Somali Democratic Republic
National Refugee Commission

United Nations High Commissioner for Refugees

Farjano Settlement Project
Land Evaluation

Sir M MacDonald & Partners Limited
Demeter House, Station Road, Cambridge CB1 2RS, United Kingdom

April 1985

1980
THE QUEEN'S AWARD FOR EXPORT ACHIEVEMENT

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Date: 26th April, 1985

Mr. E.Q. Blavo,
The Representative,
United Nations High Commissioner for Refugees,
P.O. Box 2925,
Mogadishu,
Somali Democratic Republic.

Dear Sir,

Farjano Settlement Project
Land Evaluation

In accordance with our Agreement dated 15th December, 1984, and the Supplementary Agreement for the Sheikh Mohamed Hikam Community Project site, we have pleasure in submitting twenty copies of the Land Evaluation Report.

Throughout the study we have been assisted by our Associates, Hunting Technical Services Ltd., who were responsible for collecting information for the land evaluation of rainfed agriculture, settlements, forestry and small scale irrigation.

Unfortunately, due to delays in securing customs clearance at Mogadishu and an unexpectedly long processing time for the clay soils at the laboratory, the soil moisture retention results are not yet available. The moisture retention capacities used in the land suitability evaluation have been based on our previous soil studies in Somalia. We intend to issue an addendum once these results become available.

We should like to take this opportunity of recording our thanks and appreciation for the co-operation we have received from your staff in Mogadishu and from the Somali Authorities in carrying out this assignment.

Yours faithfully,
for Sir M. MacDonald & Partners Limited

P.J. Drury

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ACKNOWLEDGEMENTS

Sir M. MacDonald & Partners wish to acknowledge Hunting Technical Services for carrying out the natural resource and land evaluation of the Farjano Settlement Project.

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- Mr. Schellhaus and all of his team at the Technical Unit of UNHCR for technical and administrative support.

SUMMARY AND CONCLUSIONS

1. Introduction

This land evaluation of the Farjano Settlement Project in the Lower Shabeelle Region of Somalia has examined 16 000 hectares of alluvial soils. The evaluation was requested by UNHCR with the aim of locating land suitable for semi-mechanised rainfed (dryland) agriculture on which refugee settlers will become farmers, under the direction of a farm management system that provides land preparation and planting services. The evaluation was also to examine the land suitability for settlement location, forestry and small-scale irrigation. A topographic survey was to be carried out to provide a contoured base map, and an additional topographical survey was requested of the Farjano village irrigated farm (Sheikh Mohammed Hikam).

2. Topographical Surveys

These were carried out by surveying along existing roads and on traces especially cut for the survey. In the main study area survey points every 100 m were made along traces, 1 km apart. The survey points were based on an arbitrary datum of 100 m, located along the Sablaale - Modun road at the end of line 9, since it proved impossible to locate a known benchmark. However, this arbitrary datum is approximately 45 m above sea level.

The topographical map was prepared on a laydown of 1 : 30 000 aerial photographs and based on enlargement of 1 : 100 000 topographical map. This was then enlarged to 1 : 25 000. Contour information was requested at 1 m intervals, but the amount of detail and relation of this to known geomorphological features, enabled a 0.5 m contour interval to be drawn.

The survey of the Farjano village of Sheikh Mohammed Hikam was carried out in a similar way, except that no additional traces were cut. This survey had to be curtailed slightly because of administrative reasons which prevented the survey team from gaining full access to the Farjano - Haaway area. We would have wished to examine the Farjano - Haaway swamp and the weir at Haaway to assess the levels of the swamp and weir but this was not possible. Since development will depend on a complete understanding of water flow and water requirements in the Haaway area, it is essential that these administrative difficulties be overcome.

3. Environment

3.1 Climate

The study briefly examined the rainfall records of the region. Records are incomplete and only one station (Sablaale) operates at present. Rainfall increases from 300 mm at Modun to 500 mm at Sablaale and in good years the Sablaale area may receive a total of 500 mm in the gu season alone. Der season rainfall is often less than 150 mm and inadequate for rainfed cropping. The reason for the rise in rainfall inland from the coast is attributed to moist or swampy surface conditions between Haaway and Sablaale. Moist air masses receive supplementary moisture from these swampy areas and induce additional rainfall over them. Reclamation of swamps and dense riparian woodland areas could lead to rainfall reductions that would be deleterious for the rainfed farming development.

3.2 Water Resources

Water resources were not examined in detail. Surface waters from the Shabeelle and Webi Goof showed ECs of between 900 and 1 200 µmho/cm, which is average for this time of the year, though marginal for irrigation with leaching and drainage requirements being fulfilled. Shallow wells were extremely saline (EC 7 000 µmho/cm) and existing tubewells taking water from around 50 m gave an EC of about 200 µmho of marginal quality for domestic use. It is recommended that settlements be provided with deep tubewells, but the hydrogeological situation is not yet assessed to ensure that supplies exist in areas suitable for settlement.

The Shabeelle river and swamps are used for domestic, stock, and irrigated land use. Over usage of the Shabeelle is likely if large scale irrigation schemes go ahead. The capacity of the Shabeelle for any additional irrigation has been stated in earlier studies to be strictly limited. At the time of the study, February 1985, the Shabeelle was completely dry and only waters held up by the Hawaay barrage and Sablaale swamp were available for the existing farms. It is evident that further usage would result in a long period when no water would be available for stock or domestic usage, let alone for irrigation.

3.3 Present Land Use and Natural Vegetation

The present land use in the survey area is a mixture of irrigated farming, traditional rainfed farming, semi-mechanised rainfed farming, and grazing by livestock and wildlife. Collection of fuelwood and house building materials is extensively carried out. Development of the area for rainfed farming will result in an expansion of fuelwood and building material activities, at the expense of grazing for livestock belonging to settlers and indigenous agro-pastoralists and seasonal pastoralists.

To assist planners to locate areas suitable for collection or harvesting of the natural vegetation, and to initiate studies of the range carrying capacity, a combined land use and natural vegetation mapping exercise was carried out, using data routinely gathered at soil sites.

There may be conflicts as to future utilisation of the rangeland in the study area. Part will be cleared for rainfed farming or small-scale irrigation. Lands selected for settlement location should remain uncleared of larger trees and be hand cleared to minimise disruption of the soil surface. Selection of lands for fuelwood collection and regeneration need to be assessed on the basis of their existing composition. Finally, the grazing needs of the indigenous peoples who have traditional grazing rights, should be integrated with these activities. The best grazing lands are those in the high rainfall areas of the south-west of the area, but these are also tsetse infested and largely unused: areas free of tsetse are largely denuded of herbs and grasses.

3.4 Wind Erosion

Wind erosion is likely to be a hazard if land clearing is extended on to lighter textured soils and conceivably on clay soils, though the surface mulch formed is generally wind stable. Mechanisation of the existing arable farm is strictly controlled to reduce wind erosion, and the adopted machinery equipment has evolved from long term experience in other areas of the world. It is likely, however, that uncontrolled mechanisation by other farming communities could lead to serious wind erosion at certain times of the year.

4. Soils

The soils of the study area are mostly alluvial in origin deposited by present and earlier courses of the Webi Shabeelle. The soil survey carried out 339 observations throughout the survey area, mostly along trace lines, giving a density of one site per 47 ha (or 2.1 sites per km^2). Over 11% of sites were profile pits, and samples were taken from ten representative profiles for both chemical and physical analysis. Field determinations of electrical conductivity were also carried out.

Almost 70% of the study area lies on deep coverplain clay soils (A1, A21, C1, C2), whilst an additional 8% lies on channel and recent coverplain clay soils liable to seasonal flooding or waterlogging (A3, B1, B2, B3). Some 15% of the study area is occupied by less heavy clays and clay loam soils formed on slightly more elevated areas bordering old channels. These upper coverplain and levee soils (D1, D2, D4) vary in texture, with some sandy members, and also have significant salinity and alkalinity hazards. Sandier soils developed on levees (D3) and aeolian land forms (E) are free draining but suffer from droughtiness. Soils developed in the permanent swamps (F) are wet, impermeable clays, slightly peaty in places and liable to develop salinity if reclaimed. Finally, existing settlements, seasonal or permanent occupy 2.6% of the area. With the exception of Sablaale, these settlements lie on, or very close to upper coverplain soils, which are quicker to drain after rainfall than the heavy clay soils.

In general, chemical data show that the essential plant nutrients (N, P and organic carbon) are low, with deficient P in many subsoils. Micronutrients (Mn, Fe, Cu, Zn) are adequate and the Mn toxicity possibility raised in an earlier study was likely due to a spurious result.

5. Land Suitability for Settlements

The criteria important for settlement location include soils with good drainage, and clays that do not have swelling characteristics which could cause cracking of permanent structures. Sandy soils on levees and sand terrace (D3 and E) are the most suitable and are rated class S1 (0.8% of area). Upper coverplain soils (D1) in the western part of the study area occupy 8% of the area and have a class S2 rating. It is recommended that these D1 and E soils are utilised for settlement. D1 soils have a lower rating for rainfed suitability than most of the coverplain soils. They are also used for settlements and tracks, indicative of their usefulness. They lie in a linear belt, some 4 to 5 km east of the Sablaale - Haaway road, and are eminently placed to be the centre of new settlements, with rainfed development on C1 and C2 soils to the west, and on A1 soils to the east. The settlement plan calls for the development of two units of approximately 1 900 ha total, and 420 families total. There is ample room for this given the utilisation proposed above.

6. Land Suitability for Forestry

The brief nature of the vegetation and fuelwood resources survey, has meant that the evaluation for forestry is provisional. The vegetation and plant usage survey was carried out to assess present production. Land suitability evaluation, based on an expansion of rainfed growth, was then applied to various criteria indicative of good growth. Irrigation for forestry is also possible however. Heavy textured subsoils restrict root penetration in many of the clay soils, whilst on the levee soils salinity and alkalinity at shallow depths are often indicated by stunted bushland. Dense woodland occurs along the Webi Goof and Shabeelle river, and the edges of this may be suitable for plantations. For the rainfed farm, reseach is needed to locate species that are fast growing, provide an effective shelter belt, offer fuelwood and building material possibilities, and are preferably disliked by stock so as to ensure their long term survival. Organisations within Somalia, including the Afgoi Forestry School of the National Range Agency, UNDP-UNSO Sand Stabilisation Project and voluntary agencies working in the refugee camps, are carrying out research, but there is a need for co-ordination of different groups so that results can be speedily applied to other areas.

7. Land Suitability for Small Scale Irrigation

An examination of current irrigation in the study area and its immediate environs shows that there are serious problems currently being encountered, or likely to develop shortly. Poor irrigation management leads to over-irrigation of fields, with subsequent waterlogging. Crop yields decline, land is abandoned and is followed by an increase of salinity close to the surface. The shallow groundwater table is very saline, and capillary rise of salts means that the rooting zone may become unsuitable for plant growth. There are huge areas of land abandoned for these reasons between Sablaale and Kurtun Waarey, and they suggest a poor future for irrigation development that is not properly managed.

Experience at Jowhar Sugar Estate has shown that to maintain low levels of salinity, efficient irrigation to meet the leaching requirement needs to be combined with field drains and open collector drains. Salinity and watertables can then be kept within acceptable limits, so that crop yields do not decline.

At Farjano, where irrigation is carried out on A3 soils, there are already indications that salinity is building up rapidly in the subsoil, due to capillary rise from a deeper watertable, and it could rise close to the surface. Surface drains are not present at this farm.

It is proposed by UNHCR that small scale irrigation schemes of 1 to 2 ha only be commissioned along the Webi Goof adjacent to proposed settlements. These schemes should be developed on A3 soils, since they are already affected by flooding and pumping costs will be low. Their slight salinity will require some reclamation, and open collector drains around fields are essential. It may be necessary to block off these lands from the adjacent swamps, but since the soils are so slowly permeable, lateral movement from the swamp is not a problem. It is better not to utilise the A1 soils that border the swamp, since these are largely free of salts and better suited for rainfed agriculture. The suitability of D1 soils along the Webi Goof is also good for irrigation and these may drain better because of their slightly elevated position.

A final problem is the capacity of the Webi Goof to provide irrigation water. If this is used in the dry seasons then it will diminish downstream usage of the water for stock, wildlife, and the Haaway rice farm (at present 500 ha but planned to increase to 5 000 ha). This all needs further study which can be carried out during detailed project planning and implementation.

8. Land Suitability for Semi-mechanised Rainfed Farming

The principal limiting factor to successful rainfed farming in this area is the amount of seasonal rainfall and whether it is sufficient to grow suitable crops. It is unfortunate that the rainfall factor is the least understood and is based on incomplete records of short duration. A number of recent good cropping years in the gu season may well have had above average rainfall. The der season, however, has a very high risk of total failure for crop growth and, as a result, settlers may continue to require supplementary (free) food aid in the dry season.

To overcome this problem, given the marginal rainfall resource, will require above all skilful management of the scheme. Even so, according to an early World Bank appraisal "partial or even complete failures of the limited number of drought tolerant crops that are otherwise suitable for the area must be expected in a number of years".

In this land evaluation the rainfall has been placed as a limiting factor for the eastern quarter of the study area. The suitability of the soils in this area have been assessed; however, since rainfall may change or may give some very good years, the land suitability needs to be known.

The evaluation is based on the FAO system, with subclass factors being applied to soil characteristics.

The results of this evaluation show that the coverplain soils (A1, A2, C1, C2) are moderately suitable for rainfed agriculture, and these lands amount to over 50% of the study area. Within the western part of the area, and adjacent to the proposed settlement locations on D1 and E soil units there are sufficient lands to meet the requirement of 4 000 ha for the first two farms. This is exclusive of any agriculture being developed on the loamy D1 soils. These soils, with an erosion risk and droughty topsoil in places, should only be included in small areas in the farm at present. It may prove later to be worthwhile expanding agriculture on to these soils, once improved techniques of rainfall absorbance can be developed on them.

Marginally suitable soils also include the channel areas (B1, B2, B3) where slow seasonal drainage and high risk of flooding pose problems for the developer.

Unsuitable lands (A3, D4) occur on the most recent course of the Shabeelle where there are existing salinity and alkalinity problems, unlikely to be rectified by rainfed farming. Similarly the loamy older upper coverplain soils (D2) in the east of the area with inherent very high salinity and alkalinity should be avoided for rainfed agriculture.

Sandier soils (E and D4) have severe droughtiness problems in the topsoils which will cause germination failure. These lands are better suited for settlement, and irrigation locally.

CHAPTER 1

INTRODUCTION

1.1 Scope of Report

On the 15th December 1984 a tripartite agreement was signed between Sir M. MacDonald & Partners (MMP), the National Refugee Commission (NRC) and the United Nations High Commissioner for Refugees (UNHCR), under which Sir M. MacDonald would carry out a land evaluation and topography survey of some 16 000 ha of land on the left bank of the Webi Shabeelle between Sablaale and Farjano settlements, Lower Shabeelle Region. The objective of this survey was to identify specific areas of land suitable for development for semi-mechanised dry land agriculture, forestry and human settlement. A contoured topographical map at 1 : 25 000 was to be produced.

The full Terms of Reference are included in Appendix A. An earlier TOR included provision for a detailed vegetation survey for the purpose of identifying rural energy sources of fuel wood and house building materials. This survey was deleted, but the requirement for forestry suitability was retained. It was agreed with UNHCR that land use and natural vegetation maps would be produced, since these data were being collected routinely at soil observation sites. Land suitability for forestry has been derived from an assessment of the existing vegetation. A further request from UNHCR to examine the suitability of area along the Webi Goof for small scale irrigation has also been fulfilled.

In a separate agreement with UNHCR, Sir M. MacDonald & Partners carried out a topographical survey of the Farjano village irrigated farm and its proposed expansion. The results of this survey are given in Chapter 6.

This report presents the findings and conclusions of the surveys. Chapter 1 presents an introduction and background to settlement development at Sablaale. In Chapter 2 the topographical survey of the Farjano Settlement Project is described in detail.

This is supplemented by the additional survey at Farjano village, given in Chapter 6, which also discusses the development of this irrigation scheme. The soil and land evaluation surveys carried out at a few observation sites at Farjano village, have enabled some conclusions on development to be drawn up.

In Chapter 3 sections on geomorphology and parent materials, climate, water sources, land use and vegetation and erosion are discussed.

Chapter 4 describes the soils of the study area, whilst in Chapter 5 land suitability for semi-mechanised rainfed agriculture, human settlements, forestry and small scale irrigation is presented.

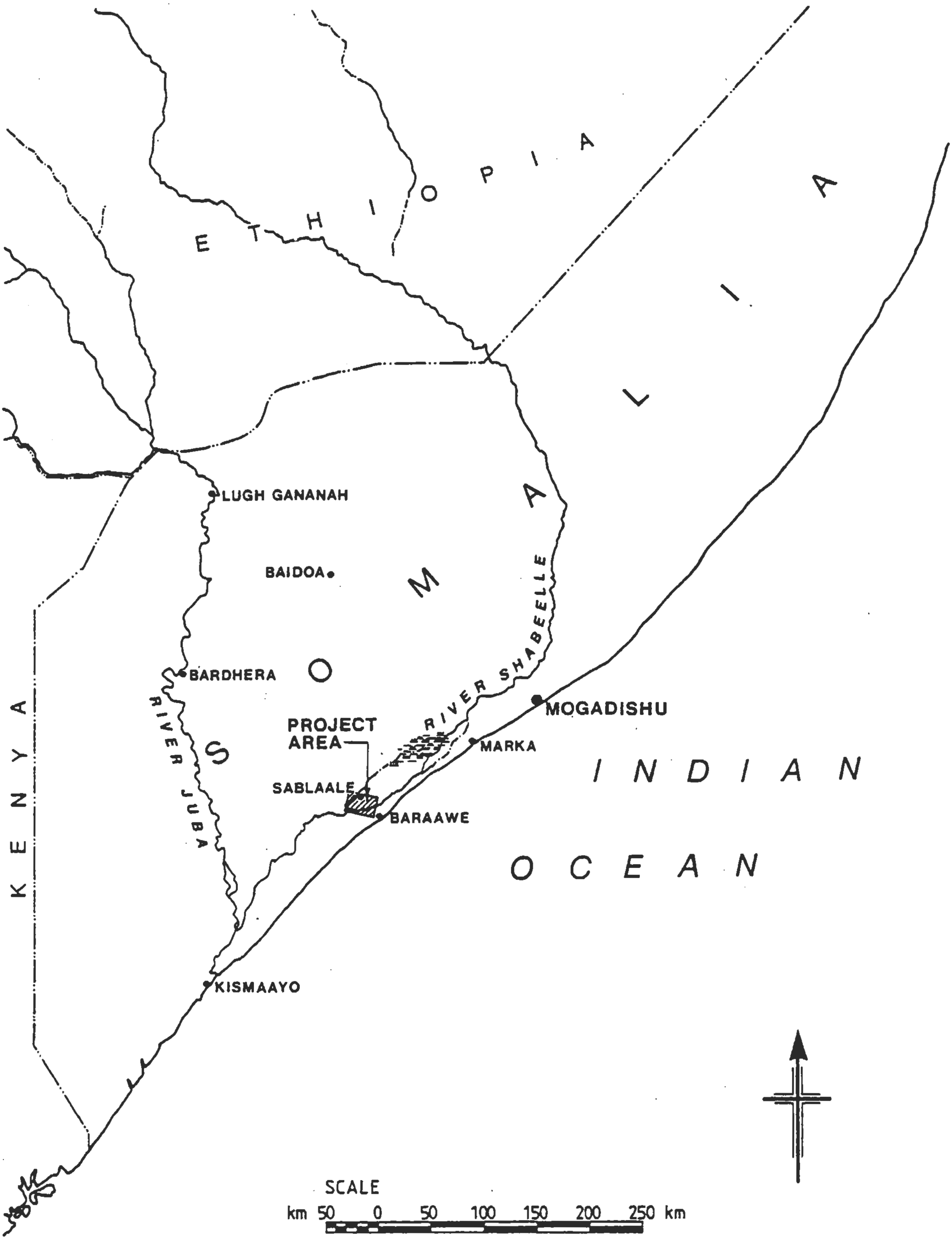
Finally in Chapter 7 the environmental impact of development is assessed.

1.2 Study Area Location

The Farjano Settlement Project is located in the Lower Shabeelle Region of Somalia, and lies on alluvial lands between the Shabeelle River and the Coastal Dunes. The western boundary lies a short distance west of the upgraded all-

Figure 1.1

Project Locaion Map



weather track from Sablaale to Farjano and Haaway. The northern boundary follows the upgraded all weather track from Sablaale to Modun, as far east as the culvert at the Webi Goof crossing. The southern boundary follows the Webi Goof, from where it crosses the Sablaale to Modun track as a dry course, westwards to the village of Farjano. This southern boundary along the Webi Goof is for most of its length a permanent swamp, and only a few kilometres near the culvert on the Sablaale to Modun track are dry. The original survey was to be extended across the Webi Goof as far as the old Modun-Haaway track. Following discussions with UNHCR it was agreed to fix the boundary at Webi Goof, since this is a permanently flooded area and a natural limit to the proposed scheme.

1.3 Background to Development

Large scale agricultural development in the Sablaale area of the Lower Shabeelle floodplain commenced in 1975 when pastoralists from Northern Somalia, who had been displaced by the severe regional drought of 1973 and 1974, were resettled at Sablaale.

The first five years of the settlement saw the development and expansion of irrigated agriculture at Sablaale under the control of the Settlement Development Agency. Maize, rice, sesame and sorghum were irrigated by water gravity fed from outlets in the Sablaale swamp.

By 1984 major housing projects at Sablaale and Sablaale Yaarey had been completed, with funds from Holland. German technical assistance aid had earlier completed the construction of workshops and supplied farm machinery for the SDA settlement.

In 1981 agricultural trials were started by A. Macpherson of J. Bingle pty. for the Settlement Development Agency, and supported by the World Bank, at Sablaale and Kurtun Waarey. The purpose of the trials was to establish the potential for semi-mechanised rainfed agriculture in areas of suitable rainfall.

The first 4 years of the development are now completed, and have shown that rainfed cropping can be successful, provided that there is careful planning and timely execution of farming activities. Cropping has so far been very successful in the main (gu) rainy season, but in the secondary (der) rainy season, results have been disappointing and in general crop failures in this season can be expected.

The relative success of semi-mechanised rainfed agriculture has stimulated considerable interest amongst organisations concerned with rural development in Somalia, but opinions have differed as to the long term merits of the schemes.

A reconnaissance study carried out in 1982 and 1983 for UNHCR (GTZ 1982/84) identified large areas of existing dry land agriculture and bushland, with potential for refugee settlements, and recommended that a pilot study be carried out to improve traditional agriculture rather than expand the semi-mechanised rainfed agriculture. The reasons given in the GTZ study for this conclusion included that semi-mechanised agriculture is highly dependent on imported goods and services, and that, based on earlier experience, it would be difficult to retain trained Somali personnel in the rural areas. The study also concluded that a superior system could be devised than one where farmers have to accept a rigid land tenure and superimposed production system in which most of the decision making is carried out by the (expatriate) farm management.

Similar conclusions were reached by Spooner (1984) who considered that a more integrated agricultural system is preferable. This would be based on improvement of the traditional agricultural system with some semi-mechanised farming, greater provision of livestock systems, diversifying crop production, better storage of crops, and reduction of the serious problem of post-harvest losses. Animal traction could play an important role in the future, and the skills of settlers should be fully realised to develop local industries and community activities. The dependence of semi-mechanised agriculture system on fuel was seen in the long term to be unrealistic for Somalia.

The World Bank (1984) in contrast concluded that an expansion of semi-mechanised agriculture was justified. The expansion should be commenced with detailed soil surveys and development of land tenure systems. These should be carried out adjacent to the existing semi-mechanised farms. The World Bank mission concluded that the expansion is not without risk. It involves major technological and sociological changes and high levels of organisational and managerial expertise. Initially technical assistance would be necessary to develop and manage the farms, but gradually trained Somali technicians would take over the management of the farms. The World Bank also recommended that a Rainfed Agricultural Corporation be established in the Ministry of Agriculture and would be responsible for tenants affairs, field services, strengthening of field agricultural personnel and expanding the extension services.

The need for a Somali experienced consultant to carry out a land evaluation survey of proposed new settlements was recommened by GTZ (1984), the World Bank (1984) and Agrisystems (1984). The experience gained from establishing a settlement in an unsuitable area at Dujuma on the Juba river (HTS 1977) has shown that pre-evaluation of sites is essential.

Accordingly UNHCR approached Sir M. MacDonald & Partners in 1984 to carry out a land evaluation of 16 000 ha in the Farjano-Sablaale area.

CHAPTER 2

TOPOGRAPHICAL SURVEY

2.1 Survey Method

An initial study of the allocated area on 1 : 30 000 aerial photography (NTTCP February 1983) revealed a number of existing trace lines. These were identified as having been cut for previous survey work between 1963 and 1976.

An early reconnaissance survey with members of the UNHCR Technical Team in October 1984 and subsequently in November with an engineer from ONAT confirmed the position of a number of these old trace lines. A Survey Method was thus derived utilising existing trace lines and cutting new intermediate lines at approximately 1 km intervals along a base line. (See Figure 2.1.)

2.2 Trace Cutting

The survey engineer moved to site on 7 December 1984 and established a programme for the setting out of trace lines in conjunction with the ONAT programme for trace cutting.

Two bulldozers arrived on site on 9 December 1984 and were joined by two others 2 days later. Trace cutting commenced on 11 December 1984 and was completed by 30 January 1985 despite a stoppage for lack of fuel from 3 to 18 January. Thus a clearance rate of 1.2 km per machine per day was achieved when the bulldozers were operating. A table of the length of traces cut by ONAT is contained in Appendix B.

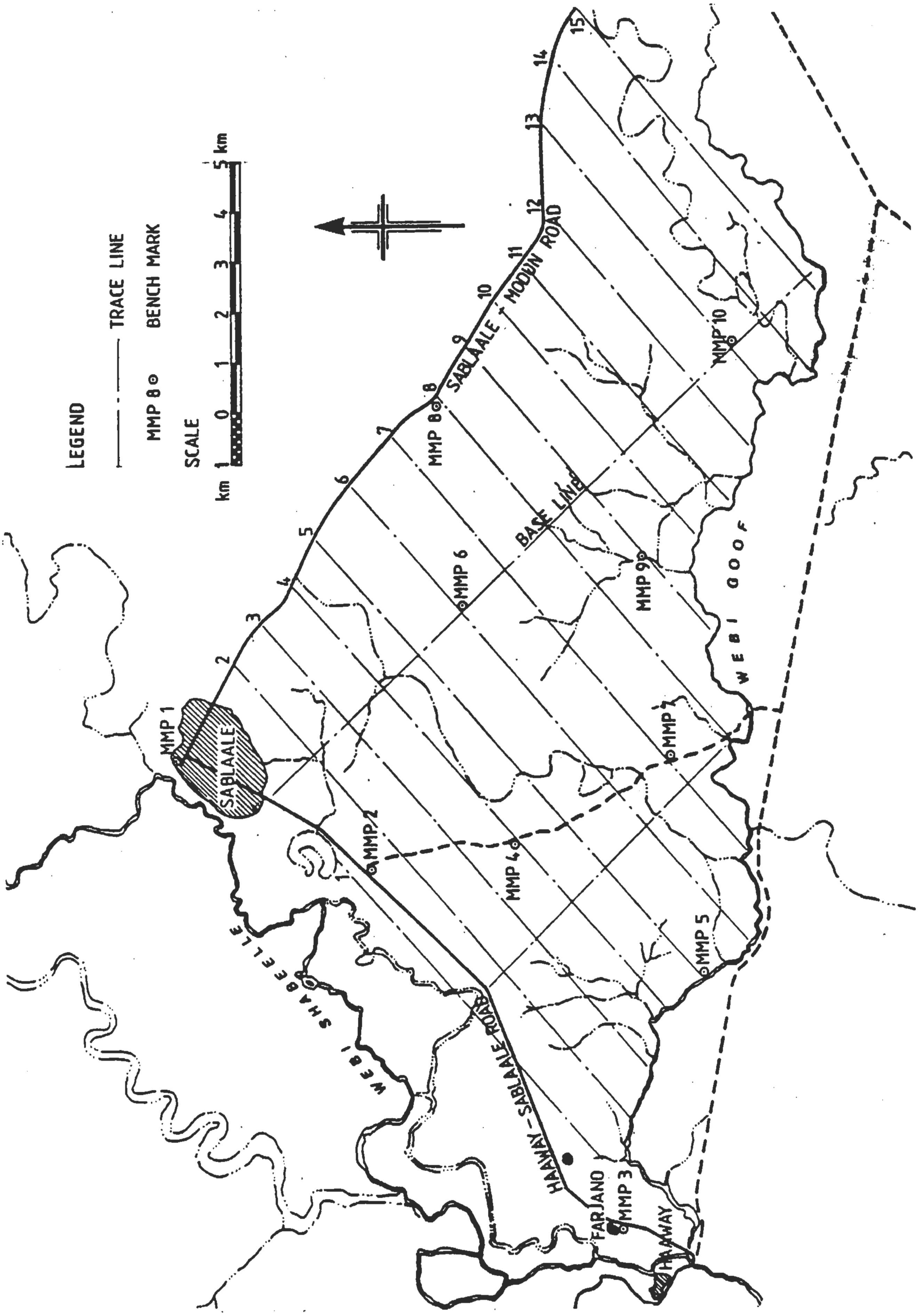
It was apparent from the start of trace cutting that water was backing up the Webi Goof from the Haaway Barrage as far as the intersection with the base line. However, no water was encountered on the Sablaale-Modun Road where a pipe culvert (upstream invert level = 98.642 m) discharges surface water drainage from north of the road embankment into the Webi Goof channel. Since bulldozing across the Webi Goof swamp water was impossible, the southern boundary of the project area was redefined as being the Webi Goof rather than the old road to Haaway. The vegetation was relatively sparse west of Trace 15 and so a survey of ground levels was carried out without a trace being cut by bulldozer. Thus a total project area of 16 000 ha was surveyed.

2.3 Topographic Level Survey

The initial reconnaissance survey noted the existence of concrete pillar bench marks, established between 1963 and 1965 along the old Afgoi-Gelib road. A search at the Somali Survey and Mapping Department, Ministry of Defence, failed to locate the records for these bench marks. Thus, a temporary bench mark (TBM) was established at the intersection of Trace 9 and the Sablaale-Modun road and assigned an arbitrary value of 100.000 m. A subsequent survey along the Sablaale-Modun road to the intersection of the old Afgoi-Gelib road, 12.5 km south-east, enabled a relative level of 101.601 to be assigned to the bench mark BM 335 (for location of BM 335, see project area layout on Drawing Nr 5). At the present time the level of BM 335 relative to sea level is not known exactly but is in the order of 45 m.

Figure 2.1

Location of Bench Marks



Further survey work was undertaken to record ground levels and reduced levels of a series of temporary bench marks along the Sablaale-Modun road from Trace 9 to Sablaale, along the Sablaale-Haaway road as far as the Haaway swamp and along the base line. A TBM system was thus established such that levels could be tied in around a closed loop as each trace was cut and surveyed from the base line to the Sablaale-Modun road. Water levels were recorded in the Webi Goof at the end of each trace line. A table of the recorded water levels can be found in Appendix B. This shows the reduction in water level with time for the period of survey.

Ground levels were recorded at 100 m intervals along all the trace lines and perimeter roads. Any intermediate depressions or rises were surveyed to increase the accuracy of the final contour map (Drawing Nr 13920/1).

A number of points arise from the study of topography in the project area:

(a) The area is generally flat and surface gradients in the order of between 1 in 1 000 and 1 in 5 000 are typical.

(b) Where steeper gradients are encountered, these are predominantly across courses of old river beds or surface runoff channels into the Webi Goof. A cross section of the Webi Shabeelle at Sablaale is shown in Figure 2.2.

(c) The Webi Goof is a pronounced feature with a centre channel depth of up to 2.5 m and a seasonal flood channel top width of more than 100 m in the lower reaches (downstream of Trace 2). The upper reaches within the survey area are much narrower, typically 30 m and a bed level less than 1.5 m below surrounding ground level.

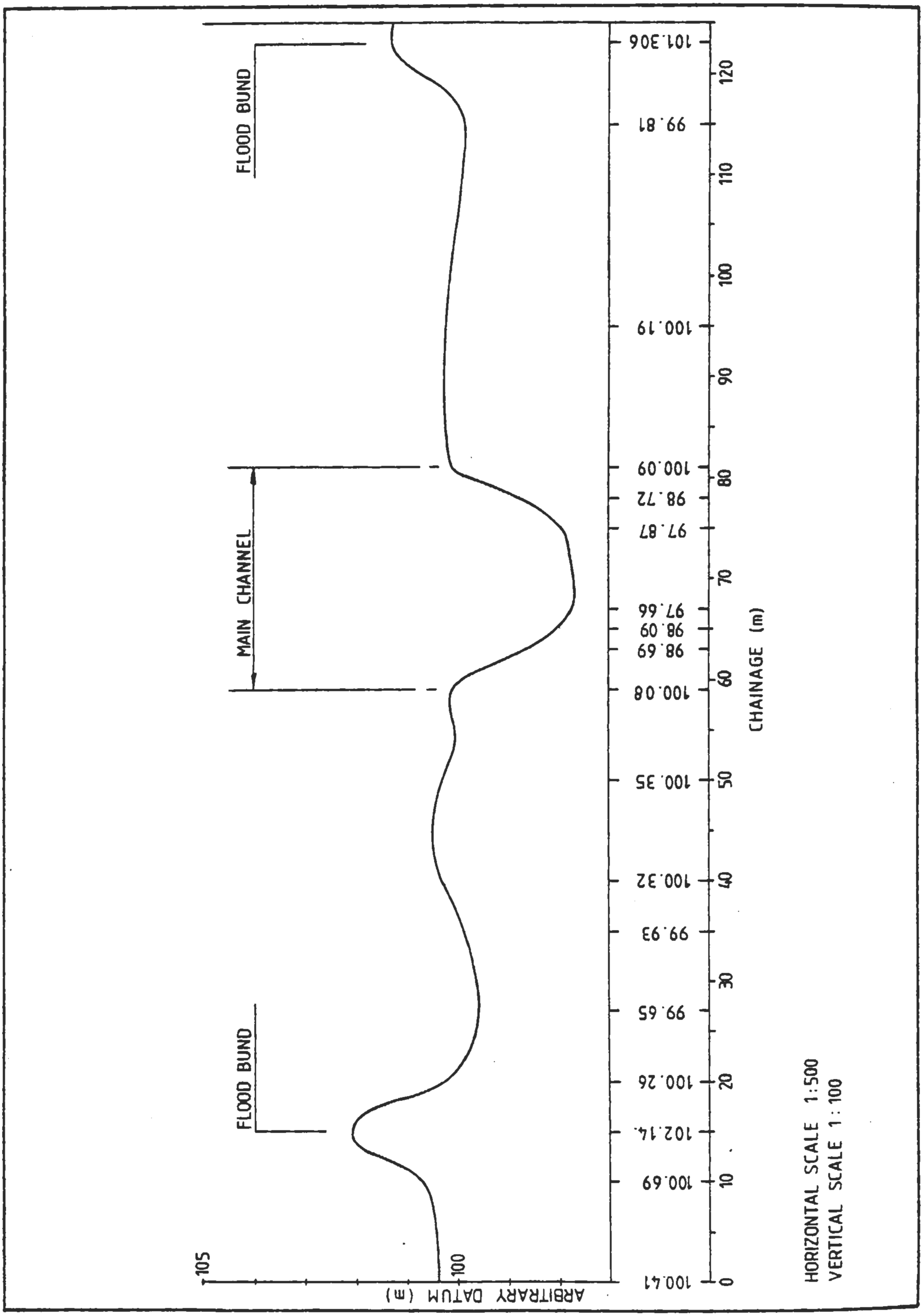
2.4 Bench Marks

Permanent bench marks of the 2 m long anchored steel tube type were chosen as being most suitable for the project area, and unlikely to be disturbed. The bench marks were located after trace cutting was completed and the Temporary Bench Mark system established and checked.

A total of 10 permanent bench marks was established over the 16 000 ha project area, in locations accessible by 2 wheel drive transport, two of which are in the Sablaale and Farjano settlements. The locations of these 10 bench marks are shown in Figure 2.1 and the table of reduced levels relative to BM 335 is given in Appendix B.

Figure 2.2

River Shabeelle
– Cross Section at Sablaale



CHAPTER 3

ENVIRONMENT AND LAND USE

3.1 Geomorphology and Parent Materials

The study area lies almost entirely on fluvial alluvium of the Webi Shabeelle river, and straddles several generations of river courses represented by channels, levees, depressions and coverplains. A small area appears to represent the upper part of an aeolian dune complex and is the oldest landform in the area. To the south east of the study area the floodplains merge with aeolian landforms, which include old strongly stabilised red dunes, weakly stabilised yellowish red sand dunes and active yellowish red dunes.

The present course of the Shabeelle is a weakly sinuous but well defined channel. The river exits from the Sablaale swamp through a number of channels, and is largely free of coarser sediment. This has partly resulted in almost no levee formation along the present course, but the youthfulness of the course must also be a factor. The present course occupies the depressional land between two major recent river courses, the Far Marjaan and the older Togga Sablaale. Breaks in the levees of the older courses results in flooding backing up the older courses. Deposition of sediments from the present course is predominantly fine textured, and the soils developed on these materials are often gypseous and saline in the subsoil.

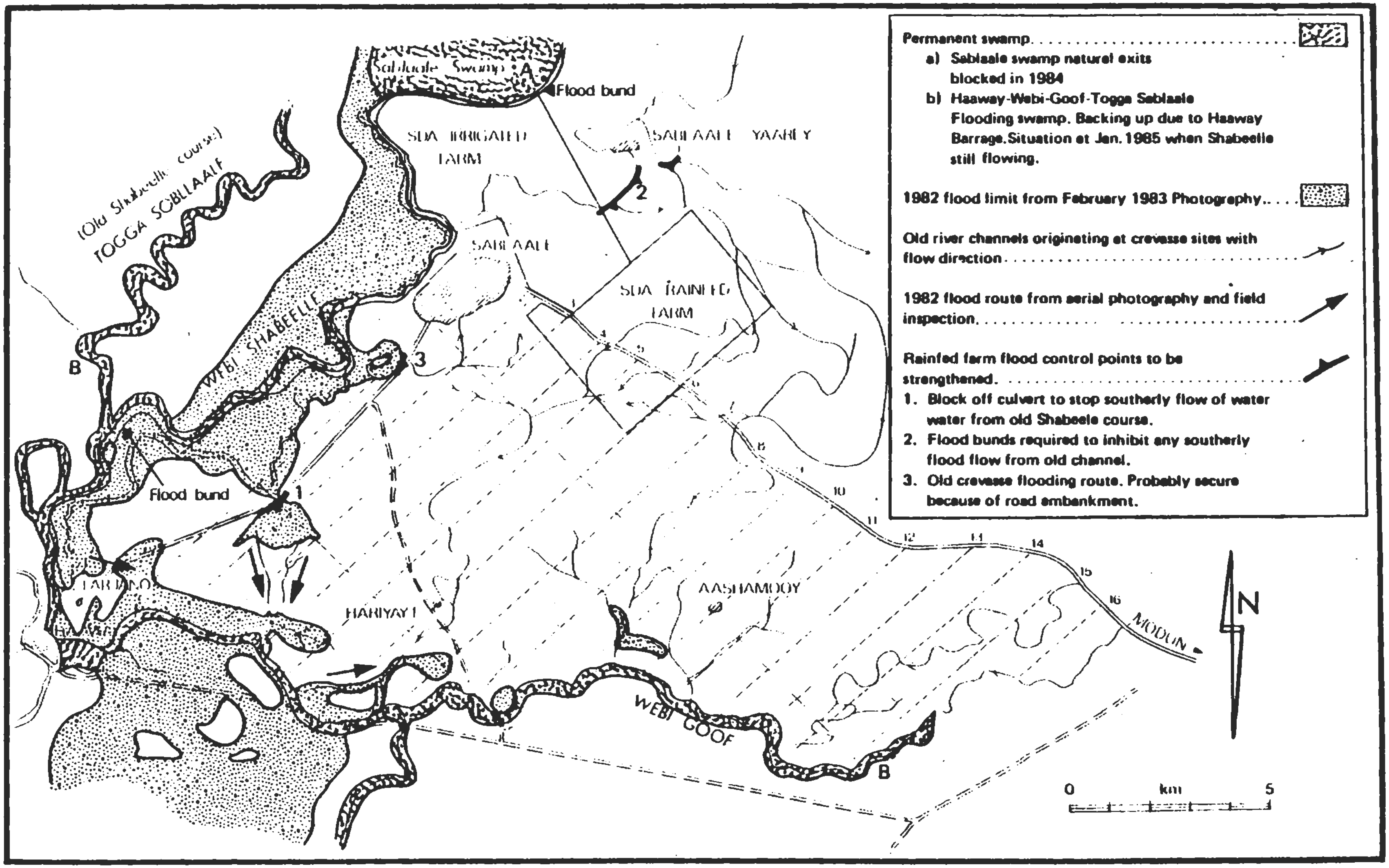
The older courses of the Shabeelle are numerous and include the Togga Sablaale, Far Marjaan, and Webi Goof complexes as major features with levees and channels still prominent topographically. Adjacent to these channels are extensive vertisol clay coverplains, through which meander minor flood channels, that in many instances can be traced back to a meander loop and flood overflow crevase feature adjacent to Sablaale Yaarey village (Figure 3.1).

