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Jamhuuriyadda Dimoqraadiga Soomaaliyeed
Wasaaradda Beeraha

Somali Democratic Republic
Ministry of Agriculture

Mashruuca Horumarinta Beeraha Gobolka Bay

Bay Region Agricultural Development Project

Volume 1
Main Report

August 1982

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Consultants in Agricultural Development

Our Ref. Bay Region/5/HP/MS 15th November, 1982

Mohamed Warsame Dualeh
Project Director
Bay Region Agricultural Development Project
P.O. Box 2971
Mogadisho
Somalia

Dear Sir,

Bay Region Agricultural Development Project

In accordance with Clause 11 of our contract agreement signed on 23rd November 1981 we have pleasure in forwarding the final report on the above study.

The report comprises four volumes as follows:

Volume 1: The Main Report presenting in Part I our main findings in the resource evaluation surveys and outlining in Part II our tentative planning proposals for the Project.

Volume 2: Technical Appendices containing the results of the HIPAS studies, the aerial census tables and selected field data collected during the resource studies.

Volume 3: Resource and Planning Maps.

Volume 4: Remote Sensing Imagery and slides including aerial views of the Region taken during the course of the aerial census.

Volumes 1, 2 and 3 are presented in 25 copies, Volume 4 is a single set of slides and imagery.

In preparing this report we have taken into account your letter BRADP/643/3/10/1982 of 3rd October, 1982 in which you made comment on the draft. These comments have been incorporated into this final version.

We would like to acknowledge the assistance received from the technical staff of BRADP, other Government Ministries and Departments and representatives of International Agencies during the course of our studies.

We would also wish to express our appreciation to our associates Sir M. MacDonald and Partners for providing staff for the engineering and hydrological studies and to Resource Management and Research for the aerial census survey.

Yours faithfully,
For HUNTING TECHNICAL SERVICES LIMITED

H. Piper
Director and Regional Manager for Africa.

Mashruuca Horumarinta Beeraha Gobolka Bay

Bay Region Agricultural Development Project

Volume 1
Main Report

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SPELLING OF PLACES NAMES

In order to reconcile differences between the spelling of place names shown on Somali mapping and the spelling adopted in this report a list of equivalents is given below:

Mapping	Report
Shabeelle	Shebelli
Bulo Barde	Bulo Burti
Mugdisho	Mogadishu
Jalalaqsi	Jalalagsie
Jawhar	Jowhar
Afgooye	Afgoi
Wanla Weyne	Wanle Weyn
Jubba	Juba
Yoontoy	Ionte
Kismaayo	Kismayo
Beled Weyne	Belet Weyn
Mahadday Weyne	Mahaddai Weyn
Baardheere	Bardeera
Saacow	Saakow
Jilib	Gelib
Baydhabo	Baidoa
Buurhakaba	Bur Acaba
Dinsoor	Dinsor
Qansaxdheere	Kansadere
Luuq	Lugh Ganana
Xuddur	Oddur
Tayeeglow	Tieglio
Yaaq Braawe	Yak Brawe

SUMMARY

RESOURCES

The Bay Region covers an area of approximately four million hectares comprising the Administrative Districts of Kansa Dere, Baidoa, Bur Acaba and Dinsor, between the Juba and Shebelli rivers.

The climate of the area is tropical and arid to semi-arid. The mean annual temperature is 26.3°C with the highest mean temperatures occurring in February/March and the lowest in July/August. There is a bimodal rainfall pattern influenced by the monsoon winds with two set seasons, the 'Gu' in April and May and the 'Der' in October and November. Mean annual rainfalls range from 589 mm at Baidoa to 313 at Lugh Ganana.

The area can be subdivided on the basis of geology and geomorphology into five major units. These include the moderately deep cultivable clay plains developed on Jurassic Limestone and Precambrian Basement Complex strata which occupy 18 per cent of the Region. Much of the limestone plateau which comprises some 33 per cent of the Region has shallow concretionary soils and regosols. Twenty nine per cent of the area is sandy soils on basement complex peneplains. A small strip of land called the basement complex-limestone interface comprises a long scarp face or cuesta. The remainder of the area consists of the coastal plain deposits.

All the evidence points to the fact that none of the aquifer systems in the Bay Region are suitable for large scale development of irrigation. The basement complex rocks are generally not permeable enough to sustain well yields of the magnitude required for economically viable irrigation. On the limestone plateau the depth to static water level would make pumpage prohibitively expensive. Within the limestone depression six exploratory holes were drilled, four were dry, one produced a small yield and only one is viewed as sufficiently productive to be completed as a permanent production well. The karstic features observed in the existing irrigation areas along the Togga Shiik Asharow are unlikely to occur elsewhere in the region.

The vegetation of the Region is predominantly semi-arid wooded savanna. Some 11 per cent of the area consists of cropped land and associated fallows and the remaining area excluding towns and villages is rangeland. These rangelands support an average biomass of 5 100 kg/km^2. Three main vegetation mapping units were identified: mixed species covering 37.8 per cent of the area; mixed acacia species 33.2 per cent; acacia species 5.2 per cent; and dense thickets and cultivation the remainder. An examination of land use changes over the period 1973 to 1982 revealed only a small net increase in the cultivated area and some increase in village sizes.

