once the crop is established the immediate problem concerns the control of weed growth. Some control will have been obtained during cultivation operations, but weed growth is so prolific on Shebelli soils under conditions of plentiful water supply, that the use of a post-emergence herbidice is recommended. 'Propanil' has given encouraging results at the Afgoi Research Station and is likely to prove the most effective particularly against grasses and sedges which present the most serious problem. The recommended rate of application of this herbicide is 4-5 kg/ha in a single application when the weeds are at the 3-6 leaf stage; the timing of the application is critical. This herbicide will effectively check weed growth and so give the rice a good start, but hand weeding will be necessary in the later stages. Should grassy weeds be especially troublesome a herbicide treatment to destroy weeds germinated by rainfall during the preceding 'Gu' fallow should prove effective.

In both Dawn and Saturn varieties over 50 per cent of panicle emergence will have occurred 60 days after planting and they are ready to harvest at approximately 120 days after planting. Harvesting by combine harvester is recommended since this will eliminate the large losses which can occur when the crop is harvested by hand due to shattering in the field, handling, and due to bird and rodent damage. The losses due to birds are expected to be considerable and, in the absence of any other solution to this problem, farmers and their families may have to spend a number of days in fields engaged in bird scaring operations as the rice crop ripens. No serious insect pest or disease problems have so far been noted in the rice crop.

The yields of Dawn and Saturn rice varieties obtained in the observation plots grown at the Afgoi Research Station, whilst not spectacular, have been reasonably consistent and encouraging as will be noted in Table 8.1.

TABLE 8.1 Yields of dryland rice varieties in kg/ha obtained at the Afgoi Research Station

Year	Season	Planted	Harvested	Dawn	Saturn
1966	'Der'	27th August	23rd December	1709	2388
1967	'Gu'	Not available	Not available	1900	1900
1967	'Der'	16th August	14th December	-	1800
		16th August	22nd December	2000	
1968	'Gu'	7th April	19th August	2800	

Source: Afgoi Research Station Progress Reports.

The higher yield obtained in the 1968 'Gu' season reflects the more liberal use of nitrogenous fertilisers and better irrigation practice. On the basis of observations made on the rice crops to date, it is obvious that nitrogenous fertilisers must be applied if satisfactory yields are to be obtained. However, the response in terms of yield increase per unit application of nitrogen is not known and requires investigation. Timing of application and split dressings also require investigation, since large applications of nitrogen to the seed bed tends to accentuate the weed problem in the early stages of crop growth. In the absence of any experimental data on response to nitrogen, only a tentative recommendation can be made. An economic response could be expected from 100 kg per ha of urea applied at time of planting.

No information is available on the response of the rice crop to applications of potash and phosphate fertilisers on Shebelli soils, but the indications are that these fertilisers will not be required in the early years of cropping virgin soils.

Symptons of a trace element deficiency, said to be iron, were reported by an F.A.O. agronomist working at the Afgoi Research Station in 1964-65, but these were not observed in either 1967 or 1968 rice crops. Furthermore, applications of a complex of trace elements to the Dawn variety growing on the Research Station in the 1968 'Gu' season had no noticeable beneficial effects. The soils of the Shebelli Valley generally have a pH of 7.5-8.0 indicating that trace element deficiencies could occur.

Groundnut

Precise information on the performance of groundnut varieties grown in the 'Gu' season, with planting in the latter half of April or first half of May, is not available. It will not be possible, therefore, to make any definite recommendation on varieties until further field trials have been carried out. The need for a short term (100 day) variety immediately limits the field of choice, as also does the preference for a variety resistant to the diseases, Cercospora leaf spot and Rosette virus. From the range of varieties tested at the Afgoi Research Station in other seasons of the year, the best seems to be the variety known as Sudan I.

Land preparation for the groundnut crop will begin with the burning of the rice straw and this will be followed by chisel ploughing, to a depth of 15-20 cm, discing and then ridging. An inter-ridge spacing of 75 cm and a within-row spacing of 15 cm is recommended.

Shelled nuts should be used for planting. This seed should be dressed prior to planting to guard against attacks by fungi and termites. Two seeds per hole should be planted and, at the above spacing, this will require a seed rate of 130 kg/ha assuming that the Sudan I variety is grown.

Sowing will have to begin by mid-April and must be completed in sufficient time for the crop to mature by late July. Planting can be

carried out by hand. The application of up to 100 kg per ha of nitrogenous fertiliser broadcast prior to ridging can be expected to give an economic return. Responses to applications of potash and phosphate have not so far been demonstrated.

Weed control is essential in the early stages of crop growth if satisfactory yields are to be achieved. Labour is likely to be in plentiful supply for hand weeding, since only half the cultivated area will be under crop during the 'Gu' season. The use of herbicides is not, therefore, recommended for the groundnut crop. Mechanical cultivation in the form of a re-ridging operation, some four weeks after planting, will facilitate weed control.

Yield data pertaining to irrigated groundnuts on Shebelli soils is limited. Moreover there is very little information on the basic conditions under which the yields were obtained. Without such information, no accurate estimate of the yields likely to be achieved by a 100-day variety grown in the 'Gu' season can be made. However, the yields given in Table 8.2 show that groundnuts can be successfully grown during this season.

TABLE 8.2 Yields of three groundnut varieties when grown in the 'Gu' season in quintals per ha of unshelled nuts

Year	Africana	Khandeish	Coromandel
1929	17.56	-	-
1931	-	6.48	9.26
1932	12.63	11.45	4.95
1933	15.60	18.00	18.00
1934	14.50	17.29	20.05
1935	7.40	5.87	-
1936	7.68	8.04	-
1937	12.95	10.52	-

Source: 'Diversification of Agriculture'. Italconsult Report.

It is unfortunate that none of the three successful variety trials recently carried out at the Afgoi Research Station have been planted at the beginning of the 'Gu' rains. Nevertheless the results from these trials are given in Table 8.3 to illustrate the general performance of the crop.

TABLE 8.3 Yields of groundnuts obtained in variety trials at the Afgoi Research Station in kg per ha (unshelled nuts)

Trial No. 1		Trial No. 2		Trial No. 3	
Variety	Yield	Variety	Yield	Variety	Yield
Virginia Bunch	4513	Virginia Bunch	1217	Early Varieties	
Virginia Runner	4011	Virginia Runner	1538	Local Large	2110
Dixie Runner	4246	Dixie Runner	1476	Sudan I	2016
S.E. Runner	4617	S.E. Runner	1399	Local Small	1668
Early Runner	2959	Early Runner	939		
Florigiant	4884	Florigiant	1286	Late Varieties	
Huckaby	4662	Huckaby	1883	Florigiant	2824
W.A. Carver	3936	W.A. Carver	876	Sudan II	2787
Local	3019	Local	1007		

Trial No. 1	Planted Dec. 11th 1965.	Harvested May, 4, 5, 7th, 1966.
Trial No. 2	Planted June 15th 1965.	Harvested Oct. 11th 1965.
Trial No. 3	Planted Oct. 4th 1967.	Harvested Feb. 3rd 1968. (early varieties).
		Harvested Feb. 14th 1968 (late varieties).

Source: Afgoi Research Station Progress Reports.

On the basis of the limited data presented in Tables 8.2 and 8.3 and following observation of growing crops it is estimated that an average yield of around 1,500 kg per ha could be expected from a 100-day variety grown in the 'Gu' season.

Harvesting will normally be carried out from mid-July to mid-August. The use of a tractor mounted blade cutting just below the nuts to loosen the soil greatly facilitates the lifting operation, which will be otherwise undertaken by hand. For stripping the nuts from the haulm a simple hand-operated machine developed in the Sudan, is recommended; this machine could easily be fabricated locally. It is envisaged that the crop will be sold in-shell.

Ground haulms are commonly used as stock feed in other countries and they could find a ready market in Somalia. The groundnut harvest, however, must be carried out as swiftly as possible, in order to make way for the following cotton crop and the farmer will have little time available for the laborious work of collecting the groundnut haulms and carting them away for sale.

Cotton

Medium staple cotton varieties were not seriously considered for growing in Somalia until the 1950's, when the Italian Administration grew a large number of exotic varieties in trial plots. Unfortunately, only general comments on the performance of these varieties have been located (Italconsult Report on "Diversification of Agriculture"). Four cotton variety trials have been carried out at the Afgoi Research Station since 1964, regrettably they were badly managed and poorly documented, and are therefore of limited value in making a choice of suitable varieties. Bulk seed importations have been introduced by the Agricultural Development Agency (varieties Prima S. 1 and Carolina Queen); seed of an Acala variety has been imported by the German Technical Assistance Programme. No valid comparison of these varieties has been made, although all seem to have been equally disappointing when grown by local farmers because of the failure to control insect pests.

It is not possible, with the limited amount of information available, to make any definite recommendation on which variety should be grown but, in view of the favourable results obtained in the Sudan, Kenya and elsewhere, it is suggested that an Acala variety is likely to give worthwhile results. The more desirable characteristics of Acala cotton include an open growth habit allowing good penetration of insecticides; large bolls and a short opening period which gives increased picking efficiency; a high ginning percentage and high lint yields. A relatively short term variety is preferable since, in some years, it may only be possible to irrigate for 80-90 days after planting due to shortage of river water.

Land preparation for the cotton crop can be confined to a single ridging operation, providing good weed control has been maintained in the preceding groundnut crop. The ridges on which the groundnuts were grown will be split - the previous groundnut blading operation should create sufficient tilth to provide the cotton with a satisfactory seed bed.

An inter-ridge spacing of 75 cm (similar to groundnuts) and a within-row spacing of 30 cm are recommended. Planting should be carried out by hand; with 6-10 seeds per hole, giving a seed rate of approximately 35 kg per ha using undelinted seed. Ideally, acid-treated (delinted)seed should be planted for reasons previously discussed.

The mixing of seed of different varieties which has been a common practice should be avoided in the future, this will require a greater degree of control and supervision of the privately-owned ginneries than is exercised at the present time. The provision of good quality viable seed for planting will require proper organisation.

After planting, re-sowing of gaps should be carried out as soon as they become apparent. Thinning to 2 plants per hole will take place 2-3 weeks after planting, giving a theoretical plant population of 88,000 per ha. Hand weeding can be carried out simultaneously with the above operations.

Re-ridging by tractor some 4-5 weeks after planting is recommended to aid weed control and ensure even distribution of water. An additional re-ridging operation may be required if weed growth becomes a serious threat to the crop. Other cultural practices have been discussed in section 8.3 whilst the application of insecticide by knapsack sprayers for cotton under flood irrigation conditions has been recommended, aerial application of insecticides to the cotton crop is suggested. This method of application is becoming increasingly used in other cotton growing countries in East and Central Africa, and, although it is a seemingly revolutionary step in Somalia, there is no doubt that this method could be successfully employed on a large scheme. The advantages of aerial spraying include:

(i) The even application of insecticides at correct rates.

(ii) Correct timing of application.

(iii) It is possible to spray when the ground is unfit for mechanical methods.

(iv) No damage is caused in the crop.

(v) Costs are comparatively low at about So. Shs. 20 per ha per application.

Aerial spraying does have one disadvantage - wasteful spraying of cotton that is too young or too old, since it is difficult in large blocks of cotton to ensure that planting is carried out over a sufficiently short period. It would appear that aircraft are available for hire in Somalia, for this work, since the banana estates are already using commercial air spray firms to apply fungicides to the crop. The Desert Locust Control Organisation, which has bases in the country, have undertaken cotton spray work on a commercial basis in other parts of East Africa and the organisation may be interested in such work in Somalia.