The Togga Sablaale lies outside the area but has an important role in water storage for the Haaway swamp, which in turn is important to the supply of irrigation water for the Haaway rice farm. The Togga Sablaale merges upstream with the Sablaale Swamp, but is is apparently closed at this end. A recent study of the Shabelle swamps (MMP 1983) suggests that the presence of water in the Togga Sablaale indicates that it intercepts overland flow moving southwards off the higher land of the Bay Region. There is however little evidence for overland flow, and this water would be unable to enter the Togga Sablaale channel since there is a well defined levee. Observations made in 1981 during the Shabeelle and Juba floods indicate that flood waters follow the depression coverplains between old courses (MMP 1981), and will only enter the old channels where these channels diverge from the recent course (MMP 1981).

The Far Majaan course is moderately sinuous with well defined levees, backswamps and meander loops. These depressional lands are still flooded, and the abandoned meander loop immediately east of Xawaala Buuley was fifteen years ago, a permanent lake with excellent fishing. The importance of this old course at the present is in flood protection for the proposed development to the south. Soils found on the levees have high salinity and alkalinity due to a high watertable and the nature of the sediments.

A complex of former courses, running north south, lies some 5 km east of the Far Majaan. These have broad levees, upper coverplains and prominent channels but have been almost covered by deep clay soils found on coverplains deposited by

FIGURE 3.1 FLOODING AND FLOOD PROTECTION



the Far Majaan and Webi Goof channels, such that they are very flat. Soils on these upper coverplains are medium textured but have some salinity and alkalinity. In the midst of the levee-upper coverplain there is a red sandy terrace landform, which appears to represent the upper surface of an aeolian sand dune complex, most of which is buried beneath later alluvium. The subsurface relations of this buried surface is at present unknown, but is likely to have an important effect on groundwater distribution and quality.

In the east of the study area is a former channel complex, with levees, depression and channels, that are still prominent features due to their subsequent distance from later Shabeelle courses. Soils developed on this old Webi Goof complex include vertisol clays in the channels and saline-alkaline soils on the levees.

The present Webi Goof channel can be traced upstream for many kilometres, towards Kurtun Waarey, and probably represents a short lived Shabelle course that never become well established. There are well defined sandy levees in parts, but generally the surrounding clay plains pass abruptly into the channel. There is occasional flowage along this channel to the west, resulting from surface runoff, but the Webi Goof channel is presently only flooded by water backing up from the barrage at Haaway.

3.2 Climate

3.2.1 Introduction

The success or failure of the semi-restrained rainfed agricultural development of the lower Shabeelle is, above all, dependent on a supply of rainfall sufficient for crop growth. The suitability of the land resource is vital to successful modern management, but without rainfall there would be no development. Unfortunately there is a severe lack of long term reliable climatic data for the area, and the likely disposition of mean rainfall isohyets, for example, will continue to be a matter of subjective judgement until a scattering of stations rectifies this matter.

3.2.2 Rainfall

The rainfall in this area coincides with the movements of the inter tropical convergence zone (ITCZ). This zone of convergence between the two trade winds migrates northwards across the equator into Somalia in April (SE trades), bringing a moist air mass over the area. Instability associated with the ITCZ results in rainfall over Southern Somalia, with enhancement and decrease in rainfall due to local effects.

This first passage of the ITCZ brings the Gu rains, which commence at the end of March and continue through to May, lasting some 35 to 45 days. Rainfall of Sablaale in the gu season is about 500 mm (Table 3.3). The south-easterly air streams continue until July, however, as the ITCZ continues to move northwards over Ethiopia, and these pick up moisture in the Indian Ocean which is dropped along the coastal belt. These are the haggai rains and bring some rainfall to the coastal area (including Sablaale) until early August.

This is fortunate since it effectively extends the growing season beyond the minimum period of 100 days for crop growth. Shorter growth varieties are being sought however.

TABLE 3.1

Climatic Rainfall Data for Avai, Modun and Brava
Source - Fantoli (1965), HTS (1977)

AVAI (Haaway)

Monthly rainfall (mm)

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total year
1933	27.0	0.0	0.0	91.0	58.0	27.0	75.0	25.0	0.0	0.0	26.0	116.0	445.1
1934	0.0	0.0	0.0	88.0	128.0	61.0	?	?	?	?	?	?	(227.0)
1935	?	?	?	?	?	?	42.0	0.0	45.5	49.5	30.0	7.0	(174.0)
1936	0.0	0.0	0.0	?	?	?	?	?	?	?	?	?	(0.0)
1939	0.0	0.0	0.0	95.3	?	?	?	?	?	?	?	?	(95.3)
1954	0.0	0.0	0.0	108.5	56.5	67.0	28.0	23.0	4.0	31.5	14.5	0.0	333.0
1955	0.0	0.0	0.0	47.0	145.5	15.0	9.0	0.0	0.0	3.5	41.5	0.0	261.5
1956	0.0	0.0	0.0	62.5	33.5	29.0	15.5	0.0	3.5	15.5	139.5	0.0	299.0
1957	8.0	0.0	0.0	221.5	180.5	31.0	57.0	0.0	0.0	0.0	201.0	67.0	766.0
1958	0.0	0.0	0.0	38.0	157.0	54.0	0.0	4.0	0.0	0.0	0.0	0.0	253.0
Mean	3.9	0.0	0.0	93.9	108.4	40.5	32.3	7.4	7.5	14.3	64.6	27.1	399.9

Note : HTS (1977) analysis gave mean 510 mm

Rainy days

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total year
1933	1	0	0	5	2	3	4	2	0	0	1	3	21.0
1934	0	0	0	7	7	2	?	?	?	?	?	?	(16.0)
1935	?	?	?	?	?	?	4	0	2	2	1	1	(10)
1936	0	0	0	0	?	?	?	?	?	?	?	?	?
1939	0	0	0	15	?	?	?	?	?	?	?	?	(15)
1954	0	0	0	5	6	4	4	3	1	2	1	0	26
1955	0	0	0	2	7	1	3	0	0	1	4	0	18
1956	0	0	0	3	3	4	1	0	1	1	6	0	19
1957	1	0	0	9	11	3	4	0	0	0	8	5	41
1958	0	0	0	3	3	1	0	1	0	0	0	0	8
Mean	0.2	0.0	0.0	6.1	5.6	2.6	2.8	0.8	0.5	0.8	3.0	1.3	23.7

TABLE 3.1 (cont.)

Modun

Monthly rainfall (mm)

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total year
1954	0.0	0.0	2.0	64.5	9.5	102.0	40.0	33.2	4.0	14.7	0.0	0.0	269.9
1955	0.5	0.0	0.0	33.5	122.0	17.0	10.0	2.0	4.2	0.0	12.7	0.0	201.9
1956	0.0	0.0	0.0	17.0	31.0	37.0	35.5	4.5	0.0	0.0	0.0	10.0	135.0
1957	0.0	0.0	0.0	0.0	51.0	31.0	162.5	0.0	0.0	0.0	65.0	0.0	309.5
1958	0.0	0.0	0.0	9.0	106.0	129.0	0.0	40.0	0.0	0.0	0.0	0.0	284.0
Mean	0.1	0.0	0.4	24.8	63.9	63.2	49.6	15.9	1.6	2.9	15.5	2.0	239.9

Note : Mean rainfall HTS (1977): 310 mm

Rainy days

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total year
1954	0	0	1	5	3	12	5	5	1	2	0	0	34
1955	1	0	0	7	10	8	4	1	2	0	3	0	36
1956	0	0	0	4	4	8	6	1	0	0	0	0	25
1957	0	0	0	0	5	4	3	0	0	0	4	0	21
1958	0	0	0	1	5	3	0	5	0	0	0	0	14
Mean	0.2	0.0	0.2	3.4	5.4	7.0	4.6	2.4	0.6	0.4	1.4	0.4	26.0

TABLE 3.1 (cont.)

BRAVA (Baraawe)

Monthly rainfall mm

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total year
1915	0.0	0.0	0.7	4.0	108.0	265.0	8.9	4.5	7.5	0.0	4.1	4.0	413.0
1916	0.0	0.0	40.0	30.6	9.0	68.0	23.0	23.0	13.0	15.0	?.	?	(221.6)
1922	0.0	0.0	4.5	143.5	209.5	47.0	64.7	5.7	10.7	23.7	1.2	20.0	530.5
1923	0.0	0.0	2.3	106.0	153.0	126.8	98.6	25.2	11.8	33.0	42.5	26.2	625.4
1924	0.0	0.0	0.0	94.2	136.8	133.4	95.5	17.5	0.0	0.0	11.3	1.0	489.7
1925	0.0	0.0	0.0	0.0	2.5	65.5	254.5	41.5	21.5	0.0	54.0	15.0	454.5
1926	0.0	0.0	0.0	86.5	120.0	53.5	107.5	15.5	6.0	0.0	18.5	0.0	417.5
1927	0.0	0.0	0.0	85.0	288.5	303.0	134.5	22.0	8.0	0.0	58.0	0.0	839.0
1928	0.0	0.0	0.0	5.0	15.0	91.0	7.0	53.0	0.0	0.0	20.0	10.0	201.0
1929	0.0	0.0	0.0	30.0	1.7	140.4	74.6	56.1	193.5	0.0	64.0	18.5	578.8
1930	4.0	0.0	12.0	133.5	174.5	7.5	32.0	11.0	0.0	26.0	111.0	2.0	513.5
1931	0.0	0.0	0.0	8.0	?	17.0	?	0.0	0.0	7.0	0.0	0.0	(32.0)
1932	0.0	0.0	?	73.5	19.5	156.5	32.5	14.0	0.0	0.0	0.0	0.9	(296.9)
1933	5.5	0.0	0.0	60.0	18.2	80.5	88.5	15.0	11.5	5.0	0.0	39.5	323.7
1934	0.0	0.0	0.0	99.0	129.5	64.0	31.5	76.5	32.5	49.5	0.5	1.5	484.5
1935	0.0	0.0	0.0	0.0	72.5	95.0	56.0	33.5	49.5	0.0	0.0	14.0	320.5
1936	0.0	0.0	0.0	60.3	2.8	151.0	95.0	24.0	19.5	6.0	0.0	32.0	390.6
1937	0.0	0.0	0.0	6.5	9.8	9.0	64.6	11.5	20.2	8.0	0.0	0.0	129.6
1938	0.0	0.0	0.0	26.0	52.7	100.3	57.9	50.6	16.3	93.0	0.3	0.0	397.1
1939	0.0	0.0	0.0	13.6	3.4	65.6	1.3	18.6	3.0	35.6	0.0	0.0	141.1
1940	0.0	0.0	3.0	?	?	?	?	?	?	?	?	?	(3.0)
1954	0.0	0.0	0.0	75.5	76.5	91.2	18.8	39.0	3.0	54.0	0.0	0.0	358.0
1955	2.0	0.0	0.0	24.7	127.0	31.0	7.5	0.0	4.0	0.0	4.3	0.0	200.5
1956	0.0	0.0	0.0	49.0	54.0	32.5	63.0	0.0	0.0	0.0	5.0	32.0	235.5
1957	0.0	0.0	0.0	3.0	21.0	50.0	174.0	3.0	0.0	0.8	87.5	24.0	363.3
1958	0.0	0.0	0.0	28.8	184.0	153.4	2.0	2.4	0.0	0.0	0.0	0.0	370.7
Mean	0.4	0.0	2.7	45.8	81.0	95.9	66.4	22.5	17.3	14.2	20.1	10.0	376.3

Note: Mean rainfall (HTS 1977) : 399 mm

Between May and October there are southerly or south-westerly air streams. The sea track of these air masses is slight and rainfall steadily decreases. From October through to March the north-east Trade winds dominate the area as the ITCZ passes southwards. Instability associated with the movement overhead of the ITCZ results in rainfall of the der season. This lasts for some 40 to 50 days and is usually terminated, in the Sablaale area by the 10th December. Because these der rains air masses originate from the north-east rainfall is slight and the season has a much higher risk of crop failure than the gu. Der season rainfall at Sablaale has varied from 105 to 489 mm (Table 3.3) in the past four seasons. Finally from December to March the north easterly trades continue to blow, but are dry and hot, and constitute the jillal dry season.

Rainfall class limits for rainfed land suitability have been based on available rainfall data, and the Inter Riverine Study (HTS 1977). Lands with less than 400 mm are considered unsuitable for semi-mechanised rainfed agriculture.

Climatic data for Brava, Modun, Avai (Haaway) taken from Fantoli (1975) and analysed by HTS (1977) are given in Tables 3.1 and 3.2. Data from Sablaale recorded for the Settlement Development Agency are given in Tables 3.3 and 3.4 whilst likely rainfall distribution is given in Figure 3.2.

TABLE 3.2

(Brava) Baraawe

Principal wind directions

	Major	Minor
January	NE; E	
February	NE; E	
March	E; NE	
April	SE; E	SW and calm
May	SW	SE; S
June	SW; S	
July	SW	
August	SW	S
September	SW; S	
October	SW; S	Calm
November	Calm; SE	NE; N
December	NE; E	Calm

Source : Fantoli 1965

3.2.3 Discussion

In the study area rainfall decreases between Brava and Modun probably due to a slight rain shadow effect of the coastal sand dunes (up to 185 m high). The lack of vegetation along the coast and on the extensive areas of mobile sand dunes may have a significant effect also on this decrease. Rainfall increases between Modun and Sablaale, and there is a noticeable increase in natural vegetation density some 10 km east of Sablaale. This very approximate line has been shown on the present land use map, as equivalent to 400 mm, but it must be stressed

FIGURE 3.2 RAINFALL DISTRIBUTION AND WIND DIRECTIONS

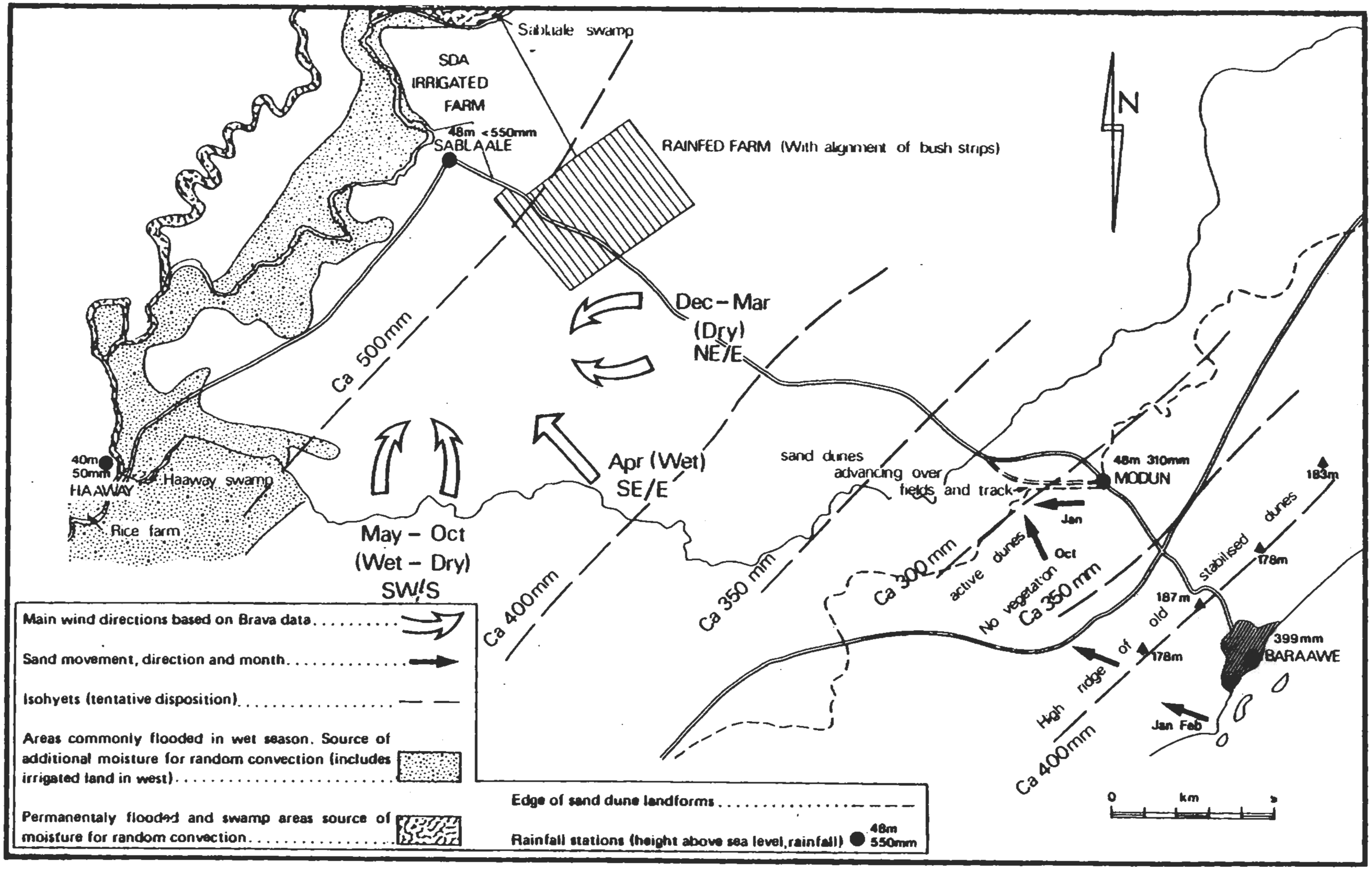


TABLE 3.3

Rainfall Data for Sablaale (mm)
Sablaale Station
Settlement Development Agency

500 m east of Government Rest House, Sablaale, approximately 50 m asl

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total year
1981	-	-	71.5	148.6	180.6	-	-	-	0	4.0	81.0	22.0	>543.7
1982	0	0	0	145.0	95.0	165.0	83.1	9.0	0	251.9	66.3	28.0	843.3
1983	0	0	0	123.5	177.4	30.5	129.5	17.5	0	2.5	83.5	19.5	583.9
1984	0	0	0	111.8	214.5	133.5	42.5	3.0	6.4	2.5	104.0	7.0	625.2
1985	0	0	-	-									
Mean	0	0	17.9	132.2	166.8	109.7	85.0	9.8	1.6	97.0	76.9	23.2	>550
Season	Jillal	|		Gu	|		Haggai		|		Der	|	

Note : Indicates data incomplete

TABLE 3.4

Gu and Der Season Rainfall (mm)

		Gu/Haggai season rainfall	Der season rainfall
Sablaale 1981	Total	499.7	143.0
Sablaale 1982	Total	497.1	489.2
Sablaale 1983	Total	478.4	105.5
Sablaale 1984	Total	505.3	113.5
Avai 1933-36 1939 1954-58	Total	282.5	113.6
Avai 1939-36 1939 1954-58	Range	140-490	0-158.5

that this is a tentative conclusion. Closer to the Shabeelle there is a denser natural vegetation, exclusive of the effects of flooding and riverside water tables. This overall increase from Modun to Sablaale has been suggested as being due to greater convection of air mass over the clay plains in its passage towards the Shabeelle. This is probably unlikely since an increase is considered to occur only where there is a source of moisture at the surface sufficient for generation of random convection. The moisture sources in the Sablaale area include the Sablaale swamp, the Haaway swamp and flooding in the Togga Sablaale. This effect was first mentioned by HTS (1977).

Obviously, if there is a direct link between the moisture sources in the Sablaale-Haaway swamps and the rainfall distribution of the area, then extremely careful planning must be carried out to preserve the moisture sources along the Webi Shabeelle. Reclamation of swamps, flood control and felling of riparian woodland may all lead to a lowering of the rainfall in the Sablaale-Haaway area, and could jeopardise successful development of rainfed agriculture. The setting up of a network of rainfall stations and liaison with other organisations considering development in this area need to be urgently started.

3.2.4 Humidity and Evapotranspiration

No data were collected to assess the relative humidity and evapotranspiration. MacPherson (1983), states that the average relative humidity of the area is 78%, and that evaporation is in excess of 2 000 mm per year. This information agrees with results from the Genale-Bulo Marerta Project (MMP 1978) which indicate a design crop evapotranspiration rate of 1 900 mm per year, or an average of 6.0 mm per day in the driest month, reducing to 4.6 mm per day at the end of the gu rains. Similar rates can be expected to occur in Sablaale. It also shows that evapotranspiration will usually exceed rainfall in most months, except in wetter years.

3.3 Water Resources

3.3.1 Introduction

No detailed study of the water resources of the study area was undertaken during the course of the land evaluation. Some measurements of salinity in river Shabeelle and groundwater were made, and other information was available from earlier studies on the Webi Shabeelle (MMP 1978, MMP 1983).

3.3.2 Webi Shabeelle

No flow records are available for the river Shabeelle within the study area, and the nearest hydrometric station is at Aw Dheggle, which is some 200 km upstream of Sablaale.

Within the lower Shabeelle region river flows occur in two distinct seasons corresponding to the two rainy seasons in the upper catchment of the Shabeelle within Ethiopia. The two main periods of high flow occur in August to October (der flow), and April and May (gu flow). In between there are low flows, and in February and March the Shabeelle commonly dries up over a large part of its length. In February 1985 the river was dry at Sablaale. Abstraction of water from the Sablaale swamp into some 1 800 ha of the irrigated farm partly accounts for this but outlet levels in the swamp were almost dry by the end of February 1985.

In March 1983 slightly higher flow rates were recorded at Sablaale and Haaway of 9.95 m^3/s and 8.56 m^3/s respectively.

At Haaway a barrage has been in operation for many years but is now damaged. It does have an important effect though in maintaining a permanent reservoir of water upstream. This water is used for irrigation of the Haaway rice scheme, some 500 ha in area, and expected to rise to 5 000 ha (MMP 1981). In January 1985 this backing up extended almost as far as Sablaale; a long way up the Togga Sablaale; and many kilometers up the Webi Goof (Figure 3.1). Benefiting from this flooding were Tunni agropastoralists for domestic and livestock supply of water irrigation at the Haaway rice farm; and wildlife in the swamps.

Future expansion of irrigated land was discussed in the Genale-Bulo Marerta study (MMP 1978), and showed that there was capacity in the Shabeelle river for irrigation of 2 400 hecatares at Sablaale, and 5 000 ha at Haaway. The proposed additional expansions totalling 7 500 ha of irrigation throughout the western part of the study area are shown in Figure 3.4.

A more detailed study of the water resources available for irrigation is likely to show that there is insufficient capacity in the Shabeelle for successful irrigation of these proposed expansions.

3.3.3 Water Quality for Irrigation and Domestic Use

Electric conductivity measurements were made of surface and well waters throughout the study area. These are shown on Figure 3.3.

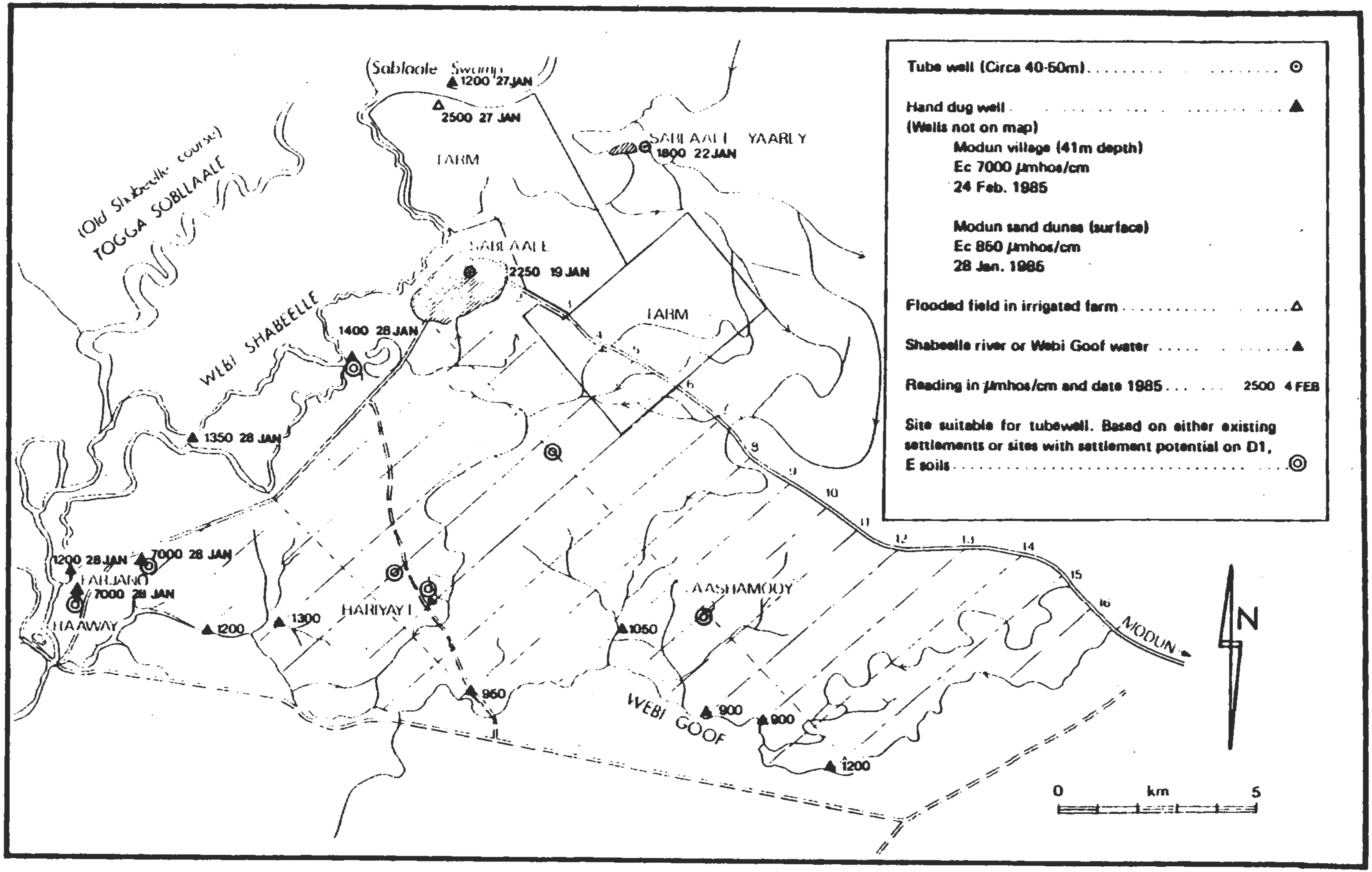
There are few water sources, the Shabelle river and swamps, shallow wells on the cover plains, deep wells on the coverplains, and shallow wells in the sand dunes.

The Shabeelle river and swamps show a range of EC from 800 to 1 400 µmho/cm. These are characteristics of dry season flows and represent medium to high salinity waters. Sodium was not measured but, from experience at Genale (MMP, 1978) it is known to be low in the Shabeelle. The salinity, however, has serious consequences for irrigation since leaching will be very slow in the clay soils, allowing a build up of salinity and high watertables. This is indeed what has happened in the SDA irrigation farm at Sablaale, and is becoming apparant at Farjano. Standing waters in fields near the Sablaale swamp have a high EC of 2 500 µmho, too high for irrigation.

It is a problem which is not being tackled at Sablaale, and would undoubtedly be a serious hazard if large scale expansion of irrigation were to take place in the Farjano area. A side effect of salinisation is that the land is particularly useless for a long time after, where there is inadequate reclamation, if it is decided to return it to rainfed agriculture, since rainfall alone would be insufficient to leach out salts.

A shallow aquifer exists in the area to about 6 m depth below ground level near Farjano, and 40 m depth near Modun. This is extremely saline, with an EC of 7 000 µmho. This is far too harmful for irrigation and unsuitable also for domestic use. It is used at Farjano village however for domestic use, but river water is preferred. A network of shallow wells was proposed by UNHCR to test the extent of this aquifer. The very high salinities found in the three boreholes measured suggest that there is a regional shallow watertable of high salinity which is of little use for domestic or agricultural use, and we recommend that

FIGURE 3.3 ELECTRICAL CONDUCTIVITY WELL AND SURFACE WATERS



this water is used only for washing purposes. Even this purpose would be harmful in village sites, since spillage and seepage would kill off plant life around wells and adjacent gardens. The sodium content of the shallow aquifer is not known. High ESP values in some of the Farjano soils, however, could reflect groundwater with high salinity and high sodium values.

The quality of water from deeper tubewells however is better, with ECs of 1 800 µmho at Sablaale Yaarey, and 2 250 µmho at Sablaale. A sample collected by GTZ (1982) showed an EC of 1 400 µmho/cm at Sablaale and a depth of 50 m. It yielded 10 to 15 m^3/hour. This is suitable for domestic use but is again marginal for irrigated agriculture. We propose that settlements be given one tubewell for domestic use. The quality may be found to vary however, given the occurrence of buried sand landforms where the quality may be higher. Proposed sites, near existing settlements and in areas where new settlements are likley, are shown in Figure 3.3.

The shallow wells on the edge of the old stabilised sand dune belt are well known for their quality. Samples collected from the base of the dunes at Brava and near Modun both gave EC of 850 µmho/cm. At Modun the well site, prior to 1962 was located close to the old Modun to Kismayo road. This road is now some 300 m inside the dune belt, though the well itself remains in a hollow surrounded by dunes. It is a well of extreme local importance and a strenuous attempt should be made to stabilise the dunes in this area and allow a more permanent well to be constructed. At present it is only a saucer shaped feature dug to the watertable. One problem is that without grazing control around the well site stabilisation is unlikely to be successful. These wells on the dunes are too remote to be of use to the proposed settlements at Farjano.

3.4 Natural Vegetation

The natural vegetation of the study area is represented by several district groups of mixed vegetation communities that reflect soil and hydrologic characteristics. Superimposed over this area secondary vegetation groups which represent formerly cleared land, where invasive species have formed plant communities comprised of a few species. The vegetation falls within eco-climatic Zone V described by Pratt and Gwynne (1978), with rainfall rarely exceeding evapotranspiration.

The primary vegetation of the area includes Acacia, Ficus, Thespesia, riparian woodland (W1, W2) along the Webi Shabeelle and Webi Goof webi rivers; wooded Acacia tortilis wooded bushland (B1) on sandy terrace and mixed bushland (B2) and shrubland (S2) with Lawsonia sp, Boscia sp, Albizia sp, Thespesia, throughout the rest of the area. The denser areas of mixed bushland reflect higher rainfall areas, and there is a marked decrease in density some 10 kms east of Sablaale. This is thought to be appoximately representative of the 400 mm isohyet. Rainfall increases between Modun and Sabaale, from about 300 to 500 mm. This boundary, used in land suitability classification to delineate the eastern limit for rainfed farming, is tentative.

Secondary vegetation includes Acacia nilotica and Acacia zanzibarica bushland (B3) and Acacia zanzibarica, Dichrostachys cinerea shrubland. These communities represent invasive vegetation following clearing of land for charcoal and fuel wood collection. In more poorly drained old channels there are grassland communities with Acacia sp bushes (G1, G2).

Permanent swamp communities occur along the Webi Goof, and comprise dense vegetation with sedges and grasses (PS). The area of permanent swamp is in fact quite small, being restricted to the Haaway area. The recent report on lower

Shabeelle swamps (MMP 1983) exaggerates the extent of swamps and shows the maximum limit of flooding in 1982. This can vary from year to year, depending on flood conditions, but area of permanent swamp are restricted.

The vegetation has been mapped from the aerial photography, and is based on observations made at soil sites throughout the area. A full vegetation survey to assess range capacity and domestic potential of the vegetation was originally planned for this survey. This was later deleted, but in view of the requirement to evaluate the land for settlement and forestry use it was considered important to describe the vegetation to a certain degree. This has been accomplished by mapping (see Section 3.6 and Drawing 2), and by including a plant list with names and utilisation (Appendix E).

A preliminary survey of the vegetation of the study area was carried out by W.H. Helin of Interchurch Response in February 1985. The preliminary report of this study concludes that about 1 470 ha of mixed bushland (B2 category of this report) would be required to build 420 traditional style houses for the proposed new settlements. There is sufficient materials available, but present levels of cutting for fuelwood and building materials going into Sablaale may diminish the resource. A more detailed survey incorporating the vegetation lists and mapping of this land evaluation report, was recommended in the preliminary report. This is what was originally suggested in the terms of reference for the land evaluation of the Farjano settlement project, and ideally should have been carried out concurrently with the land evaluation. However, we recommend that this fuelwood and building material study is now carried out.

3.5 Wildlife

There is considerable wildlife in the study area and a note was kept of all larger mammals and reptiles seen or reported during the course of the study.

These sightings and reportings have been summarised in tabular form, together with comments on the likely effect of development on their movements and habitat (Table 3.5).

It is likely that many larger animals will move into bushland further downstream on the Shabeelle. These lands, with little potential for agriculture because of alkalinity, include a proposed but as yet ungazetted 16 000 ha national park, and may offer the best long term prospects for wildlife conservation in the region.

Birds have not been included in this list, but are plentiful in different habitats. In particular, along the Webi Goof, and Webi Shabeelle fish eagles have teritories, whilst the Sablaale swamp has large populations of cormorants, pelicans and egrets. In severely flooded fields of the irrigated SDA farm at Sablaale large populations of migratory geese were seen. An improvement of drainage in this farm would lead to a relocation of these populations into the more inaccessible parts of the Sablaale swamp. Within the main part of the study area, there are not great numbers of birds. Given the desire to maintain swamps and woodland in this region, for the purpose of increasing rainfall, the outlook for bird populations is good. There is little or no hunting of birdlife, but a number of hippo and waterbuck have been shot recently.

3.6 Present Land Use

3.6.1 Introduction

Present land use and vegetation mapping has been carried out in the study area in order to assess the broad extent of fuelwood and house building materials, the nature of different agricultural practices, and the delineation of proposed

TABLE 3.5

Wildlife - Record of Larger Mammals and Reptiles

Animal	Seen	Spoor or tracks only	Said to be in area	Numbers	Main area	Situation likely, under agricultural development	Notes
Elephant	No	Yes	Yes	150?	Denser bushland over much of area	Will move away	Moved south westwards out of area in Mid-January 1985. Estimate of numbers high.
Lion	No	No	Yes	Few	Webi Goof woodland	Will move away	Prey on goats along Webi Goof.
Leopard	No	No	Yes	Few	Webi Goof woodland	Will move away	Prey on goats along Webi Goof.
Cheetah	No	No	Yes	-	Bushland	Will move away	
Dik Dik	Yes	-	Yes	very common	Bushland	Likely to remain in area	Many breeding pairs.
Hippopotamus	Yes	Yes	Yes	very common	Swamps and rivers	Likely to remain in area	Increasingly being shot because they come into unprotected farm land.
Crocodile	Yes	-	Yes	very common	Swamps and rivers	Likely to remain in area	Prey on goats, sheep along Webi Goof area.
Warthog	Yes	-	Yes	Common	Throughout area	Likely to remain in area	Crop predator.
Wildcat	Yes	No	Yes	Common	Probably throughout	Likely to remain in area	
Monitor lizard	Yes	No	Yes	Common	Swamps		
Large tortoise	Yes	No	Yes	Few	Bushland	Likely to be destroyed	
Common waterbuck	Yes	No	Yes	Many	Dense bush-land and swamps	Likely to move away	Increasingly being shot for food.
Bushbuck	Yes	No	Yes	-	Bushland	Likely to move away	
Gerenuk	Yes	No	Yes	Few	Bushland	Likely to move away	
Buffalo	No	Yes	Yes	Many	Swamps and dense forest	May move into denser swamp-forest	Heard, but rarely seen.
Hyaena	Yes	No	Yes	Common	Dense bush	Unlikely to be affected	Comes into settlement at night.
Mongoose	Yes	No	Yes	Many	Bushland and rivers	Unlikely to be affected	
Squirrel	Yes	No	Yes	Many	Bushland	Unlikely to be affected	
Serval cat	Yes	No	Yes	Few	Bushland	Will move away	Prey on sheep, goats, dik dik,
Jackal	Yes	No	Yes	Few	Bushland	Unlikely to be affected	
Unidentified gazelle	Yes	No	-	Few	Bushland	Will move away	
Python	Yes	No	Yes	Common	Swamps and riparian woodland	Likely to be destroyed	
Other snakes	Yes	No	Yes	Common	Bushland and woodland	Likely to be destroyed	Egyptian cobra.
Baboon	Yes	Yes	Yes	Common	Throughout	Likely to remain	Not a serious problem at present but must be monitored. Potential crop predator.
Rat	Yes	-	Yes	Many	Throughout	Likely to remain	Crop predator.

Note: - No data.

agricultural development exclusive of semi-mechanised rainfed agriculture. These activities are discussed in the following sections.

3.6.2 Traditional Rainfed Farming

Rainfed farming has been carried out by Tunni agropastoralists in the eastern part of the study area for a long time. The zone of rainfed farming extends to the edge of the sand dunes, where in some sites recent sand invasion has overwhelmed fields. The main season for cropping is in the gu, and the principle crops are maize, cowpeas, sorghum, cotton, sesame, and potatoes. Cropping during the der season is rare. In Table 3.6 data from the last 25 years is presented, which reflects conditions in the Far Dheer area. This lies in the extreme east of the study area.

These figures have not been checked against regional rainfall patterns, but show that only rarely are there sufficient Der rains to warrant planting. In some years there are total failures of rain, which presumably also affect the Sablaale area. Planting is not however usually carried out until the first rains appear. As a result, late sowing for gu and der is frequent. The Tunni farmers however, are adept at storage of grain supluses, for periods of up to seven years. In early 1985, maize from the 1983 gu season was being used in Aashamooy village, east of Sablaale, having been brought from storage pits at the edge of the sand dunes.

During the dry season the Tunni live in semi-permanent villages within the study area, including Hariyayt, Aashamooy and Dhuunyale. They graze large herds of cattle and goats throughtout the study area, except within the parts affected by tsetse fly infestation. They also produce charcoal which is sold in Sablaale.

Table 3.7 lists some of the major constraints identified by the World Bank (1984).

TABLE 3.7

Major Constraints to Traditional Rainfed Agriculture

1. Paucity of relevant research.

2. Absence of reliable source of quality seed.

3. Moribund extension service.

4. Limited power resources (human, animal, tractor) capable of planting, cultivating and harvesting rainfed crops within a relatively short time span.

5. Complete absence of herbicides, insecticides and fertilisers.

6. Severe problems of rats and birds.

7. Primitive harvesting, threshing and storage resulting in substantial post-harvest losses.

9. Competion of animals for land, crops and labour.

Source : World Bank 1984.

TABLE 3.6

Rainfed Farming in Far Dheer Area

Year	Gu	Der	Crop	Notes
1961	-	-	-	Extensive river flooding over area
1962	x	//	-	Very high der rain
1965	//	x	-	Flooding over whole area
1966	x	x	No crops	Very dry
1967	//	x	Maize, cotton	
1968	/	x	Maize	
1969	/	x	Maize, cotton	
1970	//	x	Maize	
1971	x	x	No crops	Very dry
1972	/	//	-	
1973	/	x	Maize, cotton	
1974	/	//	Maize, cotton, sesame	
1975	/	x	Maize	
1976	/	x	Cotton, maize, cowpeas	
1977	/	x	Maize	
1978	/	x	Maize, cotton, cowpeas	
1979	/	x	Maize	
1980	/	x	Maize	
1981	/	x	Maize	
1982	/	x	Sorghum	
1983	/	x	Maize, cotton	
1984	x	x	No crops	Very dry

Source: Mohamed Noor, Sablaale.

Notes:
- x No rain or crop.
- // Very good rains.
- / Adequate rains.
- \- No data.

3.6.3 Traditional Flood Irrigation Agriculture

This is carried out at only one site, immediately east of Xawaala Buuley village. This lies in an old meander of the Shabelle and was until fiften years ago a permanent swamp. Maize is cultivated in the gu season on the receding flood.