The Bay Region supports the highest livestock density in Somalia. The total livestock population of 1.02 million animals in the Region comprises 31 per cent camels, kept for milk, meat and as pack animals, 30 per cent cattle (East African Short Horns), 34.2 per cent goats (White Somali) with the balance made up of sheep (Somali Blackface), and donkeys. There are also few horses.

The human population of approximately 440 000 people comprises some 8.9 per cent of the total population of Somalia. Of the region's rural population some 37 per cent are residing in temporary nomadic accommodation. The majority of livestock households are

semi-nomadic with much smaller proportions of wholly nomadic and sedentary peoples. Livestock migration patterns in the area are mainly localised. These are numerous and diverse with movement into the crop residue areas and into local browse areas during the dry seasons. The larger inter and intra regional movements are frequently concentrated along the main drainage lines and between the major sources of water.

The local stock have, over the years, developed resistance to nutritional hardships and endemic diseases. Present levels of animal productivity are at their maximum within the constraints of present management and husbandry practices. The annual increment in livestock numbers within the region was estimated at 17.7 per cent for camels, 30.6 per cent for cattle and 54.7 per cent for sheep and goats. It is likely that these figures represent an overestimation brought about by the recent favourable climatic conditions.

Water supply in the Region is derived from two sources. Surface run-off collected in uars and groundwater from hand-dug wells or tubewells into water-bearing strata. The majority of the uars dry up during the dry season but a number of important all year uars were identified throughout the region, and in addition the Commission of European Communities has funded the construction of 21 polythene lined uars which form important links along the stock migration routes.

Virtually all transport within Somalia and in the Bay Region is by road. The main paved roads from Baidoa lead to Lugh Ganana and Mogadishu. There is an extensive network of dirt roads of varying condition which are generally impassible during the wet season.

EVALUATION

The land was classified according to the USDA system of classification modified to suit the local conditions. A dual system of notation was adopted with one class for rainfed agriculture and a second for the rangeland. Within the rainfed classification of eight classes four main subclass limitations were identified, these included salinity, sodium hazard, soil texture and topography. The main subclass limitations in the range capability were, erosion and rock pavements. Both of these limitations would severely affect range improvement capability.

No Class I rainfed land was identified in the reconnaissance surveys; 9.2 per cent of the area falls in Class II; 5.5 per cent in Class III; 40 per cent in Class IV; and the remainder in Classes V to VIII. Class 1 rangeland was identified in 1.4 per cent of the region; 13.9 per cent is Class 2; 25.5 per cent is Class 3; and the remainder falls in Classes 4 or 5.

An assessment of the areas where expansion of the crop acreage could be achieved indicated that there was little potential on the clay plains near Baidoa and Bur Acaba. In the former much of the cultivated land is already in the cultivation cycle and in the latter rainfall is a major limitation to crop production. However, there was considerably more potential for expansion in the clay plains west and southwest of Dinsor where up to 70 000 ha of land might be brought into the cultivation cycle. A lack of suitable domestic water supplies was a major restraint to development. It was not thought that any further expansion of the irrigated areas could be achieved and that the existing schemes were well adapted to their local environments. Improvement of the water supply in the Shiik Asharow valley might lead to a small increase in efficiency in the existing areas of cultivation and a trial borehole in this area was recommended. Further exploratory drilling in the limestone depression eastern areas would also assist in the hydrogeological mapping.

There are extensive areas of rangeland which are underutilised at present mainly in a narrow band in the south of the region (17 per cent) with a smaller area in the northeast (11.3 per cent). The major constraint to expansion of the range utilisation in these areas, especially during the dry season, was identified as a lack of adequate water supplies. In the south of the region it is possible that groundwater might be available from the coastal deposits and it was suggested that trial boreholes be sited in that area.

The present study confirms the view that arable farming has been practised in the Bay Region for many years and, contrary to the view that the system is characterised by shifting cultivation, the systems practised in the major areas of cultivation (i.e. the clay plains) are long established, stable and well adapted to their agro-ecological environment. Besides this there is a considerable degree of integration between livestock and arable activities.

The aim of the PADUs set out in the Appraisal Document was to determine how best farmers and pastoralists can be organised so that they are motivated to preserve the productive potential of their land. However, taking arable and rangeland together a major difficulty with the PADUs is that it would be almost impossible to find a group of farmers which would conform to such a rigidly defined model. In the first place grazing rights to a block of 55 000 ha of range may not be exclusive to a group of arable farmers and, secondly, throughout the majority of the cultivated areas the cropped land accounts for over 90 per cent of the land in the cultivation cycle and fallow or abandoned land no more than 10 per cent. The other major disagreements with the proposals are:

- two lots of field trials, i.e. those to be carried out by the Bonka Research Station and those on the PADUs, cannot be justified given the demand for skilled manpower to carry them out;

- the emphasis on building up organic matter through the establishment of grass leys on these soils, which are predominantly clays and inherently fertile, cannot be justified. In any case organic matter accumulated over a four year period would be oxidised within the first season of cultivation and would contribute little;

- given the present limited knowledge of the farming systems, the role of animals in providing draught power for land preparation is not at all certain and hence the assumption that the major constraint to more widespread use of animal draught is the scarcity of feed in the dry season, has yet to be confirmed;

- the proposed trials, with their sophisticated experimental design and data collection and analysis systems, are unlikely to be implemented as the project will not have all the scientists necessary to carry them out.