A further pest of cotton which is worthy of mention is the cut-worm. Its distribution seems to be rather irregular, but it may cause

damage, particularly in crops grown on virgin soils. Successful control of this pest has been obtained with an application to the soil of 4 kg of 3 per cent B. H. C. per ha before planting.

Harvesting of the cotton crop should begin towards the end of December and continue until the end of February. The dry, sunny and windy conditions prevailing at this time of year are generally favourable for harvesting. The picking season for the selected Acala variety should not exceed two months; with a picking interval of 2-3 weeks, some 3-4 pickings will be required.

The real potential of cotton along the Shebelli has not yet been demonstrated. Only one cotton experiment, a variety trial, has been properly carried out at the Afgoi Research Station since the station began work in 1964 and the results give some indication of what might be achieved. The yields from this variety trial, carried out in 1965-66, are given in Table 8. 4. It is apparent that satisfactory control was achieved in this trial, since it was grown through the dry 'Gilgai' season, when pest populations are at their lowest; three applications of mixture of Endrin and DDT were applied. The yields should be viewed with caution in the light of the fact that the plot size was 1 row of 10 metres length replicated six times.

Further evidence should be forthcoming from the trials carried out by German Technical Assistance personnel at Genale during 1968. Satisfactory yields have been obtained on a commercial scale in the past and the yields of early crops of some of the early Italian settlers are worth quoting.

1922 Egyptian cotton 100 ha produced 205 quintal lint

1923 Egyptian cotton 670 ha produced 2, 254 quintal lint

Reference: Report 'Diversification of Agriculture' Italconsult.

TABLE 8.4 Yields obtained in a cotton variety trial carried out at the Afgoi Research Station

Variety	Yield in kg per ha
Prima 52	825
Cooker 100	1936
Carolina	2579
Local	277
Prima S. 1	640
U.K. 51	1347
UKA 59/8	1022
UKA 59/246	1295
Deltapine 15	2629
UKA 59/242	1672
Austin	2189
UKA 59/240	1009
Rex 1	1282
Stoneville 7A	3118
Fox 4	2315
Stoneville 213	1837
A 57-1	1400

Planting date: December 15th 1965.

Harvesting date: Commenced 31st Match 1966.

According to records from the estate of the Duca de Villabruzzi (now the Johar Sugar Estate), yields of over 10 quintal per ha of seed cotton were obtained on quite large areas during the 1930's. Some reasonable yields were achieved in the past and assuming the application of recent knowledge and modern techniques, there is no reason why economic yields should not be obtained in the future. The soils are well suited to cotton growing and, if a high standard of crop husbandry can be maintained with proper irrigation practices, an average yield of 20 quintals should be attainable.

Onions

This crop has been mentioned as having considerable potential as a small cash crop for growing on a limited area. A brief note is, therefore, included on the cultivation requirements and potential performance of the crop.

The variety Texas Grano has given good results in variety trials at the Afgoi Research Station and can be firmly recommended. The bulbs of this variety are well formed, rounded to oval in shape, and have a yellowish skin. Storage quality appears to be quite good providing they are well-cured. It has been well received on the local markets.

Land preparation on vegetable plots will be carried out by hand. A weed-free seed bed is essential for this crop and it is important, therefore, that the soil is worked a number of times before planting. The East African 'jimbe' is recommended for cultivation since a much deeper tilth can be turned than with the very lightweight local tool known as the 'jambo'. A pre-planting irrigation would be useful to germinate weed seeds. A fine seed bed is required. Ridges can be made with the local tool known as the 'kewawa'. An inter-ridge spacing of 75 cm is recommended and two rows of onions will be planted on these ridges, which should be flat-topped and not more than 10 cm in height. Rows should be 20 cm apart. Sowing can be done by a small hand planter. A seed rate of 7 lbs. per ha produced good results at the Afgoi Research Station and can be provisionally recommended.

Weed-free conditions should be maintained throughout the actively growing stage of the crop. A top dressing of ammonium sulphate, equivalent to 100 kg N per ha, should be applied 3-4 weeks after planting. The need for applications of potash and phosphate has yet to be proved.

Thrips are, perhaps, the most serious problem in local onion production, but at the Afgoi Research Station they have been successfully controlled with malathion. Two or three applications are normally required. Fungicide may also be necessary for the control of onion smut. A yield of 12,500 kg of onion bulbs was obtained from 1 ha of Texas Grano variety when direct-seeded and treated as a commercial crop.

CHAPTER 9

CROP PRODUCTION INPUTS - WATER, LABOUR AND MACHINERY

9.1 Climatic Data for the Calculation of Crop Water Requirements

In Chapter 5 reference has been made to the methods used for the calculation of crop and rotational water requirements. The following sections refer to the estimation of irrigation requirements for the recommended crops to be grown under controlled and flood conditions.

The only climatic data available in Somalia at the beginning of 1968 which could be used for estimating crop water use was temperature. Using this climatic parameter, consumptive use may be estimated by the method of Blaney and Criddle. There is however little variation in mean daily temperature throughout the year in the lower Shebelli flood plain, therefore application of the Blaney and Criddle method results in a uniform potential consumptive use throughout the year. Considerable variation does occur from season to season in terms of shunshine, wind and humidity, and for this reason calculation of monthly consumptive use by the Blaney and Criddle method could result in considerable over or under estimation, although seasonal consumptive use calculated by this method should be reasonably accurate.

In February 1968, a meteorological station was set up at Afgoi to record those meteorological factors required to estimate crop water use by the Penman method. Although only one full year of results was available, it was considered that these would give a better estimate of crop water requirements throughout the growing season. The estimated potential evaporation turf (E_t) was calculated for 5 day periods throughout the year and the results are shown graphically in Figure 9.1 The variation in potential evaporation throughout the year is particularly noticeable.

9.2 Water Requirement for Flood Irrigated Crops

In assessing the water requirements for flood irrigated crops it was assumed that the soils would be raised to field capacity to a depth of at least 2 metres and that the crop roots would ultimately exploit soil moisture reserves to a depth of at least 1.6 metres at which depth a limiting horizon may occur. The moisture content of the soil within this ultimate rooting zone at field capacity is 96 cm and assuming the crop will, by maturity, extract moisture until the pF value of the soil reaches 10 atmospheres the available moisture will then be equivalent to 35 to 40 cm. In addition rainfall of 10 to 20 cm will supplement soil moisture during the growing season giving a total available moisture of over 50 cm.

Using the Blaney and Criddle method to calculate seasonal consumption use for the recommended crops the total use under optimum soil moisture conditions would be:-

Cotton	58 cms
Sesame	50 cms
Sorghum	44 cms
Groundnuts	49 cms

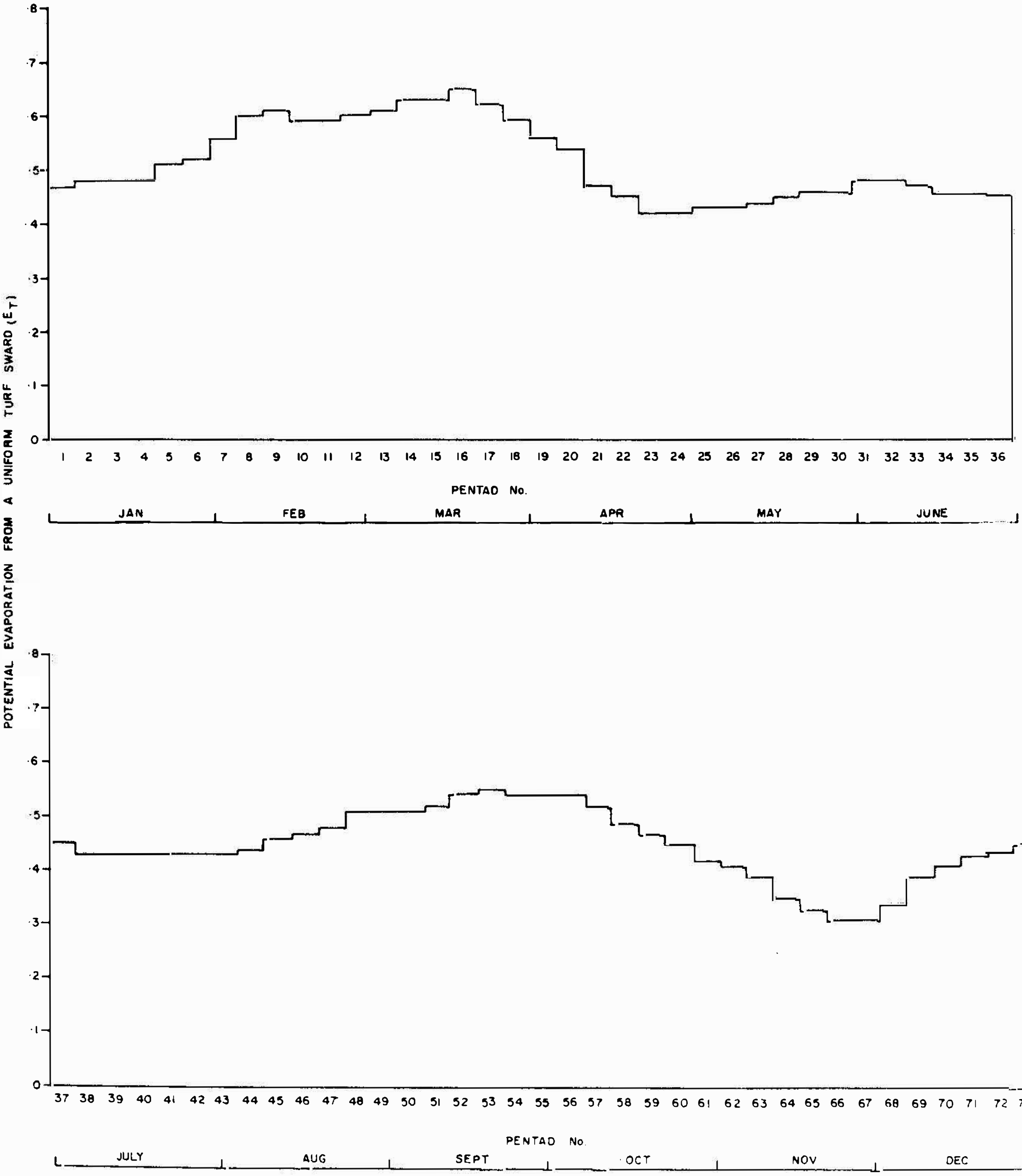
The gradual increase in soil moisture stress which will occur during the later part of the crop growing season will in fact result in crop water loss being rather lower than these figures indicate. It is apparent that the available moisture reserves will be adequate for crop growth.

As the soil moisture reserves may be depleted to a level below permanent wilting point by continued evaporation from cracks and through dead plant material. prior to flood irrigation for the succeeding season a total application of at least 50 cm will be required to return the soil to field capacity.

Although moisture stresses as high as 10 atmospheres suction will be experienced by the crops when reaching full maturity the stress just before fruit formation will not exceed 4 atmospheres and should not therefore detract from acceptable crop yields.

Figure 9·1

EVAPORATION FROM A UNIFORM TURF SWARD E_T IN CMS/DAY
ESTIMATED BY PENMANS METHOD FOR EACH PENTAD AND
SMOOTHED BY TAKING 5 PENTAD MOVING AVERAGES



9.3 Water Requirements of Crops Under Controlled Irrigation

The method described in Section 5.3 was used to calculate a daily soil water balance for each crop throughout its growing season using the E_t values shown in Figure 9.1.

Crop factors (K) for the three recommended crops are given in the graphs in Figure 9.2 based on a generalised consumptive use curve, reaching a peak at time of flowering and fruit setting.