3.6.4 Irrigated Agriculture

In the study area irrigated agriculture was being carried out at Farjano for maize and cowpeas in early 1985. Abandonment of some fields appear to have been caused by high water tables, but field tests show that salinity is also a significant problem.

Irrigated agriculture at the Haaway rice farm, was not investigated but is believed to be well organised. On the SDA irrigated farm at Sablaale however, significant problems were noted which are very relevant to small scale irrigation proposed for the Farjano settlement project. These are discussed in Chapter 5.

3.6.5 Land Use and Vegetation Mapping

This map combining land use and natural vegetation groups. The mapping units are shown in Table 3.8. A vegetation density index has been adopted to give a preliminary assessment of the percentage canopy cover in bushland, shrubland, woodland and grassland groups.

3.6.6 Proposed Development

During the course of the land evaluation study it was learnt that some 7 500 ha of land within the study area had been allocated to locally formed cooperatives. These were all formed to develop agriculture by pump and flood irrigation from the Webi Shabeelle. All of these irrigation cooperatives lie on land that was also within the 16 000 ha allocated for the UNHCR Farjano Settlement Project study. During January and February 1985 work on irrigation canals, and bush clearing was expanded on several of these cooperatives.

The southern and eastern limit of these proposed cooperatives are shown on Figure 3.4. In Drawing 2, areas of cleared land are also indicated.

In February 1985 the Ministry of Agriculture revoked claims on these cooperatives and ordered all work to stop.

Even if the cooperatives were to go ahead it is unlikely that there would be sufficient water in the Webi Shabeelle to irrigate all 7 500 ha, except in years of heavy flooding, and any development is likely to seriously affect the operation of the Haaway rice farm (500 ha). Consequences of irrigation development on salinity and drainage are given in Chapter 5.

FIGURE 3.4 EXISTING AND PROPOSED DEVELOPMENT IN SABLAALE - HAAWAY AREA
(Exclusive of Farjano Settlement Project)

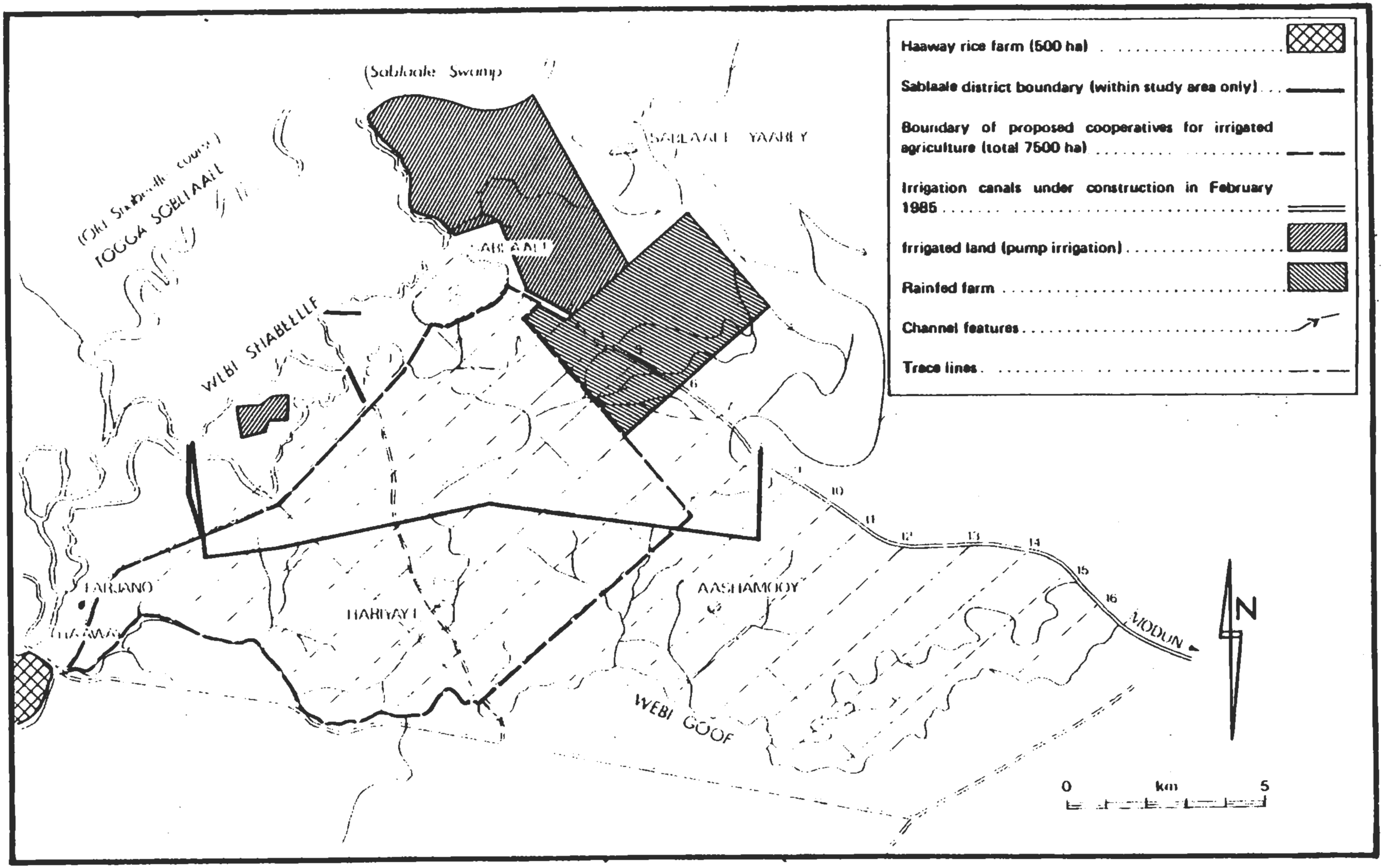


TABLE 3.8

Land Cover Types

Map symbol	Land cover unit	Description	Land use
G1	Grassland	Sparsely bushed grassland: post-charcoal regeneration.	Livestock grazing.
G2	Grassland	Sparsely bushed grassland post charcoal regeneration.	Not grazed by livestock because of tsetse.
PS	Permanent swamp	Swamp grassland, including open water, herbaceous swamp and Typha sp., Cyperus rotundus Panicum coloratum, Echinochloa haploclada.	Settlement and livestock watering; wildlife refuge and grazing; thatch and mat making resources; fishing.
W1	Woodland	Mixed woodland along Webi Goof (10 m) includes Acacia nilotica, A. tortilis, Thespesia danis.	Grazing by wildlife and livestock, charcoal, building materials, local tsetse infestation.
W2	Woodland	Mixed woodland along Webi Shabelli old course Ficus, Acacia trees to 20 m.	Grazing by wildlife; charcoal and building materials.
B1	Bushland	Mixed wooded bushland; with Acacia tortilis trees to 10 m on sandy soils, other species as for B1.	Livestock grazing, charcoal and building materials.
B2	Bushland	Mixed bushland 5 m tall with few to common trees 8 m. Pre-charcoal 'natural' vegetation. 'Securinega leucopyros, Phyllanthus Somalensis, Acacia nilotica, Lawsonia inermis, Dobera glabra, Thespesia danis Salvadora persica.	Livestock grazing, charcoal and building materials.
B3	Bushland	Secondary Acacia sp. bushland A. nilotica, A. zanzibarica. Dichostachys cinerea. A. nilotica, A. zanzibarica. Later post-charcoal regeneration.	Livestock grazing, charcoal and building materials.
S1	Shrubland	Secondary Acacia - Dichrostachys thorn shrubs 2 m. Early post-charcoal regeneration.	Livestock grazing.
S2	Shrubland	Mixed shrubland (2 m) with few bushes to 5 m. 'Natural' vegetation. Species as for B2.	Livestock grazing.
R1	Agricultural land	Semi mechanised rainfed agriculture.	Gu and der season rain-fed cropping.
R2	Agricultural land	Traditional rainfed agriculture.	Der or gu rainfed cropping.
R3	Agricultural land	Traditional flood irrigation agriculture.	Gu season cropping.
R4	Agricultural land	Irrigated agriculture.	Pump irrigation for mixed cropping.
R5	Cleared land	Land recently cleared for agricultural development.	Rough browsing at present.
U1	Permanent settlement	Permanent settlements (Sablaale localised Tunni settlements).	Housing and infrastructure.
U2	Seasonal settlement	Seasonal settlement of Tunni agropastoralists.	Traditionally built houses.
	Tsetse limit	Approximate limit of tsetse infestation (in dry season).	
	Larger bush line	Line indicating danger bushland, and considered to indicate approximately 400 mm isohyet.	

3.6.7 Semi-Mechanised Rainfed Agriculture

A recent World Bank study on semi-mechanised rainfed agriculture in Somalia has recommended that an expansion of this type of agriculture is feasible in the Lower Shabeelle region, as long as certain management practices are strictly adhered to (World Bank, 1984). The study notes that in Somalia the major restriction on yield and expansion of rainfed farming area is the deficiency, variability and short duration of growing season moisture.

In traditional rainfed agriculture farmers allow weeds to grow for livestock grazing purposes, but are aware of the value of moisture conservation and weed control. They are opportunist planters however, planting only when the rains arrive and if there are no rains they utilise surplus stored from earlier years and consider it more important to maintain their livestock populations.

To overcome this shortfall of moisture a system of moisture storage long perfected in Australia and the United States of America, has been introduced in Somalia at the two semi-mechanised rainfed agricultural schemes at Kurtun Waarey and Sablaale.

This system of moisture conservation involves the maintenance of weed-free fallows in fields over two wet seasons (gu and der). Thus each field has a crop in it once every 18 months and by alternating maize and sunflower in the gu and sunflower and cowpea in the der there is rotation with a return period of 6 years. The overall cropping intensity is 33.3% per season, or 66.6% per annum. This in contrast to average rainfed cropping intensities of 200% in Somalia, though it should be pointed out that this is not the case near Modun, where planting is delayed until there is sufficient rainfall (Table 3.6). Potential yields resulting from adoption of moisture conservation fallowing are given in Table 3.9 and are estimates of the World Bank (1984). Actual yields are given in Table 3.10.

These yields were estimated assuming a fallow efficiency of 25% of the rainfall entering the soil, with 10% of rainfall running off and an evaporative loss of 65%. The World Bank (1984) considers that the fallowing efficiency could be increased to 35-40%.

At Sablaale the rainfed farm consists of bush strips 33 m wide alternating with arable strip 100 m wide. Strips are several kilometres long and run in an east south-east direction, from the higher into lower rainfall areas.

Each farmer settler on the semi-mechanised farm has three strips of arable land, 100 m x 300 m in three successive strips and also four strips of bushland, 33 x 300 m between them. This gives a total of 12 ha, of which 9 ha are cultivated land. In any one season only one strip will be sown, with one half of the strip given to one crop (e.g. cowpeas) and the other to the second crop (e.g. safflower). The other two strips are fallowed and kept weed free. Table 3.11 shows an example of this over a six year period.

TABLE 3.9

Potential Yields in Trials at Kurtun Waarey - Sablaale

Crop	Season grown	Preceding fallow practice	Yield potential (kg/ha) Mean[1]	75% exceedance[1]
Maize	Gu	Zero	420	325
	Gu	Der	1 500	890
	Gu	Gu + Der	2 900	2 200
Sunflower	Gu	Zero	290	230
	Gu	Der	820	330
	Gu	Gu + Der	1 470	1 140
Safflower	Der	Zero	20	0[2]
	Der	Der	230	150
	Der	Gu + Der	450	270
Cowpea	Gu	Zero	520	420
	Der	Zero	25	0[2]
	Der	Der	460	280
	Der	Gu + Der	950	560

Notes: (1) If the occurrence of specific rainfalls is normally distributed there is a 50% chance that the rainfall received (and hence yield realised) will equal or exceed the 'mean' rainfall (and hence yield) levels and a 75% chance that the rainfall received will equal or exceed the '75% exceedance' rainfall (and hence yield) levels indicated.

(2) Crop failure, i.e. vegetative growth may occur but there is insufficient moisture to carry the grain fill period through to yield levels that justify the cost of harvesting.

Source: World Bank 1984, after SDA Technical Reports on Sablaale & Kurtun Waarey.

TABLE 3.10

Recent Yields at Sablaale Semi-mechanised Rainfed Farm

Gu	1984			
	Maize	long fallow	2 536 kg/ha	
		short fallow	1 697 kg/ha	
		average	2 116 kg/ha	
	Sunflower	long fallow	249 kg/ha	
		short fallow	146 kg/ha	
		average	197 kg/ha	
Der	1983 and 1984			
	Cowpeas	long fallow	2 150 kg/ha	1984
		short fallow	1 220 kg/ha	1984
	Safflower	long fallow	81 kg/ha	1984
			513 kg/ha	1983
		short fallow	0	

Note: Short fallow indicates land newly cleared.
Source: SDA Technical Report No 10, 1984; Biggs 1983.

TABLE 3.11

Rotation and Farming System

Block		A		B		C	
Sub-block		A1	A2	B1	B2	C1	C2
Year and season							
1	Gu	Maize	Sunflower	Fallow	Fallow	Fallow	Fallow
	Der	Fallow	Fallow	Cowpea	Safflower	Fallow	Fallow
2	Gu	Fallow	Fallow	Fallow	Fallow	Maize	Sunflower
	Der	Cowpea	Safflower	Fallow	Fallow	Fallow	Fallow
3	Gu	Fallow	Fallow	Maize	Sunflower	Fallow	Fallow
	Der	Fallow	Fallow	Fallow	Fallow	Cowpea	Safflower
4	Gu	Sunflower	Maize	Fallow	Fallow	Fallow	Fallow
	Der	Fallow	Fallow	Safflower	Cowpea	Fallow	Fallow
5	Gu	Fallow	Fallow	Fallow	Fallow	Sunflower	Maize
	Der	Safflower	Cowpea	Fallow	Fallow	Fallow	Fallow
6	Gu	Fallow	Fallow	Sunflower	Maize	Fallow	Fallow
	Der	Fallow	Fallow	Fallow	Fallow	Safflower	Cowpea

Source: World Bank 1984.

Initial land clearing is done mechanically by bulldozers and it is planned to use chains mounted on tractors at Kurtun Waarey farm. The benefits of efficient mechanical clearance are mainly in the speed of the operation and the clearing of stumps and roots in fields. It is noticeable, however, that this is often done at the expense of the bush strips which consist of useless heaped piles of soil and vegetation pushed off the field. The role of settlers in the clearing process, so that the range resource may be more satisfactorily utilised as a rural energy source, should be given greater importance in future planning. It is pointless destroying bushland that may be of use for fuel wood, material for houses and effective bush strips. Following land clearing, the soil is prepared for cultivation initially with offset disc farrows. These, however invert the soil and any moisture remaining in the uncultivated soil is likely to be lost. For initial land preparation from virgin bushland this may be unavoidable and these lands should go straight into fallow to build up moisture reserves.

For primary and secondary land preparation a chisel plough has been used. This has wide sweeping tynes to cut off roots, but there is considerable surface damage to the soil.

Herbicides are used prior to sowing crops in order to eliminate weeds. Pre-planting of Trifluralin has been carried out after the start of rains as a pre-emergent for sunflower, safflower and cowpeas. The herbicide Attrazine has also been used as a pre- early and post-emergent weed control on maize and sorghum (now discontinued) crops.

Planting is carried out either by a trashworker cultidrill for very large plant populations or by the Janke 8 row precision planter. The former is used extensively for weed clearance prior to cultivation, and it can also be used for non-precision sowing and fertiliser application. The precision planter can establish exact spacing between seeds and at an exact depth. Water injection is also carried out simultaneously with sowing, depending on the moisture status in the soil. It is not recommended for use on dry soils, but only after a certain amount of rainfall has entered the soil.

A problem encountered with the precision planter is its tendency to bounce over ridges in the gilgai of the clay soils. This gives an irregular planting depth, and land planning has been recommended (Gibbs 1983, World Bank, 1984). As a result the degree of gilgai development has been assessed at each soil observation site, but this has not been mapped, nor used as an important factor in land suitability evaluation. It is the natural inclination of these soils to form gilgai undulations but once under cultivation movement appears to be reduced, probably because of seasonal cultivations.

Once the crop has emerged it is the responsibility of the farmer settler to carry out weeding, harvesting and disposal of the crop. The high numbers of wet days makes mechanical weeding difficult and mechanical harvesting was shown to be expensive and wasteful. Payment in kind is made by the farmers to the Farm Manager to cover the costs of land clearing, preparation, weeding and sowing. This system has proved successful so far and it is hoped soon to introduce some form of land tenure for the farmers.

Ongoing research is assessing potential crops for the two seasons. The emphasis is on shorter maturing and deeper rooting varieties. The World Bank report recommends that this should be carried out using the resources of the international agricultural institutes. This report also examines the role of machinery. It suggests that disc harrows are inefficient because they overturn the soil too much and would like to see the introduction of a larger broadacre planter instead of the trashworker culti-drill. This would give extra capacity for opportunity cropping of pulses, for example, in very wet years. A blade plough may prove more efficient in moisture conservation than the chisel plough, as it overturns only about 10% of the soil surface, but may not be suited to the heavy clay soils.

Finally, the use of fertilisers will not be necessary until moisture conservation techniques are fully realised. There is no response at present to fertilisers in traditional rainfed crops. Under the moisture conservation fallow system responses, especially to nitrogen, are likely in good rainfall years, and with the introduction of responsive varieties.

The semi-mechanised rainfed farming system, as envisaged by the World Bank (1984) is reproduced in full in Table 3.12, and has been useful in preparing land suitability guidelines.

3.7 Erosion

3.7.1 Water Erosion

At present erosion by water is not a problem in the study area. There is no evidence of rills, gullies and subsurface piping. This can be attributed to the rapid infiltration of rainwater into the soils, and static nature of seasonal flooding.

TABLE 3.12

Summary of Farming System

Objectives		Associated characteristics
1. To provide sufficient moisture	(a)	Precede each crop by two seasons of fallow.
	(b)	Choose crops of suitable growing season and moisture requirement.
2. To slow degradation of soil structure and the depletion of soil fertility	(a)	Maintain a clean but 'rough' fallow with the minimum number of cultivations of carefully selected village methods and hence equipment and the judicious use of herbicides.
	(b)	Encourage farmers to leave crop residues on the field.
	(c)	Adjust the crop rotation.
	(d)	Apply artificial fertiliser.
3. To reduce the impact of any crop predators, pests and diseases	(a)	Avoid crops that cannot be protected at a reasonable cost (e.g. avoid sorghum because of quelea quelea bird predations).
	(b)	Adopt a farm configuration that minimises predator, pest and disease habitats and/or assists with rapid and cost-effective preventative and/or control measures.
	(c)	Adjust times of crop planting to avoid any peak seasonal periods of predator, pest and disease activity.
	(d)	Choose crop rotations to break any predator, pest or disease life cycles.
	(e)	Monitor predator, pest and disease populations and implement preventative action or control measures whenever the expected levels of crop loss justify the cost involved.
	(f)	Provide farmers with an area of established crop that has a yield potential sufficient to justify protection through to disposal of output.
	(g)	Limit the area of established crop provided to each farm family to a level that is consistent with the resources they have available to provide protection.
4. To create employment at higher and more stable levels of cash income than would otherwise be the case	(a)	Provide farmers with an area of established crop that has a higher and more stable yield potential than can be achieved under traditional methods.
	(b)	Adjust the area of established crop to match the resources a farmer can provide to protect, weed, harvest, thresh and market.
	(c)	Avoid crops which, if included in the rotation, are unable to meet this objective.

TABLE 3.12 (cont.)

5.	To ensure the system is financially and economically viable	(a)	Adopt a farm configuration that minimises the costs of all inputs especially imported inputs (machines, fuel, oil, herbicides, pesticides, fertilisers and technical assistance).
		(b)	Use only crops with positive gross margins and a combination of crops that are technically acceptable (see 1(a), 2(c), 3(a) and (c) and 4(c) above); and (i) when taken together maximise the gross margin of the entire farming system; and (ii) either save by import replacement or generate by increased exports, foreign exchange.

Source: World Bank 1984

In years when there has been substantial flooding, and in the past this has covered much of the study area, flowing water is thought to have deposited considerable sand in the soils, but this was transported into the area.

Potential erosion from severe flooding however, is likely to be greater where flood waters are allowed to pass through cultivated lands. Several danger spots are indicated on Figure 3.1 where protection is needed.

Erosion resulting from impact of raindrops has led to formation of crusts in the upper coverplain soils. This may in fact protect the surface from erosion, but reduces infiltration of rainfall.

3.7.2 Wind Erosion

Wind erosion in the study area includes the movement of aeolian sands into the area from the east.

The net movement of sands from the active dunes near Modun is slight due to seasonal changes in wind direction which diminish the overall movement. In October to February strong dry winds are blowing from the east, south-east, and north east, which has resulted in movement of dunes across fields and tracks.

The good quality surface water well in the sand dunes at Modun is frequently overwhelmed by advancing dunes and has to be dug out again. The dry season track from Modun to Sablaale is being threatened at present, and in the long term the all weather track from Modun to Sablaale could also become covered by sand sheets flowing in advance of the dunes.

Comparison of 1962 and 1983 photography in the area 2.5 km west of Modun shows a maximum net movement of 350 m, an advance of 17.5 m a year. The range is from 50 to 300 m along a 3 km front. The movement is small because between May and October, southerly and south-westerly winds blow sand back towards Modun. Because there are insignificant westerly winds however the net movement is towards the west.

The main hazard from drifting sand is to communications. Although fields are being overwhelmed in the Modun they lie well outside the area of development being studied in this report.

A programme of sand dune fixation is being carried out in the Modun-Brava area. This is financed by UNDP-UNSO (United Nations Sudan Sahel Office) and is being managed by a technical team from Denmark. Programmes of nursery establishment of trees and extension work for local farmers and pastoralists is being undertaken. It is worth pointing out however that the initial colonisation of bare dunes probably occurs during very wet years, and is initiated by the spread of indigenous grasses and herbs lying amidst larger bushes. (Some of these important colonisers are listed in Appendix E.) Once the edge of the dunes have been stabilised, larger Acacia tortilis trees will become dominant, replacing the early colonisers. Removal of these larger trees, for fuelwood and charcoal or house materials is likely to result in remobilisation of the sands. This appears to be happening around Modun.

3.7.3 Wind Erosion in Fields and Tracks

Wind erosion of fine textured soils in fields and along tracks is not a serious problem. There is at times during the dry season a significant dust haze in the area, but this results from fine calcaréous dust being blown inland from the coastal strip.

The soils of the study area are mostly fairly low in silt sized materials that are the most easily transportable by wind. On the upper coverplains where there are moderate silt contents, a natural rain crust inhibits wind erosion. Under cultivation however, where mechanisation is likely to powder turn the topsoils into very friable structure, and even powder, there is a significant potential hazard. Paradoxically surface roughness decreases wind erosion risk but increases evaporation from the soil.

On the clay soils, there is a natural control against wind erosion in the form of the surface crumb mulch. The mean size of these particles is larger and the particles are heavier than the winds can move. The degree of mechanisation planned may reduce this limit especially in the lighter textured clay loamy soils. Use of twin disc harrows will increase pulverisation and should not be used.

Along tracks where pounding by vehicles and livestock does reduce soil structural units to dust, there is a significant hazard. The use of a calcareous beach rock for the main access road into Sablaale illustrates this, in that dust clouds are dispersed along the edge of the tracks, covering crops and dwelling houses. A sandier base would have been more suitable.

3.7.4 Wind Action and Bush Strips

The alignment of the shelter belts in the rainfed farm at Sablaale is shown in Figure 3.2. In relation to the prevailing winds it is apparent that the main gu rain showers will be channeled along the field corridors between the bush strips. In the dry season the strips are at slightly opposed angles to the wind direction and will have an undesired effect of increasing wind velocity and increasing evapotranspiration.

It would thus be worthwhile investigating the effect of having wind breaks at right angles to these main strips. A corridor many kilometres long may produce a microclimate of its own, channelling winds along it. The planting of cross strips may be more useful.

All this presupposes that the bush strips are in fact bushed. At both Sablaale and Kurtun Waarey the older parts of the farms have bush strips that are devoid of vegetation. These areas were mechanically cleared prior to the start of cultivation but little attempt has been made to replant them and use them for their designated purposes. In 1985 trials will commence at both settlements to grow bush or tree crops that will provide shelter, fuelwood and house building materials.

The bush strips can be effective in reducing wind velocities, and also reducing considerably evapotranspiration in fields. A medium density porous belt (equivalent to B_2m vegetation type), 6 m high would reduce wind velocities by 20% over a 90 m length. This is almost the width of the present strips. The ET-crop can also be reduced similarly: a bush strip 6 m high will reduce ET by 5% at 150 m, but up to 30% at 60 m downwind of the bush strip.

Increasingly this type of afforestation has been given over to exotic fast growing species, but we would also recommend that a careful look is given to the possibility of using some of the local species, which occur throughout the area.

Some are already used for these purposes and can be coppiced. Thespesia danis in particular can be a troublesome invasive shrub in cultivated fields, but it could probably be put to an important use in bush strips. It is one of the most commonly used indigenous species collected for home building materials.

CHAPTER 4

SOILS

4.1 Methods of Study

The soil survey of the Farjano Settlement Project was carried out at semi-detailed level and as required by the Terms of Reference. The total surveyed area was 16 000 ha. In all 300 soil auger observations and 39 soil profile pits were examined; giving an overall density of 1 site per 47 ha.

Soil sample sites were generally at 500 m intervals along the traces cut for the topographical survey. The traces were at 1 km intervals. Additional sites were made wherever it was convenient, such as adjacent to tracks, old traces and on cleared land.

Samples from representative soil mapping units were taken and analysed at laboratories in the United Kingdom. Four horizons from each of 10 profile pits were sampled. Analysis was as requested in the TOR. Analytical methods are summarised in Table 4.1.

TABLE 4.1

Analytical Methods

Parameter and units	Method
pH	1 : 2½ soil water suspension
Exchangeable cations (meq/100 g)	Sodium acetate
CEC (meq/100 g)	Ammonium acetate
Electrical conductivity (mmhos/cm)	Saturation extract
Available phosphorus (ppm)	Olsen
Total nitrogen (ppm)	Kjeldahl digestion
Organic carbon (%)	Walkley-Black uncorrected
Particle size analysis	Bouyouscos
Available Cu, Mn, Fe, Zn	DPTA

Soil mapping was carried out by transferring mapping detail from the aerial photography onto a preliminary base map at 1 : 30 000. This was prepared as an aerial photograph lay down, with control provided by survey data. This was then enlarged to 1 : 25 000 and matched against a 1 : 25 000 enlargement of the 1 : 100 000 topographical base map (Sheet NA 38-100). Soil boundaries were closely matched with the contours drawn up from the topographical survey.

4.2 Previous Studies

There are two important sources of information on the soils of this area, and upon which major planning decisions have been based. These are the FAO-Lockwood (1968) study of southern Somalia, and the Inter Riverine Agricultural Study carried out by Hunting Technical Services (1977).

In the FAO-Lockwood Survey Corporation study, a reconnaissance was carried out over the whole of Southern Somalia. Soil series and associations were drawn up and mapped at 1 : 100 000 or 1 : 500 000. Descriptions were supported by a large number of analytical results carried out at Afgoi Research Station.

In the Sablaale area a number of soils were mapped but no analyses were carried out. Along the Shabeelle river, as far as Haaway (Avai) they mapped the Haharro soil on recent alluvium, as a grey clay characteristic of permanent swamps. The Avai soil covered much of the area surveyed for this report. It is a dark brown clayey vertisol, free of salts and alkalinity in upper horizons but increasing in salinity and alkalinity with depth. The analyses responsible for these findings were taken from soil sites outside the present study area. In the north eastern part of the Farjano study area the Ururgala soil is mapped. It is a dark brown vertisol, an older alluvium, and with very high salinity and low to high alkalinity in the subsoil. The Shabeelle soil is mapped in the western part of the area from near Avai (Haaway).

Finally, in the extreme east of the Farjano area the Goojca soil was mapped by Lockwood. It is dark greyish brown vertisol free of salinity or alkalinity, formed on old alluvium associated with the Webi Goof and used extensively for traditional dryland farming.

The Inter Riverine Study (HTS 1977) carried out no additional soil field work in this area. The analytical data from the FAO-Lockwood study were scrutinised and a land suitability evaluation carried out for rainfed and irrigated agriculture. In Figure 4.1 the HTS soil and land suitability mapping has been reproduced, with the addition of the Farjano Settlement Project Study area boundary. The Inter Riverine suitability classification was based on USDA and equivalent FAO values are given in Table 5.13. Details of the mapped soils and others whose significance is relevant to the present mapping are given in Table 4.2.

More recently, some analyses were carried out by GTZ (1984) in the existing semi mechanised rainfed farm at Sablaale and also on the SDA irrigated farm at Sablaale give data for salinity levels in the irrigated farm which have been useful in formulating guidelines for small scale irrigation suitability. In the rainfed farm salinities were within acceptable limits for two of the three sites, but rather high (3.4 mmhos/cm in 0 to 40 cm; 2.6 in 40 to 70 cm) for the third. We suspect this is a spurious result. Of more importance are nutrient and micronutrient levels in the dryland farm. These results have been commented on by Biggs (1983) who noted that values of P and Mg were all very low. Amongst micronutrients Cu and Fe were regarded as adequate whilst Zn was low and the values for Mn were considered a very serious toxicity risk. These data lie just outside the study area but are of interest and have been reproduced in Table 4.3. It should be pointed out that the concentration for some analyses and the methods of analysis were not shown by GTZ (1984) and since toxic and deficiency levels will vary according to the extractant used, it is difficult to give an objective conclusion on them.

4.3 Soil Formation and Soil Processes

4.3.1 Introduction

Almost all of the soils in the study area have been formed in alluvial sediments deposited by present and former courses of the Webi Shabeelle. The history of the river changes has already been discussed in Section 2.1. The oldest soils are formed on sandy sediments that appear to represent the upper part of a former aeolian sand dune landform, that has been protected from subsequent erosion by the elevated lands of broad levees that surround it.

FIGURE 4.1 PREVIOUS SOIL MAPPING - LOCKWOOD/FAO 1968 : HTS 1977 RECONNAISANCE

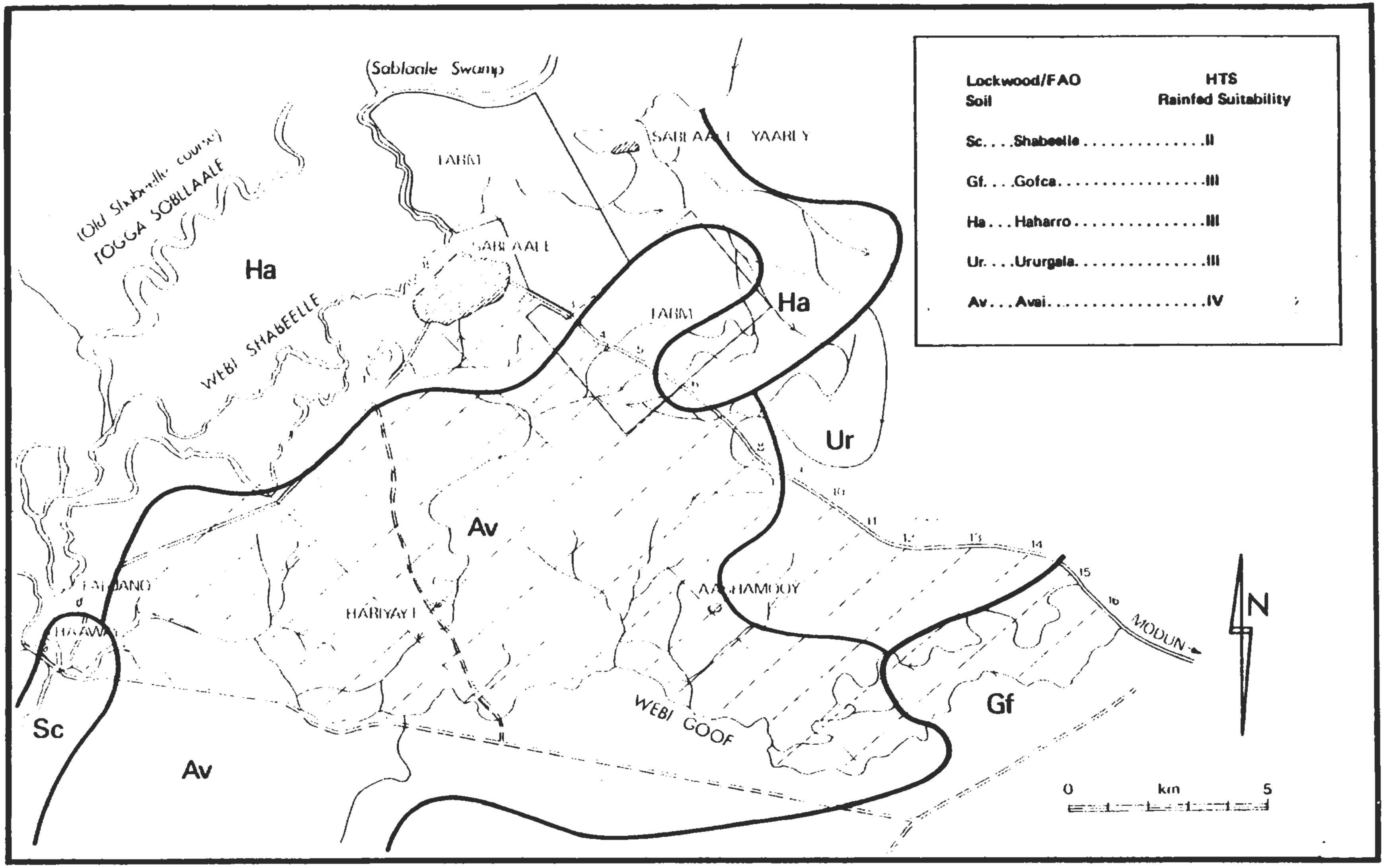


TABLE 4.2

Characteristics of Lower Shabeelle Region Soils, from Earlier Studies (HTS 1977, FAO-Lockwood 1968)

Lockwood-FAO soil name	Landform	Description	(HTS 1977) Rainfed land classification class
Haharro (Ha)	Recent alluvium of Shabeelle swamp	Grey clay	III. Mod well suited because of low rainfall otherwise Class II.
Avai (Av)	Older alluvial cover-plain of Shabeelle	Dark brown to greyish brown clay vertisol; surface mulch; gilgai and sink holes; soft $CaCO_3$ concretions; moderate salinity and alkalinity in subsoil	IV.
Ururgala (Ur)	Older alluvial cover-plain of Shabeelle	Dark brown clay vertisol; slight gilgai; soft mulch at surface; sink-holes and cracks; non saline surface horizons; very high salinity and high alkalinity in deep subsoil grazed and browsed; not cultivated.	III.
Gofca (G8)	Older alluvial channel and coverplain of Webi Goof	Very dark greyish brown to dark brown clay; surface mulch with strong gilgai relief; no salinity or alkali throughout. Rainfed farming for sorghum and cotton.	III.
Savro (Sv)	Older alluvial cover-plain of Shabeelle	Yellowish brown to dark yellowish brown clay loam over dark brown clay for subsoil; firm surface with fine concretions; non saline in upper horizons, but high salinity and alkalinity in subsoil; slickenslides in subsoil; browsed, not under cultivation.	III.

TABLE 4.2 (cont.)

Lockwood-FAO soil name	Landform	Description	(HTS 1977) Rainfed land classification class
Shabelle (Sc)	Sub recent alluvial meander plain of Shabeelle.	Dark greyish brown to dark clay vertisol; surface mulch; often cultivated in low lying areas by flood irrigation.	II.
Channel Remnants (C)	Older abandoned courses of Shabeelle	Variable soils, including dark brown soils of old levees; and fine textured dark greyish brown clay verisols of old channels.	Variable I-IV
Calalaio (Cl)	Remnant sand dunes	Dark reddish brown sandy clay loan. Firm surface; tends to be two droughty for cultivation; $CaCO_3$ concretions in subsoil.	Not suitable

TABLE 4.3

Chemical Analysis from Semi-mechanised Farm

Site	Depth (cm)	pH	EC mmho/cm	ppm P_2O_5 100 g	ppm K_2O 100 g	ppm Mg 100 g	Cu	Zn	ppm Mn	Fe	Boron
S30	0-40	7.2	3.4	12	55	25	2.9	13.3	55.7	45.5	0.31
S30	40-70	7.1	2.6	9	34	45					
S31	0-40	7.1	1.7	10	42	29					
S31	40-70	7.1	1.9	9	32	50					
S32	0-40	7.0	1.3	8	49	28					
S32	40-70	7.0	1.4	8	49	29					

Source: GTZ 1984

Location:			
	S30	600 m	NE of PM 35
	S31	1 300 m	NE of PM 35
	S32	2 600 m	NE of PM 35

Note: Values for P, K and Mg are probably in ppm according to Biggs 1983. This seems likely.

4.3.2 Terrace Soils

Pedogenesis is most advanced in these Sandy Terrace Soils (E), which have $CaCO_3$ layers and a concretionary $CaCO_3$ layer at about 1.2 m. These soils may have originated as a sand dune but have been partly covered by alluvial sediments subsequently. Fluctuating groundwaters have cemented the $CaCO_3$ layer, which probably originated as a subsurface layer of $CaCO_3$ in the dune, into a hard concretionary pan. Washed sand particles in these soils indicate that the red sand is aeolian in origin.

4.3.3 Upper Coverplain Soils

On the levee and upper coverplain soils (D1, D2, D4) which occur throughout the study area, there are firm surfaces and weakly developed cambic surface horizons. In the most recent levee soils (D3) observed along part of the Webi Goof, there is still prominent stratification, but this is absent in all other soils with the exception of some sandy alluvial deposits in the coverplain clays. The upper coverplain soils have blocky structure in the subsoil and some slickenslides.

Texture are loamy and clayey and silt content is low. The soil surface is usually smooth, however, with no gilgai or surface mulch characteristic of the lower coverplain soils. Calcium carbonate concretions are common on the surface of some of these upper coverplain soils, and they are present in the finer textured subsoils. This may be due to surface winnowing of the topsoils over a long time, leaving concentration on the surface. Shell fragments are not common in these soils but some large land snail tests are found occasionally.

4.3.4 Lower Coverplain Soils

In the lower coverplain soils (A1, A2, C1, C2) the soil textures are predominantly clayey, though the development of a surface mulch and shell or concretions has tended to give loamy particle size classes. Silt content is very low. The surface has a fine crumb mulch that readily slakes in water: we could not find any evidence of the long term structural stability of the mulch. The same can be said of the cracking subsurface. This gives rise to massive prismatic structure that breaks steadily into angular blocky, subangular blocky down to the surface crumb mulch. This structure appears strong and permanent but is in fact a transient phenomenon. In the rainy season the soils lose all structural stability when wet and a different cracking pattern emerges in the following dry season.

A permanent feature of the lower coverplain soils is their surface microrelief in the form of gilgai. Gilgai result from seasonal drying and swelling of montmorillonite clays. In the dry season the soil cracks out and prominent cracks form in the hollows of the gilgai. The cracks extend to a metre or more and finer mulch material shell fragments and concretions drop down into the crack. At the start of the rainy season there is a rapid increase in the supply of this material. As a result when the soil wets up and swells there is an excess of volume. To overcome this the soil bulges upwards where the crack was. In the adjacent area there is depressional or no movement and a hollow forms. This becomes the cracking area for the following season. As a surface mulch forms during the dry season it obscures the cracking below but large sinkholes (also called solution holes in some reports) coallesce as structural units disintegrate into finer units. With cultivation the land is kept more or less level and so the gilgai does not get an opportunity to become fully developed. Where land is left fallow for a number of years or seasons however the gilgai remanifests itself.

In the subsoil the gilgai is represented by intersecting shear planes and slickenslides. Broken freshwater shell fragments testify to the disruption caused. Below about 1.2 m there is a permanent moist soil and clay movement appears to be minimal. Gypsum crystals are common in some of these soils below a metre and forms a basis for division of soil mapping units on the lower coverplain. The presence of gypsum has nothing to do with any possible solution of this mineral and formation of sinkholes in gilgai areas. The sinkholes result solely from seasonal drying and wetting.