The available moisture at field capacity (in centimetres) for Afgoi soils at different depths is shown in Figure 9.3 which is derived from data from laboratory studies of moisture retention characteristics of soils taken from six representative profiles in the area. Field capacity was assumed to be the stable moisture content under soil suction of 0.3 atmospheres and permanent wilting point occurring at a moisture content at 15 atmospheres. The depth of soil exploited by the crop roots at full development was estimated from observations of rooting in the Afgoi soils and from knowledge of the rooting habits of each crop. It has been assumed that the maximum depth of root exploitation will be reached before the crop's peak evaporation demand occurs at time of flowering.

The actual evaporation from the growing crops (E_a) allowing for build up of moisture stress conditions between successive irrigations was estimated, using the relationship given in Figure 9.4. The soil moisture retention curve was compiled from the soil physics laboratory data on the six Afgoi profiles.

The daily water balance calculations for each crop are shown in Annex XIII of Vol. IV/ VA and the accumulated irrigation requirements in Figures 9.5 and 9.6. In estimating the irrigation requirements of the 'Der' season cotton and upland rice crops, rainfall was ignored since the variability of the rainfall at this season makes it impossible to rely on rain to meet part of the crop's water needs at any particular phase of the growing season. In most years, however, total water requirements will be somewhat lower than those estimated due to the contribution of rain

at some stage of the growing season. In the case of the 'Gu' season groundnut crop, the uncertainty of irrigation water supply in April and early May, necessitates the consideration of rainfall occurring during that season. Accumulated monthly precipitation was calculated for the period April to July for the 24 years during which complete records were available. The accumulated totals at the end of each month are plotted in order of probability of occurrence in Figure 5.1 and straight lines fitted to the data. By reference to this data accumulated rainfall to the end of each month may be estimated and the monthly values obtained by subtraction. The graph indicates little variation from year to year in total monthly rain in June and July, but considerable variations in April (nil to over 20 cms) and to a lesser extent in May (0 to 10 cms). In order to assess the variation in irrigation requirements for different years, the percipitation and distribution in seasons of median rainfall, together with seasons in which the rainfall was as low and as poorly distributed as would be expected to occur once in ten years were estimated, and are shown in Table 9.1.

TABLE 9.1 Rainfall estimate for Median and 10 per cent Dry Season

Month	Median Season		10% Dry Season	
	Accum. total	Amount	Accum. total	Amount
April	9.3 cm	9.3 cm	Nil	Nil
May	17.2 cm	7.9 cm	4.0 cm	4.0 cm
June	22.4 cm.	5.2 cm	8.6 cm	4.6 cm
July	28.6 cm	6.2 cm	13.3 cm	4.7 cm

In order to assess the rainfall expectation in five day periods, throughout the cropping season, the data was examined (24 years) and months approximating to the expected monthly rainfall selected. The pentad rainfalls were obtained from the daily rainfall data for the selected months and are given in Table 9.2.

Figure 9·2

VALUES OF CROP COEFFICIENTS (K)

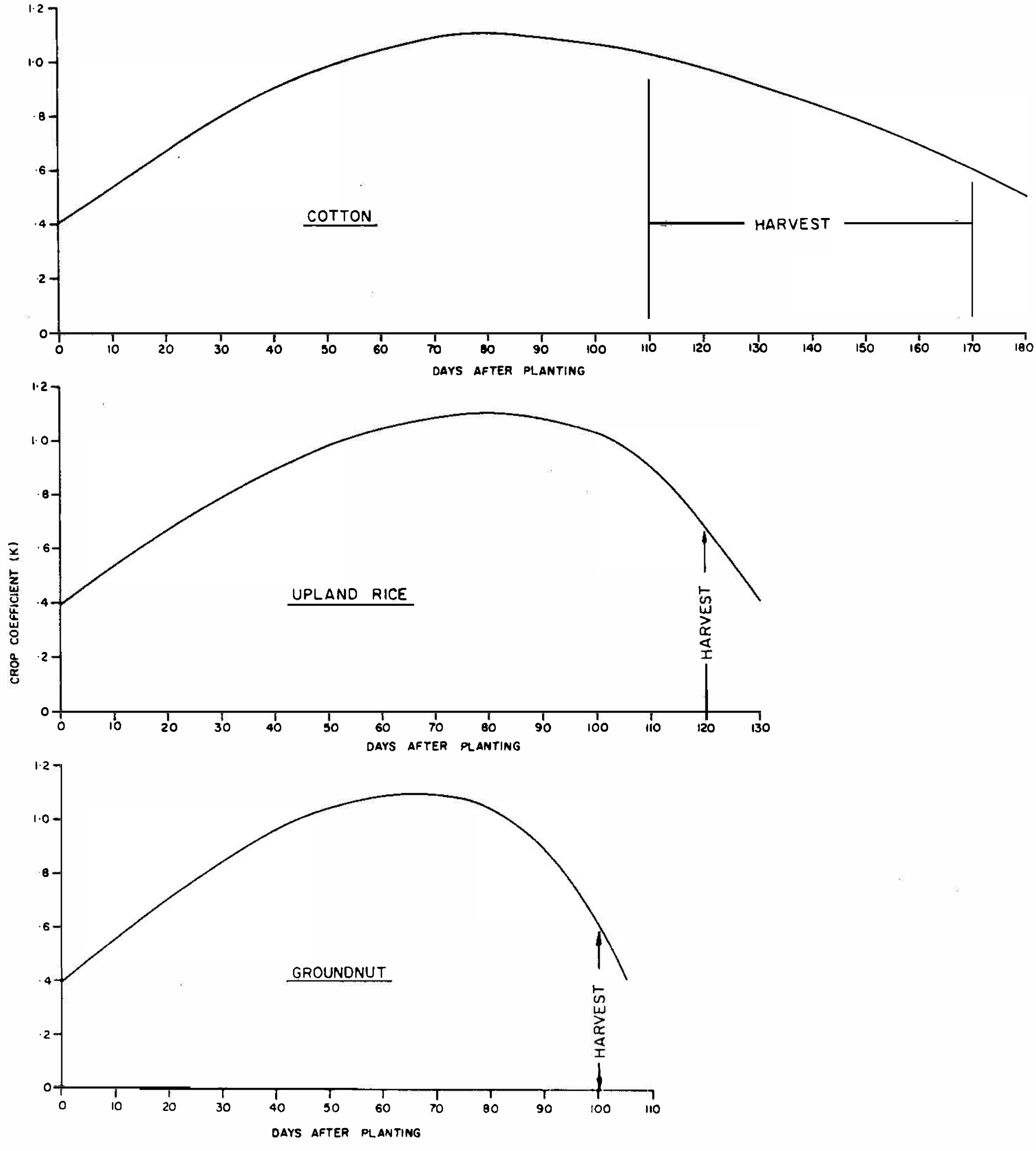


Figure 9·3

AVAILABLE MOISTURE CONTENT OF AFGOI / MORDILE SOILS AT FIELD CAPACITY

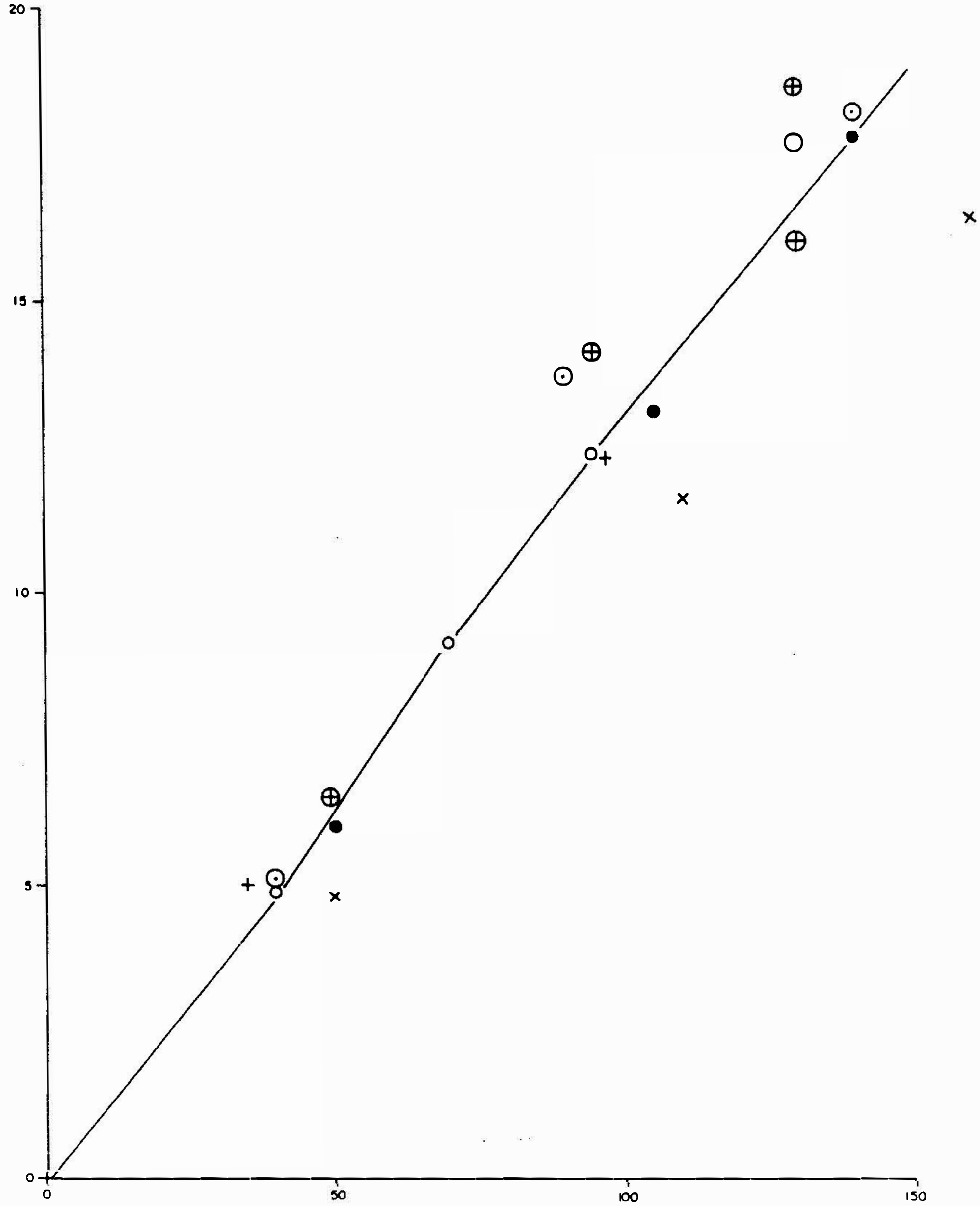


TABLE 9.2 Pentad rainfalls selected as typical for Median and 10 per cent Dry seasons

Pentad	Median Season		10% Dry Season	
	Month	Amount	Month	Amount
19		Nil		Nil
20		Nil		Nil
21	April 1962	2.50	-	Nil
22		Nil		Nil
23		4.95		Nil
24		1.70		Nil
25		Nil		Nil
26		3.70		2.24
27	May 1962	1.10	May 1965	1.27
28		Nil		Nil
29		1.25		Nil
30		1.40		Nil
31		Nil		1.41
32		Nil		1.60
33	June 1957	1.88	June 1960	1.52
34		.66		.26
35		.38		Nil
36		2.25		.08
37		2.49		.05
38		1.11		1.98
39	July 1965	.92	July 1966	.28
40		.69		.91
41		.18		1.72
42		.76		.10

The rainfall expectation in a 10 per cent Dry season is so small and likely to be so poorly distributed as to have little effect on the irrigation requirement and has therefore been ignored in calculating the crop water needs under such conditions. Rainfall has, however, been taken into account in the estimate of irrigation requirement for a median season. In the daily water balance calculations, the pental rainfall has been credited on the third day of each pentad, the calculating procedure for the estimation of crop water use being identical for both cotton and upland rice.

Because of the limited climatic data available on which to base irrigation requirement calculations and the lack of local information on crop water use, it is considered advisable to add a 20 per cent contingency allowance to the estimated field requirements. This is shown in Figures 9.5 and 9.6: accumulated irrigation requirements for each crop.

The applications of irrigation water should be spaced as uniformly as possible to facilitate straightforward operation of the irrigation system and as far as possible, applications should be reasonably uniform to avoid undue peaks in irrigation demand which would result in unnecessarily large canals and pumping capacity.

The recommended irrigation regime for each of the crops are shown in Tables 9.3, 9.4 and 9.5.

TABLE 9.3 Irrigation Requirements for Cotton at Field Outlet

Irrigation No.	Amount	Accumulated Total
1	7.5 cm	7.5
2	8.0	15.5
3	9.5	25.0
4	10.0	35.0
5	10.0	45.0
6	10.0	55.0
7	8.5	63.5
8	8.5	72.0

Initial irrigation to commence in mid-September, irrigation interval to be of 12 days duration.

Figure 9·4

SOIL MOISTURE RETENSION AND RELEASE FOR DIFFERENT CROP EVAPORATION DEMAND

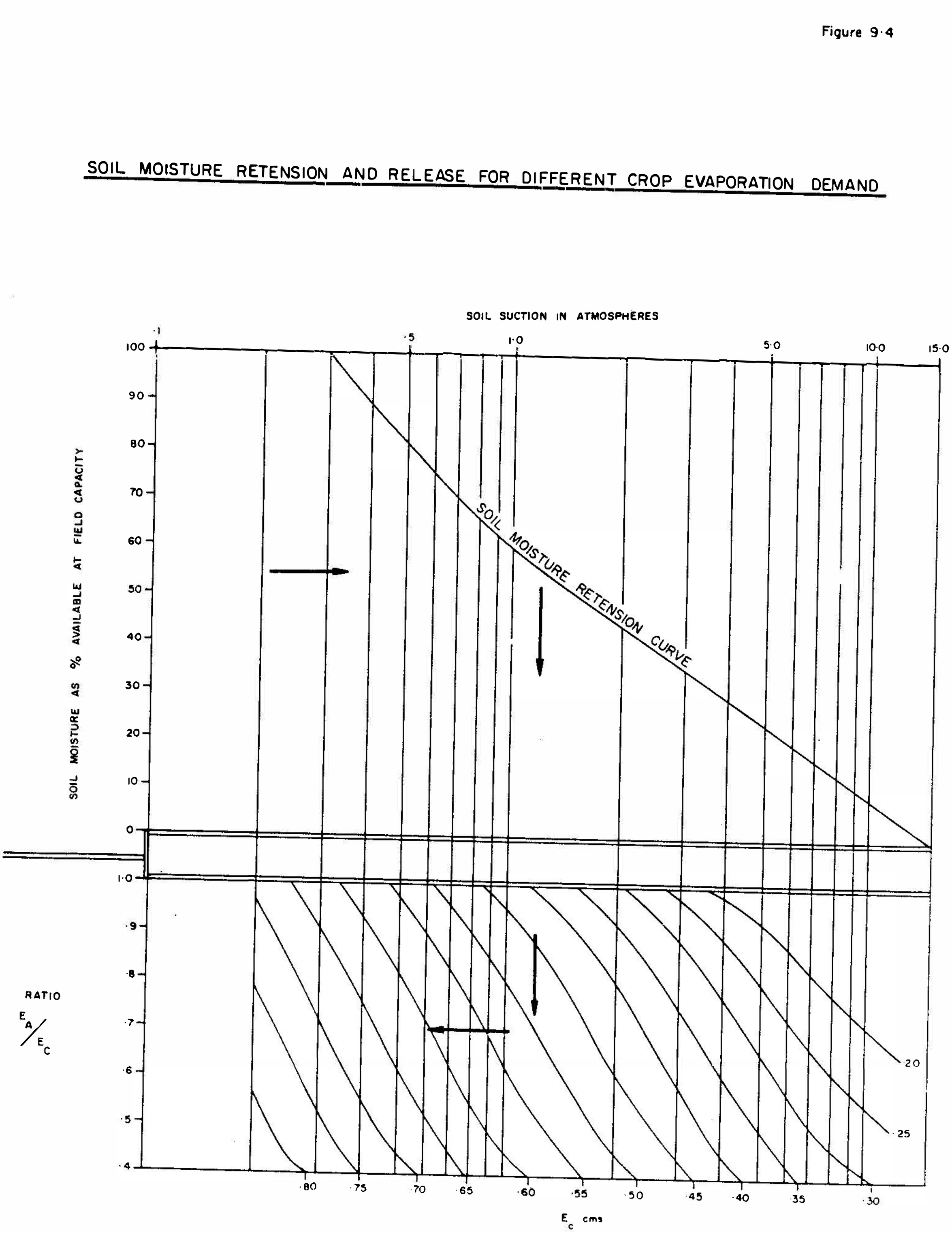
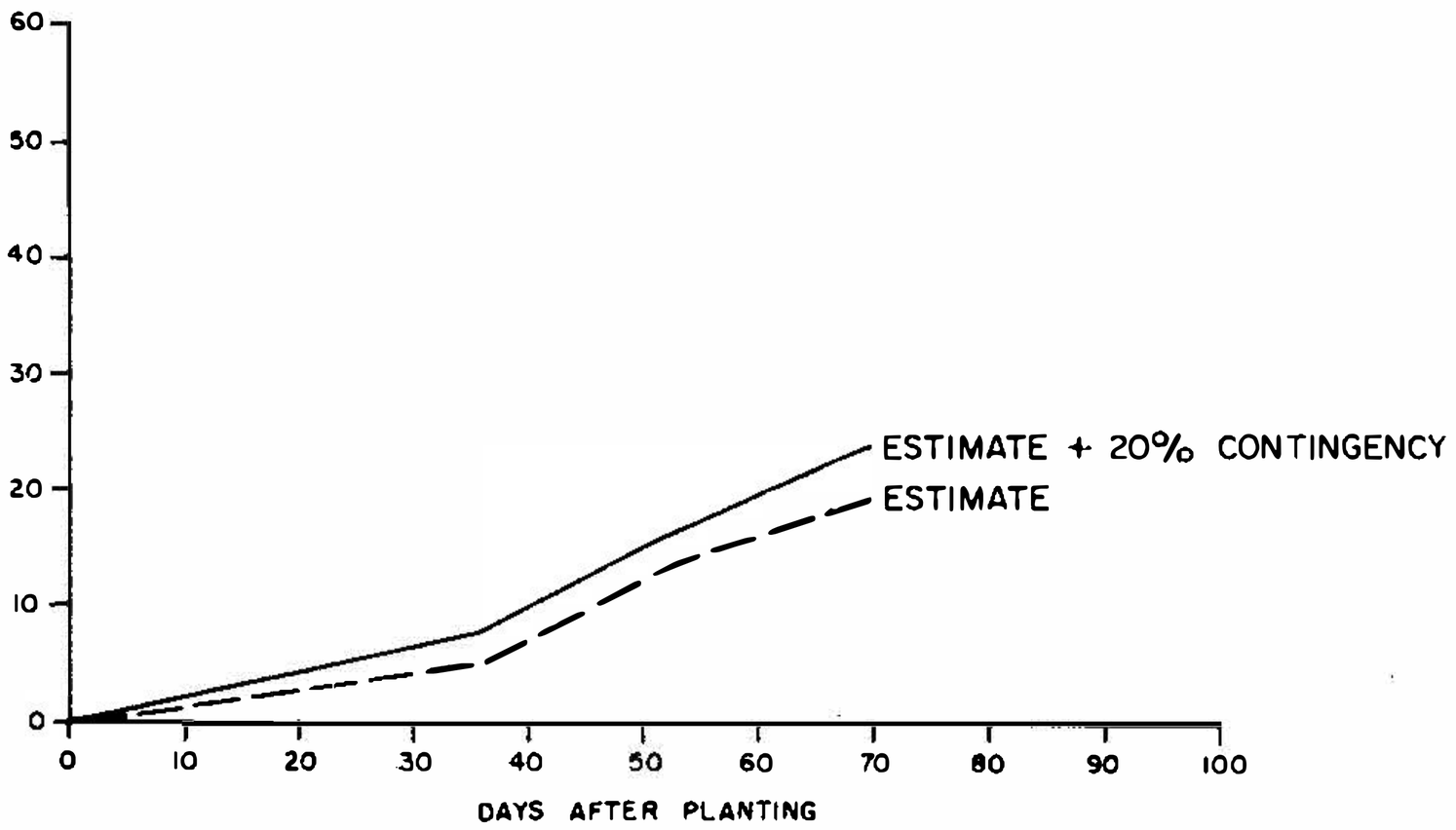