Another important feature in lower coverplain soils is the presence of sand particles. This has been used to distinguish between A1.2 and C1.2 mapping units. The sand is fluvial in origin, and occurs both throughout the profile and also as prominent layers of stratified pale, fine sandy loam 2 to 10 cm thick. Since these occur in gilgai soils it is evident they have formed recently, otherwise gilgai movement would have destroyed such layering. However, there is no trace of sand on the surface. The sand is not aeolian in origin (this was checked at Modun) but it does strongly resemble sands that occur within the Sablaale swamp. It is likely that this sand results from the regional inundations of the area (see Table 3.6) such as occurred in 1965. At this time flooding from the Shabeelle extended over the whole area, leaving many shell deposits where long term swamps had occurred. Sand was also brought overland by the flood water and washed straight down cracks in the clay soils. Since then much of the sand has been incorporated into the clays, and shells broken up, but pockets of sand and unbroken shells remain. This could indicate that some areas may get very little rainfall over many years, as they have not been flooded since.

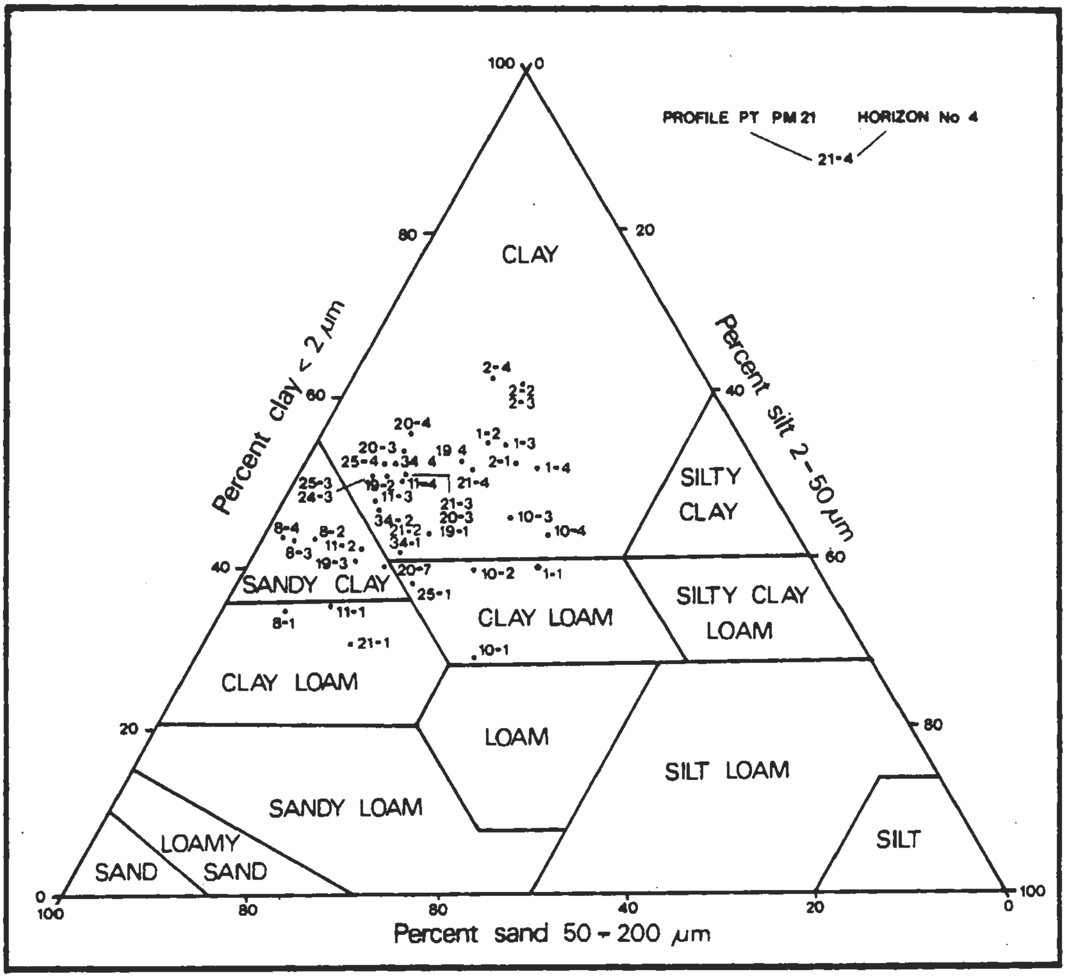
A final feature of these vertisols of the lower coverplain is the presence of fine $CaCO_3$ concretions and soft powdery $CaCO_3$ in the profiles. It is likely that the concretions form in the swamps when soft alluvial clay is ripening to form a cracking veritisol. Some softer concretions were noticed in the existing clay soils of the Webi Goof swamp, and in basal parts of the coverplain clays. The process may continue outside the swamps: neo-gypsum is forming in the deep subsoils of the clays and it is likely $CaCO_3$ will be equally affected. Soft powdery $CaCO_3$ particles appear to reflect leaching down profile due to seasonal rainfall. It was observed in some soils.

4.3.5 Old Channel Clays

The soils of the old channels (B1, B2) are very similar to the lower coveplain soils. A paler surface colour, stronger gilgai microrelief, abundant shell fragments, strong cracking structure, and slight presence of sand layers characterise these soils. They also have the highest clay content of the area (Figure 4.2).

The channel clay soils are most likely to be flooded every year due to their linear distribution, that will traverse the paths of several rainfall storms, and runoff from adjacent levees.

FIGURE 4.2 DISTRIBUTION OF PARTICLE SIZES



4.3.6 Recent Alluvial Soils

Soils developed on more recent and present alluvium include the clayey soils along the Webi Goof (F), clayey soils in recent meanders and channels of the Shabeelle (B3) and clayey soils (A3) on depressions and flat areas permanently affected by Webi Goof and Shabeelle flooding.

Soil formation in the Webi Goof swamp is slight, with profiles ranging from soft unconsolidated mud to firm plastic clays that have not yet dried out to form vertisols. A thin peaty surface horizon is present in some areas.

In the other soils on recent channels and coverplains much of the characteristics of vertisols on the older coveplains are present. Perhaps due to annual flooding and heavy vegetation growth of grasses and herbs, surface mulches are not well formed, although the soils readily crack and form weak gilgai. Layers of diatomite in A3 soils testify to a recent lacustrine environment and show that the change from swamp soil to cracking clay vertisol is rapid and probably permanent.

4.4 Soil Mapping Units

4.4.1 Introduction

In this section the soil mapping units are described in detail. Reference should be made to the representative profiles and accompaning analytical results. It includes discussions of soil chemistry and physics. Features of the soil mapping units are summarised in Table 4.4, whilst area measurements are given in Table 4.5.

4.4.2 Mapping Unit A1

This soil is a very dark greyish brown to dark brown vertisol, with a surface crumb structured clay loam topsoil mulch over subangular blocky to prismatically structured clay. Surface and topsoil colours include 10 YR 3/2 and 10 YR 4/2. and these change little with depth, but there may be 2.5 hue mottling in the subsoil. Mottles are absent, $CaCO_3$ concretions may or may not be present. Vertical cracks extend to about 1 m but may be deeper. Generally the soil is moist below 1 m. This is a widespread soil mapping unit which mainly occurs east of the large north-south old channel 5 km east of Sablaale. The site chosen for analysis (PM11) contains slightly more sand than expected, and this is probably due to high content of fine concretionary matter, since a high sand content was not apparent in the field. Chemical data for these soils suggest that montmorillonite is the main clay mineral. Salinity is low throughout the profile and alkalinity is low in the upper horizons, and although the ESP rises in the deep subsoil it is not to a significant level of toxicity. Other exchangeable cations are all quite high, but the very high calcium values are balanced by high Mg, which otherwise could be less available.

Of the plant nutrients, nitrogen, carbon and phosphorus are all low as expected, but micronutrients are adequate.

TABLE 4.4

Soil Mapping Units

Map symbol	Landform and parent material	Soil Profile characteristics	Soil drainage	Site drainage	Gilgai microrelief	Slope	Main vegetation group	Number of observation
A1	Lower coverplain on older Shabeelle alluvium	Dark greyish brown clay loam over clay. Surface mulch, with sinkholes. strongly calcareous. Angular blocky and prismatic structure.	Moderate	Slight seasonal flooding	Slight to moderate (U1-U2)	<1%	Mixed bushland	113
A2	Lower coverplain on older Shabeelle alluvium	Dark greyish brown clay loem over clay. Surface mulch, with sinkholes. Strongly calcareous. Gypsum crystals common below 90 cms. Angular blocky and prismatic structure.	Moderate	Slight to moderate seasonal flooding	Slight to moderate (U1-U2)	<1%	Mixed bushland	33
A3	Lower coverplain on recent Shabeelle alluvium	Brown to light yellowish brown clay. Strongly calcareous gypseous close to surface. Saline subsoil. Firm or mulched surface.	Moderate to imperfect	Strong seasonal flooding	Slight to moderate (U1-U2)	<1%	Grassland and bushland	10
B1	Channel on older Shabeelle alluvium	Dark grey clay over dark greyish brown clay. Firm or mulched surface. Prominent subangular blocky and prismatic structure.	Imperfect to poor	Strong seasonal flooding	Moderate to strong (U2-U3)	≤2% on edges onto levee	Grassland	17
B2	Channel on older Shabeelle alluvium	Dark grey clay over dark greyish brown clay. Firm or mulched surface. Prominent subangular blocky and prismatic structure. Gypsum crystals common.	Imperfect to poor	Strong seasonal flooding	Moderate to strong (U2-U3)	≤2% on edges onto levee	Grassland	4
B3	Channel and meander core in recent Shabeelle alluvium	Very dark greyish brown clay, with fine loamy and diatomite layers. Soft to firm cultivated surface.	Imperfect to poor	Strong seasonal flooding	Slight (U1)	<5% on edges onto levee	Grassland	2
C1	Lower coverplain on subrecent Shabeelle alluvium	Dark grey to greyish brown clay; sandy patches and throughout profile; strongly calcareous; prismatic subsurface structure; mulched surface.	Moderate	Slight seasonal flooding	Slight to moderate (U1-U2)	<1%	Mixed bushland	54
C2	Lower coverplain on subrecent Shabeelle alluvium	Dark grey to greyish brown clay; sandy particles and throughout profile; strong calcareous; prismatic subsurface structure; mulched surface; gypsum crystals common.	Moderate	Slight seasonal flooding	Slight to moderate (U1-U2)	<1%	Mixed bushland	33
D1	Upper coverplain	Dark yellowish brown to dark brown clay to very fine sandy clay. Firm surface, with slight sandy smear. Slickenslide in subsoil. Slightly gypseous and saline subsoil.	Well	Good - usually rapid after rain	None (UO)	≤1%	Bushland	36
D2	Upper coverplain and levee on old Shabeelle-Webi Goof alluvium	Brown clay loam to clay; strongly calcareous; saline and alkaline. Subsoil, but also gypseous; weak vertic properties. Firm, smooth surface.	Well	Good - usually rapid after rain	None (UO)	≤1%	Bushland	13
D3	Levee on subrecent alluvium along Webi Goof	Dark brown loamy sand to sandy loam over dark greyish brown clay to sandy loam; strongly calcareous; stratified profile; soft surface.	Somewhat excessive	Very good	None (UO)	2-5%	Woodland	2
D4	Upper coverplain and levee on sub-recent alluvium of Webi Shabeelle	Dark greyish brown clay loam over brown clay; strongly calcerous; moist saline subsoil. Maybe alkaline but gypsum common. Fine smooth surface.	Moderate to well	Good - usually rapid after rain	None (UO)	≤1%	Woodland	6
E	Sand terrace on old aeolian alluvial complex	Very dark greyish brown to strong brown sand loam over dark brown to dark redish brown fine sandy clay and fine sandy clay loam. Firm or soft surface with sandy smear; $CaCO_3$ concretionary subsoil but non calcareous topsoil.	Somewhat excessive	Very good	None (UO)	<1%	Wooded bushland	9
F	Permanent swamp on recent Shabeelle alluvium	Dark greyish brown clay; organic rich topsoil. Sometimes peaty; over moist massive clay with soft $CaCO_3$ concretions.	Very poor to poor	Permanently flooded	None (UO)	<1%	Swamp vegetation	7
							Total	339

TABLE 4.5

Area Measurements of Soil Mapping Units

Soil mapping unit	Hectares	% of area
A1	5 830	36.4
A2	540	3.4
A3	672	4.2
B1	420	2.6
B2	45	0.3
B3	154	1.0
C1	2 320	14.5
C2	1 995	12.5
D1	1 335	8.3
D2	810	5.1
D3	33	0.2
D4	245	1.5
E	103	0.6
F	253	1.6
A1-2 Complex	554	3.5
B1-2 Complex	420	2.6
Settlements	271	1.7
TOTAL	16 000 ha	100%

4.4.3 Mapping Unit A2

These soils are almost identical to the A1 soils, but have been distinguished because of appreciable gypsum in the subsoil. The soils also share some subsoil mottling. Gypsum first appears generally below 50 and 80 cm and although the gypsum content was not analysed it is estimated at less than 10%. These soils occupy slightly lower areas than adjacent A1 soils and this may account for the gypsum crystallisation and slightly higher salinity. Otherwise the chemical properties of A1 and A2 are similar. The soils have been mapped in the extreme east of the area on old alluvium of a former Shabeelle course and elsewhere adjacent to A1 soils.

4.4.4 Mapping Unit A3

The A3 soils occur on recent alluvium of the Shabeelle. They are deep clay vertisols, with mottled subsoils. Only limited chemical data, from field EC determinations is available. These show a steady increase of salinity with depth due to the effects of a fairly shallow water table, seasonal flooding along the Webi Goof swamp and slow permeability in the clay profile. Gypsum is common throughout the profile and may first appear within 15 cm of the surface.

4.4.5 Mapping Unit B1

Soils on old channels without gypsum have been mapped as B1 unit. They are clayey throughout and analysis for Profile A12 shows over 60% clay in the subsoil, reflecting the quieter sedimentation conditions that would have prevailed in the channels, compared to adjacent coverplains. Some of the examined profiles contain stratified sand deposits, thought to be associated with recent floods. This suggests that the mid-1960 (and other) flooding utilised the old channels as pathways for floodwaters. The analysed profile is low in salinity and alkalinity, reflecting seasonal flooding by rainwaters and subsequent slow leaching of salts down the profile. Seasonal flooding is common and the soils remain wet for a longer time than adjacent coverplains. The CEC/clay of the soils is fairly high and indicates a mixed clay mined assemblage dominated by montmorillonite. Essential plant nutrients are all very low, and of the micronutrients zinc is low in the topsoil but adequate in subsoil; iron, copper and manganese are adequate.

4.4.6 Mapping Unit B2

These soils are similar to the B1 soils, and have been distinguished soley on the basis of gypsum in the subsoil, which in all cases was below 80 cms. No chemical data is available for this soil unfortunately, but a slightly higher salinity can be expected on the basis of the gypsum presence. This soil has been mapped by itself and as a complex with B1 soils it is regarded as a phase of B1 soils.

4.4.7 Mapping Unit B3

The B3 soil has been mapped in the most recent channels of the Webi Shabeelle. These included an old meander core near Xawaala Buuley, where layers of diatomite occurs in the clay profile. Another profile displays stratified layers of clay and clay loam, indicating that pedogenesis is slight. Salinity increases in the subsoil. The major limitation to these soils is their liability to seasonal flooding and higher water tables probably result in some capillary rise of salts into root zones.

4.4.8 Mapping Unit C1

This mapping unit occurs on coverplain soils adjacent to the Webi Shabelle, and has also been mapped in the eastern part of the area adjacent to an old river channel. The soils of this unit are dark grey to greyish brown clayey vertisols, with an appreciable sand content throughout the profile. The surface horizon may be a clay, clay loam, sandy clay or sandy clay with a soft often deep surface mulch, common intact freshwater shells and shell fragments. In the subsoil the texture is a clay or sandy clay and there may be strong brown mottles. The subsurface colours of soil are pale and often very varied, but the surface is locally dark and higher in organic matter than other coverplain soils, reflecting a recent swampy inundation adjacent to the Webi Shabelle. Mottling in the subsoil is common and its presence is further evidence for recent inundation. The C1 soils mapped in the eastern part of the study area have similar textured profiles but are probably older. A characteristic of the C1 (and C2) soils is the common presence of undistrubed lenses of pale fine sandy loam or loamy fine sand, that occupies pockets in the subsoil, at the base of old cracks or within structural peds. Their origin has been discussed in Section 4.3.4.

Despite the presence of sand particles and sandy lenses, the vertisolic nature of the soil is unchanged with slickenslides in the massive deep subsoils, passing off into a prismatically structural subsoil and crumb surface mulch.

Chemical data is available from two profiles. The soils are slightly saline and have no alkalinity. Organic carbon is high in one of the surface horizons as noted earlier, but essential nutrients are essentially all low. High Ca:Mg ratios in the topsoils are caused by high exchangeable calcium and this could induce Mg deficiency in crops. All micronutrients are low and deficient values occur for zinc. The CEC clay indicates that the soils are dominated by expanding lattice clays, probably montmorillonite.

4.4.9 Mapping Unit C2

The C2 soils are very similar to the C1 soils. They have been distinguished on the presence of gypsum in the subsoil. The analysis also show slightly higher salinity in subsoil of C2 soils than in the C1 soils, but the field relations of C1 and C2 remain poorly understood. Although there is a significant rise in the ESP of the subsoils in one of the profiles this horizon also contains considerable gypsum, probably up to 15%, which diminishes the hazard to alkalinity considerably. Essential plant nutrient are all low and available micronutrients are present in similar proportions to the C1 soils.

4.4.10 Mapping Unit D1

Soils of mapping unit D1 have formed on levees and upper coverplains next to old channels. There is little relief except on the channel edge, and textures are predominantly fine. The surface is smooth, and firm, and sinkholes are rare. Gilgai only occur rarely. The surface horizon is a dark yellowish brown to brown soft clay loam to sandy clay loam, and this passes down into angular blocky dark yellowish brown clay, sandy clay or sandy clay loam. $CaCO_3$ concretions are common throughout and below 60 cm gypsum may appear. Analysis from the sampled pit (PM10) shows that these soils have the highest silt content in the study area, but amounting only to 25%. The surface horizon is likely to be droughty and a tendency to cap after rainfall results in high runoff. Salinity and alkalinity increase with depth, but the very high ESP in the deep subsoil is offset by moderate amount of gypsum in the profile. The CEC clay suggests that the surface horizon has a non-montmorillonite clay mineral, probably vermiculite. There are some slickenslides in the subsoil, but most field evidence points to a profile that is not dominated by montmorillonitic swelling clays. Essential plant nutrients are low and similar to earlier described profiles.

4.4.11 Mapping Unit D2

These soils have been mapped in the east of the study area adjacent to an old river channel, and they represent a complex of soils on old levees and upper coverplains (broader plains than the levees). The levee soils are dry throughout, but on the broader areas of the upper coverplains there may be moist conditions below 25 cm but generally below 50 cm. In both soils the profile is similar, with a smooth firm surface, devoid of gilgai and with only a few rare sinkholes. Concretions form a slight smear on the surface and have probably been winnowed from loose topsoil. The topsoil is a brown clay loam or sandy clay loam passing down into a weakly vertic structured brown to dark yellowish brown clay subsoil.

Excavated pits in the broader upper coverplain soils show saline efflorescences, and this is supported by field and laboratory analyses. The soils have high ECs close to the surface, and this is maintained for several metres depth. The water table was not found, but it is likely that it is associated with the old channel and that capillary rise has brought up salts. Another feature of this soil is its very high alkalinity indicated by the ESP. Again gypsum is present in the subsoil, but since the alkalinity is high close to the surface these soils have an overall high sodium hazard.

4.4.12 Mapping Unit D3

The D3 soil is mapped locally along the Webi Goof channel, where there is a prominent levee. This is a complex of soils with widely varying textures, but with a coarse horizon prominent in a large part of the profile which makes the soil droughty at the surface, or gives a limited rooting depth. In a more detailed survey it would probably be possible to map out D2 and D3 soils in greater detail.

4.4.13 Mapping Unit D4

These soils have formed an upper coverplain and levees of the most recent abandoned Shabeelle course. They are very similar to D1 and D2 soils. They have moist soil close to the surface, saline efflorescences on cut faces, and high salinity close to the surface. They are also likely to be highly alkaline. Gypsum is, however, common in the subsoil in a soft form which suggests it is crystallising at the present time.

4.4.14 Mapping Unit E

Soils of this mapping unit are confined to one area 7 km south of Sablaale. Formed on old aeolian sand dunes with some later alluvial deposition, the soils have a firm to soft surface, often with a sandy smar. The topsoil is a heavy loam to fine sandy clay loam, and passes down into fine sandy clay loam and fine sandy clay. Profiles may be non-calcareous or strongly calcareous, but in the deep subsoil there is a concretionary layer of $CaCO_3$, composed of 2 to 4 mm sized concretions in a clayey matrix. Salinity and alkalinity are low throughout the profile, indicating that the soils are well leached. The sandy topsoil is likely to be droughty soon after rain, but the heavier textured subsoil has a moderate water holding capacity. Essential plant nutirents are low in the analysed profile, notably for phosphorous.

4.4.15 Mapping Unit F

This is a complex of permanently wet soils mapped along the Webi Goof swamp. A surface peaty or organic rich layer may be present in wet and well vegetated sites. Elsewhere there is dark greyish brown clay at the surface, with subsurface firm mottled clay and soft calcium carbonate concretions. There is little evidence of gypsum, but it may be present in an amosphous form. Salinity in the area field sample shows a moderate level at the surface, which is not unexpected in these clays with very low permeability and poor drainage.

4.5 Soil Classification

The soils of the study area have been classified according to the FAO and USDA systems. These are shown in Table 4.6. This is provisional and final classification for some of the soils cannot be realised with the present amount of analytical data.

4.6 Soil Moisture Relations

4.6.1 Introduction

The success or failure of rainfed farming in Somalia is primarily dependent on rainfall. The World Bank (1984) has stressed that crop failures are likely unless moisture conservation by fallowing and timeliness of field operations, as well as opportunistic planting are carried out. In this section soil moisture conservation and results of soil moisture retention analytical work are discussed.

4.6.2 Soil Moisture Conservation

The practice of soil moisture conservation by fallowing has been carried out in the mid-west of the United States of America and Australia for over a hundred years (Russel and Greacen 1977). This experience has been recognised as very important and central to the success of semi-mechanised rainfed agriculture in Somalia (World Bank 1984).

TABLE 4.6

Soil Classification - FAO and USDA Systems

Soil mapping unit	FAO	USDA (Soil taxonomy)
A1, A2, A3, B1, B2 C1, C2	Chromic Vertisol	Entic Chromustert
C1	Pellic Vertisol	Typic Pellustert
B3	Vertic Cambisol Chromic Vertisol	Vertic Ustropept Entic Chromustert
D1	Vertic Cambisol	Vertic Ustropept
D2	Calcic Cambisol Vertic Cambisol	Typic Ustropept Vertic Ustropept
D3	Calcaric Fluvisol	Typic Ustifluvent
D4	Vertic Cambisol Calcic Cambisol	Vertic Ustropept Typic Ustropept
E	Calcic Luvisol	Typic Haplustalf
F	Gleyic Fluvisol Chromic Vertisol	Typic Fluvaquent Vertic Fluvaquent

FAO: 1974
USDA: 1975

Note: Soils in the area have an ustic soil moisture regime (with the exception of mapping unit F). They also have a warmer ISO soil temperature regime, where the annual range is less than 5°C.

Elsewhere in Africa, however, there is a limited tradition of fallowing for moisture conservation, though it has increasingly become disused due to pressure on land use. In northern Ethiopia fallowing is carried out on certain soils to maintain moisture and also improve fertility. A common problem is the tendency of many soils (clayey to sandy) to form surface crusts and caps through action of high intensity rainfall, leading to slow infiltration and rapid runoff. Precultivation before rainfall so as to prepare the soil surface for maximum rainfall acceptance was recommended by HTS (1976), and Virgo and Munro (1977). The Farjano analogy is on the upper coverplain soils (D1, D2, D4) which have a capping tendency. It is likely that improved land preparation in some form would greatly increase the fallowing efficiency, which at present must be less than 10% due to runoff and evaporation. This land preparation has to be carefully balanced against soil pulverisation and risk of wind erosion.

On clay vertisol soils the opening of cracks is important to rapid refilling of soil moisture reservoirs in the profile. Results from Tigrai, Ethiopia, showed that if surface mulches fell into cracks, through the trampling action of livestock, then the soil cracks sealed up much faster than if they were left open. In the Farjano area it is thus important to keep cracks open through the last cropping season, and following dry season, until replenishment commences with the next wet season. This may be very difficult to achieve due to livestock browsing of crop residues and weeds.

The importance of soil moisture conservation was initially not truly recognised in East Africa. Pereira et al. (1958) considered that although considerable moisture gains could be gained from moisture conservation fallowing in Kenya, particularly in the 30 to 60 cm and 150 to 180 cm depths, the bare fallow was inappropriate to East Africa because of the high erosion risks in the long dry season. They suggested a quick growing annual grass to reduce erosion. This could be a useful idea for the Farjano area, as long as a shallow rooted grass was chosen, so that deeper moisture levels were untouched.

More recently in Kenya, Whiteman (1984) has shown that on 90% of the occasions when a crop failure occurred, a bare fallow in the preceding fallow would have allowed adequate subsistence yields to have been achieved. In Botswana, Whiteman (1975) similarly showed that substantial moisture reserves could be accumulated on sandy soils if a bare fallow was maintained.

In the Farjano area the outlook for moisture conservation is hopeful, provided that the basic rules are followed, in maximising surface infiltration, preventing crusting, and reducing mechanical disturbance of topsoils by vehicles or livestock.

4.6.3 Analytical and Field Data

In the Farjano study area intact soil cores were taken from principal horizons of representative soils. In view of the extremely dry state of the soils it was necessary to pre-wet the profiles, and allow them to drain for some two days, so as to reach an approximate state of field capacity. Results of field soil moisture investigations on C1 soils are given in Table 4.7. The soil moisture characteristics will be submited later when they become available.

The available water capacity (AWC) is defined as the proportion of soil water available to sustain plant life and is taken as the difference between suctions at 0.1 and 15 bars. The easily available water capacity (EAWC), taken as the difference between 0.1 and 1.0 bars, is important in assessing available water for vertisols, due to the unequal availability of water at higher suctions. The water held between 0.0 and 0.1 bar, the aeration porosity is also considered to be important for assessing available water capacities in Somali vertisols (HTS 1978, 1979). This water may not be easily available, however, due to anaerobic effects on plant roots in pores.

Results from previous studies on the Lower Shabeelle floodplain (HTS 1979) showed that most of the water in vertisols is held in the less available AWC range (1 to 15 bars). The EAWC accounts for less of the total AWC in the vertisols than on levee and upper coverplain soils.

TABLE 4.7

Soil Moisture Characteristics 12th/13th February 1985

Soil site	Soil unit	Land use	% soil moisture (weight/weight) at depth 5-10 (cm)	25-30 (cm)	50-55 (cm)	80-85 (cm)	Comments
PM 36	C1	Cowpeas in der 1984	9.5	15.7	18.6	20.4	Crop was total failure, yet moisture remains in subsoil. Moisture stress greatest in January/February.
PM 37	C1	Weed free fallow since end of gu 1984	12.7	18.6	18.8	19.3	Suggests that profile received considerable water in der 1984.
PM 25	C1	Dense acacia thicket (B3-d) bare surface	8.7	15.1	15.8	15.5	Shows that tree roots utilising moisture throughout profile.
PM 4	C1	Cleared land (R5)	10.0	14.0	14.8	20.9	Surface horizons depleted of water by grasses and herbs, but considerable moisture at depth.
M 283	C1	Fallow since end of gu 1984	8.3	18.8	19.9	20.7	Surface horizon dry from evaporation, and poor weeding was noticeable. Good storage below. Has received der 1984 rainfall totalling 113 mm. Equivalent to 25 mm at 25% fallow efficiency.
M 292	C1	Weed free fallow since end of gu 1984	10.1	15.2	19.5	20.3	Shows similar storage to M 283, but has received total rainfall approximately 723 mm since fallow started. Equivalent to 180 mm at 25% fallow efficiency.

Note: Sample taken in field and immediately weighed, then air dried for 4 hours and oven dried for 4 hours. Overnight oven drying was impractical.

CHAPTER 5

LAND SUITABILITY

5.1 Introduction

Land suitability evaluation has been carried out primarily with the aim of selecting land for semi-mechanised rainfed agriculture. Additional requirements have been to assess the land for human settlements small scale irrigation along the Webi Goof and forestry. These are covered in the succeeding sections and are accompanied by tables giving suitability ratings and results. Land suitability mapping for rainfed agriculture and human settlements are given on Drawing 4. Results for smalll scale irrigation and forestry are given in the text only.

The land suitability evaluation follows the guidelines laid down by FAO (1976, 1984). Previous surveys in Somalia have used the USDA suitability classification. Results from these studies have been matched to the more universally adopted FAO system.

In the evaluation, land units, represented by the soil mapping units, have been critically assessed as to their overall suitability for a given use. This is carried out by measuring soil characteristics, important in the proposed land use, against a series of ratings. In the FAO system there are suitable and non-suitable orders, and these are subdivided into Suitability Classes. There are three suitable classes, and two non-suitable classes. In addition a suitability phase, conditionaly suitable, can be used where improvement is likely to result in upgrading from non-suitable to suitable. The full definitions are given in Table 5.1.

5.2 Semi-mechanised Rainfed Agriculture

Guidelines for rainfed agriculture have been adopted for the Farjano Settlement Project from earlier studies carried out in Somalia. (HTS 1977[1], 1977[2], 1982) and from characteristics important in the area, and for rainfed farming. These are discussed in the following section and summarised in Table 5.2.

5.2.1 Soil Textures(s) and Available Water Capacity (m)

The particle size distribution of sand, silt and clay in the soil is the first and most important factor in the evaluation. With the exception of rainfall, all other suitability sub-class factors depend primarily on this relationship. For rainfed agriculture, the ability of the soil to receive and store moisture in the rooting zone depends on the nature of the surface horizons. Sandy soils readily accept water but lose it equally fast, soils with a high clay content can store considerable water but a certain proportion is held at high moisture tensions. The optimum textures for storage are loams to friable clays.

In the study area however the upper coveplain soils (D1, D2, D4) have a tendency to cap, probably because of high $CaCO_3$ content, since silt contents are low. This reduces evaporation of soil moisture, and probably prevents accumulation of salts at the surface in the saline members of the upper coverplain soils (D2, D4). In the vertisols however there is an extensive network of cracks in the

TABLE 5.1

Definitions of Land Suitability Classes

	Definition	Farjano study area
Suitability order		
order S, suitable	Land on which sustained use of the kind under consideration is expected to yield benefits which justify the inputs, without unacceptable risk of damage to land resources.	
Suitability class		
class S1, highly suitable	Land having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level.	Not found in study area
class S2, moderately suitable	Land having limitations which in aggregate are moderately severe for sustained application of a given use: the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use, although still attractive, will be appreciably inferior to that expected on class S1 land.	Present
class S3, marginally suitable	Land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits, or increase required inputs, this expenditure will be only marginally justified.	Present
Phase		
Sc conditionally suitable	Land which if certain conditions are met is given a suitable class, but which otherwise is unsuitable. In this study it is used to show class of soils assuming higher rainfall.	Present

TABLE 5.1 (cont.)

	Definition	Farjano study area
Suitability order		
order N, not suitable	Land which has qualities that preclude sustained use of the kind under consideration.	Present
Suitability class		
class N1, currently not suitable	Land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at currently acceptable cost; the limitations are so severe as to preclude successful sustained use of the land in the given manner. In this study delineates the lower rainfall area, where more data is required.	Present
class N2, permanently not suitable	Land having limitations which appear so severe as to preclude any possibilities of successful sustained use of the land in the given manner.	Present
NR, not relevant	Land which has not been assessed for a given use, because the application of the use to that area is precluded by the initial assumptions of the evaluation.	Settlement sites

Source: FAO 1976.

TABLE 5.2

Land Suitability Criteria for Semi-mechanised Rainfed Agriculture

Adapted for Farjano Settlement Project

Subclass factor and symbol	Suitability class S1 Highly suitable	S2 Moderately	S3 Marginally	N2 Permanently not suitable
Soil Texture (s) In top metre	Loam to friable clay	Permeable clay to clay loam	Slowly permeable clay to sandy clay loam	Sand to sandy loam
Salinity				
0-50 cm (z)	0 - 1.9	2 - 3.9	4 - 7.9	>8
50-100 cm (z)	0 - 1.9	2 - 7.9	2 - 7.9	>8
100-150 cm (z)	0 - 3.9	4 - 7.9	8 - 16	>16
Alkalinity ESP				
0-50 cm (x)	0 - 12	0 - 12	12 - 17	>17
50-100 cm (x)	0 - 12	11 - 17	17 - 35	>35
100-150 cm (x)	0 - 17	17 - 35	>35	>35
Soil Drainage (d)	Moderate to well	Moderate to imperfect	Moderately poor or somewhat excessive	Very poor or excessive
Erosion hazard (e)	None	Slight	Moderate	Severe
Flooding hazard (f)	None	Slight	Strong seasonal	Permanently flooded
Available water capacity (m)	High	Moderate	Low	Poor
Surface conditions (g)	Soft deep mulch	Slightly firm surface; shallow mulch	Firm surface	Very hard crust
Rainfall (mm) (r)	>550	500 - 550	400 - 500	<400

Note: Rainfall class limits based on HTS (1977).

subsoil, and the spatial area of these features exceed that of the ground surface. For a surface area 10 x 10 m it is estimated that the sub-surface area of cracks may amount to 600 m^2, and this constitutes a large surface for evaporation. The surface mulch will slow down evaporation to some degree in these clays but an open system of cracks would permit rapid drying of the edges of the prismatic columns and moisture would remain in the centre of the prisms. Under rainfed conditions this may happen due to the slow development of the mulch. Balancing these evaporative losses is the enormous capacity of the cracking system to receive rainfall and thus recharge soil moisture. Sub-surface cracks extend for at least several metres in some of the coverplain clays and once recharged by rainfall and maintained by carefully managed moisture conservation fallowing techniques, these soils have good potential for rainfed cropping.

5.2.2 Salinity (z)

Salinity in the soils is an important factor in the evaluation, since if it exists naturally in significant amounts then rainfall is unlikely to reduce it by leaching. Where lands have been irrigated salinity has risen as can be seen at the Sablaale and Farjano irrigated farms. If these farms were to be returned to rainfed agriculture, a serious reclamation problem would exist.

Salinity levels have been taken from the Inter Riverine Study (HTS 1978), slightly modified for the Farjano area. They represent average values above which crops will suffer large yield reductions. Many crops however have great tolerances where yield reduction is less. Table 5.3 shows range of tolerances of crops presently grown in the Shabeelle area and yield decreases. Both the ECe saturation extract of soil, and the ECw of irrigation water are shown since the latter is discussed in later sections.

TABLE 5.3

Crop Tolerances to Salinity of ECe and ECw

Crop	0%		10%		25%		50%		Maximum
	ECe	ECw	ECe	ECw	ECe	ECw	ECe	ECw	ECe
Cotton	7.7	5.1	9.6	6.4	13	8.4	17	12	27
Safflower	5.3	3.5	6.2	4.1	7.6	5.0	9.9	6.6	14.5
Sorghum	4.0	2.7	5.1	3.4	7.2	4.8	11	7.2	18
Maize	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10
Cowpeas	1.3	0.9	2.0	1.3	3.1	2.1	4.9	3.2	8.5

Note: Readings in mmho/cm.

Source: Water Quality for Agriculture FAO Irrigation and Drainage Paper 29, 1976.

5.2.3 Alkalinity (x)

Alkalinity has been assessed by calculating the exchange sodium percentage (ESP) in the exchange complex. Suitability ratings are modified from the Inter Riverine study. The presence of gypsum has not been taken into account for these classes, but soils with very high sodium and ESP values represent a very significant hazard to crop growth even though gypsum is present. Besides, in some soils the ESP is high in horizons where no gypsum was reported. The presence of a high ESP poses a threat to nutrient uptake, since the sodium ion blocks the entry of other ions. It also causes destabilising of soil structure. The tendency for the upper coverplain soils (D1, D2, D4) to form smooth surface pans is considered to be more likely due to fine free carbonate ($CaCO_3$) than the effect of sodium. Some of the soils, however, have been downgraded due to their high sodium content.

5.2.4 Soil Drainage (d)

The slow drainage properties of the clay soils in the coverplains and old channels can result in waterlogging conditions in the root zone, and also limit the time during which mechanised equipment can carry out essential work on the farm. It is a moderate problem on the coverplains, and a serious one in the channels. There is little that can be done against this, except to control flooding in the channels (see below). Timeliness of field operations becomes essential and crucial with the clay soils which may change from an impassable to a very dry state in a short time.

5.2.5 Erosion (e)

Erosion by water is not seen as a serious problem in the study area. The area is protected from river flooding by the flood bund along the Shabeelle. Some erosion of levee soils into channel takes place, but the tendency of the levee-upper coverplain soils to form surface caps reduces erosion.

Wind erosion is potentially more serious. Although all the study area soils are wind stable naturally, under mechanisation there is a much greater risk of deflation commencing. The pulverisation of topsoils by discs forms soil particles smaller than the wind stable mulches on the clays, but this is reduced by minimal use of offset-discs and the natural tendency for structural units to reform after wetting. On the more loamy upper coverplain soils any ploughing activities pulverise soil structure and these soils have the greater risk to subsequent wind erosion. Accordingly these soils have been downgraded because of this factor.

5.2.6 Flooding (f)

The risk of flooding depends on the geomorphic setting of the soil. Flooding of land under rainfed agriculture leads to crop losses. Of the crops presently grown in the area only sorghum has a high tolerance to waterlogging greater than a few days.

Permanently flooded areas along the Webi Goof and Shabeelle are not suitable for rainfed cultivation, and since their reclamation is likely to affect other development and climatic aspects they have been rejected as permanently unsuitable.

Seasonal flooding of old channels and meanders can result from rainfall accumulation or flood waters entering depressional areas from outside. The former is going to give serious problems in most wet years and they are given a low suitability for rainfed cropping. Counter-measures are cross-channel bunds to restrict movement of flooding and encourage deep percolation. To protect the land from external flooding, flood-protection bunds must be built at weak points. This type of flooding has not been considered in the evaluation, since in the absence of bunds it would be necessary to reject many of the channel depressions.

On the coverplain clay soils flooding is seasonal and usually limited to rainfall. Water flows down sinkholes in the gilgai hollows, and is an important part of the refilling of the soil moisture reservoir in the soil profile. Later the surface wets up, seals and continued rainfall results in surface flooding, detrimental to the mobility of mechanised equipment and waterlogging crops. The clay soils are given a moderate suitability because of this problem.

5.2.7 Surface Conditions (g)

This factor is closely linked to the susceptibility of the soil to erosion discussed earlier. The nature of the surface is also important to rapid reception of rainfall and its usefulness as a seed bed. The surface mulch of the coverplain clay soils offers a fine natural surface mulch that is a good seed bed and a very rapid absorber of rainfall. It might be thought that because of the natural mulch it is unnecessary to cultivate the land at all and weeding carrried out by herbicides would reduce the need for any mechanised disturbance that increases soil moisture loss. However, the mulch does not appear to form so rapidly as in one season. Observations to suggest this were made during the study on lands that have had rainfall recently and not for a long time. A generalised conclusion is that the mulch develops as a factor of time, but an inadequate knowledge of recent rainfall distribution makes this tentative. Disturbance of the ground by livestock, baboons and warthog may also play an important role in mulching. Trampling by livestock and wildlife causes surface mulches to form, filling cracks, and thus reducing rainfall infiltration.

On the upper coverplain soils with their tendency to surface capping, if these lands are cultivated then mechanical disruption is probably important to prepare a seed bed. Capping however is effective in reducing evaporation from the soil subsurface, whereas the subsurface cracks of the vertisols are likely to increase evaporation.

5.2.8 Results of Land Suitability Evaluation

Using the criteria given in Table 5.2 and discussed above, soil mapping units were critically assessed to give an overall and suitability class. These are shown in Table 5.4. Application of these classes to the soil map produced a land suitability map. Areas are also given in Table 5.5. In areas of lower rainfall an eastern boundary has been adopted, beyond which rainfall is considered to be less than 400 mm. It must be emphasised that this boundary is tentative: it may lie well to the west of where it is actually shown. We recommend that, until an effective network of raingauges is established throughout the study area, a north east-south west boundary shown by Trace line number 8 (that starts at the Sablaale check point), is taken to be the eastern limit of development.

5.3 Land Suitability for Settlements

5.3.1 Introduction

In assessing the suitability of the land units for future settlement location a number of important considerations have been investigated. These include especially soil, hydrologic, hydrogeologic, vegetation resources and environmental factors.

TABLE 5.4

Land Suitability Characteristics of Mapping Units for Rainfed Agriculture

Mapping Unit	Class levels of deficiencies								Final suitability class
	s	z	x	d	e	f	m	g	
A1	S2	S1	S1	S1	S1	S2	S2	S2	S2 mg
A2	S2	S2	S1	S1	S1	S2	S2	S1	S2 mzf
A3	S1	S3	S1	S1	S3	S1	S2	S2	S3 dfz
B1	S3	S1	S1	S2	S1	S3	S2	S1	S3 f
B2	S3	S1	S1	S2	S3	S2	S2	S1	S3 f
B3	S2	S2	S1	S2	S1	S3	S2	S1	S3 f
C1	S2	S1	S1	S1	S1	S2	S2	S2	S2 mf
C2	S2	S2	S1	S1	S1	S2	S2	S1	S2 mzf
D1	S1	S2	S32	S1	S3	S1	S2/1	S3	S3 gxe
D2	S1	N2	N2	S1	S3	S1	S2/1	S3	N2 zx
D3	N2	S1	S1	S1	S3	S1	N2	S1	N2 sm
D4	S1	N2	S3	S2	S3	S1	S1	S3	N2 z
E	N2	S1	S1	S1	S3	S1	N2	S2	N2 ms
F	S1	S1	S1	N2	S1	N2	S2	N2	N2 df

Note:
(1) Rainfall excluded in this table.
(2) For explanation of symbols see Tables 5.1 and 5.2.
(3) To reduce symbols on the land suitability map, subclass for soil texture (s) is not included. In no case does the rating depend solely on this factor.

TABLE 5.5

Areas of Land Suitability for Rainfed Agriculture

Class		Area (ha)	% total area
S2 mf		6 066	37.9
S2 mzf		2 015	12.6
S3 f		819	5.1
S3 dfz		672	4.2
S3 mzf		554	3.5
S3 gxe		1 335	8.3
Sub-total		11 461	71.6
N1r - Sc2 mf		1 546	9.6
N1r - Sc2 mzf		1 058	6.7
N1r - Sc3 f		220	1.4
Sub-total		2 824	17.7
N2 z		245	1.5
N2 ms		103	0.6
N2 df		253	1.6
N2 smr		33	0.2
N2 zxr		810	5.1
Sub-total		1 444	9.0
Settlements	Sub-total	271	1.7
GRAND TOTAL		16 000 ha	100%

Using the FAO guidleines on land evaluation (FAO, 1976) these factors have been applied against each and land unit to give a suitability rating for a particular mapping unit. The factors are discussed below. These and additional minor factors are given in Table 5.6. Land suitability classes of land units are given in Table 5.7, the minor factors have not been used in this rating. Areas are given in Table 5.8.

5.3.2 Major Factors

Experience in many parts of the lower Shabeelle and Juba valleys has shown that where houses are built on cracking clays, foundations and walls have to be very strongly designed to withstand or avoid seasonal movement of the clays. In Sablaale, huts, houses and administrative buildings are built largely on lower coverplain (C1/C2) cracking clays and analysis shows that these are likely to contain a high proportion of the expanding lattice clay mineral montmorillonite.

Soil replacement with suitable non swelling soils to a depth of some 2.5 m below buildings has been found to be a successful method in the Mogambo Project (Juba valley) for the building of houses etc. in areas with swelling clay soils.

This is borne out by the presence of cracks in concrete blockwork structures only a few years old, and while the mud built traditional style dwellings are better adapted to movement, they too begin to collapse irreparably after some 10 years.

At Sablaale Yaarey the new houses built of concrete block and mortar are only a few years old but an examination showed that almost every house had some crack that had been repaired. Despite its geomorphic position on the edge of the old channel of Far Marjaan, the soils of Sablaale Yaarey are clayey and must have a substantial montmorillonite content. Greater damage may be likely in the long term. Latrines on these soils are unlikely to be suitable in the rainy seasons.

For long term stability of huts and villages a non-cracking clay is thought to be most desirable. Fortunately there are such soils in the study area which have these properties, and include the loamy and clayey upper coverplain D1, D2, D4 soils. They are often the location of existing settlements. These silts have weak vertic subsoils, a smooth firm surface and rare or no sinkholes. Under irrigation some movement is likely, and wastage from domestic water supply could result in movement also. As a result these soils mostly have an S2 suitability for settlements. Sablaale Yaarey may be partly built on these soils, but a detailed investigation was not carried out there.

The D2 and D4 upper coverplain soils with high salinity close to the surface are further downgraded to S3 because of the danger of salts rising upwards by capillary movement into foundations, and damaging or weakening structures. Domestic water usage in latrines and vegetable gardens could enhance this effect, and surface drains may be important if it is decided to develop infrastructure on these soils.

The soils of the sandy terrace landform (soil unit E) have fine and coarse loamy topsoils and a clayey subsoil. The surface is smooth, sandy, and devoid of sinkholes. It drains rapidly after rainfall and there is no obvious vertisolic movement of clays. There is no gilgai microrelief. There is a slight hazard from possible aeolian deflation of the sands but this is probably insignificant. These soils are considered the most suitable for settlement and are given a Class S1 suitability. It is recommended that settlements are located partly or wholly on them.

TABLE 5.6

Land Suitability Criteria for Settlement Location

	Highly suitable S1	Moderately suitable S2	Marginally suitable S3	Permanently unsuitable N2
Major Factor				
Gilgai and sinkholes (g)	None (U0)	Slight (U1)	Moderate (U2)	Severe (U3)
Properties in subsoil (V)	None	Slight	Strong	Not classified
Soil drainage (d)	Excessive	Well	Moderate to poor	Very poor
Site drainage and flooding hazard (s)	Low to nil	Slight	Moderate	Strong to permanently flooded
All weather properties for tracks (t)	Fairly good to good all year use on sandy or loamy soils	Limited dry season use only	Dry season use only	Permanently wet
Local Minor Factors				
Existing tree cover for shade	Good-common large trees 10 to 15 m	Tress and open bushland < 10 m high	Dense low bushland and shrubs	Open areas without potential for regrowth
Linear arrangement of village	Long, broad mapping units adjacent to good suitable arable land	Long, broad, mapping units some distance from suitable arable land	Narrow and/or short parcels of land	Very small parcels of land, or areas too remote from suitable arable land
Fuelwood building materials	Dense mixed bushland and woodland	Moderately dense to open mixed bushland	Open to dense secondary Acacia sp thorn bushland	No materials available
Groundwater suitability (quality and cost)	Shallow groundwater of good quality at site	Shallow groundwater of good quality near to site	Good to marginal quality from tube-well at site	Poor quality shallow or deep groundwater at site

TABLE 5.7

Land Suitability Characteristics for Small Scale Irrigation

Factor	Highly suitable S1	Moderately suitable S2	Marginally suitable S3	Not suitable N2
Texture in upper m (s)	Loam to friable clay	Sandy loam to permeable clay	Loamy sand or heavy clay	Lands which fail to meet the minimum requirements of the other classes
Infiltration (n)				
Time for 100 mm to enter	1.5 to 8.0 hours	8.0 to 20 hours	20 to 40 hours	
Soil drainage permeability (P)				
Upper 1.0 m	0.3 to 1.0 m/day	0.1 to 1.0 m/day	< 0.3 m/day	
Subsoil	0.3 to 1.0 m/day	0.1 to 0.3 m/day	< 0.10 m/day	
AWC (m)	> 120 mm per m	80 to 120 mm per m	50 to 80 mm per m	
Salinity (mmho/cm)				
0 to 50	0 to 1.9	2 to 3.9	4 to 7.9	
50 to 100	0 to 1.9	2 to 7.9	2 to 7.9	
100 to 150	0 to 3.9	4 to 7.9	8 to 1.6	
Alkalinity (X)				
ESP 0-50	0 to 12	0 to 12	12 to 17	
50-100	0 to 12	12 to 17	17 to 35	
100-150	0 to 17	17 to 35	> 35	
Flooding susceptibility (f)	None	Slight superficial flooding	Extended periods of drainage requiring surface drainage measures (and likely to require field drains)	
Topography (t) (rectifiable)	None	Weak gilgai	Strong gilgai	

Note: The criteria for infiltration, permeability and AWC are provisional, and based on experience gained on the Genale-Bulo Marerta Irrigation Project (MMP, 1984). No infiltration or oermeability data was collected to assess the Farjano soils. Estimates for infiltration and permeability were made by comparing Farjano soils with data on soils from the Genale study, and other MMP/HTS reports on Somalia.

TABLE 5.8

Land Suitability Characteristics of Mapping Units for Small Scale Irrigation

Mapping unit	Class levels of deficiencies								Provisional overall class
	s	z	x	f	t	n*	p*	m*	
A1	S3	S1	S1	S2	S2	S3	S3	S2	S3
A2	S3	S1	S1	S2	S2	S3	S3	S2	S3
A3	S1	S3	S2	S3	S1	S3	S3	S2	S3
B1	S3	S1	S1	S3	S3	S3	S3	S2	S3
B2	S3	S1	S1	S3	S3	S3	S3	S2	S3
C1	S2	S2	S1	S2	S2	S2	S2	S2	S2
C2	S2	S2	S1	S2	S2	S2	S2	S2	S2
D1	S1	S2	S2	S1	S1	S1	S1	S2	S2
D2	S1	N2	N2	S1	S1	S1	S1	S2	N2
D3	S2	S1	S1	S1	S1	S1	N2	S3	N2
D4	S1	N2	N2	S1	S1	S1	S1	S2	N2
E	S2	S1	S1	S1	S1	S1	S1	S3	S3
F	S3	S1	S1	N2	S1	N2	N2	S2	N2

Note: * Estimates based on field observations as no test data available.

The susceptibility of the coverplain soils A1, A2 and C1, C2 to flooding and waterlogging, makes these land units, respectively, moderately suitable and marginal for settlements. Access is also severely limited in the wet season. In the channel soils and areas liable to seasonal inundation along the Webi Shabeelle the limitations are such that these lands have been excluded (N2) from suitable locations for settlement. Strictly speaking the lower coverplain soils should also be rejected, but the presence of existing settlements on these soils and their maintenance throughout the year enables them to be given the lowest suitability class (S3).

5.3.3 Minor Factors

Minor factors are detailed in Table 5.6. More information is needed to assess the groundwater resources, and the present knowledge is summarised in Chapter 3.

Given that there is substantial existing woodland in the land units most suitable for settlements, it would be sensible to maintain this resource. To cut down the trees in order to provide space for house building would be wasteful, likely to increase wind erosion and evaporation, and disrupt the soil surface. We strongly advise that planning utilises existing shade cover in this way. The scope of bushland and woodland for fuelwood supplies and building materials has been discussed in Chapter 3, but a full investigation is necessary. A similar conclusion must be drawn that indiscriminate land clearing of bushland should be avoided.

The potential of the clayey soils for brickmaking and pottery has been briefly examined. Samples for patterns were tested at Brava and Sablaale under the direction of Mrs. E. Low of Euro Action Acord. Results showed that clay soils from soil mapping units E, (Site PM 8) and D1 (PM 10) gave poor results, with very friable pottery. A sample from soil D2 (Site PM 21) however gave a strong pottery. This soil is saline and alkaline, the others are not, but the reason for the differences are not clear at this stage. The clays of the coverplain soils are unsuitable because of their montmorillarite content. Soils from Site PM 8 was thought to be suited because its origin may be similar to the good quality potters clay originating from erosion of the Brava sand dunes.

5.4 Land Suitability for Small Scale Irrigation

5.4.1 Introduction

The request for investigating the suitability of lands for small scale irrigation schemes, of 1 to 2 ha along the Webi Goof, was made at a rather late stage in the land evaluation of the Farjano Settlement Project. Accordingly it has not been possible to include in the evaluation, infiltration or permeability tests, nor carry out a more comprehensive range of soil chemical tests to assess potential or existing hazards. Brief examinations were made in the SDA irrigated farm at Sablaale, and the irrigated farm at Farjano, but it was not possible to visit the rice farm at Haaway and assess its present condition.

The capability of the land to be successfully irrigated and the capacities of the rivers to irrigate sufficiently are matters often taken for granted along the Shabeelle and Juba rivers. Entrepreneurs obtain a pump, and irrigate a small or large piece of land for short term gain. The long term effects are all too noticeable however, in abandoned land, and uncontrolled usage and wastage of irrigation water leading to overall shortages. In larger schemes there is poor water usage, which has led to large rehabilitation.

The most detailed work to date has been carried out at the Jowhar Sugar Plantation in the middle Shabeelle, and this has been reported in detail by MMP (1976, 1978, 1984). The results of this work will be discussed first, since they bear considerably on existing and proposed development at Sablaale and Farjano.

5.4.2 Results from Jowhar

At Jowhar Sugar Estate, reductions in yields had been attributed to several major factors:

(i) Saline soil and irrigation water

(ii) Poor soil drainage, high water tables and waterlogging

(iii) Insufficient irrigation water

(iv) Poor management of the irrigation and drainage system.

The drainage and reclamation study carried out by MMP (1976, 1978) showed that a complexibity of problems was responsible for the decline in yields - amongst which soil, water and drainage factors were important. The effects of irrigation were to suppress soil cracking and keep the soil moist for all the year, raise water tables because of the absence of adequate drainage, and increase soluble salts in the upper soil horizons. The high salinity in abandoned fields was thought however to have happened after, rather than be the cause for, abandonment. Slow permeability and restricted pore space in the clay soils was restricting the root system of crops, and leading to waterlogging conditions. Drainage and leaching tests however showed that reclamation was possible. A leaching requirement of 10% was recommended, and the installation of buried field drains and open collector drains to dispose of leaching waters.

The 1978 study (MMP 1978) carried out trials for drainage and reclamation. The principle soil factors responsible for reducing yields were waterlogging and salinity. By installing buried field drains at 2.0 m, and 25 m spacing the water table quickly dropped from, for example, 0.25 m to 1 m below the surface; waterlogging was reduced appreciably allowing oxygen to get to roots at shallow depths; and salinity was reduced to tolerate levels specifically by leaching of the toxic chloride ion.

In the 1984 study on Jowhar a field drainage spacing of 50 m was recommended in order to maintain the watertable at 1 m. The leaching requirement was amended to 15%.

5.4.3 Evidence from Sablaale and Farjano

Soil samples were collected by GTZ (1984) from the irrigated farm at Sablaale. These show a wide range of salinities, generally over 1.5 mmho/cm in the surface horizon but locally up to 30 mmho/cm.

Higher values were experienced in abandoned fields, where the subsurface salinity reached 48 mmho/cm at 60 cm in one site. In cultivated fields subsurface EC ranged from 3 to 20 mmho and tended to be higher in rice fields.

Investigations in February 1985 in an abandoned field now heavily grassed showed low EC all within Class S1 suitability (Tables 5.9 and 5.10), and watertables were deep (2.9 m) though saline (EC 10.0 mmho/cm).

TABLE 5.9

Land Suitability Characteristics of Mapping Units for Settlements

Mapping Unit	Class levels of deficiencies g	v	d	s	f	Final suitability class
A1	S2	S3	S2	S2	S3	S3 vt
A2	S2	S3	S2	S2	S3	S3 vt
A3	S3	S3	N2	N2	S3	N2 sd
B1	S3	S3	N2	N2	S3	N2 sd
B2	S3	S3	N2	N2	S3	N2 sd
C1	S2	S3	S2	S2	S3	S3 vt
C2	S2	S3	S2	S2	S3	S3 vt
D1	S1	S2	S2	S1	S1	S2 d
D2	S1	S1	S2	S2	S1	S2 d
D3	S1	S1	S1	S1	S1	S1
D4	S1	S2	S2	S1	S2	S2 dvt
E	S1	S1	S1	S1	S1	S1
F	N2	N2	N2	N2	N2	N2 sd

Notes: (1) For explanations of symbols see Tables 5.1 and 5.5
(2) Minor subclass factors, detailed in Table 5.5 are not included in the evaluation rating.
(3) To simplify the map legend the symbol for land unit F is only given two factors.

TABLE 5.10

Areas of Land Suitability for Settlements

Class	Area (ha)	Percentage total area
S1	136	0.8
S2 d	810	5.1
S2 vtd	1 580	9.8
S3 dv	20	0.1
S3 vt	10 665	66.7
S3 dvt	554	3.5
Suitable land sub-total	13 765	86
N2 sd	1 964	12.3
Existing settlements	271	1.7
Total	16 000	100.0

Note: For explanation of symbols refer to Tables 5.1 and 5.6

In the irrigated farm water is often left on fields for a long time in excessive quantities, and no use is made of the open drains that run on the lower edge of farms. The low salinity in the abandoned field suggests that some natural leaching has occurred due to the deep nature of the watertable. Elsewhere, there appears to be high watertables and fairly high salinity in cropped fields, whereas in abandoned fields salinities have generally risen to excessive levels due to capillary rise of salts. These symptoms vary from field to field, and reflect soil differences of permeability and drainage and a large variation in the amount of irrigation water giving rise to high watertables and high salinity, and also improved drainage and salinity. It is obviously a complex problem, and illustrates what can occur given uncontrolled irrigation.

At Farjano, fairly high ECs (up to 6 mmho at 60 cm) were recorded in the fields, some of which were abandoned. The lack of a drainage system in this farm is also leading to higher watertables. Indirect evidence is given in the A3 soils mapped to the east of Farjano. These have soluble salt contents, in the form of gypsum, near the surface and ECs are high close to the surface.

These observations at Farjano and Sablaale indicate that very similar conditions exist as have been experienced at Jowhar and illustrate the risk of irrigating on clayey soils, without controlling water tables and without maintaining a sufficient leaching requirement. The suitability guidelines for small scale irrigation have been drawn up accordingly.

Soils along the Webi Goof which have been considered for irrigation especially include the A3, D1, B1, C2 and A1 mapping units. It is likely that irrigation development will be carried out immediately adjacent to the lands most suitable for settlement location.

The A3 soils, which border the Webi Goof and are seasonally flooded in many years, should be the first lands to be irrigated. It will be essential though to put in surface drains around fields, and field drains may be necessary. There is slight to moderate salinity in these soils and it will be necessary to leach salts out.

The more loamy D1 soils have a higher suitability for irrigation, and slight saline and alkaline hazards would be kept in the deep sub-soil by sufficient leaching water. The D1 soils are in slightly elevated positions and this will assist leaching, but involve a higher pumping cost.

The B1 soils which are subject to seasonal waterlogging may prove to be suited to flood irrigation. Waterlogging and rise of salts are likely to be persistent problems if measures are not taken to control them.

The A1 and C2 soils are marginally and moderately suited for irrigation respectively. Irrigation is likely to raise salinity, and it is more appropriate to retain these soils for rainfed agriculture at present.

5.5 Land Suitability for Forestry

Land evaluation for forestry aims to locate lands which will be suitable for afforestation. The afforestation is for shelter belts and to provide fuel wood and building materials from natural vegetation. No species have been investigated for their suitability in this study, but research at the Afgoi Foresters School and National Range Agency is aimed at giving practical results. Several voluntary agencies are carrying out trials at refugee camps.

Proposed guidelines, based on soil drainage, moisture availability, salinity, alkalinity, conservation measures, rooting depth of the soil, and limits to reclamation are given in Table 5.11. In Table 5.12 these factors are applied against each soil mapping unit to give an overall suitability.

If lands were to be irrigated for sustained production of forest products, at least 6.25 ha would be required to provide for each family. This figure is based on research carried out by Hughes (1984) on the Bura Irrigation Scheme on the Tara river, Kenya. Possible species identified included:

Prosopis juliflora
Eucalyptus camaldulensis
Azadirachta indica
Cassia siamea

Given the present rate of removal of bushland and woodland for domestic use, rapid replenishment is essential.

5.6 Comparison with Previous Surveys

The only previous land suitability evaluation for the area is that of the Inter Riverine Agriculture Study (HTS 1977). The study area, as has been shown earlier, was indicated to be on several soils whose actual disposition has been shown to be different due to the reconnaissance nature of the earlier FAO-Lockwood Survey of 1968.

In Table 5.13, the older FAO-Lockwood mapping units are shown, with their suitability for rainfed and irrigated cropping given by the Inter Riverine Study. The soil and land suitability classes for rainfed and irrigated agriculture are also given. It is always difficult however to correlate data from a small scale reconnaissance study to a much more detailed survey of a small area, and inevitably there will be discrepancies between the two scales of mapping.

Generally, though, the two mapping systems are comparable. If the rainfall factor is removed from the HTS Inter Riverine Study, and if the USDA classes are revised to fit the FOA system there is satisfactory accord.

TABLE 5.11

Land Suitability Classification for Forestry (Provisional)

Subclass factor	Suitability class S1	S2	S3	N2
Drainage (d)	Well	Moderate with short periods of seasonal flooding	Poor with long periods of seasonal flooding	Very poor and permanently flooded
Profile moisture (m)	Good-moist all year round	Moderate - seasonally moist	Poor - very droughty for much of year	Soil either too wet or too dry
Salinity (z)	Nil	Slight	Moderate	Severe
Alkalinity (x)	Nil	Slight	Moderate	High
Soil conservation measures required	None	Slight costs. Soil may erode by wind if unprotected	Moderate cost. Soil very sensitive to disruption and may erode	Too costly to carry out
Rooting depth (r)	Deep > 150 cm No limit	Moderate - massive clay limiting root growth. 75-150 cm	Shallow. 25-75 cm or hard pan at depth	Very shallow < 25 cm
Limits to mechanisation (t)	None	Slight, clay soils, surface pans	Moderate. Heavy clay soils	Severe - bedrock close to surface

Based on: FAO Forestry Paper 11. 1975 Savanna Afforestation in Africa.

TABLE 5.12

Land Suitability Characteristics of Mapping Units for Forestry

Mapping unit	Class levels of deficiencies Subclass symbol d	m	z	x	c	r	t	Overall class
A1	S2	S2	S2	S1	S2	S1	S2	S2
A2	S2	S2	S2	S1	S1	S2	S2	S2
A3	S2	S1	S2	S1	S2	S1	S2	S2
B1	S3	S2	S2	S1	S2	S2	S3	S3 dt
B2	S3	S2	S2	S1	S2	S2	S3	S3 dt
B3	S3	S1	S2	S1	S2	S1	S2	S3 d
C1	S2	S2	S2	S1	S2	S1	S2	S2
C2	S2	S2	S2	S1	S2	S1	S2	S2
D1	S1	S2	S2	S2	S3	S1	S2	S3 c
D2	S1	S1	N2	N2	S3	S2	S2	N2 zx
D3	S1	S2	S1	S1	S2	S1	S1	S2
D4	S1	S1	N2	N2	S3	S2	S2	N2 zx
E	S1	S3	S1	S1	S3	S3	S2	S3 mcr
F	N2	N2	S1	S1	S1	N2	S1	N2 dmr

Note: (1) For explanation of symbols refer to Tables 5.1 and 5.7.

(2) This is based on existing rainfall. If irrigation were to be used, a reassessment would be necessary but conclusions given in Table 5.8 provide a guideline.

TABLE 5.13

Correlation of Soils and Land Suitability Class with Older Surveys

Mapping unit	Land suitability Rain-fed	Land suitability Irri-gation	Approximate correlation with FAO-Lockwood soil	HTS (1977) suitability class Rainfed	HTS (1977) suitability class Irrigation
A1	S2	S3	Gofca (Gf)	III(II)	II
A2	S2	S3	Gofca (Gf)	III(II)	II
A3	S3	S3	Shabeelle slackwater	II	II
B1	S3	S3	Channel remnant (c)	I-IV variable	I-IV variable
B2	S3	S3	Channel remnant (c)	I-IV	I-IV variable
B3	S3	S3	Channel remnant (c)	I-IV	I-IV variable
C1	S2	S2	Avai (Av)	IV(III)	IV
C2	S2	S2	Avai (Av)	IV (III)	IV
D1	S3	S2	Levee associated channel remnant (c)	I-IV variable	I-IV
D2	N2	N2	Savro (Sv)	III	II
D3	N2	N2	Levee associated channel remnant (c)	I-IV variable	I-IV
D4	N2	N2	Levee associated channel remnant (c)	I-IV variable	II-IV
E	N2	S3	Calalaio (Cl)	Not suitable	Not suitable
F	N2	N2	Haharro (Ha)	III<500 mm II > 500 mm	II

Notes:

1. Calalaio soil not mapped by FAO-Lockwood in Farjano area.
2. Haharro soil is swamp soil. Present distribution limited.
3. Savro soil occurs to west of Haaway, Soil in Farjano is more saline and alkaline but otherwise similar.
4. Avai soil as mapped (Figure 4.1) covers many of soil units of this study. It is mainly similar to C1/C2 soil. Higher rainfall suitability shown in brackets.
5. Gofca soil is more widespread than mapped FAO-Lockwood (see Figure 4.1). Correlates with A1/A2 soils. Higher rainfall suitability shown in brackets.
6. Ururgala soil, a vertisol with high alkalinity in subsoil was not found. It may lie east of study area.
7. Channel remnants include channels and levees soils of different ages.
8. Shabeelle slackwater soil occurs in depressions adjacent to old levees and channels.

CHAPTER 6

SHEIKH MOHAMMED HIKAM COMMUNITY PROJECT

6.1 Introduction

In January 1985, Sir M. MacDonald & Partners (Somalia) were invited by the UNHCR Technical team to make a survey of the Sheikh Mohammed Hikam Community Project at Farjano.

6.2 Description of Irrigated Farm

The settlement known as Farjano village, is situated 12.5 km south-west of Sablaale, on the all weather road to Haaway (see Drawing Nr 13920/5). A community project initiated by Sheikh Mohammed Hikam in 1980 aimed to provide food and shelter for 130 refugee families. Dwellings were constructed with local timber and reeds, and a programme of bush clearing was undertaken to prepare land for development of an irrigated farm. By early 1983, 85 ha had been cleared and 60 ha of this was being farmed using water pumped from the river Shabeelle. By February 1985 the estimated area of land cleared had increased to 130 ha, 90 ha of which was being actively farmed.

The farm is effectively bounded on all sides by rivers, swamps and seasonally flooded channels. Initial development was limited to this 'island' of slightly higher ground between the river Shabeelle, the Haaway Swamp, Webi Goof and a flood channel on the northern boundary linking the Webi Goof to an old river course of the Shabeelle, giving a total area for potential development of about 150 ha. Due to this restriction a new project has been initiated to develop land north-east of the Farjano settlement area, between the Webi Goof and the Sablaale-Haaway road. In 1984 work was started on a new supply canal linking the new development area with an offtake on the river Shabeelle (see Project Area Layout on Drawing 13920/5). This supply canal is intended to operate as part of a flood irrigation programme when high water levels occur in the Shabeelle river.

At the beginning of December 1984, work was started to clear an area of bush 1.5 km north-east of the Farjano village. A village of 15 houses was constructed with local materials in a similar style to those at Farjano and 50 refugees were settled by the end of the month. Work was also completed at this time on the hand digging of a 6 m well, although water quality was seen to be relatively poor. Bush clearing was still in progress at the time of survey, 25 ha having been cleared by the middle of February 1985.

6.3 Survey Method

A site visit was made prior to the start of the survey and a study made of the aerial photography (NTTCP 1983). It was concluded that:

(a) A topographic survey of the farm should show ground contours at 0.25 m intervals, since the area is relatively flat.

(b) Bed levels and embankment top levels should be surveyed for primary and secondary canals.

(c) A survey of the new supply canal was required to check its capability to supply flood irrigation water to the new development area north-east of Farjano village.

The actual survey of the Community Project was carried out in early February 1985. Systematic surveying of the canal system was achieved by starting at the river and following primary, then secondary canals, measuring canal bed and embankment top levels and ground levels in fields adjacent to the canal embankments. Additional survey lines were required to gather topographical information from uncultivated areas and where canals were more than 100 m apart. Ground levels were also obtained for the area of cleared bush at the new refugee settlement north east of Farjano village. Further survey work was virtually impossible due to the density of bush and to administrative difficulties in gaining access to the area.

6.4 Supplementary Observations

6.4.1 Existing Irrigated Farm

Two pumps are used to irrigate the 90 ha of cultivated fields. Maize is the main crop, with some smaller areas devoted to the production of onions and tomatoes. The main pump raising water from the Shabeelle river is mounted on a concrete pad which has a corrugated iron roof for protection. A large concrete outlet box has been constructed to smooth flow to the main canal. A smaller pump offtakes from a point on the old Shabeelle water course and utilises backed up water from the main river channel. Successful pumping at this second location is dependent upon high water levels in the Shabeelle river. It is interesting to note that a third pumping location further upstream on this old Shabeelle water course has been abandoned due to insufficient water. This has led to a number of canals and fields in the north-west corner of the site being neglected and falling into disrepair.

Since the larger of the two pumps offtakes directly from the Shabeelle river and has a much greater pumping capacity, an ever increasing percentage of the actively farmed land depends upon this water source. Failure of the pump, shortage of diesel and/or oil and water abstraction for upstream irrigation schemes on the river Shabeelle are all factors affecting the farm's productivity.

Some areas of the farm, particularly those fields in the north-west corner of the site, suffer from saline soil conditions. The situation is aggravated here and in other parts of the farm by the fact that land is infrequently irrigated, and drainage channels have not been integrated into the irrigation scheme.

A study of the bed levels and adjacent ground levels (see Drawing Nr 13920/5) shows that many of the primary and secondary canals have bed levels well below the surrounding ground levels. This is, brought about by the method of canal construction used for a number of canals in the system where embankments have been formed using material taken from a canal trench excavation. One disadvantage of this technique is the 'dead storage' created in the canal, water which is below the surrounding ground level and therefore unavailable to irrigate the land. The Farjano Irrigated Farm suffers from the volume of dead storage in the canal system as the pumps must operate to fill this dead storage before water is available for irrigation. Given that a water level could be maintained in the river Shabeelle sufficient to meet pumping capacities, a programme of pumping and irrigation is recommended in order that the pumping costs be kept to a minimum.

It should be noted however that the method of canal construction being adopted at present is to bulldoze material from a 25 m strip either side of the canal line to form embankments, thus enclosing a canal bed at original ground level. This method is more successful at Farjano, although attention should be given to the levelling of land adjacent to these canals to avoid ponding of irrigation water. Seepage occurs through new embankments where root debris has been bulldozed from the surface soils and embankment material has not been compacted. These problems could be overcome if there were better control of materials being placed and the forming of the canal embankments to achieve better compaction and stability.

6.4.2 New Supply Canal

As described in Section 6.1, a new supply canal is under construction north-east of Farjano, with an offtake upstream of the present irrigated farm on the Shabeelle river. A survey of the location and canal features is presented on Drawing Nr 13920/5. A number of points are worth noting:

(a) A 510 m section of canal was incomplete at the time of survey, one embankment only having been constructed.

(b) The new supply canal stops at the Sablaale-Haaway road embankment. A pipe culvert will have to be constructed before the proposed system can be continued south of this road embankment.

(c) The embankment top levels along the bunded channel from the head pond to the Shabeelle river should be raised to at least the level of the existing Shabeelle river flood bund. The present scheme is likely to be breached when the river next floods.

(d) The bed level of the head pond should be raised to the original bed level of the old Shabeelle river channel, thus decreasing the possibility of collapse, should erosion of the upstream embankment occur when flood water rises in the old channel.

(e) Protection of the head pond outlet is essential to reduce the embankment erosion as water enters the main canal.

The survey has also shown that the location of this new supply canal offers a potentially good offtake point and alignment for new development areas between the Sablaale-Haaway Road and the Webi Goof north-east of the existing irrigation scheme.

CHAPTER 7

ENVIRONMENTAL IMPACT OF DEVELOPMENT

7.1 Introduction

In this section a brief environmental imput assessment is presented, which outlines major and minor changes thought likely to occur given development of the area.

The environmental impact assessment predicts environmental changes, physical and social, beneficial or deleterious, resulting from a proposed development, and indicates how potential harmful effects can be minimised or eliminated by modification to the original project design.

7.2 Farjano Study Area

Impacts on the environment resulting from an expansion of semi-mechanised rain-fed (dryland) agriculture have been assessed. The impact of other associated and proposed developments have also been examined. This assessment is entirely in tabular form, and is given in the following pages (Table 7.1).

TABLE 7.1

Environmental Impact Assessment

Factor	Possible environmental changes	Proposed remedies
A. Bush clearance	1. Wildlife will decrease	1. Large animals will move away naturally (elephants already have) if development is carried out steadily; problem of predators on livestock along Webi Goof likely to remain for some time; Importance of hippo to fisheries nutrition to be assessed.
	2. Wind erosion due to mechanical ripping of loamy soils.	2. Careful management to avoid pulverisation essential.
	3. Loss of rural energy sources for fuelwood and building materials if mechanically cleared.	3. Hand clearing in areas of suitable bushland for these sources. Coppicing possible in several species. Clearance strictly controlled in settlement areas to provide shade and shelter from winds.
	4. Loss of bush strip vegetation (due to overclearance) results in increasing wind velocities and higher ET.	4. Conservation of bushland and woodland in strips, and urgent replanting of denuded bush strips with suitable species, noted for fuelwood or windbreak properties.
B. Woodland clearance along Shabeelle-Goof rivers	1. Wet season erosion of sediment into swamps may lead to siltation of Webi Goof swamp and result in greater degree of flooding.	1. Maintain riparian woodland on levee soils D4, A3, D3 and along swamp.
	2. Possible effects on microclimate, chiefly rainfall change.	2. Effects unknown at present and best to retain floodlands.
C. Swamp reclamation reducing permanent and seasonal flooding.	1. Likely to decrease moisture supply considered to be relevant to inducing rainfall increments.	1. No changes to swamps is recommended until more data on rainfall pattern available. Reinstate climatic stations at Haaway, Modun, Brava. New stations to be set up at Sablaale Check Point, Hariyayt, Aashamooy and Farjano. Local people should be recruited.
	2. Reduces reservoir at Haaway for dry season irrigation. Loss of fisheries and wildlife.	2. No change to swamps is recommended until survey carried out to estimate irrigation water requirements at Haaway and lower Shabeelle area.
D. Irrigation along Webi Goof	1. Rise in salinity and watertables very likely, resulting in decreased yields and abandonment of lands.	1. Careful monitoring of watertables. Installation of surface drains, and field drains may be essential. Leaching requirement to be assessed.
	2. Reduction of water available for irrigation at Haaway, especially in dry season.	2. Effect unknown due to lack of knowledge of Haaway requirements.
	3. Reduction of water available for domestic use and livestock.	3. Tubewells likely to give main sources, but Webi Goof water will remain important source for Tunni pastoralists. Careful balancing of water usage essential.
	4. Over consumption likely leading to salinisation, loss of fisheries and wildlife.	4. Study water requirement in detail.

TABLE 7.1 (cont.)

Factor	Possible environmental changes	Proposed remedies
E. Irrigating land this is scheduled for rainfed agriculture	1. Likely rise of salts and water-tables will make adaption to rainfed very difficult.	1. Reclamation by leaching too costly. Best to avoid double usage. Soils already saline (D4, A3) will be seriously affected by by irrigation unless drainage is installed.
	2. Capacity of Webi Shabeelle insufficient to irrigate 7 500 ha proposed. Salinisation and abandonment likely.	2. Study capacity of Webi Shabeelle to plan for maximum irrigation possible in area. Install gauges at Sablaale and Haaway as recommended by MMP 1983.
F. Use of pesticides and herbicides	1. Long term effects likely on domestic and stock waters, and build up in soils to toxic levels possible if nondegradable chemicals used.	1. Short lived biodegradeable chemicals should continue to be used.
G. Post harvest losses	1. Invasions of pests and diseases likely to destroy surpluses unless these are correctly stored.	1. Training in crop storage techniques, perhaps using local knowledge of Tunni agro-pastoralists.
H. Environmental health	1. Pollution of surface because of inadequate sewerage.	1. Installation of adequate sewerage systems on suitable soils (D1, D2, D3, E) to allow soakaway. Clay coverplain soils have poor properties for this.
	2. Pollution of groundwaters by sewage.	2. Study shallow aquifer system to design best location for sewage disposal in relation to tubewells.
	3. Spread of bilharzia in Webi Goof and SDA farm.	3. Maintain weed free canals and ditches; education in hygiene essential; attempt to eliminate open waters as sources for domestic usage.
	4. Malaria affecting new settlers near to swamps.	4. Malaria prophylaxis probably only suitable course. Already widely taken. Elimination from swamps difficult, but genetic vector control may be important in future.
	5. Tsetse fly and trypanosomiasis restricting development.	5. Long term control being investigated at present.
I. Wind erosion	1. Movement of sands on to fields and tracks in east of area.	1. Slight problem to proposed farm, but serious for access. Area within UNDP/UNSO sand stabilisation project at Brava. Grazing control on dune front, and planting of species to reduce wind velocities. Spread of indigenous grass, herbs, shrubs, and bushes will follow.
	2. Deflation risk in fields due to overmechanisation. Not so much a problem in coverplain soils (A, B, C) but likely in marginally suitable D1 soils.	2. Rainfed agriculture management aware of danger and will monitor effects. Damage likely to be much greater if uncontrolled mechanisation goes ahead by the irrigation co-operatives, which will use unsuitable machinery.

TABLE 7.1 (cont.)

Factor	Possible environmental changes	Proposed remedies
J. Shelter belts	1. Bush clearance in the strips leads to high evapotranspiration (ET) and increased wind velocities in arable fields.	1. Afforestation or grazing control in bush strips; possible reorientation of strip to counteract wind directions; bush strips to be grown to maximise effect of reducing velocities and ET in fields.
	2. Extensive growth in belts will lead to lateral roots that will take moisture from adjacent arable strip.	2. Adopt species which do not have extensive lateral roots.
K. Flood damage	1. Flooding of rainfed area likely unless there is flood controlling along Goof, Shabeelle and old channels	1a. Strengthen weak points along Shabeelle and Far Marjaan courses to control southerly flow of flood waters. 1b. Along Webi Goof blocking of depressional areas and old channels will reduce backing up of flooding from Webi Goof into proposed development area.
L Overgrazing by livestock and land tenure	1. Increased arable land, with accompaning land tenure rights, will lead to severe overstocking on adjacent lands, overgrazing of an already degraded rangeland likely. Land tenure rights liable to cause conflicts.	1. A most complex issue. Study needs to be carried out to assess carrying capacity of existing rangeland in areas not to be developed, role of grazing in bush strip; possibilities of grazing in areas at present dominated by tsetse. Traditional grazing rights of Tunni agro-pastoralists, Jiido pastoralists, and Rahanwayn camel peoples could conflict with proposed development. Severe problems have commonly been encountered with this problem in refugee settlement areas elsewhere, and it would be most unfortunate if the problem is not solved here. Integration of indigenous peoples, recent settlers and new settlers must be a long term aim.
M. Settlement location	1. Siting settlements on cracking clay vertisols (soils A, B, C) likely to result in short term damage and long term failure to structures.	1. Site settlements on soils which either have slight vertic properties and no evidence of movement (D1, D2, D4) or on sandier soils (E, D3). Tracks should also be placed on these soils.

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APPENDIX A

TERMS OF REFERENCE

1. Introduction

The objective of the survey would be to identify specific areas of land suitable for development for semi-mechanised dryland agriculture, forestry and human settlement.

In order to accomplish this objective, the overall distribution and characteristics of the soils and vegetation within the study area are needed to be appraised.

2. Approach to the Work

2.1 Preliminary Studies

All existing data would be collected and reviewed and a stereoscopic examination of the existing 1 : 30 000 scale aerial photography carried out to delineate soil and landscape patterns identifiable on the photographs. This information would be plotted on to transparent overlays to the photographs. Based on this preliminary assessment of the land resource and field inspections a soil observation network will be designed to provide an efficient coverage of the selected study areas. Since most of the area is likely to be covered with dense acacia thicket, it will be necessary to set out a baseline and cut traces along compass bearings. Traces would be established at one kilometre intervals and soils inspected at approximately 500 metre intervals along traces. The actual location of the inspection sites would be at the discretion of the soil scientist.

2.2 Field Studies - Soil Survey

A soil inspection density of two sites every square kilometre will be used to prepare soil and land class maps at a scale of 1 : 25 000.

Observations will be by auger or spade to 1.2 metres depth or other impending layer - coarse gravel, hardpan or bedrock if shallower.

The site of each bore or pit observation will be described in terms of geomorphology, physiography, parent material, topography, micro-relief, surface features, type and density of vegetation, land use, external drainage and erosion or aeolian sand hazard. Soil profiles would be described by horizon or strata in terms of sequence, depth, colour, texture, porosity, gravel content, mottles, moisture status and consistency and visible carbonates, gypsum and other salts. Field descriptions will follow the FAO Guidelines for Soil Descriptions.