Figure 9·5

ACCUMULATED IRRIGATION REQUIREMENT AT FIELD OUTLET

GROUNDNUT - GROWING SEASON RAINFALL MEDIAN IN AMOUNT AND DISTRIBUTION



GROUNDNUT - 10% DRY GROWING SEASON RAINFALL IGNORED AS DISTRIBUTION UNFAVOURABLE

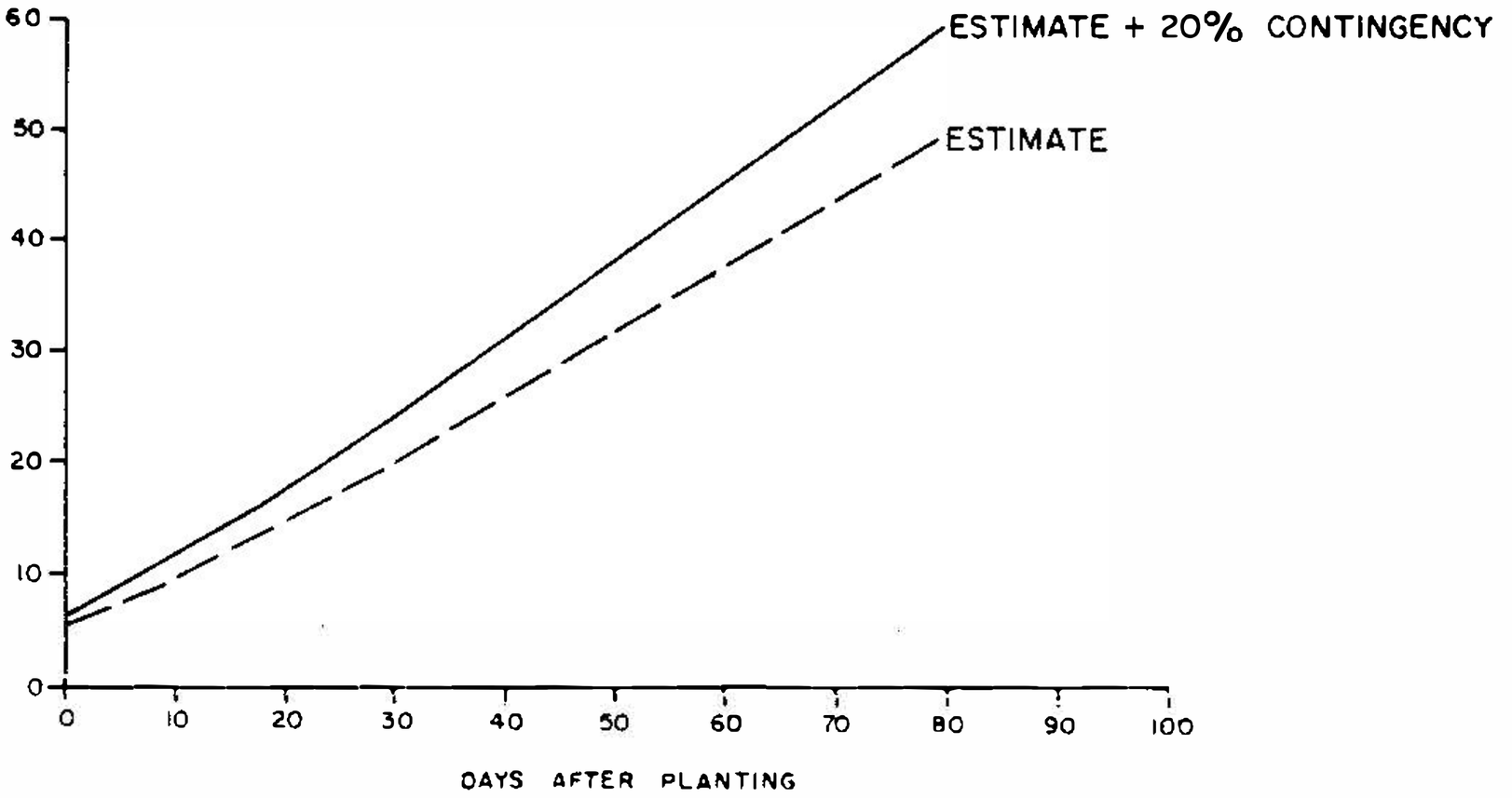


Figure 9·6

ACCUMULATED IRRIGATION REQUIREMENTS AT FIELD OUTLET

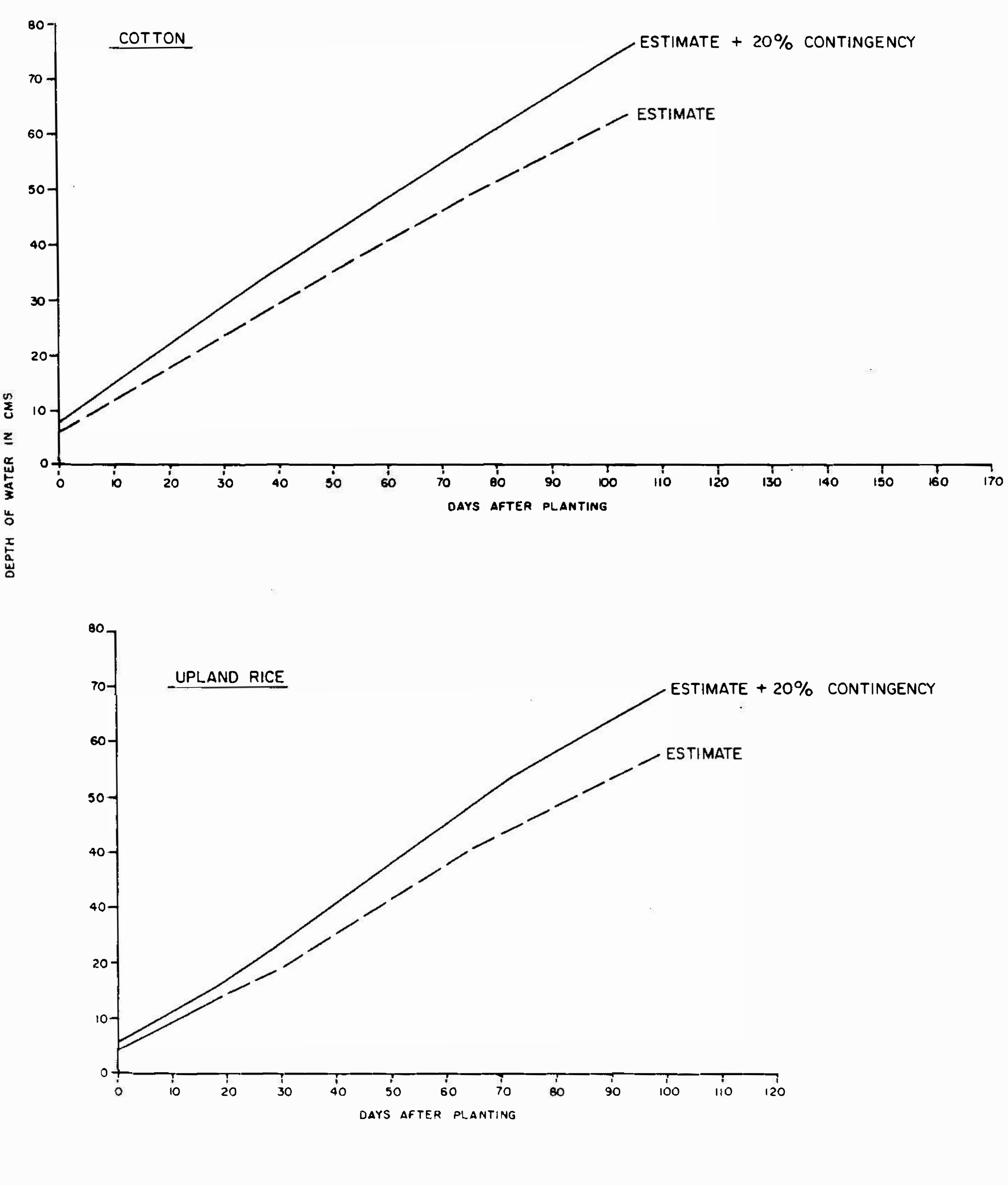


TABLE 9.4 Irrigation Requirements for Upland Rice at Field Outlet

Irrigation No.	Amount	Accumulated Total
1	5.5 cm	5.5
2	6.0	11.5
3	6.0	17.5
4	6.0	23.5
5	6.5	30.0
6	7.0	37.0
7	7.5	44.5
8	7.0	51.5
9	6.0	57.5
10	6.0	63.5
11	5.0	68.5

First irrigation to commence in late August all subsequent applications being at 10 day intervals.

TABLE 9.5 Irrigation Requirements for Groundnuts at Field Outlet

Median Year			10% Dry Year		
Irrig. No.	Amount	Accum. Total	Irrig. No.	Amount	Accum. Total
1	8.0	8.0	1	6.0	6.0
2	8.0	16.0	2	5.0	11.0
3	8.0	24.0	3	6.0	17.0
			4	8.0	25.0
			5	9.0	34.0
			6	9.0	43.0
			7	8.0	51.0
			8	8.0	59.0

In a 10% dry season, the initial irrigation should commence on 19 April, the first two irrigation intervals being of 10 days duration and all subsequent applications at 12 day intervals.

In a median year the initial irrigation is required to commence on 23rd May and the second and third applications after 15 and 18 day intervals respectively. If water should be available, an additional post planting irrigation would be beneficial.

As a check on the estimated total irrigation requirement the seasonal consumptive use was estimated using Blaney and Criddle's method. A 75 per cent irrigation efficiency factor was assumed and the results are compared with the previously calculated total irrigation requirements in Table 9.6.

TABLE 9.6 Comparison of estimated irrigation requirement with seasonal requirements calculated by Blaney and Criddle's method

Crop	Month	t °F	p	f	K	U cms	U/Eff. Factor	Estimate using Penman
Cotton	Sept(½)	79	8.22	3.25				
	Oct.	80	8.46	6.77				
	Nov.	80	8.16	6.53				
	Dec.	80	8.42	6.73				
	Jan.	81	8.43	6.82				
				30.10	.70	54.5	72.0	72.0
Rice	Sept.	79	8.22	6.50				
	Oct.	80	8.46	6.77				
	Nov.	80	8.16	6.53				
	Dec.	80	8.42	6.73				
				26.53	.80	54.0	72.0	68.5
Groundnut	Apr.(½)	83	8.25	3.37				
	May	81	8.55	6.93				
	June	79	8.29	6.55				
	July(3/4)	77	8.57	4.95				
				21.80	.75	42.2	56.0	59.0

A pre-planting irrigation has been omitted from the above estimates due to the short season during which irrigation water is likely to be available in many years. Although not essential, a pre-planting irrigation would be

beneficial both in improving the tilth of the seed bed and in ensuring rapid germination after planting. It is recommended that a pre-planting irrigation be applied in those years when water is available. In the event of a pre-planting application being possible, the early post-planting irrigation requirements will be reduced. The amount of water to be applied prior to planting should not exceed the maximum post-planting application on which the canal design is based.

9.4 Seasonal Irrigation Requirements of other Crops for Controlled Irrigation

In order to enable the water requirements of existing areas of controlled irrigation to be estimated the seasonal consumptive use of other crops was estimated by Blaney and Criddle's method; the results are shown in Table 9.7.

TABLE 9.7 Seasonal consumptive use of other crops

Crop	Growing Season	Consumptive use in cumecs	Efficiency factor %	Field Requirements cms
Sugar cane	Year	173	80	216
Bananas	Year	187	75	250
Maize	(mid-April-mid-Aug.) and (mid-Aug.-mid-Dec.)	57	75	75

9.5 Labour Inputs and Labour Availability

An assessment of the labour requirements for each cultural operation for the recommended crops was made to enable the total labour requirements throughout the year to be calculated for typical holdings. The estimated labour requirements for flood irrigated crops are shown in Table 9.8 and for controlled irrigation crops in Table 9.9. There is no factual information available on the labour output of the Somali farmer. Estimates have been derived from a variety of sources in other countries but including allowance for local conditions.

TABLE 9.8 Estimated Labour Requirements for Selected Flood Irrigated Crops (man-days/ha)

Operation	Cotton	Sesame	Sorghum	Groundnuts
Planting	7	7	7	7
Resowing and thinning	5	3	3	3
Weeding	21	15	15	15
Harvesting	37½	10	10	4
Groundnut stripping				11
Threshing		30	15	
Bagging and Transport	6			5
Cotton root pulling	24			
Total	100½	65	50	45

TABLE 9.9 Labour Requirements for Selected Crops under Controlled Irrigation (man-days/ha)

Operation	Groundnuts	Cotton	Rice
Field Preparation	3	3	3
Sowing	7	7	1
Resowing and thinning		5	
Irrigating	4	4	6
Weeding	18	18	18
Lifting and stacking groundnuts	4		
Stripping groundnuts	12		
Harvesting cotton		52	
Bagging and Transportation	5	7	1
Uprooting and burning cotton		25	
Burning rice straw			4
Total	53	121	33

Under flood irrigation cropping the farmer and his family will be actively engaged in crop cultivation for approximately 7 months each year. During this period it has been estimated that the farmer could contribute 9 man-days of work during each 10 day period and that his family could provide the equivalent of a further 9 man-days in a similar period for planting and weeding operations and the equivalent of 12 man-days in 10 days during cotton harvesting. Any additional labour required for a holding would be hired but because of the probable shortage of labour for hire at peak seasons such hired labour should be kept to a minimum.

Under controlled irrigation the farmer and his family would be engaged in crop cultivation throughout most of the year. It has been estimated that the farmer would in these circumstances provide up to 8 man-days of work in any 10 day period whilst his family would provide 5 man-day equivalents for planting, weeding and groundnut harvesting operations and 8 man-day equivalents for cotton picking. The balance of labour for a holding would require to be hired.

9.6 Machinery Inputs

In settlement projects of the kind envisaged, in which few high value cash crops can be included it is essential to utilise as fully as possible the available man-power of the farmer and his family. Mechanisation should only be introduced for the essential land preparation operations, to supplement labour for the completion of tasks when labour becomes a constraint, and for transportation of produce from the fields. In order to assess the requirements for tractors and equipment for the proposed cropping regimes the work output of the various machines used for cultivation operations was estimated and is shown in Table 9.10.

TABLE 9.10 Estimated Outputs of Machinery

	Tractor speed k.p.h.	Operating hours per day	Completed ha per day
Disc plough	6	8	5
Chisel plough	4.5	8	6
Disc harrow	6	8	12
Land smoothing	-	8	4.5
Ridging	4.5	8	6
Re-ridging	6	8	10
Disc harrowing & sowing rice	6	10	12
Spraying	6	8	30
Blading groundnuts	6	10	8-10
Combine harvesting rice	4.5	8	8

For the transportation of produce it was assumed that the average round trip from field to collecting centre and return would be 10 km and that a tractor and trailer would complete 4 such journeys in one day. The average load on a 5 ton trailer for each of the selected crops was estimated as follows:

Seed cotton	2 tons
Groundnuts in shell	3-3½ tons
Rice	4½ tons
Sorghum	3 tons
Sesame	5 tons

The estimated requirements for tractors and equipment for the proposed flood and controlled irrigation projects are given in Volumes II and III respectively.

CHAPTER 10

THE POTENTIAL FOR DEVELOPMENT OF RAINLAND CROP PRODUCTION IN THE SHEBELLI VALLEY AND ADJACENT AREAS

10.1 Introduction

During the course of the irrigation development studies it became apparent that an assessment of the potential for investment in the rain-fed agriculture sector should be made for comparative purposes. This chapter outlines the existing constraints associated with the development of rainland agriculture and indicates the extent of development which would be possible if these constraints were overcome.

A brief reconnaissance study was undertaken of dry-land farming conditions in the Upper Shebelli Valley Region; Shebelli Flood Plain and part of the Eluviated Plain region. In very approximate terms the area studied extended about 100 km inland from the coast from Avai to Mahaddei Uen then for some 40 km on either bank of the Shebelli River to the Ethiopian border.

In the period after independence it would appear inevitable that political considerations should take precedence over economic factors, especially in a country that has had two separate systems of Government, conducted in two different languages, in the past. The problem is further accentuated by the fact that the country has few significant exploitable natural resources and has to depend on foreign finance not only for the development budget but also to balance the local recurrent budget. Although determined steps have been taken to remove the budgetary deficiencies of the pre-independence period, these still remain and are likely to remain for some time. The Government therefore cannot afford, and should not contemplate, any development which is likely to result in additional re-current expenditure without a reasonable chance of appreciable economic expansion.

10.2 Manpower

Apart from the weakness in the financial sector, there exist manpower constraints which are evident in the whole Government structure. At this stage, even if finance were available, there are inadequatly trained and experienced manpower available to project Government policies beyond the purely administrative sphere. In fact the tendency of the last five years has been for the civil service to grow administratively whilst lagging technically. A high proportion of professional and technical men are presently assigned to administrative work of lesser national importance, moreover such people are not being paid commensurate to their training and raising the national income. The rapid expansion of Government activities in many new but important fields has generally resulted in the dilution of the better trained and experienced technical and administrative personnel in existing vital areas of development by transfers to completely new spheres of activity. Many important middle level posts in Government have had two and even three incumbents in the course of a year. This lack of continuity inevitably results in lowering of morale and poor work output.

A further problem that is beginning to have an effect is that many of the young and recently qualified technical staff are being posted up country to work under much older and unqualified senior staff, who are unwilling to accept change, and appear to be determined that the newcomers shall not undermine their present positions and way of life. There is also evidence that many of the more newly trained people are either resigning or becoming increasingly frustrated. The deficiencies in recurrent expenditure, which precludes them from being given the basic tools to undertake their work, is a greater frustration to them than to their elders.

10.3 The Second Five-Year Plan Priorities

Government, appreciating the deficiencies in finance and manpower and its brake on development, has decided certain priority in the Second Five-Year Plan. The first is that it must consolidate developments initiated in the period of the First Plan which shows signs of success; secondly it must

endeavour to close the present budgetary gap and finally it must reorganise and regroup its resources of manpower and finance before launching into new development in the future. Perhaps the most important of these is to close the budgetary gap. Special emphasis is placed on self-help schemes and self-liquidating projects.

10.4 Statistics and General Information

Since basic statistics in almost all fields are deficient, it is recognised that planning must be straightforward in concept and the continued operation of a project must be within the means of the population in the foreseeable future.

The basic infrastructure of the country on which development must be based is still inadequate and for this reason a high priority has been given to the provision of facilities and services under the category of consolidating and completing projects initiated under the First Plan. A great deal of basic information is still required on animal and crop husbandry and water. Farmers in a country so readily affected by the vagaries of the weather are naturally most conservative in their approach to change. Concrete evidence is therefore essential that an innovation is practical and profitable before any attempt should be made to introduce it. Thus research and the testing of the fruits of research must precede the launching of wide scale extension campaigns.

The recommendations of the IBRD/FAO Project Identification Mission to Somalia in 1968 are worthy of special attention. This report considered that research should operate closely with fact finding farms to establish the commercial viability of the results. The conception that crop production should be associated with livestock as part of a farming system is emphasised. Unfortunately this cannot be more than an expression of faith until a sound system of livestock marketing is accepted and established, based initially on purchase by weight and eventually introducing quality factors.

Although Somalia has to face a period of preparation for development in the agricultural field, nevertheless there is no reason why a study of the rain-grown cropping regime, associated with livestock, which is the most important system of food and commodity production, closely followed by nomadic livestock husbandry, might indicate ways and means of increasing production now, as well as in the future.

10.5 Government Organisations

The division of the original Ministry of Agriculture into three Ministries is considered to be a retrograde step (Ministry of Agriculture, Ministry of Rural Development and Ministry of Livestock, Fisheries and Natural Resources). Instead of a co-ordinated effort being made to use to advantage all available staff, facilities and finance, duplication of effort has been common and all too frequently ministerial, departmental and sectoral loyalties have been given precedence over national requirements and plans. This has been accentuated further by the formation of semi-autonomous bodies such as the Agricultural Development Agency (ADA) and the Livestock Development Agency (LDA), which have become responsible for special sectors of development with demands on staff and funds which are already in short supply. By allocating the LDA the right to collect cesses on the export of livestock a certain amount of additional money has been made available to allow it to function reasonably efficiently although not to full capacity, but the same cannot be said for the ADA, which is so short of staff and funds that it cannot undertake its responsibilities. The Extension Division of the Ministry of Agriculture has almost the same responsibility as the ADA resulting in the duplication of effort and unnecessary overhead costs.

10.6 Investigation of New Agricultural Methods

It is normally accepted that research should be undertaken through properly sited, staffed and equipped experimental stations under the direction of qualified scientists. The only agronomic experimental work being carried out in the country apart from a small amount undertaken by the Chinese, West German and Russian Missions, is on the Central Agricultural Research Station, Afgoi, and

on the Bonka sub-station near Baidoa.. Both are working under the auspices of the University of Wyoming. The programme has mainly been concerned with irrigation crop husbandry on the Central Station, however some rain-grown crop work has commenced. The Bonka sub-station, which began to operate effectively in 1967/68, is devoted mainly to dry-land farming problems. It is apparent that the results obtained to date have not been systematically and scientifically tested out in different seasons under the different ecological sub-zones which characterise the area. Furthermore virtually no work has yet been done to assess the economic and practical viability of the preliminary results on any scale.

10.7 Extension and Training of Extension Staff

The technical extension staff in all sectors of development are inadequate in number, lacking guidance and supervision and consist mainly of technically untrained or partly trained men. As there is a chronic shortage of transport and funds to operate such transport as may be available, most of the staff remain immobile. Rarely do they have an opportunity of contacting farmers. Thus to all intents and purposes, with the exception of general effort made by the University of Wyoming and the attention given to cotton production under the Agricultural Development Agency and Livestock under the LDA, extension as understood in most developing countries does not exist in Somalia in the rain-grown crop areas.

It is unfortunate that there are few technological advances which can be advocated with confidence in Somalia at this stage. Thus the extension worker in the agricultural field has little to offer the farmer apart from persuading him to train and use oxen for farming (if equipment is available); the provision of certain new varieties of seed (sorghum, cotton and beans) which have yet to be fully tested under local farming conditions, and advise on land preparation, timely planting and weeding. This does not amount to a very attractive package, even if

well trained staff were available, to convince conservative farmers who may only recently have given up their pastoral life with a certain aversion to manual work and a lien towards livestock. Obviously a great deal of preliminary work is necessary including demonstrations on a farmer's own land to confirm that new varieties of seed and practices are worth while. This will take time. The application of certain animal disease control methods may be more readily acceptable providing they do not interfere with the farmer's normal methods of livestock husbandry; any significant change in the latter will also take appreciable time.

The shortage of properly trained extension staff is one of the major constraints to development especially in the rain-grown crop areas. A cadre of technicians capable of applying scientific knowledge to farming problems must therefore be created.

It is planned to develop the training and in-training of staff for agricultural extension at the new Agricultural School near Afgoi. As the Bonka Agricultural Training College has had to close because of shortage of funds, it is to be hoped that lack of funds for the new school will not result in a similar situation.

10.8 Co-operation

The role of Co-operatives in Somalia as an instrument for development has been a popular subject with foreign authors and the aspect has been discussed in an earlier chapter. In view of the promulgation of Law 12 of 14th January, 1969, Law on Co-operative Societies, it is apparent that the time has come to review the past and plans for the future. Under this Ordinance the following is the definition of a Co-operative Society:-

> "An association of persons ..... in which members actively participate"

Except as provided otherwise in the Ordinance" ..... the village shall be the natural unit on which the co-operative shall be based. A co-operative may cover one or more villages.".

With certain outstanding exceptions it would appear the co-operatives formed in the past were never based on the philosophy and organisation normally associated with the movement. Groups of people formed associations with the main object of receiving financial assistance, either from foreign aid agencies or from Government. Money was allocated more in faith than on the submission of a technical and economically sound development plan. Even when an enterprise was reasonable and practicable a large proportion of the funds allocated were never used for the purpose for which they were intended. As an example on a smaller scale, groups of farmers from a village banded together to form small companies with the aim of raising capital to employ labour and tractors for improved cultivation. With certain exceptions, most of the funds allocated through the co-operative movement have been dissipated with little, if any impact on development. In the more isolated areas away from the influence of the entrepreneur, associations have begun to develop which, providing they can be transformed to co-operatives under the Ordinance, and entrepreneurs excluded, may flourish, providing they fully appreciate their individual and collective responsibilities and are wisely guided in the choice of technical inputs.

The most satisfactory development in this direction is the establishment of village associations, usually in religious communities, (Jamas), whereby each farmer in the village agrees to participate in a system of communal cultivation under the direction of an elected committee and manager, profits being shared according to the area each man cultivates. This type of association should be readily accepted as a co-operative society.

It should be realised that co-operation in the accepted sense of the word is a new conception to Somalia. Providing the law is scrupulously implemented and given a reliable co-operative advisory service a sound co-operative movement could be established, however this will take time and in consequence co-operatives are unlikely to become a major instrument for development in the foreseeable future.

10.9 Land Tenure

Legislation was passed in 1960 to uphold the right of every Somali citizen to live and farm wherever he chooses irrespective of his particular clan and lineage affiliations. It appears that this legislation is honoured more in default than in fact.

Land tenure pertaining to arable land is still based on usufruct rights with no written title. As long as adequate uncultivated land is available and no new land tenure legislation is introduced, this situation is likely to continue within the tribal sphere of influence. Legally, the tribe does not own the land but it has accepted traditional rights to settle. In the areas under survey even clans have their own sections of areas of land in which members have farms and these are inherited according to Muslim law, i.e. it can be divided amongst the owner's children. This rarely arises when land is plentiful as children on reaching marriageable age are allocated unused land which is available. Women can also inherit and this is not uncommon. Land is rarely sold but is often rented. Land can also be offered free by the 'land giver' to a relation or stranger providing they accept the social commitments of the community.