The soils will be mapped individually or in association as sub-groups or miscellaneous land units using the FAO soil classification system. A correlation will be established - to the extent possible with limited chemical and physical data - to the Soil Taxonomy system.

2.3 Laboratory Analysis

Laboratory analysis will be confined to samples collected from profile pits (at the rate of one put per 500 ha) and to those analyses required to elucidate capability for dryland cropping.

The results of previous studies in this area have shown that the soils are rich in clay content, moderately alkaline in reaction and have a high base saturation. Salinity values of the surface soils are generally low. Therefore, analysis will be restricted to soil texture (sand, silt and clay), pH, cation exchange capacity, exchangeable bases, calcium, magnesium, sodium and potassium, electrical conductivity and, in the top two horizons only, measurement of available phosphorus, total nitrogen and organic matter content and micro-nutrients copper, zinc, manganese and iron.

Particular attention will be paid to the moisture-holding capacity of these soils and soil cores would be collected for determination of moisture-holding characteristics at tensions of 0, 0.1, 0.3, 1.0, 5.0 and 15 bars.

2.4 Topographical Survey

As the area is covered with fairly thick bush, it will be necessary to cut traces with bulldozers. This we propose to do at 1 km centres. Approximately 10 bench marks will be established at convenient intervals throughout the area.

Levels will then be taken along the trace lines noting any important features, which will be plotted on overlays to the latest airphotography. The resulting plotted data will then be enlarged to the required scale of 1 : 25 000, and an updated topographical map produced in the Consultant's office. Contours will be plotted at 1 m intervals.

The above traces will also be used for the soil survey.

2.5 Land Evaluation

The collected data on soils and topography will be systematically interpreted in terms of land suitability for semi-mechanised dryland farming, forestry and human settlement, according to the FAO land evaluation system (FAO framework for land evaluation 1976). Land suitability orders, classes and subclasses will be distinguished.

2.6 Report and Maps

The results of the soil, land classification and topographical surveys will be presented in one volume. Soils and land suitability maps (with the location of all observation sites shown on the maps) will be presented at 1 : 25 000 scale.

The final report, complete with printed maps, will be submitted twenty weeks after arrival of the Consultant's team in Mogadishu.

APPENDIX B

BENCH MARKS

Reference Nr	Location	Reduced level (m)
BM 335	Intersection of Sablaale-Modun Road and old Afgoi-Gelib Road	101.601
MMP 1	Government Resthouse, Sablaale	101.517
MMP 2	Intersection of Xawaala Buuley Road and Sablaale-Haaway Road	99.674
MMP 3	Sablaale-Haaway Road at Farjano Settlement	98.876
MMP 4	Intersection of Xawaala Buuley Road and Trace 4	99.770
MMP 5	Trace 5 at the Webi Goof	98.295
MMP 6	Intersection of Trace 6 and the Base Line	99.365
MMP 7	Intersection of Xawaala Buuley Road and Trace 7	99.819
MMP 8	Intersection of Sablaale-Modun Road and Trace 8	99.824
MMP 9	Trace 9, 1 885 m from Base Line towards Webi Goof	97.829
MMP 10	Intersection of Trace 13 and the Base Line	98.904

WATER LEVELS DURING SURVEY PERIOD

Location			Water level (m)	Date
Webi Goof	-	Trace 8	97.558	28.12.84
Webi Goof	-	Trace 6	97.587	30.12.84
Webi Goof	-	Trace 9	97.489	5.1.85
Webi Goof	-	Trace 10	97.419	6.1.85
Webi Goof	-	Trace 14	97.534	8.1.85
Webi Goof	-	Trace 13	97.479	9.1.85
Webi Goof		Base Line	97.454	10.1.85
Farjano Swamp	-	Haaway Road	97.497	17.1.85
Webi Goof	-	Trace 4	97.362	24.1.85
Webi Goof	-	Trace 2	97.448	2.2.85
Haaway Swamp			97.185	9.2.85
River Shabelle,	-	Farjano Pump Station	97.202	9.2.85
Farjano Swamp	-	Haaway Road	97.114	10.2.85
Old river channel	-	Farjano	97.100	10.2.85
Old river channel	-	Farjano	97.153	11.2.85
Old river channel	-	Farjano	97.162	11.2.85
River Shabeelle			96.849	19.2.85

Average drop in water level per day = 13.9 mm

Length of Traces cut by ONAT December 1984 to January 1985

Trace	Chainages: Base line to Sablaale-Modun Road	Chainages: Base line to Webi Goof	Length (m)
1	0 + 000 -- 0 + 385 km	0 + 000 -- 7 490 km	7 875
2	0 + 000 -- 2 + 430 km	0 + 000 -- 9 + 450 km	11 880
3	0 + 000 -- 1 + 720 km	0 + 000 -- 8 + 970 km	10 690
4	0 + 000 -- 1 + 785 km	0 + 000 -- 7 + 650 km	9 435
5	0 + 000 -- 1 + 954 km	0 + 000 -- 8 + 475 km	10 429
6	0 + 000 -- 3 + 332 km	0 + 000 -- 8 + 668 km	12 000
7	0 + 010 -- 3 + 467 km	0 + 000 -- 7 + 390 km	10 847
8	0 + 015 -- 3 + 389 km	0 + 000 -- 5 + 610 km	8 984
9	0 + 015 -- 3 + 688 km	0 + 000 -- 1 + 920 km	5 593
10	0 + 015 -- 3 + 957 km	0 + 000 -- 1 + 630 km	5 572
11	0 + 025 -- 4 + 154 km	0 + 000 -- 2 + 320 km	6 449
12	0 + 025 -- 4 + 577 km	0 + 000 -- 1 + 820 km	6 372
13	0 + 025 -- 5 + 759 km	0 + 000 -- 0 + 800 km	6 534
14	0 + 000 -- 6 + 530 km	0 + 000 -- 1 + 530 km	8 060
15	0 + 000 -- 6 + 815 km	0 + 000 -- 0 + 430 km	7 245
BASE	0 + 000 -- 4 + 737 (Trace 9 -- Trace 5)		4 737
LINE	0 + 000 -- 6 + 290 (Trace 9 -- Webi Goof)		6 290
	0 + 000 -- 4 + 090 (Trace 5 -- Sablaale-Haaway Road)		4 090
TOTAL			143 082

APPENDIX C

SOIL PROFILE DESCRIPTIONS

Methods of Description

In this appendix 17 profile descriptions of 14 soil units are described. The method of description follows the principles of the FAO Guidelines (1968). Soil classifications are according to the FAO/UNESCO legend (1974) and Soil Taxonomy of the USDA (1975). In the detailed profile descriptions soil colours are according to the Munsell colour notations and are given in the slightly moist state. The dry colour state is also given for any surface mulch or crust. Field electrical conductivity measurements, calibrated against laboratory assessments, are given for a number of profiles. Detailed laboratory chemical and physical data are given opposite the descriptions. Locations of profiles are measured approximately from the Government rest house at Sablaale. Elevations are also approximate, in metres above sea level.

Description 1: PM 11

A. Information on the Site

Soil Mapping Unit: A1		FAO Classification: Chromic Vertisol
Date of Examination: 19 January 1985		USDA Classification: Chromic Chromustert
Location:	12 km ESE Sablaale	Author: R.N. Munro
Landform unit:	Lower coverplain (LC)	
Elevation:	Ca 50 m asl	
Land use:	Livestock browsing	
Slope:	<1%	
Microrelief:	Moderately undulating U2	
Vegetation:	open mixed bushland with Acacia nilotica, and Thespesia danis	

B. Information on Soil

Parent Material: Old calcareous alluvium of Shabeelle River
Drainage - Profile: Moderate
Drainage - Site: Slow draining during rainy season
Moisture Condition in Profile: Dry to 120; very slight moist below
Flood hazard: Only in exceptionally wet years
Depth to ground water: not encountered
Surface features: surface mulch (10YR 5/2 dry) obscures cracking
Evidence of erosion: none

C. Brief Description of Profile

Deep dark brown clay profile with surface mulch, over hard prismatic structured subsoil. Small patches of sand are insufficient to place in soil unit Cl. Analysis show higher sand content than expected, and this is thought due to presence of fine concretions of sand particle size.

D. Profile Description

Horizon	Depth (cm)	Description
A1	0 - 4	Very dark greyish brown (10YR 3/2) clay loam; surface mulch; strong fine crumb; dry and loose; strongly calcareous; many shell and $CaCo_3$ concretions. abrupt smooth to
A2	14-70	Very dark greyish brown (10YR 3/3) Clay; moderate fine to course sub-angular blocky; dry slightly hard; strongly calcareous; many very fine pores, many fine medium roots; common horizontal and few vertical cracks; gradual wavy to
B1	40-92	Dark brown (10YR 3/3) Clay; moderate medium coarse prismatic breaking to moderate medium coarse angular blocky; few prominent vertical cracks, many small vertical and horizontal cracks; dry and extremely hard; common small hard $CaCo_3$ concretions; strongly calcareous; common fine and medium roots; diffuse to
B2	90-135	Dark brown (10YR 3/3) Clay; moderate medium coarse prismatic; few vertical cracks 3 cm wide to base of profile; slickenslides within peds; common hard and soft $CaCo_3$ concretions; few patches fine sand on faces.

PROFILE No. 1 SITE No. PM11

HORIZON	DEPTH (cm)	SOIL PARTICLES %			TEXTURAL GROUP	EC (LAB) mmhos/cm	EC (FIELD) mmhos/cm
		SAND 2000-50 μm	SILT 50-2 μm	CLAY <2 μm			
A12	0-20	53	12	35	Scl	0.47	0.62
A2	20-40	46	12	42	Sc	0.66	0.55
B1	60-80	43	10	47	C	0.73	1.25
B2	95-115	40	10	50	C	1.66	1.60

Avail P (ppm)	Total N (ppm)	Organic Carbon %	pH	EXCHANGEABLE CATIONS (me/100g)				CEC me/100g
				Ca	Mg	Na	K	
8.9	1513	1.04	7.6	35.8	6.2	0.65	2.63	24.9
0	588	0.61	7.7	33.3	6.2	0.85	2.01	27.6
			7.8	35.8	11.3	1.56	0.98	32.2
			8.2	35.5	13.7	3.26	1.11	33.5

Sat'n %	ESP	Field Tex.	CEC 100g/clay	BULK DENSITY gm/cm³	AV'ABLE MICRONUTRIENTS (ppm)			
					Cu	Zn	Mn	Fe
42	3	Cl	71		1.8	0.88	18.9	12.0
42	3	C	66		1.9	1.16	7.0	8.3
51	5	C	69					
61	10	C	67					

SOIL MOISTURE TENSIONS (bars)						DEPTH (cm)
0	0·1	0·3	1·0	5	15	
						5-10
						35-40
						70-75

Description 2: PM1

A. Information on the Site

Soil Mapping Unit:	A2	FAO Classification: Chromic Vertisol
Date of Examination:	6 January 1985	USDA Classification: Chromic Chromustert
Location:	5.5 km SE Sablaale	Author: R.N. Munro
Landform unit:	Lower coverplain (LC)	
Elevation:	Ca 45 m asl	
Land use:	Livestock browsing	
Slope:	<1%	
Microrelief:	Slightly uneven U1	
Vegetation:	Moderately dense wooded bushland	

B. Information on Soil

Parent Material: Old calcareous alluvium of Webi Shabeelle
Drainage - Profile: Moderate
Drainage - Site: Slow draining during rainy season
Moisture Condition in Profile: Dry to 100; very slightly moist below
Flood hazard: Only floods in exceptionally wet years
Depth to groundwater: not encountered
Surface features: Moderately deep surface mulch (10YR 5/2 dry)
Evidence of erosion: None

C. Brief Description of Profile

Deep dark brown clay profile, with surface mulch, over hard prismatic structured subsoil. Gypsum occurs below 90 cm in slight moist massive horizon.

D. Profile Description

Horizon	Depth (cm)	Description
A1	0 - 3	Very dark greyish brown (10YR 3/2) clay loam; strong fine crumb; surface mulch; dry and loose; strong calcareous; clear wavy to
A2	3 - 30	Very dark greyish brown (10YR 3/2) clay; moderate fine to coarse angular blocky; dry hard; common vertical cracks; abundant fine medium pores; abundant fine to coarse roots; strongly calcareous; clear wavy to
B1	30-90	Dark greyish brown (10YR 4/2) Clay; moderate coarse prismatic breaking to moderate fine to coarse angular blocky; dry and very hard; common vertical cracks to base; few fine roots on faces; common fine pores; strongly calcareous; gradual to
B2	90-125	Dark greyish brown (10YR 4/2) Clay: weak coarse prismatic to massive; few fine roots on slip faces; common slickenslides; common gypsum crystals; very slight moist.

PROFILE No. 2 SITE No. PM1

HORIZON	DEPTH (cm)	SOIL PARTICLES %			TEXTURAL GROUP	EC (LAB) mmhos/cm	EC (FIELD) mmhos/cm
		SAND 2000-50 μm	SILT 50-2 μm	CLAY <2 μm			
A12	0-20	32	29	39	Cl	0.77	0.6
B1	30-45	28	18	54	C	0.87	0.87
B1	60-75	25	21	54	C	1.29	1.5
B2Y	100-120	23	26	51	C	6.20	5.0

Avail P (ppm)	Total N (ppm)	Organic Carbon %	pH	EXCHANGEABLE CATIONS (me/100g)				CEC me/100g
				Ca	Mg	Na	K	
3.4	1093	0.74	7.9	39.7	7.5	1.0	2.19	39.2
1.8	616	0.65	8.3	37.8	15.1	1.77	1.28	36.6
			8.4	38.4	15.0	3.61	1.41	40.0
			8.3	51.6	17.8	1.25	1.39	39.3

Sat'n %	ESP	Field Tex.	CEC 100g/clay	BULK DENSITY gm/cm³	AV'ABLE MICRONUTRIENTS (ppm)			
					Cu	Zn	Mn	Fe
44	3	Cl	100		3.0	0.64	28.0	14.2
46	5	C	68		2.7	0.64	6.8	12.0
60	9	C	74					
63	3	C	77					

SOIL MOISTURE TENSIONS (bars)						DEPTH (cm)
0	0·1	0·3	1·0	5	15	
						5-10
						35-40
						105-110

Description 3: M227

A. Information on the Site

Soil Mapping Unit:	A3	FAO Classification: Chromic Vertisol
Date of Examination:	3 February 1985	USDA Classification: Entic Chromustert
Location:	12 km SW Sablaale, Farjano	Author: R.N. Munro
Landform unit:	Lower coverplain (LC)	
Elevation:	Ca 40 m asl	
Land Use:	Irrigated maize with heavy weed infestation	
Slope:	<1%	
Microrelief:	Even U0	

B. Information on Soil

Parent Material: Recent alluvium of Webi Shabeelle
Drainage - Profile: Moderate
Drainage - Site: Bunded land with restricted drainage outlet
Moisture Condition in Profile: Dry to 20, moist below
Flood hazard: Nil
Depth to groundwater: Not encountered, but hand dug well nearly water table at 6 m, with EC of 7000 µmhos
Surface features: Thin surface crust (10YR 8/1) over soft topsoil
Evidence of erosion: Nil

C. Brief Description of Profile

Deep profile with brown clay loam plough layer passing down into light yellowish brown to pale brown clays, with gypsum crystals common below 50 cm. Field determination of electrical conductivity shows serious salinity hazard close to the surface.

D. Profile Description

Horizon	Depth (cm)	Description
AP	0 - 10	Brown (10YR 5/3) Clay loam; moderate fine medium subangular blocky; dry and soft; strongly calcareous;
B1	10-20	Brown (10YR 5/3) Clay; strongly calcareous
B2	20-50	Light yellowish brown (10YR 6/4) Clay; common medium district 10YR 5/4 mottles; moist and friable; strongly calcareous; dark concretions with Mn 0_2 coats
B3Y	50-120	Pale brown (10YR 6/3) Clay; few fine faint (10YR 5/6) mottles; gypsum crystals common; strongly calcareous.

Field ECE determinations:

0-10	0.75	mmhos/cm
10-20	1.5	mmhos/cm
30-40	3.0	mmhos/cm
60-70	6.5	mmhos/cm
100-110	8.0	mmhos/cm

Description 4: PM2

A. Information on the Site

Soil Mapping Unit:	B1	FAO Classification: Chromic Vertisol
Date of Examination:	6 February 1985	USDA Classification: Entic Chromustert
Location:	7 km S of Sablaale	Author: R.N. Munro
Landform unit:	Old channel (C)	
Elevation:	Ca 45 m asl	
Land use:	Livestock browsing	
Slope:	<1%	
Microrelief:	Moderately uneven gilgai U2	
Vegetation:	Grassland with few Acacia zanzibarica	

B. Information on Soil

Parent Material: Old calcareous alluvium of Webi Shabeelle
Drainage - Profile: Imperfect to poor
Drainage - Site: Liable to ponding and slow drainage
Moisture Condition in Profile: Dry throughout
Flood hazard: Slight runoff from adjacent slopes and channel flow during rainy season
Depth to groundwater: Not encountered
Surface features: Loose mulch; few shells; common sinkholes in gilgai hollows
Evidence of erosion: None

C. Brief Description of Profile

Deep greyish brown clay with shallow surface mulch and subangular blocky topsoil overlying prismatically structural clay with slickenslides and wedge structures.

D. Profile Description

Horizon	Depth (cm)	Description
A1	0 - 4	Dark grey (10YR 4/1) Clay; strong fine medium crumb structure; dry hard peds; mulch dry and loose; strongly calcareous; gradual wavy;
A2	4-25	Greyish brown (10YR 5/2) Clay; moderate fine medium subangular blocky; dry and very hard; many vertical cracks; abundant fine to coarse roots; strongly calcareous; gradual wavy to
B1	25-100	Dark greyish brown (10YR 4/2) Clay; many faint medium mottles along root lines; moderate coarse prismatic breaking to moderate coarse medium angular blocky; many vertical cracks up to 4 cm wide; many fine medium roots. slickenslides and wedge structures; shell fragments common; dry and extremely hard; diffuse to
B2	100-125	Dark greyish brown (10YR 4/2) Clay; no mottles; few vertical cracks; massive structure; few fine roots; slickenslides and wedge structures; shell fragments.

PROFILE No. 4 SITE No. PM2

HORIZON	DEPTH (cm)	SOIL PARTICLES % SAND 2000-50 μm	SILT 50-2 μm	CLAY <2 μm	TEXTURAL GROUP	EC (LAB) mmhos/cm	EC (FIELD) mmhos/cm
A12	0-20	24	24	52	C	0.52	0.88
B1	30-60	21	18	61	C	0.82	1.15
B1	90-95	21	18	61	C	1.58	1.85
B2	110-125	23	15	62	C	1.51	1.5

Avail P (ppm)	Total N (ppm)	Organic Carbon %	pH	EXCHANGEABLE CATIONS (me/100g) Ca	Mg	Na	K	CEC me/100g
1.2	1205	0.93	7.9	43.3	4.3	0.65	2.78	38.3
0	560	0.49	8.1	43.4	10.0	1.13	1.71	34.6
			8.1	41.3	12.0	1.29	1.62	35.0
			8.2	45.8	13.0	1.34	1.62	33.9

Sat'n %	ESP	Field Tex.	CEC 100g/clay	BULK DENSITY gm/cm³	AV'ABLE MICRONUTRIENTS (ppm) Cu	Zn	Mn	Fe
48	2	C	74		2.7	0.66	12.2	10.0
53	3	C	57		2.1	1.40	6.4	14.6
54	4	C	57					
59	4	C	55					

SOIL MOISTURE TENSIONS (bars) 0	0·1	0·3	1·0	5	15	DEPTH (cm)
						5-10
						30-35
						65-70

Description 5: PM5

A. Information on the Site

Soil Mapping Unit:	B2	FAO Classification: Chromic Vertisol
Date of Examination:	9 January 1985	USDA Classification: Entic Chromustert
Location:	7.5 km ESE of Sablaale	Author: R.N. Munro
Landform unit:	Old channel (C)	
Elevation:	Ca 45 m asl	
Land use:	Livestock browsing	
Slope:	<1%	
Microrelief:	Slightly uneven (U2) gilgai	
Vegetation:	Open grassed bushland few Dichrostochys; Acacia nilotica	

B. Information on Soil

Parent Material: Old calcareous alluvium of Webi Shabeelle
Drainage - Profile: Imperfect to poor
Drainage - Site: Liable to ponding and slow drainage
Moisture Condition in Profile: Dry and hard to about 70 cm. Very slight moist below 70
Flood hazard: Runoff from adjacent slopes and channel flow likely in rainy season
Depth to groundwater: Not encountered
Surface features: Well developed mulch (10YR 5/1), shells common; sinkholes common
Evidence of erosion: None

C. Brief Description of Profile

Deep clay profile formed in channel clays, with surface mulch overlying subangular blocky to angular blocky breaking from prismatic clay. Gypsum crystals common below 80 cms.

D. Profile Description

Horizon	Depth (cm)	Description
A1	0 - 5	Dark greyish brown (10YR 4/2) Clay; strong fine to medium crumb mulch structure; many fine medium roots, strongly calcareous; abrupt smooth to
A2	5-35	Dark greyish brown (10YR 4/2) Clay; moderate fine to coarse subangular blocky; common vertical cracks; many fine medium roots; many fine pores; strongly calcareous; small $CaCo_3$ concretions common
B1	35-80	Dark greyish brown (10YR 4/2) Clay; moderate medium coarse angular blocky breaking from moderate coarse prismatic; common vertical cracks; many fine common medium roots; dry very hard to very slight moist at 70 cm; shell and concretions common throughout and as pockets at base of former cracks
B2	80-120	Very dark greyish brown (10YR 3/2) Clay; few fine medium rusty mottles on root lines; massive with common slickenslides; rare vertical cracks; no roots; strongly calcareous; small gypsum crystals and $CaCo_3$ concretions.

Description 6: PM32

A. Information on the Site

Soil Mapping Unit:	B3	FAO Classification: Vertic Cambisol
Date of Examination:	4 February 1985	USDA Classification: Vertic Tropept
Location:	3 km SW Sablaale	Author: R.N. Munro
Landform unit:	Old channel (C)	
Elevation:	Ca 45 m asl	
Land use:	Traditional flood irrigated land, fallow at present	
Slope:	<1% Slightly concave basin	
Microrelief:	Even U0	

B. Information on Soil

Parent Material: Recent calcareous alluvium of Webi Shabeelle
Drainage - Profile: Imperfect to poor
Drainage - Site: Old meander loop liable to flooding in wet season
Moisture Condition in Profile: Dry to 100; very slightly moist below
Flood hazard: Runoff from adjacent levees likely in wet season
Depth to groundwater: Not encountered
Surface features: Pale mulch (10YR 6/2 dry) of cultivation layer
Evidence of erosion: None

C. Brief Description of Profile

Deep greyish brown clay profile with surface mulch and subangular to angular blocky topsoil. A prominent layer of diatomite occurs above prismatic structural clay horizon. The diatomite results from deposition in former meander loop of Shebelli river. Channel was permanent swamp some 15 years ago when it was an important fishing area.

D. Profile Description

Horizon	Depth (cm)	Description
Ap1	0-4	Dark greyish brown (10YR 4/2) Clay; moderate fine crumb structure; peds dry and hard; strongly calcareous; surface mulch; abrupt smooth to
Ap2	4-12	Very dark greyish brown (10YR 3/2) Clay; moderate fine medium subangular blocky; common vertical cracks; dry hard; many fine medium roots; strongly calcareous; clear smooth to
B1	12-27	Very dark greyish brown (10YR 3/2) Clay; moderate fine to coarse angular blocky; dry very hard; common vertical cracks; many fine medium roots; abrupt smooth to
2B2	27-37	Very pale brown (10YR 7/4) Loam; diatomite layer; weak fine subangular blocky; dry soft; common fine medium roots; abrupt smooth to
3B3	37-110	Dark greyish brown (10YR 4/2) Clay; common fine distinct 10YR 4/6 mottles; moderate coarse prismatic becoming massive at base; dry hard to very slight moist; small patches of diatomite; common small gypsum crystals
3B4	110-120	Dark greyish brown (10YR 4/2) Clay; common fine distinct mottles (10YR 4/6); patches of diatomite and few gypsum crystals

Field Ece	Depth (cm)	mmhos/cm
	0 - 20	0.9
	40 - 70	2.5
	100 - 110	3.0

Description 7: PM25

A. Information on the Site

Soil Mapping Unit:	C1	FAO Classification: Pellic Vertisol
Date of Examination:	29 January 1985	USDA Classification: Typic Pellustert
Location:	3.5 km SE Sablaale	Author: R.N. Munro
Landform unit:	Lower coverplain (LC)	
Elevation:	Ca 45 m asl	
Land use:	Livestock browsing	
Slope:	<1%	
Microrelief:	Slight to moderately uneven gilgai (U1-2); sinkholes common in gilgai hollows	
Vegetation:	Moderately dense bushland with Acacia nilotica and A. zanzibarica secondary regrowth	

B. Information on Soil

Parent Material: Old calcareous alluvium of Webi Shabeelle
Drainage - Profile: Moderate
Drainage - Site: Slow draining in wet season
Moisture Condition in Profile: Dry to 110; very slight moist below
Flood hazard: Only floods in exceptionally wet years
Depth to groundwater: Not encountered
Surface features: Surface mulch (10YR 5/1 dry); shell fragments common
Evidence of erosion: None

C. Brief Description of Profile

Deep clay profile with sandy particles throughout. A thin surface mulch overlies subanguler blocky to blocky and prismatic subsoil with common $Caco_3$ concretions and shell fragments.

D. Profile Description

Horizon	Depth (cm)	Description
A1	0 - 2	Dark grey (10YR 4/1) Clay loam; surface mulch with strong fine to medium crumb structure; dry and loose; strongly calcareous; abrupt smooth to
A2	2-20	Dark grey (10YR 4/1) Clay; moderate fine medium subangular blocky; many fine to coarse roots; many $CaCo_3$ concretions and shell fragments; dry soft; sand particles throughout; strongly calcareous; abrupt smooth to
B1	20-50	Grey (10YR 5/1) Clay; common medium faint yellowish brown mottles in moderate fine to coarse subangular blocky; common fine to coerse roots; shell fragments and $CaCo_3$ concretions common as concentrations; sand particles and sandy patches throughout; dry hard to slightly hard; clear smooth to
B2	50-110	Grey (10YR 5/1) Clay; common medium faint yellowish brown mottles; weak medium coarse prismatic breaking to moderate medium coarse angular blocky; common fine roots; dry and very hard
B3	110-135	Grey (10YR 5/1) Clay; common medium faint yellowish brown mottles; massive structure; few fine roots; very slight moist; common shell fragments; $CaC0_3$ concretions and sand particles.

PROFILE No. . 7 SITE No. PM25

HORIZON	DEPTH (cm)	SOIL PARTICLES % SAND 2000-50 µm	SILT 50-2 µm	CLAY <2 µm	TEXTURAL GROUP	EC (LAB) mmhos/cm	EC (FIELD) mmhos/cm
A12	0-20	44	19	37	Cl	0.81	0.68
B1	20-40	40	10	50	C	0.81	1.05
B2	60-80	42	8	50	C	1.98	1.5
B3	110-130	39	9	52	C	0.45	1.7

Avail P (ppm)	Total N (ppm)	Organic Carbon %	pH	EXCHANGEABLE CATIONS (me/100g) Ca	Mg	Na	K	CEC me/100g
3.1	1541	2.36	7.6	36.9	3.7	0.66	1.58	32.9
0	532	0.53	7.9	33.8	6.2	0.87	2.24	26.1
			8.0	35.8	8.3	1.18	1.35	23.8
			8.0	37.8	8.5	1.19	2.84	30.9

Sat'n %	ESP	Field Tex.	CEC 100g/clay	BULK DENSITY gm/cm^3	AV'ABLE MICRONUTRIENTS (ppm) Cu	Zn	Mn	Fe
45	0.2	Cl	89		1.6	1.10	23.6	9.6
46	3	C	52		2.0	0.30	5.3	8.3
56	5	C	48					
54	4	C	59					

SOIL MOISTURE TENSIONS (bars) O	O·1	O·3	1·O	5	15	DEPTH (cm)
						0-5
						25-30
						55-60

Description 8: PM4

A. Information on the Site

Soil Mapping Unit: C1
Date of Examination: 8 January 1985
Location: 2.5 km SE Sablaale
Landform unit: Lower coverplain (LC)
Elevation: Ca 45 m asl
Land use: Livestock browsing
Slope: <1%
Microrelief: Moderately undulating gilgai U2
Vegetation: Cleared land with secondary Acacia sp bush

FAO Classification: Chromic Vertisol
USDA Classification: Entic Chromustert
Author: R.N. Munro

B. Information on Soil

Parent Material: Old calcareous alluvium of Webi Shabeelle
Drainage - Profile: Moderate
Drainage - Site: Gilgai hollows drain slowly in wet season
Moisture Condition in Profile: Dry throughout
Flood hazard: Floods only in exceptionally wet years
Depth to groundwater: Not encountered
Surface features: Firm surface (10YR 5/1 dry) with common shell fragments
Evidence of erosion: None

C. Brief Description of Profile

Firm angular blocky clay loam topsoil with moderate organic matter, overlies prismatically structured clays. Sandy throughout often as stratified patches, but never as continuous layers.

D. Profile Description

Horizon	Depth (cm)	Description
A1	0.10	Very dark grey (10YR 3/1) Clay loam; dry and hard; moderate fine medium angular blocky; many horizontal cracks; many fine pores; abundant fine to coarse roots; moderate organic matter; strongly calcareous; clear wavy to
B1	10-30(60)	Greyish brown (10YR 5/2) Clay; dry and hard; common fine medium district 2.5y 6/4 mottles; moderate fine to coarse angular blocky; many horizontal and vertical cracks; many fine and common medium pores; abundant fine medium roots; strongly calcareous; shell fragments; organic patches, and $CaCo_3$ concretions common; (patches of this layer extend down cracks to 60 cms), clear irregular to
B2	30-100	Dark greyish brown (10YR 4/2) Clay; sandy patches throughout; moderate fine to coarse angular blocky breaking from moderate medium coarse prismatic; common vertical cracks up to 5 cm wide; slickenslide and wedge structures; few fine roots; larger roots do not penetrate far into horizon; $CaCo_3$ concretions with MnO_2 coats common; dry extremely hard; gradual to
B3	100-120	Dark greyish brown (10YR 4/2) Clay; sandy patches throughout; moderate medium to coarse angular blocky; no cracks; few fine roots; $CaCo_3$ concretions; slickenslides common; common fine medium district (2.5y 4/4) matter.

Field EC:	0-10	0.30 mmhos/cm
	15-30	0.55 mmhos/cm
	70-100	1.20 mmhos/cm

Description 9: PM19

A. Information on the Site

Soil Mapping Unit: C2
Date of Examination: 24 January 1985
Location: 4 km WSW Sablaale
Landform unit: Lower coverplain (LC)
Elevation: Ca 45 m asl
Land Use: Livestock browsing
Slope: <1%
Microrelief: Even U0
Vegetation: Moderately dense wooded bushland

FAO Classification: Chromic Vertisol
USDA Classification: Entic Chromustert
Author: R.N. Munro

B. Information on Soil

Parent Material: Old calcareous alluvium of Webi Shabeelle
Drainage - Profile: Moderate
Drainage - Site: Slow draining during rainy season
Moisture Conditions in Profile: Dry to 54; very slightly moist below
Flood hazard: Only floods in exceptionally wet years
Depth to groundwater: Not encountered
Evidence of erosion: None

C. Brief Description of Profile

Deep dark grey clay profile with angular blocky surface horizon passing into moderate prismatic structured subsoil with gypsum crystals increasing with depth.

D. Profile Description

Horizon	Depth (cm)	Description
A1	0 - 2	Dark grey (10YR 4/1) Clay; strong fine crumb mulch; shell and $CaCo_3$ concretions common; dry and loose, abrupt smooth to
A2	2 - 15	Dark grey (10YR 4/1) Clay; moderate fine to coarse subangular blocky structure; strongly calcareous; few short vertical cracks; many fine to very fine pores; abundant fine and medium roots; dry slightly hard; strongly calcareous; abrupt smooth to
B1	15-54	Dark greyish brown (10YR 4/2) Clay; moderate fine to coarse angular blocky breaking from moderate medium coarse prismatic; dry and extremely hard; many short and few long vertical cracks; common fine pores; many fine to medium roots; strongly calcareous; few medium distinct mottles (10YR 5/6); common shell fragments and accumulations of small $CaCo_3$ concretions; clear smooth to
B2	54-100	Greyish brown (10YR 5/2) Clay; moderate fine to coarse angular blocky breaking from moderate medium coarse prismatic; few vertical and wedge cracks; few fine pores; common fine medium roots; common gypsum crystals; strongly calcareous; dry very hard to very slight moist; few medium faint mottles (10YR 5/6); gradual smooth to
B3	100-130	Greyish brown (10YR 5/2) Clay; massive breaking to weak fine to coarse angular blocky; no cracks; few fine roots; many gypsum crystals; strongly calcareous; moist and very firm; common slickenslides with flattened roots; common dark $CaCo_3$ concretions; shell fragments common.

PROFILE No. 9 SITE No. PM19

HORIZON	DEPTH (cm)	SOIL PARTICLES %			TEXTURAL GROUP	EC (LAB) mmhos/cm	EC (FIELD) mmhos/cm
		SAND 2000-50 μm	SILT 50-2 μm	CLAY <2 μm			
A1.2	0-15	39	18	43	C	0.63	0.75
B1	30-45	38	12	50	C	1.39	1.15
B2Y	60-75	48	12	50	C	0.42	0.52
B3Y	100-120	31	17	52	C	2.70	3.70

Avail P (ppm)	Total N (ppm)	Organic Carbon %	pH	EXCHANGEABLE CATIONS (me/100g)				CEC me/100g
				Ca	Mg	Na	K	
2.5	1261	0.76	7.7	41.2	4.7	0.7	2.29	29.5
0	532	0.51	8.0	41.8	6.3	1.0	1.19	31.3
			8.0	35.7	4.7	0.73	2.90	24.0
			8.0	65.1	15.2	3.13	1.0	32.1

Sat'n %	ESP	Field Tex.	CEC 100g/ clay		AV'ABLE MICRONUTRIENTS (ppm)			
					Cu	Zn	Mn	Fe
49	2	C	69		2.3	0.52	13.8	11.6
53	3	C	63		1.9	0.84	7.1	9.6
41	3	C	48					
58	10	C	62					

Description 10: PM20

A. Information on the Site

Soil Mapping Unit:	C2	FAO Classification: Chromic Vertisol
Date of Examination:	24 January 1984	USDA Classification: Entic Chromustert
Location:	4.5 km WSW Sablaale	Author: R.N. Munro
Landform unit:	Lower coverplain (C1)	
Elevation:	Ca 45 m asl	
Land use:	Livestock browsing restricted due to tsetse	
Slope:	<1%	
Microrelief:	Moderately uneven gilgai (U2); sinkholes common	
Vegetation:	Acacia zanzibarica	

B. Information on Soil

Parent Material: Old calcareous alluvium of Webi Shabeelle
Drainage - Profile: Moderate
Drainage - Site: Slow in wet season
Moisture Condition in Profile: Dry throughout
Flood hazard: Floods only in exceptionally wet years
Depth to groundwater: Not encountered
Surface features: Thin mulch (0-2 cm; 10YR 6/2). Shell fragments common
Evidence of erosion: None

C. Brief Description of Profile

Deep clay profile with thin surface mulch overlying subangular blocky topsoil and angular blocky to prismatic subsoil. Sand particles common, with stratified sandy patches, and common gypsum crystal congregations below 100 cm. Olive mottles within peds and on faces.

D. Profile Description

Horizon	Depth (cm)	Description
A1	0-15	Dark grey (10YR 4/1) Clay; dry very hard; moderate fine to coarse subangular blocky; few vertical cracks; abundant fine medium cracks; strongly calcareous; mulch 0-2 cm; sand patches and $CaCo_3$ concretions common; clear smooth to
B1	15-55	Greyish brown (2.5Y 5/2) Clay; dry hard; common fine medium faint (2.5Y 5/4) mottles; moderate fine to coarse angular blocky; breaking from moderate fine medium prismatic; many short vertical and horizontal cracks; common fine roots; strongly calcareous; clear wavy to
B2	55-102	Greyish brown (2.5Y 5/2) Clay; dry very hard; many medium distinct olive mottles (2.5Y 5/6); moderate medium coarse prismatic breaking to moderate medium coarse angular blocky; few vertical cracks to base; common fine roots crushed by slickenslides faces; sand patches as stratified layers; sandy throughout; clear wavy to
B3Y	102-120	Greyish brown (2.5Y 5/2) Clay; dry and very hard; few medium distinct mottles (2.5Y 5/6); massive breaking to moderate fine to coarse angular blocky; crushed roots on slickenslide faces; gypsum crystals common; sandy throughout.

PROFILE No. 10 SITE No. PM20

HORIZON	DEPTH (cm)	SOIL PARTICLES % SAND 2000-50 µm	SILT 50-2 µm	CLAY <2 µm	TEXTURAL GROUP	EC (LAB) mmhos/cm	EC (FIELD) mmhos/cm
A1	0-20	47	14	39	Sc	0.39	0.35
B1	20-40	38	12	50	C	0.82	0.95
B2	60-80	38	10	53	C	1.73	1.5
B3Y	102-120	35	10	55	C	2.26	2.0

Avail P (ppm)	Total N (ppm)	Organic Carbon %	pH	EXCHANGEABLE CATIONS (me/100g) Ca	Mg	Na	K	CEC me/100g
5.3	1121	0.70	7.9	39.4	4.7	0.83	1.83	30.6
0.3	420	0.47	8.0	38.2	9.3	1.03	1.01	31.7
			8.0	39.7	13.3	1.45	1.02	34.7
			8.1	40.1	15.2	1.71	1.47	33.5

Sat'n %	ESP	Field Tex.	CEC 100g/clay	BULK DENSITY gm/cm³	AV'ABLE MICRONUTRIENTS (ppm) Cu	Zn	Mn	Fe
47	3	C	78		2.1	1.18	9.1	11.6
49	3	C	63		1.6	0.48	6.3	10.2
55	4	C	66					
59	5	C	61					

SOIL MOISTURE TENSIONS (bars) 0	0·1	0·3	1·0	5	15	DEPTH (cm)
						5-10
						30-35
						60-65

Description 11: PM34

A. Information on the Site

Soil Mapping Unit:	C2	FAO Classification: Chromic Vertisol
Date of Examination:	12 February 1985	USDA Classification: Entic Chromustert
Location:	8 km SW Sablaale	Author: R.N. Munro
Landform unit:	Lower coverplain (LC)	
Elevation:	Ca 45 m asl	
Land use:	Browsed by wildlife because of tsetse	
Slope:	<1%	
Microrelief:	Slight gilgai (U0-1) common potholes	
Vegetation:	Grassed bushland with mixed thorn bush	

B. Information on Soil

Parent Material: Old calcareous alluvium of Webi Shabeelle
Drainage - Profile: Moderate
Drainage - Site: Slowly draining in wet season
Moisture Condition in Profile: Dry until 120, very slightly moist below
Flood hazard: Floods in wetter years
Depth to groundwater: Not encountered
Surface features: Surface mulch (10YR 5/1) 0-2 cm; polygonal cracks common
Evidence of erosion: None

C. Brief Description of Profile

Deep dark greyish brown clay profile, without mottles, but sandy throughout; Gypsum crystals common below 75 cm.

D. Profile Description

Horizon	Depth (cm)	Description
A1	0-15	Very dark grey (10YR 3/1) Clay; dry hard; strong fine moderate crumb mulch breaking down from moderate fine medium subangular blocky; abundant fine medium roots; shell fragments; strongly calcareous; clear smooth to
B1	15-50	Dark greyish brown (10YR 4/2) Clay; moderate fine medium angular blocky breaking to moderate medium prismatic; many short vertical and horizontal cracks; many fine medium cracks; sandy throughout but no sand lenses; dry very hard; strongly calcareous, clear smooth to
B2	50-75	Dark greyish brown (10YR 4/2) Clay; moderate medium to coarse prismatic breaking to moderate fine medium angular blocky; few long vertical cracks to bare; many short vertical cracks; common fine medium roots; sandy throughout with $CaCo_3$ concretions common; strongly calcareous; dry very hard, abrupt smooth to
B3Y	75-120	Dark greyish brown (10YR 4/2) Clay; moderate medium coarse angular blocky to massive. Few large vertical cracks; few fine roots; strongly calcareous; many gypsum crystals.