Official buying and selling of land is not permitted - although transactions in land in the flood plain do take place. The Government presented a bill to the national assembly on land registration in 1967 with the aim to regularising land ownership, however it had to be withdrawn in the face of strong opposition. The bill has been amended but has not yet been resubmitted. Until it becomes law the position will remain unsatisfactory.

The rights to use browse, pasture and water away from the settled arable areas is open to any individual. As a result, and especially in periods of drought, pastorals or semi-pastorals (and in severe droughts as instanced in 1965, even farmers) may move hundreds of miles with their stock in search of pasture and water.

10.10 Climate and Soils

Climatic conditions have been discussed in detail in Chapter 5, nevertheless it is proposed to reiterate this aspect since the success of dry land farming is entirely dependent upon both the volume and distribution of rainfall. Although the total rainfall if occurring in one farming season would give reasonable chances of a successful harvest, this is not the case when the data is broken down into the two peaks. In the main cropping season ('Gu') precipitation may vary from 180 to 300 mm whereas the fall in the 'Der' season ranges from 90 to 280 mm. High evaporation and intense solar radiation takes place during the latter season.

Actual precipitation varies considerably from the calculated mean monthly rainfall with the result that rainfall in either one or both seasons may be inadequate to produce a satisfactory crop. No reliable statistics are available on short term rainfall intensities. The uncertainty of rainfall results in frequent partial crop failures and food shortages. These are very often localised, due to another characteristic of the rainfall, namely its local inconsistency, as it tends to fall in strips across the country missing certain areas and falling exclusively on others. Severe droughts can disrupt even well settled communities and, as in 1959 in the Baidoa area, this resulted in the abandonment of many villages and the death of thousands of head of livestock and caused a temporary reversion to nomadism.

The rainfall probability graph, Figure 5.1 is of special importance in assessing the agricultural value of the seasonal rains and the problems being faced by the farmer. It would appear that two in seven crops are likely to fail and only one will be above average. Rainfall constitutes the chief hazard to the rationalisation of livestock production in general and the integration of crop and animal husbandry in particular.

The importance of the monsoon winds has already been stressed in influencing the distribution of rain. The north-west monsoon dominates the climate between December and February and the south-west monsoon

between June and August. These monsoon winds appear to remain remarkably steady but in some cases having sufficient velocity to damage crops in the field such as cotton.

Temperatures vary between 25° and 35°C throughout the year and the relative humidity between 40 per cent and 80 per cent, being lower in the more arid areas.

A wide range of soils are found in the area from alluvials and clays near the river, to loams and sands inland. Most of these soils are alkaline. The wetting and drying of the clays and clay loams, resulting in alternate swelling and cracking, maintains a good soil structure without significant pan formation. The latter may change with the introduction of extensive ox and tractor cultivation. The soils used for dry farming have a reasonable water-holding capacity without which crop husbandry in such a low rainfall regime would be impossible.

10.11 The People

In the Shebelli River area the people are either pastoralists or farmers of either hamitic, negro or Arab origin. This does not exclude the farmer from owning livestock nor the pastoralist from growing crops; in point of fact it has been estimated that about two-thirds of the farmers are stock owners. When the vagaries of the weather are considered, ownership of livestock is obviously a most useful insurance policy against crop failure.

The farmers have settled mainly on the black alluvial soils of the flood plain or on the red soils between the Shebelli and Juba Rivers. In the latter areas the pastoralists graze the bush between areas of cultivation; this area is also utilised by settled farmers at certain times of the year. Farmers generally live in permanent villages cultivating suitable soils surrounding the village. When the distance from the village to the cultivated area becomes too great (i.e. over 4 kms) a new village is established. Solitary farmsteads are almost unknown due to the dangers from both human and animal marauders. Settlements in proximity to the river do not normally keep cattle due mainly to the incidence of tsetse fly. On the other hand in the dry season, livestock can be brought to the river for

watering at night when the tsetse fly is inactive. It is an accepted custom for the farmers to allow passage for the herds of the pastoralists through their land to the river.

The inhabitants of the area are divided into tribes which in turn are sub-divided into clans, each of which has a chief or leader who inherits the title or is elected. Even under present conditions leaders play a most important role as a link between the clan, the tribe and the local government representatives. They are of special significance when changes of any kind are contemplated. Without their support the introduction of innovation in the agricultural field is unlikely to make any lasting progress.

10.12 Crop Husbandry

The majority of farmers residing along the Shebelli and between the Shebelli and the Juba Rivers depend on rainfall for crop cultivation - the exceptions are those who live along the River where a high water table supplements rainfall or where flood irrigation by inundation is possible. Controlled Irrigation Schemes are generally under the direction of foreigners with the exception of a small number of Somali nationals who have obtained possession of irrigation farms originally developed in colonial times.

Dry farming, in which two crops a year can be taken from the same land, is mainly on a subsistence basis with the main aim of producing sufficient food for the family or clan. The marketing of surpluses is only contemplated when the family food stores are adequately stocked or when cash is required. The problem of food shortage is basic to the thinking of almost all dry land farmers and accounts for their conservatism and slow reaction to the introduction of change in agricultural inputs and practices. The fear of food shortage is one of the reasons why cultivators are reluctant to sell surplus farm produce;other contributory factors include poor marketing opportunities, lack of roads and transport and fluctuating prices. Under such conditions

the farm-gate prices of food crops in good crop years are low and in years of failure very high. Surpluses of grain are seldom threshed out at once and sales normally extend over a number of months.

Rarely are crops grown specifically for cash with the exception of cotton, sesame, and vegetables in areas close to a reliable market, but, as the cash incentive over and above essential family needs has been slow to develop, the overall areas devoted to these crops are small. It should also be remembered that at least 60 per cent of the farmers also own livestock, the offtake above local consumption is sold; thus there are usually two sources of cash income.

The major areas in the dry farming lands are planted to sorghum which is a relatively drought resistant crop in both seasons. In the higher rainfall season 'Gu' and on the heavier lands, maize, cotton and sesame are also grown and frequently inter-cropped. Peas, beans, squash and tomatoes are commonly used for inter-cropping in localised areas.

Land preparation invariably commences prior to the onset of the rains and the speed of this operation depends on the soil type and the cleanliness of the land; a cultivator can prepare from 1/8 to 1/2 a hectare a day. A working day consists of about 6 hours, i.e. from dawn to noon, but if necessary, having had a meal, he will continue to dusk. Labourers are hired normally for a 6-hour, i.e. half day, but will occasionally undertake a 12-hour task.

Few oxen are yet in use for land preparation although the number is increasing. Hired machinery is also used but the farmers' inability or unwillingness to pay cash and the absence of credit facilities preclude any real expansion. Perhaps the uneconomic results of mechanisation in the past may be the basic reason for reluctance to accept and pay for the use of hired machinery services.

Rainfall is the main limiting factor to reliable crop production and also influences cropping patterns and the acceptance of new agricultural inputs. In order to facilitate water conservation the farmer, having cultivated his fields to a depth of about 8 cms, then divides them up into

a grid system, two paces square, by making a ridge a few centimetres high with a special wooden tool (kewawa). A cultivator can complete 1/4 to 1/2 hectare of conservation works in a morning or 1/2 to 1 hectare per day.

The seed is usually sown just before the rain commences in nine equi-distant holes in each grid or square, at a spacing of 0.6 to 0.9 metres apart. There are 480 to 600 squares to the 'darab' and 4 'darabs' to the hectare. A farmer is able to sow an 1/8 to 1/4 hectare per morning, or 1/4 to 1/2 a hectare per day. This is a relatively high rate and cannot be sustained for any length of time. In the 'Gu' season interplanting of crops is common and cowpea, sesame, green gram and pumpkin are mixed with sorghum and maize. During 'Der' sorghum is the main crop and it is also interplanted.

Almost all weeding is done by hand except when oxen are available which is very rarely. A growing interest is being taken in ox power but the number of available trained oxen is very small. Ox cultivation for weed control is unlikely to have a significant effect in the foreseeable future. The value of attaining a weed free crop as a means of water conservation is fully appreciated and every effort is made by hand weeding to keep weed growth to a minimum. As a rule two or even three weedings are required and if weed control is well advanced a fourth cultivation is sometimes undertaken as a mulching operation. Rainfall is such that it is not difficult to achieve a sequence of suitable conditions for cultivation at the right time, i.e. before the weeds make too much growth and begin to compete with the crop.

Where land has been mechanically ploughed it frequently happens that larger areas are broken and planted than the available family manpower plus hired labour can handle. There is a tendency for mechanisation to encourage weed spread especially of species having rhizomes, and stolons.

The speed at which hand weeding can be accomplished depends on the cleanliness of the land and is about 1/10 to 1/8 ha per day. Since water in the form of rainfall is the ultimate limiting factor to production, weediness

aggravates any shortage of rain. Thus the cleanliness of a farm, other factors being equal, depends on the area under cultivation in relationship to the adult family labour available. As already mentioned, land preparation by tractor has intensified the problem as there is always a tendency to prepare more land than can be kept clean by family labour. Casual labour becomes available in most areas when the small farmer completes the essential operations on his own farm, however this availability is often too late for the large farmer.

As the grain crops mature so they become subject to constant bird attack (Quelea) which requires labour for bird scaring during the hours of daylight. Damage can be very severe and local opinion gives estimates of crop loss at over 20 per cent per annum. The birds are mainly migratory moving north and south following the seasons; control is only possible by means of a regional measure on a similar basis to the desert locust programme.

All harvesting is undertaken by hand and due to the risk of severe bird attack, sorghum is often harvested in the dough stage which results in an appreciable loss in yield. The heads of both sorghum and maize are removed from the plant, piled in heaps in the field and left to dry. About 2 man-days per hectare are required to complete this operation. Thereafter the heads are carted to the villages, stored in pits in the ground which are lined with crop refuse and sealed with mud. Grain under such conditions can be kept intact for a considerable period of time but deteriorates rapidly once the pit is open to the air.

Sesame is harvested by cutting the plant near the ground and stooked to dry out and mature. With present yields a man can harvest one hectare per day.

Cotton is picked in the normal manner, usually in one grade, being regraded later if it is not used or sold immediately. About 4 man-days per hectare are required for picking. The ginneries are usually willing to buy seed cotton in three grades, but no attempt has been made to standardise grading.

10.13 Livestock Husbandry

Due to the importance of livestock to Somalia in general and in rain-grown farming in particular, it is necessary to examine this aspect carefully particularly from the point of view of marketing.

The contribution of livestock to the foreign exchange earnings in the past came from hides and skins but over the past few years the export of livestock on the hoof has overtaken this trade. Somalia is predominantly a livestock country and at least 70 per cent of its population derive all, or part, of their livelihood from animal husbandry. Thus to engender economic progress the livestock sector must receive special attention. There has been a rapidly increasing export to the Arabian Peninsula and East Africa and, with a prohibition on the export of female stock, there are now assessed to be less than 10 per cent of males in cattle herds; sheep and goat herds have few males beyond the two tooth stage. The position with regard to camels would appear to be similar. It is suggested that the prohibition of the export of females should be reviewed.

There are indications that pastoralists are gradually turning to farming in the areas surveyed and increasing numbers are either settling permanently or partially settled. This may account for the fact that recent independent studies indicate the range land within easy access to farming areas is deteriorating. Those pastoralists who have settled are more reluctant to move their livestock long distances in search of grazing than they would have been a decade ago. On the other hand, settled farming produces appreciable quantities of crop residues such as maize and sorghum stover which is a useful livestock feed. Appreciating this important change in areas of relatively high farming potential there remains the problem of the integration of livestock into the present pattern of crop husbandry for the achievement of optimum results.

There are signs that oxen are being accepted as a means of cultivating land but this has not gone beyond the initial land preparation stage although the use of oxen for weed control would undoubtedly ease

the pressure on the family pool of labour at critical periods. The construction and cleaning of tank-dams (Uars) could also be undertaken with ease using oxen and a simple dam scoop as is the case in many other countries.

It is not particularly difficult to train oxen, unfortunately ox-drawn equipment is not available locally, without which there is little incentive to undertake such training. The Department of Agriculture, assisted by USAID, are endeavouring to encourage ox cultivation by establishing an ox-training centre in the area coupled with the introduction of simple ox-drawn implements which it is hoped will be manufactured locally.

The incidence of tsetse fly has a predominant influence on the successful introduction of mixed farming in the Shebelli River valley in which cattle have been excluded from thousands of hectares of cultivated and grazing land on account of this fly. The elimination of tsetse fly would open up extensive grazing areas for livestock.

The two main cattle breeds found in the area are the Gharee (Duara) a most attractive dual purpose breed, and the Abgal (Garara) a hardy light boned beef with the ability to withstand infrequent watering. The latter is found mainly to the east of the Shebelli River. Both breeds have good milk producing qualities which accounts for the common practice of slaughtering bull calves. The appreciable loss of potential meat by this practice suggests that a system should be evolved to save these calves for conversion into beef. The integration of livestock and crop husbandry, assuming the livestock marketing system has been improved, may encourage farmers to accept a system of intensive feeding of castrated males for special beef markets.

There is little doubt that the integration of crop and animal husbandry near the river could develop a balanced farming system which will tend towards dairying or the production of animals for urban dairies. This is unlikely to happen in the main rain-grown crop areas to the west of the river where beef production will play a major role.

The organisation of marketing in Somalia is well developed when examined from the collection point of view. Animals are purchased in many parts of the country, moved on foot to the coast where they are shipped or sold to meat packing factories. Most of the surplus animals from the Lower Shebelli area move through Mogadiscio. Therefore buying points should be established, a holding and quarantine ground developed to facilitate an expansion in this trade. As already discussed an incentive for the production of prime beef presupposes the introduction of marketing by weight and grade. This would discourage the sale of immature animals and foster the producer to improve facilities to bring younger animals to an optimum weight. This is in fact being attempted by the LDA in the south of the country but without much success, to date. However, appreciable time is required to introduce such a radical innovation to the attention of conservative stock-owners; providing pressure is maintained it is believed that success will eventually be achieved as has been the case in neighbouring countries in Eastern Africa.

No livestock industry can hope to prosper, especially when it aims to market abroad, without the control of certain endemic diseases. Mention has already been made of trypsomaisis which has a local effect in restricting livestock development but there are more important diseases such as rinderpest, inoculation campaigns against which must be conscientiously and systematically undertaken in every part of the country to ensure that each year's calf crop is inoculated. Unless this is satisfactorily undertaken, epidemics will rage and importing countries may refuse to accept either animals on the hoof or unprocessed meat from Somalia. Contagious bovine pleuro-pneumonia is also important but can be controlled by vaccination which is normally given simultaneously with rinderpest inoculation. Foot and mouth and tick-borne diseases are also beginning to receive special attention by the LDA, but it will take some time to bring these diseases under control.

Low fertility is attributed essentially to dietary deficiencies rather than genetical factors. This can be reduced by improving the conditions under which livestock live.

Finally, low milk production is also attributed in part to poor feeding but improved nutrition can only be brought about by rotational grazing and the integration of crop and animal husbandry. Under present conditions the genetical potential of all types of livestock (growth rates, breeding interval, hardiness, disease resistance and milk production) has not yet been fully utilised. Authorities who have studied the national herd in Somalia consider that the productivity of local stock could be doubled. The exploitation of the potential will take time, and alternatives such as the importation of improved tropical breeds are apt to be expensive, moreover a new breed must be carefully tested before it can be finally accepted. It is believed that improved systems of livestock management, including feeding and prophylaxis, must be introduced in order that the potential of existing livestock shall be attained.

10.14 Criteria Relating to Possible Rainland Development

Statistics pertaining to the area under review are fragmentary and it is difficult to separate from the national statistics, information relevant to the area. As shown in Table 10.1, from an area of some 517,000 ha of potentially cultivable land in the Shebelli flood plain and adjacent regions only 155,000 ha is presently cultivated.

TABLE 10.1 Area of cultivable land for Dry Farming in the Shebelli flood plain and adjacent regions

	Present '000 ha	Estimated Future Potential '000 ha
Total Area	4,421	4,421
Potentially cultivable	517	517
Not cultivated	362	272
Cultivated	155	245
Rainfed cultivation	130	190

The existing areas of rainland cultivation are widely dispersed which makes the task of the already inadequate extension services even more difficult. It is not surprising that these extension services experiencing acute shortages of trained personnel and finance have achieved very little impact on productivity. The extension service is the principal agency through which the distribution of improved varieties and the introduction of improved cultivation methods can be brought about.

Providing that necessary trained extension and research staff become available through a properly organised and practically orientated training programme and assuming the necessary finances for their operations are forthcoming, an expansion of rainfed agriculture by some 60,000 ha over a period of 12 years should prove possible in addition to an increase of some 30,000 ha under irrigated crops. In order to maximise the cost effectiveness of the extension services it is essential its operation and the expansion of cultivation should be concentrated at specific focal points where the conditions for agricultural production are most favourable.

The area cultivated by the individual farmer is at present limited to the amount of land which he and his family can prepare for planting and maintain free from weed infestation using traditional hand tools. The introduction of work oxen for land preparation and interrow cultivation in those areas where tsetse fly is not a limiting factor would result in an appreciable increase in the area a farmer could cultivate. Such an innovation would however necessitate the establishment of training facilities for the farmer's oxen and the provision of cheap locally constructed but efficient ox-drawn implements. Most farmers would be unable to pay for the equipment immediately and their introduction would depend upon the availability of medium term credit facilities.

Short term credit would also be required to pay for labour at peak periods, tractor mechanisation where such services already exist and for improved seeds, insecticides etc. for specific crops such as cotton, and possibly, fertilisers at a later stage. Since co-operatives are in a

relative early stage of development, a special credit organisation would need to be established in the selected development areas.

The high risk of crop failure due to drought makes the introduction of large scale mechanised crop production schemes unlikely to prove economic. Where these have been successful in other countries such as the Sudan the rainfall expectation during the crop season is approximately twice that occurring in the Shebelli Valley. For this reason the extension of expensive tractors and equipment cannot be recommended in the initial stages.

Water supplies for human and animal consumption in the area are presently inadequate and a farmer's family frequently spend a large part of their time carrying water over long distances during dry weather. The provision of reliable sources of water is essential in selected development areas and would free a considerable amount of labour for productive work.

Very little data is available on present crop yields and the prediction of future yields is even more difficult due to the paucity of experimental yield data and lack of factual information from existing holdings. It is reasonable to assume that an average farmer might achieve 40 per cent of the average experimental yields at the end of a 12 year development period providing deficiencies in infrastructure, extension services, credit facilities and field experimentation are made good and improved varieties are introduced. This estimate takes into account the insuperable problem of the vagaries of seasonal rainfall. Table 10.2 gives estimates of present and future yields for the major rainfed crops.

It seems likely that increases in the cultivated area of the more profitable cotton, sesame and groundnut crops will be considerably greater in proportion to the staple food grains, maize and sorghum; the expanding local demand for which would be largely met by increases in yield. Estimates of current areas and approximate future areas under cultivation following a 12 year development programme are shown in Table 10.3.

TABLE 10.2 Estimated present and future yields of rainfed crops in kg per ha

Crop	Present		Future	
	'Gu'	'Der'	'Gu'	'Der'
Sorghum	300	250	450	400
Maize	400		550	
Cotton	150		300	
Sesame	200		300	
Groundnuts (shelled)		300		400
Others (average)	300	200	400	300

TABLE 10.3 Estimate of present areas of crops and future areas following a 12 year development programme

Crop	Present area ha	Future area ha	Increase
Sorghum	90,000	110,000	20,000
Maize	55,000	65,000	10,000
Cotton	8,000	15,000	7,000
Others	17,000	40,000	23,000
Total	170,000	230,000	60,000

The Agriculture and Water Survey report indicates an area of some 115,000 sq. km suitable for livestock grazing within and adjacent to the Shebelli Valley. Estimates of present stocking rates for cattle suggest a present population of some 600,000 animals in this area in addition to some 425,000 camels and over 1 million goats and sheep. It is probable that significant increases in numbers will be largely confined to beef cattle and with improved water supplies, disease control and marketing, an overall increase of 50 per cent over a period of 12 years appears to be practically possible taking into account the constraints already discussed in the development of crop production. This would result in

a total cattle population of 900,000 and assuming a 5 year period to reach maturity would provide an animal offtake of perhaps 150,000 mature beef steers, equivalent to an increase of 50,000 over present production.

The estimated value of increased agricultural production during a 12 year development period is shown in Table 10.4.

TABLE 10.4 Value of estimated increased production after a 12 year period of development

Production increment	Value Shs. '000
20,000 tons sorghum @ Shs. 250	5,000
12,000 tons maize @ Shs. 300	3,600
3,300 tons cotton @ Shs. 1000	3,300
9,800 tons other crops @ Shs.700	6,900
50,000 beef cattle @ Shs. 350	17,500
Total	36,300

10.15 Costs of Proposed Rainland Cropping Development

An accurate assessment of the cost of such a development programme for rainfed agriculture is not possible without extensive and detailed studies, however, the order of magnitude of developments and financial requirements is outlined as follows:

a) Extension and Research Services

Headquarters personnel would comprise approximately 15 Senior Extension, Animal Health and Research officers in addition to administrative staff. Salaries and Headquarters operating costs including transport would amount to perhaps Shs. 300,000 annually with a similar sum required for the provision of buildings and other capital items giving a total of Shs. 600,000. Field staff would comprise up to 150 Agriculture, Animal Health and Experimental officers whose annual cost for salaries, transport and other expenditure is estimated to be of the order of Shs. 1,800,000.

b) Ox Training

Training schools would need to be established with a staff of perhaps 10 instructors. The annual cost amounting to approximately Shs. 150, 000.

c) Water Supplies

The envisaged programme to provide adequate water supplies for domestic and livestock purposes is likely to cost Shs. 200, 000 annually.

d) Credit

Credit requirements are likely to be of the order of Shs. 10, 000, 000 the interest charge on such an amount being annually Shs. 600, 000 at 6 per cent.

In addition it will be necessary to provide a staff of supervisory Credit Officers numbering 6 in headquarters and perhaps 50 in the field with supporting administration. The cost of these personnel and their office facilities and transport amounting to perhaps Shs. 600, 000 per year.

A summary of estimated financial requirements is shown in Table 10.5. It has been assumed that these development costs will built up to a maximum in year 6 and thereafter will remain relatively constant.

TABLE 10.5 Summary of possible financial requirements in '000 Shs.

Item	Year						Total over 12 years
	1	2	3	4	5	6-12	
Extension and Research	900	1100	1400	1700	2100	2400	19, 200
Ox Training	50	100	100	150	150	150	1, 300
Credit	100	200	300	400	500	600	4, 500
Credit Admin.	100	200	300	400	500	600	4, 500
Water Supplies	200	200	200	200	200	200	2, 400
Contingencies	135	180	-	-	-	-	315
Total	1, 485	1, 980	2, 300	2, 850	3, 450	3, 950	32, 215

In conclusion it must be stressed that although the returns to rainland development appear attractive, the problems to be overcome are numerous and successful development will ultimately depend upon the farming community being prepared to accept new cultivation techniques and the rate at which that community can change from the present subsistence economy to an appreciation of the merits of cash crop production.