PROFILE No. 11 SITE No. PM34

HORIZON	DEPTH (cm)	SOIL PARTICLES % SAND 2000-50 μm	SILT 50-2 μm	CLAY <2 μm	TEXTURAL GROUP	EC (LAB) mmhos/cm	EC (FIELD) mmhos/cm
A1	0-15	43	15	42	C	0.54	0.6
B1	20-35	43	11	46	C	0.88	0.4
B2	60-75	42	8	50	C	3.32	1.4
B3Y	90-105	38	10	52	C	1.66	4.75

Avail P (ppm)	Total N (ppm)	Organic Carbon %	pH	EXCHANGEABLE CATIONS (me/100g) Ca	Mg	Na	K	CEC me/100g
0.5	1513	1.14	7.7	39.3	4.7	0.60	1.20	31.4
0	588	0.56	7.7	35.5	7.0	0.65	0.77	43.8
			8.0	38.3	10.2	2.07	0.86	31.0
			8.0	55.7	13.5	5.7	1.11	32.7

Sat'n %	ESP	Field Tex.	CEC 100g/clay		AV'ABLE MICRONUTRIENTS (ppm) Cu	Zn	Mn	Fe
49	2	C	75		2.0	0.92	18.7	8.4
50	2	C	95		1.8	0.82	8.5	8.3
52	7	C	62					
56	17	C	63					

Description 12: PM10

A. Information on the Site

Soil Mapping Unit:	D1	FAO Classification: Vertic Cambisol
Date of Examination:	14 February 1985	USDA Classification: Vertic Ustropept
Location:	6.25 km SE Sablaale	Author: R.N. Munro
Landform unit:	Upper coverplain (UC)	
Elevation:	Ca 50 m asl	
Land use:	Livestock browsing	
Slope:	<1%	
Microrelief:	Even, no gilgai (U0), few sinkholes	
Vegetation:	Open mixed bushland	

B. Information on Soil

Parent Material: Calcareous alluvium of old Webi Shabeelle river levee/coverplain
Drainage - Profile: Moderate/well
Drainage - Site: Runoff experienced in wet season
Moisture Condition in Profile: Dry throughout
Flood hazard: Low due to slight slope on land
Depth to groundwater: Not encountered
Surface features: Firm surface (10YR 5/4 dry)
Evidence of erosion: Slight aeolian deflation along adjacent track

C. Brief Description of Profile

Deep dark yellowish brown light clayey to very fine sandy clay profile. Soft platy to subangular blocky topsoil overlies angular blocky clay/sandy clay subsoil with gypsum accumulation below 80 cm.

D. Profile Description

Horizon	Depth (cm)	Description
AB1	0-20	Dark yellowish brown (10YR 3/4); clay loam; dry and slightly hard; low organic matter; weak medium platy surface over moderate fine medium subangular blocky; few vertical cracks; many fine medium roots; strongly calcareous; many fine, few medium pores; clear wavy to
B2	20-40	Dark brown (10YR 3/3) Clay; (to very fine sandy clay); dry and hard; moderate medium coarse angular blocky; common vertical and horizontal narrow cracks; common fine medium and few coarse roots; common fine medium pores; strongly calcareous
B3	40-80	Dark yellowish brown (10YR 3/4) Clay (to very fine sandy clay); moderate medium coarse angular blocky; common vertical cracks; few fine medium roots; inactive slickenslides; large roots do not penetrate into horizon; strongly calcareous; dry and very hard; clear wavy to
B4Y	80-120	Dark brown to dark yellowish brown (10YR 3/4-4/4) Clay; moderate fine to coarse, angular blocky; rare vertical cracks; inactive slickenslides; common block $CaCo_3$ concretions; gypsum crystals up to 5 mm common.

PROFILE No. 12 SITE No. PM10

HORIZON	DEPTH (cm)	SOIL PARTICLES % SAND 2000-50 μm	SILT 50-2 μm	CLAY <2 μm	TEXTURAL GROUP	EC (LAB) mmhos/cm	EC (FIELD) mmhos/cm
AB1	0-20	42	30	28	Cl	0.75	0.55
B2	20-40	38	24	38	Cl	0.49	0.45
B3	40-65	30	25	45	C	2.79	1.75
B4Y	100-120	27	30	43	C	7.96	6.5

Avail P (ppm)	Total N (ppm)	Organic Carbon %	pH	EXCHANGEABLE CATIONS (me/100g) Ca	Mg	Na	K	CEC me/100g
5.5	1289	0.82	7.7	40.7	7.8	0.69	2.34	30.3
2.0	813	1.06	8.4	34.3	11.7	1.54	1.13	33.3
			8.3	32.5	12.7	0.80	1.09	37.0
			8.3	54.2	15.5	14.3	1.08	35.2

Sat'n %	ESP	Field Tex.	CEC 100g/clay	BULK DENSITY gm/cm^3	AV'ABLE MICRONUTRIENTS (ppm) Cu	Zn	Mn	Fe
45	2	Cl	108		1.9	0.76	15.8	6.0
47	3	C	88		2.0	0.72	7.8	7.2
59	2	C	82					
58	41	C	82					

SOIL MOISTURE TENSIONS (bars) 0	0·1	0·3	1·0	5	15	DEPTH (cm)
						5-10
						30-35
						70-75

Description 13: PM21

A. Information on the Site

Soil Mapping Unit:	D2	FAO Classification:	Calcic Cambisol
Date of Examination:	26 January 1985	USDA Classification:	Typic Ustropept
Location:	17 km SE Sablaale	Author:	R.N. Munro
Landform unit:	Upper coverplain (UC)		
Elevation:	Ca 50 m asl		
Land use:	Livestock browsing		
Slope:	<1%		
Microrelief:	Even, no gilgai (U0)		
Vegetation:	Open mixed bushland		

B. Information on Soil

Parent Material: Calcareous alluvium of old Webi Shabeelle/Webi Goof channel
Drainage - Profile: Moderate/well
Drainage - Site: Runoff occurs during rains
Moisture Condition in Profile: Dry to approximately 75 cm. Slight moist to moist below
Flood hazard: Low - slight slope precludes flooding
Depth to groundwater: Not encountered, but may fluctuate seasonally to 3.0 m
Surface features: Firm surface (10YR 5/4) soft underneath; dark concretions on surface
Evidence of erosion: Aeolian erosion along tracks locally

C. Brief Description of Profile

Brown clay loam platy topsoil overlies subangular blocky to weakly prismatic clay subsoil. $CaCo_3$ concretions throughout and gypsum crystals below 65 cm. Saline efflorescences on cut faces below 65 cm also, and field EC determination shows high salinity hazard below 65 cm.

D. Profile Description

Horizon	Depth (cm)	Description
AB1	0-17	Brown (10YR 4/3) clay loam; dry and slightly hard. weak fine medium platy at surface passing into moderate fine medium subangular blocky; few vertical cracks; many fine medium roots; fine medium pores; strongly calcareous; clear smooth to
B2	17-65	Brown (10YR 4/3) Clay, dry very hard; weak medium coarse prismatic breaking to moderate medium coarse angular blocky; common vertical cracks 1 cm wide; common fine medium roots, strongly calcareous; common dark $CaCo_3$ concretions; clear wavy to
B3Y	65-130	Brown (10YR 4/3) Clay; gritty with many gypsum crystals; moderate medium coarse angular blocky to massive; dry hard to slightly moist; saline efflorescence on cut faces; few fine roots; few horizontal cracks; strongly calcareous
B4Y	130-270	Dark yellowish brown (10YR 4/4) Clay; moist very firm; gypsum crystals; dark $CaCo_3$ concretions throughout
B5Y	270-335	Brown (10YR 4/3) Clay; common fine medium distinct (7.5YR 5/6) mottle; moist very firm; dark $CaCo_3$ concretions and gypsum common; MnO_2 stains in peds.

PROFILE No. 13 SITE No. PM21

HORIZON	DEPTH (cm)	SOIL PARTICLES % SAND 2000-50 μm	SILT 50-2 μm	CLAY <2 μm	TEXTURAL GROUP	EC (LAB) mmhos/cm	EC (FIELD) mmhos/cm
AB1	0-15	54	16	30	SCl	0.57	0.52
B2	20-40	43	15	42	C	2.25	3.0
B3,Y	65-85	38	12	50	C	8.63	10.0
B3Y	100-120	31	18	51	C	17.7	15.0

Avail P (ppm)	Total N (ppm)	Organic Carbon %	pH	EXCHANGEABLE CATIONS (me/100g) Ca	Mg	Na	K	CEC me/100g
1.0	869	0.71	8.1	39.2	5.8	0.89	0.78	24.3
0	392	0.47	8.8	26.2	11.7	8.23	0.84	27.8
			8.4	33.7	13.5	20.9	0.86	28.8
			8.5	36.7	15.5	27.0	2.56	31.0

Sat'n %	ESP	Field Tex.	CEC 100g/clay		AV'ABLE MICRONUTRIENTS (ppm) Cu	Zn	Mn	Fe
36	4	Cl	81		1.6	0.86	9.4	7.1
46	30	C	66		1.6	0.60	4.2	8.3
53	73	C	58					
36	87	C	61					

Field Ec	mmhos/cm
140-160	11.0
170-190	9.5
210-220	10.0
250-270	11.5
290-310	10.0
320-330	10.5

Description 14: M257

A. Information on the Site

Soil Mapping Unit:	D3	FAO Classification: Calcaric Fluvisol
Date of Examination:	5 February 1985	USDA Classification: Typic Ustifluvent
Location:		
Landform unit:	Levee/Upper coverplain (UC)	
Elevation:	Ca 45 m asl	
Land use:	Livestock browsing	
Slope:	1%	
Microrelief:	Even, no gilgai U0. Break in slope to channel	
Vegetation:	Riverine woodland - Acacia tortilis; A. nilotica	

B. Information on Site

Parent Material: Sub recent alluvium of Webi Goof
Drainage - Profile: Somewhat excessive
Drainage - Site: Good
Moisture Condition in Profile: Dry throughout
Flood hazard: Low - slightly rained position
Depth to groundwater: Not encountered
Surface features: Soft surface (10YR 5/3 dry)
Evidence of erosion: None

C. Brief Description of Profile

Stratified profile with surface horizons of loamy sand and sandy loam over buried clay topsoil. Beneath the clay the profile coarsens from sandy clay loam to sandy loam. Mottling below one metre suggests a reasonably fluctuating water table.

D. Profile Description

Horizon	Depth (cm)	Description
A	0-10	Dark brown (10YR 3/3) loamy medium sand; dry and soft; weak fine medium subangular blocky; strongly calcareous
B1	10-45	Dark brown (10YR 3/3) medium sandy loam; dry and soft; strongly calcareous
2Ab	45-75	Very dark grey (10YR 3/1) Clay; dry and soft; moderately high organic mottles of buried topsoil; strongly calcareous
3B2	75-110	Dark greyish brown (10YR 4/2) medium sandy clay loam; dry and soft; strongly calcareous
B3	110-120	Dark greyish brown (10YR 4/2); medium sandy loam; moist very friable; few medium prominent mottles (10YR 6/8); strongly calcareous.

Description 15: M258

A. Information on the Soil

Sub Mapping Unit:	D4	FAO Classification: Vertic Cambisol
Date of Examination:	9 February 1985	USDA Classification: Vertic Ustropept
Location:	1.5 km SW Sablaale; 0.5 km from Webi Shebelli	Author: R.N. Munro
Landform unit:	Upper coverplain	
Elevation:	Ca 45 m asl	
Land Use:	Land being cleared for irrigation	
Slope:	<1%	
Microrelief:	Even; no gilgai U0	
Vegetation:	Acacia zanzibarica and Thespesia danis bushland	

B. Information on Soil

Parent Material: Sub-recent calcareous alluvium of Webi Shabeelle
Drainage - Profile: Moderate/well
Drainage - Site: Good
Moisture Condition in Profile: Dry to 58, moist below
Flood hazard: Low - raised land of former levee
Depth to groundwater: Not encountered
Surface features: Firm hard surface (10YR 5/1 dry)
Evidence of erosion: None

C. Brief Description of Profile

Clay loam topsoil, passing into weakly prismatically structural clays. The subsoil is moist, and presence of soft neo-gypsum and saline crusts developing overnight on cut faces indicate a shallow saline water table. Field ECE determination shows high salinity hazard close to the surface, and irrigation should not proceed on these soils without deep drains and sufficient water to fulfill the leaching requirement.

D. Profile Description

Horizon	Depth (cm)	Description
	0-24	Very dark greyish brown (10YR 3/2) Clay loam; dry and slightly hard; moderate medium coarse subangular blocky; many fine medium roots; strongly calcareous
	24-58	Brown (10YR 4/3) Clay; dry very hard; weak medium prismatic breaking to moderate fine medium subangular blocky; few slickenslides with crusted roots; some sand on structural faces; few fine and medium roots; strongly calcareous
	58-120	Brown (10YR 4/3) Clay; moist and very firm; massive to weak moderate prismatic; sand on structural faces; saline efforescences on cut faces; soft neo-gypsum as well as hard crystals; few fine roots

Field ECE determination:		
	0-15	0.7 mmhos/cm
	25-40	5.0 mmhos/cm
	58-70	6.5 mmhos/cm
	90-105	11.0 mmhos/cm

Description 16: PM8

A. Information on the Site

Soil Mapping Unit: E
Date of Examination: 12 January 1985
Location: 7.5 km south of Sablaale
Landform unit: Sandy terrace (T)
Elevation: Ca 45 m asl
Land use: Livestock browsing
Slope: <1%
Microrelief: Even. No gilgai (U0). No sinkholes
Vegetation: Mixed open bushland

FAO Classification: Calcic Luvisol
USDA Classification: Typic Haplustalf
Author: R.N. Munro

B. Information on Soil

Parent Material: Old reddish sandy clay alluvium and aoelian dune
Drainage - Profile: Somewhat excessive
Drainage - Soil: Well
Moisture Condition in Profile: Dry throughout
Flood hazard: None - slightly elevated area
Depth to groundwater: Not encountered
Surface features: Firm surface underneath sandy smear (10YR 4/2 dry)
Evidence of erosion: None - sandy smear protects surface

C. Brief Description of Profile

The surface is a firm loam with an irregular surface mulch of sandy loam. Below 20 cm clay content increases to sandy clay, and there are mottled patches, and calcareous concretions. Generally matrix is non-calcareous above 50 cm. Below 50 cm the profile is redder (7.5YR hues) and washed sand particles indicate aeolian origin. Calcareous concretions occur in the 42-70 horizon, and at 120 cm there is the upper part of a concretionary gravel layer. These are $CaCo_3$ concretions in reddish clay matrix. This soil is too droughty for rainfed agriculture but is ideally suited for settlements.

D. Profile Description

Horizon	Depth (cm)	Description
A1	0 - 2	Very dark greyish brown (10YR 3/2) fine sandy loam; dry and loose mulch; few fine medium roots; non-calcareous; moderate fine crumb structure; moderate organic matter; abrupt smooth to
A2	(0)2-20	Very dark greyish brown (10YR 3/3) fine sandy clay loam; dry and hard top-soil; moderate fine to coarse subangular blocky; common vertical cracks; many fine medium roots; non-calcareous; gradual wavy to
Bt_1	20-42(50)	Dark yellowish brown (10YR 3/4) fine sandy clay; few faint medium mottles (2.5YR 4/8); moderate medium coarse angular blocky; common vertical cracks; common fine and few medium roots; non-calcareous; dry and hard; gradual irregular to
Bk2	42-70(100)	Dark brown (7.5YR 3/4) fine medium sandy clay; moderate medium coarse angular blocky; dry hard; common vertical crack; few weak slickenslides; few fine rare coarse roots; slightly calcareous; common 5 mm hard $CaCo_3$ concretions; common medium prominent 10YR 4/2 mottles; gradual irregular to
B3	70-120	Brown (7.5YR 4/4) fine medium sandy clay; massive; no cracks; few fine roots; slickenslides common; dry hard; common medium prominent 10YR 4/2 mottles; slightly calcareous; abrupt smooth to
BmK4	120-125+	Dark brown (7.5YR 3/4) gravelly sandy clay loam; dry and extremely hard; massive concretionary layer of $CaCo_3$ concretions (5 mm). No roots penetrate.

PROFILE No. 16 SITE No. PM8

HORIZON	DEPTH (cm)	SOIL PARTICLES % SAND 2000-50 µm	SILT 50-2 µm	CLAY <2 µm	TEXTURAL GROUP	EC (LAB) mmhos/cm	EC (FIELD) mmhos/cm
A12	0-2-	58	8	38	Scl	0.65	0.2
B1	20-40	49	7	44	Sc	0.65	0.7
BK2	50-65	52	4	44	Sc	0.85	0.85
B3	100-120	53	3	44	Sc	0.45	0.5

Avail P (ppm)	Total N (ppm)	Organic Carbon %	pH	EXCHANGEABLE CATIONS (me/100g) Ca	Mg	Na	K	CEC me/100g
0	1009	0.87	7.0	23.0	4.3	0.67	2.18	25.4
0	448	0.40	8.1	26.2	6.8	0.69	1.42	25.2
			8.0	24.1	6.3	0.82	1.47	28.2
			8.0	20.2	4.7	0.94	1.82	25.3

Sat'n %	ESP	Field Tex.	CEC 100g/clay	BULK DENSITY gm/cm³	AV'ABLE MICRONUTRIENTS (ppm) Cu	Zn	Mn	Fe
65	4	Scl	67		1.6	0.42	20.8	16.6
43	3	Sc	57		1.4	0.48	7.8	6.2
42	3	Sc	64					
40	4	Sc	57					

SOIL MOISTURE TENSIONS (bars) 0	0·1	0·3	1·0	5	15	DEPTH (cm)
						2.7
						25-30
						55-60

Description 17: M45

A. Information on the Site

Soil Mapping Unit:	F	FAO Classification: Gleyic Fluvisol
Date of Examination:	9 January 1985	USDA Classification: Typic Fluvaquent
Location:	11.5 km S of Sablaale	Author: R.N. Munro
Landform unit:	Active swamp (S)	
Elevation:	Ca 40 m asl	
Land use:	Wildlife grazing (Buffalo, hippopotamus)	
Slope:	<1%	
Microrelief:	Slightly uneven with hippo trails	
Vegetation:	Dense riparian thicket with mixed species	

B. Information on Soil

Parent Material: Recent calcareous alluvium of Webi Goof swamp complex
Drainage - Profile: Very poor, slowly permeable clays
Drainage - Site: Poor, negligible slope and presence of swamp close
Moisture Condition in Profile: Moist throughout
Flood hazard: Flooded for large part of year
Depth to groundwater: Not encountered; surface into table of swamp <15 m to west
Surface features: Soft clay surface with decaying vegetation
Evidence of erosion: None

C. Brief Description of Profile

Clayey profile, with moderate organic matter in surface layer passing into less organic clay with calcareous concretions. Field ECE shows uniform slight salinity throughout profile.

D. Profile Description

Horizon	Depth (cm)	Description
Ah	0.20	Dark greyish brown (10YR 4/2) Clay; moderate organic matter; strongly calcareous; moist friable to firm; massive structure; no mottles
Bl	20-100	Dark greyish brown (10YR 4/2) Clay; moist and very firm; matrix moderately calcareous; small $CaCo_3$ concretions; no mottles

Field ECE determination:	0-10	1.4 mmhos/cm
	20-40	1.1 mmhos/cm
	90-100	1.3 mmhos/cm

APPENDIX D

SOIL DATA REGISTER

Explanatory Notes

1. Site No.

PM = Profile Pit
M = Auger Site

2. Photo No.

Aerial Photograph overlay for site.
(Date 20/22 February 1983; 1:30 000 flown by Aerial Survey and Development of Frankfurt, for National Tsetse and Trypanosomiasis Control Project).

3. Landform

C	Former river channel or meander core
UC	Upper coverplain
LC	Lower coverplain
L	Sandy levee
T	Sandy terrace
S	Active swamp

For descriptions see Section 3.1

4. Textural Profile

Gives field texture and thickness of horizon
e.g. Cl - $Mscl_{20}$ C_{120} indicates clay loam 0-5 cm, medium sandy clay loam 5-20; Clay 20-120 cm.

Textural Groups (after USDA)

C	Clay	Fscl	fine sandy clay loam
Cl	Clay loam	Mscl	medium sandy clay loam
Scl	Sandy clay loam	Msc	medium sandy clay
Sicl	Silty clay loam	Fsc	fine sandy clay
Sc	Sandy clay	Fsl	fine sandy loam
L	loam	Msl	medium sandy loam
Sl	Sandy loam		
Lms	loamy medium sand		

5. Soil Class

Soil Mapping Unit. Descriptions are given in Chapter 4.

6. Land Use

LB	Livestock browsing
UN	Land ungrazed by livestock due to tsetse. Grazed by wildlife
CD	Land recently cleared for development
MR-A	Semi-mechanised rainfed farm - Arable strip
MR-B	Semi-mechanised rainfed farm - Bush strip
MR-F	Semi-mechanised rainfed farm - Fallow strip
TR	Traditional rainfed agriculture
TF	Traditional flood irrigation agriculture
IR	Irrigated agriculture(Farjano settlement).

7. Vegetation - Land Cover Type	Gives natural vegetation cover, or agricultural cover at each site. These are also mapping units for the land use - vegetation map. Full descriptions in Section 3.3.
8. Land Cover Density	Gives broad interpretation of density of the vegetation cover around each observation site.

i	open	<10% canopy cover. E.g. sparse bushes or shrubs on the grasslands (G1/G2); in bushland/ shrubland, there is easy access, with bushes >5 m apart.
ii	medium	20%-60% canopy cover. Approximately <5 m between bushes. Access easy to difficult.
iii	dense	50-100% canopy cover. E.g. closed canopy of bushland (B3); thickly vegetated impenetrable woodland (W1/W2). Access generally very difficult on foot.

9. Slope — Slope in percentage scale.

10. Microrelief (gilgai) — Reflects gilgai development around each site.

U0	none - land flat or almost flat
U1	slight undulating <30 cm difference between ridge and hollow
U2	moderately undulating 30-75 cm difference between ridge and hollow
U3	strongly undulating 75 cm - 1.0 m difference between ridge and hollow

11. Surface Features

MI	Surface mulch <2 cm thick
M2	Surface mulch 2-5 cm thick
M3	Surface mulch ≥5 cm thick
F	Firm hard crusted surface
S	Soft surface of swamp
P0	No sinkholes or rare
P1	Few sinkholes 5-15 m apart
P2	Common sinkholes <5 m apart

13. Notes

LAB1	Laboratory chemical and physical analysis available
LAB2	Laboratory physical (AWC) analysis available
FLD1	Field analysis of soil moisture
FLD2	Field analysis of electrical conductivity

SOIL DATA REGISTER - FARJANO, SOMALIA 1985

Site No.	Photo No.	Landform	Textural Profile	Soil Class	Land Use	Vegetation Land Cover Type	Land Cover Density	Slope %	Micro Relief (Gilgai)	Surface Features	Notes
PM 1	42-78-119	LC	Cl_3 C_{120}	A2	LB	B2	Medium	<1%	U1	M2 P2	LAB1,2,FLD1
PM 2	42-78-117	C	C_{120}	B1	LB	G1	Medium	<1%	U2	M2 P2	LAB1,2,FLD1
PM 3	42-78-119	LC	C_{120}	A1	LB	G1	Open	<1%	U1	M2 P2	
PM 4	42-78-117	LC	Cl_{10} C_{120}	C1	LB	S1	Open	<1%	U2	F P2	FLD1
PM 5	41-79-242	C	C_{120}	B2	LB	B3	Open	<1%	U2	M3 P2	
PM 6	41-79-242	L-UC	L_{10} $Fscl_{37}$	D1	LB	G1	Open	<1%	U0	F	FLD1
PM 7	41-79-240	LC	Cl_{10} C_{120}	A1	LB	B2	Medium	<1%	U1	F	
PM 8	41-79-240	T	Fsl_2 $Fscl_{20}$ $Fmsc_{120}$ Gravelly Scl_{125+}	E	LB	B1	Medium	<1%	U0	F	FLD1,LAB1,2
PM 9	41-79-240	C	Cl_5 C_{120}	B1	LB	G1	Open	<1%	U1	M3	
PM 10	42-78-119	UC	C_{20} C_{120}	D1	LB	B2	Open	<1%	U0	F P1	FLD1,LAB1,2
PM 11	42-78-121	LC	Cl_4 C_{120}	A1	LB	B2	Open	<1%	U2	M2 P2	LAB1,FLD1
PM 12	42-78-121	LC	C_{120}	A1	LB	B2	Open	<1%	U1	P2	
PM 13	42-78-121	C	C_{120}	B1	LB	B2	Dense	<1%	U2-3	M1 P2	
PM 14	42-78-117	LC	C_{120}	C1	LB	R5	Open	<1%	U1	F P2	
PM 15	63-77-152	LC	C_{120}	C1	LB	R5	Open	<1%	U1-2	F P2	
PM 16	63-77-152	LC	Cl_{10} C_{120}	C2	LB	R5	Open	<1%	U1	P2	
PM 17	41-79-238	LC	Cl_3 C_{70} C/Msl_{80} C_{120}	A1	LB	B2	Medium	<1%	U2	M2 P2	FLD1
PM 18	41-79-236	LC	C_{130}	A1	LB	B2	Medium	<1%	U2	F P2	FLD1
PM 19	42-78-117	LC	C_{130}	A2	LB	B2	Medium	<1%	U0	F P2	FLD1,LAB1
PM 20	42-78-117	LC	C_{120}	C2	Un	G2	Open	<1%	U2	P2	LAB1,2FLD1
PM 21	41-79-236	UC	Cl_{17} C_{335}	D2	LB	B2	Open	<1%	U0	F P1	LAB1, FLD1
PM 22	41-79-236	UC	Cl_{15} C_{120}	D2	LB	B2	Open	<1%	U0	F P1	
PM 23	41-79-236	UC	Cl_{10} C_{120}	D2	LB	B2	Open	<1%	U0	F P1	
PM 24	41-79-236	LC	Cl_{15} C_{120}	A2	LB	B2	Open	<1%	U1	F P2	
PM 25	42-78-117	LC	Cl_2 C_{135}	C1	LB	B3	Dense	<1%	U1-2	M2 P2	LAB1,2,FLD1,2
PM 26	42-78-117	C	Cl_{15} C_{130}	B1	LB	G1	Open	2%	U2	F P1	
PM 27	42-78-117	LC	Cl_{12} C_{125}	C1	Un	B2	Open	<1%	U1-2	F P2	FLD1
PM 28	42-78-117	LC	L_2 C_{120}	C1	Un	B2	Medium	<1%	U2	M1 P1	
PM 29	42-78-117	LC	C_{120}	C2	LB	B2	Open	<1%	U1	M2 P2	
PM 30	42-78-117	LC	C_{120}	C1	LB	B2	Medium	<1%	U1	M2 P2	
PM 31	42-78-117	LC	C_{130}	A2	LB	B2	Open	<1%	U1	M1	FLD1
PM 32	42-78-117	CM	C_{27} L_{37} C_{120}	B3	TF	R3	Open	<1%	U0	M2	FLD1
PM 33	42-78-117	C	C_{120}	B1	LB	G1	Open	<1%	U2	M2 P2	
PM 34	41-79-244	LC	C_{120}	C2	Un	B2	Medium	<1%	U0-1	M1 P2	FLD1, LAB1
PM 35	42-78-119	LC	C_{125}	C1	MR-B	R1	Open	<1%	U1	M1 P2	
PM 36	42-78-119	LC	C_{120}	C1	MR-A	R1	Open	<1%	U0-1	M3 P0	FLD2
PM 37	42-78-119	LC	C_{120}	C1	MR-F	R1	Open	<1%	U0	M3 P0	FLD2
PM 38	42-78-117	C	C_{120}	B1	LB	G1	Open	<1%	U2	M1 P2	
PM 39	41-79-236	LC	Cl_5 C_{120}	A2	TR	R2	Open	<1%	U0	M3 P0	FLD1

Site No.	Photo No.	Landform	Textural Profile	Soil Class	Land Use	Vegetation Land Cover Type	Land Cover Density	Slope %	Micro Relief (Gilgai)	Surface Features	Notes
M 1	42-78-117	LC	Cl_{20} C_{120}	A1	LB	B2	Medium	<1%	U1	M1 P2	
M 2	42-78-117	LC	Cl_{5} C_{120}	A2	LB	B2	Medium	<1%	U1	M2 P0	
M 3	42-78-117	LC	C_{120}	A1	LB	B2	Medium	<1%	U1	M2 P2	
M 4	42-78-117	LC	Cl_{4} C_{120}	A1	LB	B2	Medium	<1%	U1	M2	
M 5	42-78-117	C	Cl_{4} C_{120}	B1	LB	G1	Open	1%	U2	M2	
M 6	41-79-242	LC	Cl_{4} C_{120}	A1	LB	B4	Open	<1%	U1	M2 P2	
M 7	41-79-242	UC	L_{2} Cl_{20} $Fscl_{50}$ C_{120}	D1	LB	B4	Medium	<1%	U0	M1 P1	
M 8	41-79-242	UC	Cl_{10} L_{20} Cl_{30} C_{120}	D1	LB	B2	Medium	<1%	U0	F P1	
M 9	41-79-242	T	$Fscl_{80}$ Fsc_{120}	E	LB	B1	Medium	<1%	U0	F P0	
M 10	41-79-242	T	$Fscl_{80}$ Fsc_{120}	E	LB	B2	Medium	<1%	U0	F P0	
M 11	41-79-242	T	$Fscl_{50}$ Fsc_{120}	E	LB	B1	Medium	<1%	U0	F P0	
M 12	41-79-242	T	$Fscl_{70}$ Fsc_{120}	E	LB	B1	Medium	<1%	U0	F P0	
M 13	41-79-242	UC	L_{20} Cl_{40} C_{120}	D1	LB	B2	Open	<1%	U0	F P0	
M 14	41-79-242	LC	Cl_{40} C_{120}	A2	LB	B2	Dense	<1%	U0	F P1	
M 15	41-79-242	LC	C_{120}	A2	LB	W1	Medium	1%	U0	M1 P1	
M 16	42-78-119	LC	C_{120}	A2	LB	B2	Open	<1%	U2	M2 P2	
M 17	42-78-119	LC	C_{120}	A1	LB	B2	Open	<1%	U2	M2 P2	
M 18	42-78-119	LC	Cl_{20} C_{120}	A1	LB	B2	Open	<1%	U2	F P2	
M 19	42-78-119	LC	C_{120}	A2	LB	B3	Dense	<1%	U2	M1 P2	
M 20	42-78-119	LC	C_{120}	A1	LB	B2	Open	<1%	U2	M1 P2	
M 21	42-78-119	LC	C_{120}	A1	LB	B2	Medium	<1%	U2	M2 P2	
M 22	42-78-119	LC	C_{120}	A1	LB	G1	Open	<1%	U2	M1 P2	
M 23	42-78-119	LC	C_{120}	A1	LB	B2	Dense	<1%	U2	M3	
M 24	42-78-119	LC	C_{120}	A1	LB	B2	Medium	<1%	U2	M3 P2	
M 25	42-78-119	LC	C_{120}	A1	LB	B2	Dense	<1%	U2	M3	
M 26	42-78-119	LC	C_{120}	A1	LB	B2	Medium	<1%	U2	M2	
M 27	41-79-240	LC	C_{120}	A1	LB	B2	Medium	<1%	U2	M1	
M 28	42-78-119	LC	C_{120}	A1	LB	G1	Open	<1%	U2	M2 P2	
M 29	42-78-119	LC	C_{120}	A1	LB	B2	Medium	<1%	U2	M2 P2	
M 30	42-78-119	LC	C_{120}	A1	LB	G1	Medium	<1%	U1	M2	

Site No.	Photo No.	Landform	Textural Profile	Soil Class	Land Use	Vegetation Land Cover Type	Land Cover Density	Slope %	Micro Relief (Gilgai)	Surface Features	Notes
M 31	42-78-119	UC	$Sicl_{25}$ C_{120}	D1	LB	G1	Medium	<1%	U0-1	F P1	
M 32	42-78-117	UC	Cl_{70} C_{120}	D1	LB	G1	Medium	<1%	U0-1	F P1	
M 33	41-79-240	LC	C_{120}	A2	LB	G1	Open	<1%	U1	M1	
M 34	41-79-240	LC	$Sicl_{25}$ C_{120}	A2	LB	B2	Open	<1%	U1	M1 P1	
M 35	41-79-242	LC	C_{120}	A1	LB	B2	Medium	<1%	U1	M1 P2	
M 36	41-79-242	C	C_{120}	B2	LB	G1	Medium	<1%	U2	M3	
M 37	41-79-242	UC	L_{20} $Fscl_{30}$ Cl_{60} C_{120}	D1	LB	B2	Medium	<1%	U0-1	F	
M 38	41-79-242	UC	$Fscl_{35}$ C_{120}	D1	LB	B2	Medium	<1%	U0	F P1	
M 39	41-79-242	UC	L_{10} $Fscl_{50}$ Fsc_{120}	D1	LB	B2	Medium	<1%	U0	F	
M 40	41-79-242	UC	Scl_{20} Sc_{40} C_{120}	D1	LB	B2	Medium	<1%	U0	F P0	
M 41	41-79-242	UC	Cl_{10} C_{120}	D1	LB	B2	Medium	<1%	U0	F	
M 42	41-79-242	C	C_{120}	B1	LB	B2	Open	<1%	U2	M3 P2	
M 43	41-79-242	LC	C_{120}	A2	LB	B2	Medium	1%	U1	M2 P2	
M 44	41-79-242	LC	C_{120}	A2	LB	B2	Dense	<1%	U1	M1	FLD1
M 45	41-79-242	S	C_{100}	F	UN	W1	Dense	<1%	U0	S	FLD1
M 46	42-79-119	LC	Cl_{5} C_{120}	A1	LB	B2	Open	<1%	U2	M3 P2	
M 47	41-79-240	LC	Cl_{10} C_{120}	A1	LB	B2	Medium	<1%	U2-3	M1 P2	
M 48	41-79-240	C	C_{120}	B1	LB	G1	Open	<1%	U2-3	F P2	
M 49	41-79-240	LC	C_{120}	A1	LB	B2	Dense	<1%	U3	M1	
M 50	41-79-240	LC	C_{120}	A1	LB	B2	Dense	<1%	U2	M1 P2	
M 51	41-79-240	LC	Cl_{20} C_{120}	A1	LB	B2	Dense	<1%	U1	F P1	
M 52	41-79-240	LC	Cl_{20} C_{120}	A1	LB	B2	Medium	<1%	U1	F P1	
M 53	41-79-242	LC	C_{120}	A1	LB	B2	Medium	<1%	U2	M3	
M 54	41-79-242	LC	C_{120}	A1	LB	B2	Open	<1%	U2	M1	
M 55	41-79-242	LC	C_{120}	A1	LB	G1	Open	<1%	U2	M1	
M 56	41-79-242	LC	C_{120}	A1	LB	B2	Open	<1%	U2	M1 P2	
M 57	41-79-242	LC	C_{120}	A1	LB	B2	Open	<1%	U2	F	
M 58	41-79-242	LC	C_{120}	A2	LB	B2	Open	<1%	U2	M1 P2	
M 59	41-79-242	S	C_{120}	F	UN	PS	Dense	<1%	U1	S P0	
M 60	41-78-119	LC	C_{120}	A1	LB	B2	Open	<1%	U1	F	

Site No.	Photo No.	Landform	Textural Profile	Soil Class	Land Use	Vegetation Land Cover Type	Land Cover Density	Slope %	Micro Relief (Gilgai)	Surface Features	Notes
M 61	42-78-119	UC	Cl_{25} C_{120}	D1	LB	B2	Open	<1%	U0	F P0	
M 62	42-78-119	LC	C_{120}	A1	LB	B2	Medium	<1%	U1	M1	
M 63	42-78-119	UC	Fsc_{120}	D1	LB	B2	Medium	<1%	U0-1	F P1	
M 64	42-78-119	LC	C_{120}	A2	LB	G1	Medium	<1%	U1	F P2	
M 65	42-78-119	LC	C_{120}	A2	MR-B	R1	Medium	<1%	U0-1	F P2	
M 66	42-78-119	LC	C_{120}	A1	MR-A	R1	Open	<1%	U1	M3 P0	
M 67	42-78-119	LC	C_{120}	A2	MR-F	R1	Open	<1%	U1	M1 P0	
M 68	42-78-119	LC	C_{120}	A1	MR-B	R1	Open	<1%	U1	M2 P2	
M 69	42-78-119	C	C_{120}	B1	LB	B3	Dense	<1%	U2	M1 P2	
M 70	42-78-119	LC	C_{120}	A2	LB	B3	Medium	<1%	U2	M2 P2	
M 71	42-78-119	LC	C_{120}	A1	LB	G1	Open	<1%	U2	M2 P2	
M 72	42-78-119	LC	C_{120}	A1	LB	G1	Medium	<1%	U1-2	M2 P2	
M 73	42-78-119	LC	C_{120}	A1	LB	G1	Medium	<1%	U2	M2 P2	
M 74	42-78-119	LC	C_{120}	A1	LB	B2	Dense	<1%	U1	F P2	
M 75	42-78-119	LC	C_{120}	A1	LB	G1	Open	<1%	U2	M1 P2	
M 76	41-79-240	LC	C_{120}	A1	LB	B2	Dense	<1%	U2	M2 P2	
M 77	41-79-240	LC	C_{120}	A1	LB	B2	Dense	<1%	U2	M3 P2	
M 78	41-79-240	LC	C_{120}	A1	LB	B2	Dense	<1%	U1-2	M1 P2	
M 79	41-79-240	LC	C_{120}	A1	LB	B2	Medium	<1%	U2	M2 P2	
M 80	41-79-240	LC	C_{120}	A1	LB	B2	Dense	<1%	U2	M1 P2	
M 81	41-79-240	LC	C_{120}	A1	LB	B2	Dense	<1%	U2	M1 P2	
M 82	41-79-240	LC	Cl_{2} C_{120}	A1	LB	B2	Dense	<1%	U3	M1 P2	
M 83	41-79-240	LC	C_{120}	A1	LB	B2	Medium	<1%	U1	M2 P0	
M 84	41-79-240	LC	C_{120}	A1	LB	B2	Medium	<1%	U2	M3 P1	
M 85	41-79-240	LC	C_{120}	A2	LB	W1	Medium	<1%	U1	F P0	
M 86	42-78-119	LC	C_{120}	C1	LB	B2	Medium	<1%	U1	F P2	
M 87	42-78-119	LC	C_{120}	A1	LB	G1	Open	<1%	U1-2	M1 P2	
M 88	42-78-119	LC	Cl_{20} C_{120}	A1	LB	B2	Medium	<1%	U1-2	F P2	
M 89	42-78-119	LC	Scl_{20} C_{120}	D1	LB	B3	Dense	<1%	U1-2	F P2	
M 90	41-79-238	LC	C_{120}	A1	LB	B2	Open	<1%	U1-2	M1 P2	

Site No.	Photo No.	Landform	Textural Profile	Soil Class	Land Use	Vegetation Land Cover Type	Land Cover Density	Slope %	Micro Relief (Gilgai)	Surface Features	Notes
M 91	41-79-240	LC	C_{120}	A1	LB	B2	Open	<1%	U2	M1 P2	
M 92	41-79-240	LC	C_{120}	A1	LB	B2	Medium	<1%	U1	M2 P2	
M 93	41-79-240	LC	C_{120}	A1	LB	B2	Medium	<1%	U1	M2 P2	
M 94	41-79-240	LC	C_{120}	A3	LB	G1	Open	<1%	U2	F P0	
M 95	41-79-238	LC	C_{120}	A1	LB	B2	Dense	<1%	U1-2	M2 P2	
M 96	41-79-238	LC	C_{120}	A1	LB	B2	Open	<1%	U2	M1 P2	
M 97	41-79-238	LC	C_{120}	A1	LB	B2	Open	<1%	U2	M2 P2	
M 98	42-78-119	LC	C_{120}	A1	LB	B2	Medium	<1%	U1-2	F P2	
M 99	42-78-121	LC	C_{120}	A1	LB	B2	Medium	<1%	U2	M2 P2	
M 100	42-78-121	LC	Cl_{5} C_{120}	A1	LB	B2	Open	<1%	U2	M3 P2	
M 101	42-78-121	LC	C_{60} Msc_{70} C_{120}	A1	LB	B2	Open	<1%	U1-2	M1 P2	
M 102	42-78-121	LC	C_{120}	A1	LB	B2	Dense	<1%	U2	M2 P2	
M 103	41-79-238	LC	Cl_{25} C_{120}	C1	LB	B2	Open	<1%	U2	F P2	
M 104	41-79-238	LC	C_{120}	A1	LB	B2	Dense	<1%	U2	M3 P2	
M 105	41-79-238	LC	C_{120}	A1	LB	B2	Medium	<1%	U2	M1 P2	
M 106	41-79-238	UC	C_{15} Msc_{120}	D1	LB	B2	Dense	<1%	U1	M1 P2	
M 107	41-79-238	UC	Scl_{15} Fsc_{55} C_{120}	D1	LB	B2	Medium	<1%	U1	M1 P2	
M 108	41-79-238	LC	Cl_{20} C_{120}	A1	LB	B2	Open	<1%	U1	F P2	
M 109	41-79-238	LC	C_{120}	A1	LB	B2	Open	<1%	-	F P2	
M 110	41-79-240	LC	C_{120}	A1	LB	B2	Medium	<1%	U1	M2 P2	
M 111	41-79-240	C	C_{120}	B1	LB	G1	Open	<1%	U2	F P0	
M 112	41-79-240	LC	C_{120}	A3	LB	G1	Medium	<1%	U2	F	
M 113	41-79-240	LC	C_{120}	A1	LB	B2	Medium	<1%	U2	M1 P2	
M 114	42-78-121	LC	C_{120}	A1	LB	S2	Open	<1%	U2	M2 P2	
M 115	41-79-238	LC	C_{120}	A1	LB	B2	Medium	<1%	U2	M3 P2	
M 116	41-79-238	LC	Cl_{15} Fsc_{60} C_{120}	C1	LB	B2	Medium	<1%	U2	F P2	
M 117	41-79-238	LC	Scl_{30} C_{120}	C1	LB	B2	Medium	<1%	U2	F P2	
M 118	41-79-238	UC	Fsl_{20} $Fscl_{20}$ Fsc_{120}	D1	LB	B2	Open	<1%	U0	F P0	
M 119	41-79-238	LC	C_{120}	A1	LB	B2	Medium	<1%	U2	M3 P2	
M 120	41-79-238	LC	Cl_{20} C_{120}	A1	LB	B2	Open	<1%	U2	M1 P2	

Site No.	Photo No.	Landform	Textural Profile	Soil Class	Land Use	Vegetation Land Cover Type	Land Cover Density	Slope %	Micro Relief (Gilgai)	Surface Features	Notes
M 121	41-79-238	LC	C_{120}	A1	LB	B2	Medium	<1%	U1	F P2	
M 122	41-79-238	LC	C_{120}	A1	LB	B2	Medium	<1%	U2	F P2	
M 123	41-79-238	LC	$Scl_5\ C_{120}$	C1	LB	B2	Open	<1%	U1	M1 P2	
M 124	41-79-238	LC	C_{120}	A1	LB	B2	Open	<1%	U2-3	M1 P2	
M 125	41-79-238	LC	C_{120}	A1	LB	B2	Open	<1%	U1	M1 P2	
M 126	41-79-238	LC	C_{120}	A1	LB	B2	Open	<1%	U1	M2 P2	
M 127	41-79-240	LC	C_{120}	A3	LB	W1	Dense	<1%	U1	F P0	FLD1
M 128	41-79-238	LC	C_{120}	A1	LB	B2	Dense	<1%	U2	M3 P2	
M 129	41-79-238	LC	$Cl_5\ C_{120}$	A1	LB	B2	Open	<1%	U1	M3 P2	
M 130	41-79-238	LC	C_{120}	A1	LB	B2	Open	<1%	U1	M1 P2	
M 131	41-79-238	LC	$Scl_{30}\ C_{120}$	C1	LB	B2	Open	<1%	U1	M1 P2	
M 132	41-79-238	LC	$Sc_{20}\ C_{120}$	C1	LB	B2	Open	<1%	U1-2	M1 P2	
M 133	41-79-238	LC	C_{120}	A1	LB	B2	Open	<1%	U2	M1 P2	
M 134	41-79-238	LC	C_{120}	A1	LB	B2	Medium	<1%	U1	M1 P2	
M 135	41-79-238	LC	C_{120}	A1	LB	B2	Open	<1%	U1-2	M1 P2	
M 136	41-79-238	LC	C_{120}	C1	LB	B2	Medium	<1%	U2	F P2	
M 137	41-79-238	LC	$Cl_5\ C_{120}$	C1	LB	B2	Medium	<1%	U2	M3 P2	
M 138	41-79-238	LC	C_{120}	C1	LB	B2	Open	<1%	U2	M1 P2	
M 139	41-79-238	LC	C_{120}	A1	LB	B2	Dense	<1%	U1	M1 P2	
M 140	42-78-117	LC	C_{120}	A1	LB	B2	Medium	<1%	U1	M2 P2	
M 141	42-78-117	UC	$Cl_{10}\ C_{120}$	D1	LB	B2	Medium	<1%	U0	F P1	
M 142	42-78-117	UC	$Cl_4\ C_{120}$	D1	LB	B2	Medium	<1%	U0	M1 P0	
M 143	42-78-117	UC	$Cl_{30}\ C_{120}$	D1	LB	B2	Medium	<1%	U0	M1 P0	
M 144	42-78-117	UC	$Cl_{20}\ C_{120}$	D1	LB	B2	Medium	<1%	U0	M1 P0	
M 145	42-78-117	C	C_{120}	B1	LB	B2	Dense	<1%	U2	M2 P2	
M 146	42-78-117	UC	$Cl_{30}\ C_{120}$	D1	LB	B2	Medium	<1%	U1	M2 P2	
M 147	42-78-117	LC	$Cl_4\ C_{120}$	A2	LB	B2	Medium	<1%	U1	M2 P2	
M 148	42-78-117	UC	$Cl_{25}\ C_{120}$	D1	LB	B2	Medium	<1%	U0	F P0	
M 149	42-78-117	LC	$Cl_4\ C_{120}$	C1	LB	B2	Medium	<1%	U1	M2 P2	
M 150	41-79-242	LC	$Cl_{10}\ C_{120}$	C1	LB	B2	Open	<1%	U1	M1 P2	

Site No.	Photo No.	Landform	Textural Profile	Soil Class	Land Use	Vegetation Land Cover Type	Land Cover Density	Slope %	Micro Relief (Gilgai)	Surface Features	Notes
M 151	41-79-242	LC	C_{120}	C1	LB	G1	Medium	<1%	U2	M1 P2	
M 152	41-79-242	LC	C_{120}	C1	LB	B2	Medium	<1%	U2	F P2	
M 153	41-79-242	LC	Cl_{4} C_{120}	C1	LB	S2	Dense	<1%	U2	M2 P2	
M 154	41-79-242	LC	Cl_{10} C_{120}	C1	LB	B2	Medium	<1%	U1	M1 P2	
M 155	41-79-242	LC	Scl_{2} Cl_{20} C_{120}	A2	LB	B2	Medium	<1%	U2	M1 P2	
M 156	41-79-242	S	C_{60} (wet)	F	UN	PS	Medium	<1%	U0	S P0	
M 157	41-79-236	LC	Cl_{20} $Fscl_{30}$ Fsc_{70} C_{120}	C1	LB	S2	Medium	<1%	U1-2	F P2	
M 158	41-79-236	LC	Cl_{20} C_{120}	A1	LB	S2	Medium	<1%	U2	F P2	
M 159	41-79-236	LC	C_{120}	A1	LB	G1	Open	<1%	U2	F P2	
M 160	41-79-236	LC	Cl_{4} C_{120}	A2	LB	B2	Open	<1%	U1	M2 P2	
M 161	41-79-238	LC	C_{120}	C1	LB	B2	Medium	<1%	U2	M1 P2	
M 162	41-79-238	LC	Cl_{30} C_{120}	C1	LB	B2	Medium	<1%	U2	M1 P2	
M 163	41-79-238	LC	Cl_{30} C_{120}	C1	LB	G1	Open	<1%	U2	F P2	
M 164	41-79-238	LC	Cl_{10} C_{120}	C1	LB	B2	Open	<1%	U1	M1 P2	
M 165	41-79-238	UC	Cl_{20} C_{120}	D1	LB	B2	Open	<1%	U1	F P1	
M 166	41-79-238	LC	C_{120}	A1	LB	B2	Medium	<1%	U1	F P1	
M 167	41-79-238	LC	C_{120}	A2	LB	B2	Open	<1%	U1	F P1	
M 168	41-79-238	LC	Cl_{25} C_{120}	A1	LB	G1	Open	<1%	U2	M1 P2	
M 169	41-79-238	S	C_{120}	F	LB	PS	Medium	<1%	U1	F P0	
M 170	41-79-236	UC	Cl_{15} C_{120}	D2	LB	B2	Open	<1%	U0	F P2	
M 171	41-79-236	LC	Cl_{10} C_{120}	A2	LB	S2	Open	<1%	U1	F P2	
M 172	41-79-236	C	C_{120}	B1	LB	B2	Medium	<1%	U2	M1 P2	
M 173	41-79-236	LC	C_{120}	A1	LB	B2	Open	<1%	U2	M1 P2	
M 174	41-79-236	LC	Cl_{15} C_{120}	A1	LB	B2	Open	<1%	U2	M2 P2	
M 175	41-79-236	LC	Cl_{15} C_{120}	A1	LB	B2	Open	<1%	U2	F P2	
M 176	41-79-236	LC	Cl_{10} C_{120}	A1	LB	B2	Open	<1%	U1	F P2	
M 177	41-79-236	LC	C_{120}	A1	LB	S2	Medium	<1%	U0-1	M2 P2	
M 178	41-79-238	LC	Cl_{25} C_{120}	A1	LB	B2	Open	<1%	U2	M1 P2	
M 179	41-80-218	LC	C_{120}	A1	LB	B2	Open	<1%	U2	M1 P2	
M 180	41-80-218	LC	C_{120}	A1	LB	B2	Open	<1%	U2	M2 P2	

Site No.	Photo No.	Landform	Textural Profile	Soil Class	Land Use	Vegetation Land Cover Type	Land Cover Density	Slope %	Micro Relief (Gilgai)	Surface Features	Notes
M 181	41-80-218	LC	C_{120}	A1	LB	B2	Open	<1%	U2	M1 P2	
M 182	41-80-218	LC	C_{120}	A1	LB	B2	Open	<1%	U1	M2 P2	
M 183	42-78-117	LC	C_{120}	C1	UN	B3	Dense	<1%	U2	M3 P2	
M 184	42-78-117	LC	C_{120}	C2	UN	B3	Dense	<1%	U2	M3 P2	
M 185	42-78-117	LC	Cl_4 C_{120}	C2	UN	B3	Dense	<1%	U2	M3 P2	
M 186	42-78-115	LC	C_{120}	C2	UN	B3	Dense	<1%	U1	M2 P2	
M 187	41-79-242	LC	Scl_2 C_{120}	C1	UN	G2	Open	<1%	U1	M1 P2	
M 188	41-79-242	LC	C_{120}	A1	UN	G2	Open	<1%	U1-2	M1 P2	
M 189	41-79-242	LC	C_{120}	A2	UN	S2	Open	<1%	U2	M1 P2	
M 190	41-79-242	LC	C_{120}	C2	UN	B2	Medium	<1%	U1-2	M2 P2	
M 191	41-79-244	LC	C_{120}	C2	UN	B2	Medium	<1%	U2	M1 P2	
M 192	41-79-244	LC	C_{120}	C2	UN	B2	Medium	<1%	U2	M1 P2	
M 193	41-79-244	LC	Cl_5 C_{120}	C2	UN	B2	Medium	<1%	U2	M3 P2	
M 194	41-79-244	S	C_{120}	F	UN	W1	Dense	<1%	U1-2	F P0	
M 195	42-78-117	LC	Cl_{15} C_{120}	C2	CD/UN	R5	Open	<1%	U2	M1 P2	
M 196	42-78-117	LC	C_{120}	C2	UN	B3	Dense	<1%	U2-3	M1 P2	
M 197	42-78-115	LC	C_{120}	C1	UN	B2	Open	<1%	U2	M2 P2	
M 198	42-78-115	LC	C_{120}	C1	UN	B3	Dense	<1%	U2	M1 P2	
M 199	42-78-115	LC	C_{120}	C1	UN	G2	Medium	<1%	U1-2	F P2	
M 200	42-75-115	LC	Cl_4 C_{120}	C2	UN	B3	Open	<1%	U2	M2 P2	
M 201	42-78-115	LC	Cl_4 C_{120}	C2	UN	B3	Medium	<1%	U1	M2 P2	
M 202	41-79-244	LC	C_{120}	C2	UN	B2	Medium	<1%	U1	M2 P2	
M 203	41-79-244	LC	C_{120}	C2	UN	B2	Medium	<1%	U2	M3 P2	
M 204	41-79-244	LC	C_{120}	C2	UN	B2	Open	<1%	U1	M1 P1	
M 205	41-79-244	LC	Cl_{20} C_{120}	C2	UN	B2	Open	<1%	U1-2	M1 P2	
M 206	41-79-244	LC	C_{120}	A3	UN	B2	Open	<1%	U2	M1 P2	
M 207	41-79-244	LC	C_{120}	A3	UN	W1	Dense	<1%	U0	F P0	
M 208	41-79-244	S	C_{120}	F	UN	PS	Dense	<1%	U0	S P0	
M 209	42-78-117	LC	C_{130}	C2	UN	G2	Open	<1%	U2	M3 P1	
M 210	42-78-117	LC	Cl_4 C_{120}	C2	LB	G1	Medium	<1%	U0	M1 P2	

Site No.	Photo No.	Landform	Textural Profile	Soil Class	Land Use	Vegetation Land Cover Type	Land Cover Density	Slope %	Micro Relief (Gilgai)	Surface Features	Notes
M 211	42-78-117	LC	C_{135}	C2	UN	B2	Medium	<1%	U1	M2 P2	
M 212	42-78-115	LC	Cl_5 C_{120}	C2	UN	B2	Medium	<1%	U1-2	M3	
M 213	42-78-115	LC	Cl_4 C_{120}	C2	UN	B2	Medium	<1%	U1	M2 P1	
M 214	42-78-115	C	C_{120}	A3	UN	G2	Open	<1%	U0	F P0	
M 215	42-78-115	UC	C_{120}	D4	UN	B2	Medium	<1%	U2	M3 P2	
M 216	42-78-115	UC	C_{120}	D4	UN	W2	Dense	<1%	U1	M1 P1	
M 217	42-78-115	C	C_{70} Cl_{120}	B3	UN	G2	Open	<1%	U3	F P0	
M 218	42-78-115	LC	Cl_4 C_{120}	C2	UN	B2	Medium	<1%	U1	M2 P2	
M 219	42-78-115	LC	C_{120}	C2	UN	B2	Medium	<1%	U1	F P2	
M 220	42-78-115	LC	C_{120}	C2	UN	B2	Medium	<1%	U1	F P2	
M 221	41-79-244	LC	C_{120}	C2	UN	B2	Medium	<1%	U1	M1 P1	
M 222	41-79-244	LC	Cl_{10} C_{120}	C2	UN	B2	Medium	<1%	U1	M1 P1	
M 223	41-79-244	LC	C_{120}	C2	UN	B2	Medium	<1%	U1	M1 P1	
M 224	41-79-244	LC	Cl_{20} C_{120}	A3	UN	B2	Medium	<1%	U1	M1 P2	
M 225	41-79-244	S	L_2 C_{120}	F	UN	W1	Dense	<1%	U0	S P0	
M 226	41-79-244	LC	C_{120}	A3	IR	R4	Open	<1%	U0	M1 P0	FLD1
M 227	41-79-244	LC	Cl_{10} C_{120}	A3	IR	R4	Open	<1%	U0	M1 P0	FLD1
M 228	42-78-117	LC	Cl_4 C_{120}	A2	LB	B3	Dense	<1%	U2	M2 P2	
M 229	42-78-117	LC	Cl_4 C_{120}	A1	LB	B3	Dense	<1%	U2	M2 P2	
M 230	42-78-117	LC	Cl_{15} C_{120}	C1	LB	B3	Dense	<1%	U0-1	F P2	
M 231	42-78-117	LC	Cl_{20} C_{120}	C1	LB	B3	Open	<1%	U1-2	F P2	
M 232	42-78-117	LC	Cl_{15} C_{120}	C1	LB	S2	Open	<1%	U0-1	F P2	
M 233	63-77-152	LC	Cl_4 C_{120}	C2	CD	R5	Open	<1%	U1	M2 P2	
M 234	41-79-244	LC	Cl_{15} C_{120}	A3	IR	R4	Open	<1%	U0	M2 P0	
M 235	63-77-152	LC	C_{120}	C1	CD	R5	Open	<1%	U2	M1 P2	
M 236	63-77-152	LC	C_{120}	C1	LB	B3	Dense	<1%	U1	F P0	
M 237	42-78-117	UC	Cl_{15} C_{120}	D4	LB	B2	Dense	<1%	U0	F P0	
M 238	42-78-117	LC	Cl_4 C_{120}	C1	UN	B2	Medium	<1%	U1-2	M2 P2	
M 239	42-78-117	LC	Scl_{15} C_{120}	C1	LB	B2	Medium	<1%	U2	F P2	
M 240	42-78-117	LC	C_{120}	C1	LB	B2	Medium	<1%	U2	F P2	

Site No.	Photo No.	Landform	Textural Profile	Soil Class	Land Use	Vegetation Land Cover Type	Land Cover Density	Slope %	Micro Relief (Gilgai)	Surface Features	Notes
M 241	42-78-117	LC	Cl_{25} C_{120}	C1	LB	B2	Medium	<1%	U1-2	M1 P2	
M 242	41-79-236	LC	Cl_{10} C_{120}	D2	LB	B2	Open	<1%	U1	F P2	
M 243	41-79-236	UC	C_{120}	D2	LB	B2	Open	<1%	U0-1	F P2	
M 244	41-79-236	UC	Cl_{15} C_{120}	D2	LB	B2	Open	<1%	U1	F P2	
M 245	41-79-236	LC	C_{120}	A2	LB	B2	Open	<1%	U1-2	M2 P2	
M 246	41-79-236	LC	C_{120}	A1	LB	S2	Dense	<1%	U2	M2 P2	
M 247	41-79-236	LC/UC	Cl_{8} C_{120}	A1	LB	B2	Open	<1%	U1-2	M1 P2	
M 248	41-79-236	UC	Cl_{20} C_{120}	D1	LB	B2	Open	<1%	U2	F P2	
M 249	41-79-236	LC	Cl_{10} C_{120}	C1	LB	B2	Open	<1%	U2	M1 P2	
M 250	41-79-236	LC	C_{120}	A2	LB.	B2	Open	<1%	U1-2	M1 P2	
M 251	41-79-238	UC	C_{120}	D1	LB	B2	Open	<1%	U0	M1	
M 252	41-79-238	C	C_{120}	B1	LB	B2	Open	<1%	U2	M2 P2	
M 253	41-79-238	UC	Cl_{10} C_{120}	D1	LB	B2	Open	<1%	U1	M1 P2	
M 254	41-79-238	C	Cl_{20} C_{120}	B2	LB	B2	Open	<1%	U2	F P2	
M 255	41-80-218	UC	Cl_{20} C_{120}	D1	LB	B2	Open	<1%	U1	M1 P2	
M 256	41-80-218	LC	C_{120}	A1	LB	B2	Open	<1%	U2	M1 P2	
M 257	41-80-218	UC	Lms_{10} Msl_{45} C_{75} $Mscl_{110}$ Msl_{120}	D3	LB	W1	Dense	<1%	U0-1	M1	
M 258	63-77-152	UC	Cl_{24} C_{120}	D4	CD	B2	Open	<1%	U0	F P0	FLD1
M 259	63-77-152	UC	Cl_{10} C_{120}	D4	LB	B2	Open	<1%	U0	F P0	FLD1
M 260	63-77-152	UC	C_{120}	D4	LB	B2	Medium	<1%	U0-1	F P2	
M 261	63-77-152	LC	C_{120}	A3	CD	R5	Open	1%	U1	M1 P2	FLD1
M 262	41-79-244	LC	C_{120}	C2	CD	R5	Open	<1%	U0		FLD1(well log)
M 263	41-79-236	LC	C_{120}	A2	TR	R2	Open	<1%	U1	M3 P0	
M 264	41-79-236	LC	Cl_{5} C_{120}	A2	TR	R2	Open	<1%	U0-1	M3 P0	
M 265	41-79-236	UC	Cl_{15} C_{120}	D1	LB	S2	Open	<1%	U0	F P2	
M 266	41-79-236	UC	Cl_{5} C_{65} Scl_{10} C_{120}	D3	LB	W1	Medium	2%	U1	M3 P1	
M 267	41-79-236	LC	C_{120}	A1	LB	B2	Open	<1%	U1	F P2	
M 268	41-79-236	UC	Cl_{10} C_{120}	D1	LB	B2	Open	<1%	U0-1	F P2	
M 269	41-79-236	C	Cl_{10} C_{120}	B1	LB	S2	Medium	2%	U2	M3 P2	
M 270	41-79-236	LC	Cl_{10} C_{120}	A2	TR/LB	S2	Open	<1%	U0	M1 P2	

Site No.	Photo No.	Landform	Textural Profile	Soil Class	Land Use	Vegetation Land Cover Type	Land Cover Density	Slope %	Micro Relief (Gilgai)	Surface Features	Notes
M 271	42-78-119	LC	Cl_{10} C_{120}	A1	LB	B2	Open	<1%	U1	F P2	
M 272	42-78-119	UC	Cl_{10} C_{120}	D1	LB	B2	Open	<1%	U0-1	M1 P1	
M 273	42-78-117	UC	Cl_{10} C_{120}	D1	LB	B2	Medium	<1%	U0	F P1	
M 274	42-78-117	UC	Cl_{10} C_{120}	D1	LB	B2	Open	<1%	U0-1	F P0	
M 275	42-78-117	UC	Cl_{10} C_{120}	D1	LB	B2	Open	<1%	U0	F P0	
M 276	42-78-117	UC	Cl_{30} C_{120}	D1	LB	B2	Open	<1%	U0-1	M1 P1	
M 277	41-79-242	T	$Mscl_{45}$ $Fscl_{60}$ Fsc_{120}	E	LB	B1	Medium	<1%	U0	M3 P1	
M 278	41-79-242	UC	Cl_{10} C_{120}	D1	LB	B2	Open	<1%	U0	F P1	
M 279	41-79-242	UC	Cl_{15} C_{10} Msc_{120}	D1	LB	B2	Open	<1%	U0	F P1	
M 280	42-78-117	LC	Cl_{5} C_{120}	C1	LB	B3	Medium	<1%	U2	M3 P2	
M 281	42-78-117	LC	Cl_{5} C_{120}	C1	LB	B3	Medium	<1%	U1-2	M3 P2	
M 282	42-78-119	LC	Cl_{5} C_{120}	C1	LB	B2	Open	<1%	U1-2	M3 P3	
M 283	42-78-119	LC	C_{120}	C1	MR-F	R1	Open	<1%	U1	M3 P0	
M 284	42-78-119	LC	C_{120}	C1	MR-B	R1	Open	<1%	U2	M1 P2	
M 285	42-78-117	LC	C_{120}	A1	LB	B2	Open	<1%	U2	M1 P2	
M 286	42-78-119	UC	Cl_{45} C_{120}	D1	LB	B2	Open	<1%	U1	M P2	
M 287	42-78-119	LC	Cl_{25} C_{120}	C1	LB	B2	Medium	<1%	U1	M1 P2	
M 288	42-78-119	LC	C_{120}	A2	MR-B	R1	Open	<1%	U0-1	M1 P2	
M 289	42-78-119	LC	C_{120}	A1	MR-A	R1	Open	<1%	U0-1	M3 P0	
M 290	42-78-119	UC	Cl_{15} C_{120}	D1	LB	B2	Open	<1%	U0	F P2	
M 291	42-78-119	C	Cl_{15} C_{120}	B1	LB	B2	Medium	1%	U2	M1 P2	
M 292	42-78-119	LC	C_{120}	C1	MR-F	R1	Open	<1%	U1	M3 P0	
M 293	41-79-242	T	Fsl_{10} $Fscl_{25}$ C_{120}	E	LB	B1	Open	<1%	U1	M1 P1	
M 294	41-79-234	C	C_{120}	B1	LB	S2	Dense	3%	U1	M1 P2	
M 295	41-79-236	UC	Cl_{20} C_{120}	D2	TR-F	S2	Open	<1%	U0	F P2	
M 296	41-79-236	UC	C_{120}	B2	LB	S2	Open	1%	U1	M3 P2	
M 297	42-78-117	UC	Cl_{4} C_{120}	D1	LB	B2	Medium	<1%	U0-1	M2 P2	
M 298	42-78-117	LC	Scl_{15} C_{120}	C1	LB	B2	Medium	<1%	U1	F P2	
M 299	42-78-117	UC	Cl_{20} C_{120}	D1	LB	B2	Medium	<1%	U0	F P1	
M 300	41-79-242	UC	Scl_{5} Cl_{20} C_{120}	D1	LB	B2	Medium	<1%	U1	M3 P2	

TABLE D3. FIELD DETERMINATION OF ELECTRICAL CONDUCTIVITY

Soil Unit	Profile	Depth	Texture	EC (mmhos/cm)
A1	PM 18	0-13 cm	C	0.3
		20-40	C	0.7
		50-70	C	0.4
		90-110	C	1.2
A2	PM 31	0-10 cm	C	0.5
		10-45	C	0.3
		45-78	C	1.0
		78-120	C	5.0
A2	PM 39	0-15 cm	Cl	0.78
		30-45	C	0.6
		70-85	C	1.5
		100-115	C	2.5
A2	M 44	0-10 cm	C	0.9
		10-20	C	1.0
		50-60	C	1.3
		90-110	C	1.5
A2	M 261	0-15 cm	C	1.0
		20-35	C	0.8
		45-60	C	1.0
		95-110	C	3.5
A3	M 127	0-15 cm	C	1.6
		20-30	C	5.0
		40-60	C	5.8
		80-100	C	5.5
		100-120	C	5.5
A3	M 226	0-20 cm	C	0.4
		60-80	C	3.2
		100-120	C	4.5
				8.0
A3	M 227	0-10 cm	Cl	0.8
		10-20	C	1.5
		30-40	C	3.0
		60-70	C	6.5
		100-110	C	8.0
C1	PM 17	0-15 cm	Cl, C	0.3
		15-30	C	0.2
		45-60	C	0.6
		80-100	C	0.7
C1	PM 27	0-12 cm	Cl	0.4
		12-28	C	0.4
		50-80	C	0.6
		110-125	C	1.1

APPENDIX E

VEGETATION LIST

Explanation to Symbols

u	utilisation by livestock or settler/pastoralist
U	Important source utilised by livestock on settler/pastoralist
n.u.	not eaten or used
-	no data

Plant Type:

S	Shrub
B	Bush
T	Tree
Suc.	Succulent
G	Grass
Par	Parasite
H	Herb
Sd	Sedge
Agw	Agricultural weed
Cr	Creeper

Main Vegetation Group. See Text.

This appendix lists plants collected in the study area, and adjacent lands. It is not a comprehensive list of plants in the area. Identifications were carried out at the Herbarium, Royal Botanic Gardens, Kew. Somali Plant names were identified by Mohamed Noor of Sablaale. Other names were taken from Bay Region Report (HTS 1982).

TABLE E.1 VEGETATION LIST

Collection	Botanical Name	Vernacular	Plant Type	Plant usage Eaten by: Donkey	Goat	Camel	Cattle	Sheep	Domestic usage Used for Charcoal	Used for House building	Notes	Main Land Use or Vegetation Group
1	Croton talaiporos	Gedboholet	B	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	Stabiliser on sand dunes	B2
2	Acacia nilotica	Tugare	B.T.	n.u.	u	u	n.u.	u	u	u	Stabliser on sand dunes. Dominant species in bushland and woodland	W, B1, B2, B3, S, G,
3	Plicosepalus curviflorus	Kadi	Par	n.u.	u	u	n.u.	n.u.	n.u.	n.u.		B1, B2,
4	Securinega leucopyros	Alan, Gogon	B	n.u.	u	u	n.u.	n.u.	u	U	Dominant species in B2, bushland	B2, S, W,
5	·unidentified·	Baragess	H	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Sand stabiliser on active dunes	Outside area on dunes
6	Panicum pinifolium	Alolworan	G	n.u.	u	n.u.	n.u.	u	n.u.	n.u.	Sand stabiliser on active dunes	Outside area on dunes
7	Euphorbaceae	Yama yama	S	n.u.	u	u	n.u.	n.u.	n.u.	u		B2,
8	Cordia sp ?	Mareer	B.S.	n.u.	u	u	n.u.	n.u.	n.u.	u	Stabiliser on dunes	B2, S,
9	Ovaria sp	Mooro	B	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	Edible fruit	Outside area on dunes
10	Heliotropium sp	Isadaramo	S	n.u.	U	U	n.u.	n.u.	n.u.	n.u.	Intoxicates animals	Outside area on dunes
11	Aristolochia rigida	Sarmudeh	Cr	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Creeper on sand dunes	Outside area on dunes
12	Capparis tomentosa	Garboboleti	T	n.u.	n.u.	u	n.u.	n.u.	n.u.	n.u.	Poisonous Fruit	B1, B2,
13	Asclepisdaceae	Wan wan	H. Agw	n.u.	u	u	u	n.u.	n.u.	n.u.		R
14	Cissus quinquangularis	Bararian	Suc..	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	Stabiliser on dunes	B2,
15	Tricalysia sp	Ged adie	B	n.u.	n.u.	u	n.u.	n.u.	n.u.	n.u.	Stabiliser on dunes	B2,
16	Salvadora persica	Adie	B.T.	n.u.	n.u.	u	n.u.	n.u.	n.u.	n.u.	Toothbrushes	B2, W,
17	Ocimum canum	Rejj	H	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Shampoo	B2,
18	Cassia obtusifolia	Shelo shelo	Agw.H	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.		R,
19	Neuracanthus sp	Deg Dego	H	n.u.	n.u.	u	n.u.	n.u.	n.u.	n.u.		B2,
20	Solanum incanum	Arundeh	B	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Stabiliser on sand dunes; Fruit poisonous	B2, R,
21	·unidentified·	Mardis	B	n.u.	u	u	n.u.	n.u.	n.u.	U		B2,
22	Caddaba sp	Galangal	H	n.u.	u	u	n.u.	n.u.	n.u.	n.u.		B2,
23	Seddera sp	Guriria	H	n.u.	n.u.	u	n.u.	n.u.	n.u.	n.u.		B2,
24	Acacia orfota (A.nubica)	Gummar	S.B.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	Birds eat fruit; stabliser on active dunes	B2,
25	Solanum sp	Ab Ab	S	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Invasive shrub on cleared land	R,
26	Opilia sp	Arsh	B	n.u.	u	u	n.u.	n.u.	n.u.	n.u.		B2,
27	Phyllanthus somalensis	Gomber, Gummur	S	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	U	Small sticks for housing, coloniser on sand dunes Leaves poisonous to stock	B2, S,
28	Phyllanthus somalensis	Gomber, Gummur	S	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	U	'' ''	B2, S,
29	Meyma tetraphylla	Ketick	B.S.	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	On sand dunes	Outside area on dunes
30	Cordia somalensis	Mareer Deh	B.S.	n.u.	u	u	n.u.	n.u.	n.u.	u	Edible fruit stabliser on sand dunes along coast	Outside area on dunes
31	Acacia mellifera	Adhet	T	n.u.	u	u	n.u.	n.u.	u	n.u.	Coarse rope	B2,
32	Lawsonia inermis	Ayrib	B.T.	n.u.	u	u	n.u.	n.u.	u	U	Common in B2 bushland	B2, W,
33	Monechma debile	Aus filter	Agw	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Weed in agricultural land	R,
34	·unidentified·	Gib gil	H	u	n.u.	u	n.u.	n.u.	n.u.	n.u.		R5,
35	Psoralea corylifolia	Hagarr	Agw	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	Weed in agricultural land	R,
36	Indigofera	Hagarrah	H	n.u.	n.u.	u	n.u.	n.u.	n.u.	n.u.		B2,
37	Thespesia danis	Kobha, Carereh	S.B.T.Agw	n.u.	n.u.	u	n.u.	n.u.	n.u.	u	Important weed in agricultural land (rainfed). Edible fruit	B2, W, R, S,
38	Pavonia		H	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Coliniser on sand dunes	Outside area on dunes
39	Neuracanthus	Washegarr	H	n.u.	u	u	n.u.	n.u.	n.u.	n.u.		B2,
40	Dichrostachys cinerea	Diktar	B.T.	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Useful indicator of overgrazed land. Invasive into cleared bushland and abandoned fields.	B1, B2, G, R, S,
41	Acacia zanzibarica	Fulai, Cheakh	B.T.	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Invasive species in B3, and G1, units	B2, G, S, B3,
42	Launea cornuta	Kabalo Career	Agw	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Highely invasive weed on exhausted farmland	R,
43	Boerhavia	Aus degiren	Agw. H	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	Weed eaten by birds	R,
44	Grewia sp	Doweh	S.B.	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Stabiliser on dunes	Outside area on dunes
45	Tarenna sp	Sareedeh	S	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Coloniser on sand dunes	Outside area on dunes

TABLE E.1 VEGETATION LIST (Continued)

Collection	Botanical Name	Vernacular	Plant Type	Plant usage -Eaten by: Donkey	Goat	Camel	Cattle	Sheep	Domestic usage Used for Charcoal	Used for House building	Notes	Main Land Use or Vegetation Group
46	Grewia villosa	Cabish	B.S.	u Fruit	u	u	u	u	n.u.	n.u.	Edible fruit	B2, S,
47	Capparidaceae	Lamouloijeh	B.T.	n.u	u	u	n.u.	n.u.	n.u.	n.u.		B1,
48	Albizia anthelmintica	Rheidab	T	n.u.	u	u	n.u.	n.u.	u	u	Common tree in bushland	B1, W, B2,
49	Albizia anthelmintica	Rheidab	T	n.u.	u	u	n.u.	n.u.	u	u		B1, W, B2,
50	Abutilon sp	Balambal	Agw H	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	Stabilised on active dunes, common in understorey of bushland	B, R,
51	Pleuro stelma cernuum	Arengaleh	Agw	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Invader of cleared land	R,
52	-unidentified-	Macouthee	B	n.u.	u	u	n.u.	n.u.	n.u.	u		B2,
53	Cadaba sp	Anama'eh	S.B.	n.u.	u	u	n.u.	u	n.u.	n.u.		B2,
54	Solanum sp	Danoon	S	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	Stabiliser on active dunes	Outside area on dunes
55	-unidentified-	Aus Daram	H	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Stabiliser on active dunes	Outside area on dunes
56	Capparidaceae	Makaram	S.B.	n.u.	u	u	n.u.	u	n.u.	-	Stabiliser on dunes	Outside area on dunes
57	Ipomoea paolii	Soof Jaree	Agw H	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Cotton boll-like	B2,
58	Suaeda sp	Harun	S.B.	-	u	u	u	u	n.u.	n.u.	Animals eat but get sick Indicator of saline land	B2,
59	Dobera glabra	Geras	B.T.	n.u.	n.u.	u	n.u.	n.u	n.u. v.smokey	n.u. difficult to use	Edible fruit; furniture; crop grinder (moye)	B1, S, W, B2,
60	Maytenus sp	Adi Shebell	B.T.	n.u.	u	u	n.u.	n.u.	n.u.	n.u.		B2, W,
61	Aerva sp	Daba'adeh	Agw	n.u.	u	u	n.u.	n.u.	n.u.	n.u.	Pillows	R,
62	Adenium obesum	Gilwah	B	n.u.	n.u.	u	n.u.	n.u.	n.u.	n.u.	Eaten by camel but it makes it sick; root used however for medicine on camels	B,
63	Lawsonia inermis	Syrib	BT	n.u.	u	u	n.u.	n.u.	u	U	Medicine for camel	B2, W,
64	Panicum coloratum	Sabouleh	G	u	u	u	u	u	n.u.	n.u.	Perennial grass often of excellent grazing value	WPS
65	Echinochloa haploclada	Sabouleh	G	u	u	u	u	u	n.u.	n.u.	Rather coarse and unpalatable except when young. Often burnt to bring new growth	G, B2, WPS
66	Paspalidum germinatum	Sabouleh	G	u	u	u	u	u	n.u.	n.u.	Important coloniser on sand dunes	sands outside area
67	Echinochloa haploclada	Sabouleh	G	u	u	u	u	u	n.u.	n.u.	Rather coarse and unpalatable except when young. Often burnt to bring up new growth	R
68	Echinochloa haploclada	Sabouleh	G	u	u	u	u	u	n.u.	n.u.	" " "	G, B2, W.
69	Echinochloa haploclada	Sabouleh	G	u	u	u	u	u	n.u.	n.u.	" " "	PS,
70	Cyparaceae Cyperus sp. nov ?	Deel	Sd	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	Species not known may be either new species or exotic brought into farm with crop seed.	R.
71	Cyperus rotundus	Deel	Sd	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.		PS. W1.
72	Dactyloctinium bogdanii	Madaharbun	G	u	n.u.	n.u.	u	u	n.u.	n.u.		G, B2,
73	Echinochloa colona	Dorar	Agw G	u	n.u.	n.u.	u	u	n.u.	n.u.	Common annual species, moisture loving grass	R,
74	Sorghum arundinaceum	Macaveh	Agw G	n.u.	n.u.	u	u	n.u.	n.u.	n.u.	Annual or short lived perennial, wild sudan grass. Less productive for fodder than cultivated sudan grass.	G, R.
75	-unidentified-	Jiri	G	u	u	u	u	u	n.u.	n.u.		G, B2,
76	Dichanthium annulotum	Jebin	G	u	u	u	u	u	n.u.	n.u.		G, R.
77	Brachiaria reptans	Jebin	Agw G	u	u	u	u	u	n.u.	n.u.	Nutritous grazing	R.
78	Tetrapogon tenellus	Jehin	G	u	u	u	u	u	n.u.	n.u.		G.
79	Sporobolus helvolus	Dub derigan	G	u	n.u.	n.u.	u	u	n.u.	n.u.	Perennial grass. Best grazing grass of Eco climatic zone UI.	G, B2,
80	Aristida mutabilis	Dub derigan	G	u	n.u.	n.u.	u	u	n.u.	n.u.		on sand dunes
81	Schoenefeldia transiens	Dub derigan	G	u	n.u.	n.u.	u	u	n.u.	n.u.		G, B2,
82	Enteropogon machrostachys	Dub derigan	G	u	n.u.	n.u.	u	u	n.u.	n.u.	Perennial grass, useful for grazing and important for reseeding denuded land	G, B2,
83	-unidentified-	Ambus	G	n.u.	u	u	U	u	n.u.	n.u.		G, B2,
84	Cenchris ciliaris	Aus dameer	G	n.u.	n.u.	n.u.	u	u	n.u.	n.u.	Good grazing value	G, B2,
85	Schoenefeldia transiens	Dub derigan	G	u	n.u.	n.u.	u	u	n.u.	n.u.		G,

TABLE E.1 VEGETATION LIST (Continued)

Collection	Botanical Name	Vernacular	Plant Type	Plant usage Eaten by: Donkey	Goat	Camel	Cattle	Sheep	Domestic usage Used for Charcoal	Used for House building	Notes	Main Land Use or Vegetation Group
A	Acacia bussei	Gololl	B	n.u.	u	u	n.u.	n.u.	u	u		Outside area on dunes
B	Acacia tortilis	Gora	T	n.u.	u	u	n.u.	n.u.	u	n.u.		W. B1,
C	Balanites aegyptiaca	Koolan	T	n.u.	u	u	n.u.	n.u.	u	n.u.	Writing paper; note that emulsion from fruit is used to control Bilharzia	B2,
D	Sensevieria sp	Haskul	Suc	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	Rope	B2,
E	-unidentified-	Murri	B	u Fruit	u	u	u	n.u.	n.u.	u		B2,
F	Markohamia zanzibarica	Luff	B.T.	n.u.	n.u.	u	n.u.	n.u.	n.u.	n.u.		B2,
G	Ficus sp	Muqi	T	u Fruit	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.		W,
H	Typha sp	Balwoolah; Da'aro	G	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	u Thatch		PS,
I	Calotropic procera	Booh	S.B.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	Stabiliser of active dunes	outside area
J	Euphorbia	Tek Tek	T	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.	n.u.		B2,
K	Boscia minimifolia	Megag, Dooreh	B.T.	n.u.	u	u	n.u.	n.u.	u	u		B1, B2, W.