In conclusion the Consultants cannot at this stage see a constructive role for a PADU based on the model conceived in the Appraisal Document, in the agricultural development of Bay Region.

RECOMMENDATIONS

There are may questions that require answers concerning the farming systems in the area and a thorough understanding of these systems is needed to provide a sound basis for realistic planning.

Immediate priority should be given to designing and implementing a field survey programme to systematically collect socio-economic and farm management data on the existing farming systems. Besides providing the understanding upon which realistic planning could be based it would also serve as a baseline survey for the Region and a starting point for introducing a continuous system of monitoring and evaluation.

The survey should be organised so that the main centres of cultivation and the major agro-ecological zones were adequately covered by a formally selected representative sample from each. It would aim at documenting such aspects as family size, areas cropped/fallow, and types of crop husbandry and yields, it would also have provision for data collection on livestock management and production coefficients. Monitoring range composition using fixed transects and introducing quantitative and qualitative herbage analysis to indicate seasonal variations in range carrying capacity would also be of value. In particular it is recommended that:

- a repeat livestock population census (i.e. utilising the same strata as that used in the current census) be carried out during the 'Gu' rains. A good indication of seasonal stocking, and range utilisation throughout the year could then be obtained;

- a more intensive programme of field surveys to provide a better understanding of livestock movements, management systems and productivity. The surveys would also help to identify constraints to improving production and eventually contribute to the formulation of appropriate development proposals.

Whilst the costs involved in carrying out an aerial census of livestock in the Region are known the resources required to carry out the field surveys will be determined by the frequency and intensity of the surveys and the level of detail aimed at. Clearly the resources of staff and transport available for these surveys are limited and a balance will have to be sought between the cost and quality of information obtained. The Consultants suggest that livestock surveys should become part of the survey programme of the Monitoring and Evaluation Unit established within the BRADP. Continuous or routine surveys would be carried out by the Unit but if necessary specific surveys dealing with highly specialised technical aspects could be carried out by Veterinary or Research staff. Given its importance to the preparation of agricultural programmes it is considered that an expatriate Technical Assistance specialist is warranted. The specialist would probably have an agricultural or farm management economics background with extensive experience and a particular interest in smallholder farming systems.

The Consultants strongly support the proposals to strengthen the research units and consider that more emphasis should be placed on adaptive research. In addition the following priority areas for research should be considered:

- screening of introduced genetic material (e.g. ICRISAT) and selection from local material should continue to be a priority at the station;

- research into dryland farming techniques and methods of moisture conservation should continue to be important. The need to liaise with other research institutes such as the Kenya Dryland Farming Station at Katumani;

- testing of other commercial crops, groundnuts and sunflower in particular;

- pest control trials to measure the effectiveness of existing controls and other potential on controls on the region's major pest stemborer (*Chilo partellus*) in sorghum;

- research into new crops such as perennial shrubs and trees to provide browse for livestock.

A sequence of research activities starting with trials at Bonka followed by trials at sub-stations in the districts, field trials in farmers' fields and finally demonstrations in farmers' fields is recommended.

Given the importance of stemborer as a pest and the high proportion of grain losses in storage, it is considered that the employment of a Technical Assistance specialist (probably an entomologist) in plant protection would be justified.

Provision of extension in the Bay Region will continue to be the responsibility of the National Extension Service which is being strengthened by the implementation of the Extension Training and Farm Management Project. Although there will be close ties and coordination between the two projects, provision of extension will not come directly under the BRADP. This could lead to some conflict of interest particularly over deployment of staff and frequency of staff transfers. It is also regarded as imperative that a livestock extension service is introduced as part of the crop extension service since the two enterprises are very closely linked.

It is essential that the full complement of trained FEA are in post as rapidly as possible. Four District Extension Agents and 35 FEAs are in post. Whilst there is no well tried and proven package of practices or innovations to offer farmers at the moment, there is clearly a worthwhile role to be fulfilled until these become available. Their immediate role would be to make contact with their farmers, gain their confidence and establish workable relationships. They could initiate discussion groups in which farmers and livestock owners can inform them of their major problems and constraints. If they are going to make an impact they will have to have something to offer. Two possibilities are pest control and oilseeds.

In the Veterinary Services implementation priorities should be directed towards the control and prevention of diseases that put the national flock/herd and human population at risk and those diseases that can only be more effectively controlled, on a national or zonal basis e.g. rinderpest, foot and mouth disease, anthrax. However, as livestock owners are generally uncooperative over routine vaccination programmes, the inclusion of tick control measures, although of doubtful economic benefit within the field programme may provide the stimulus for the acceptance of an increased disease prevention programme. Efforts should also be made to improve the data base on the animal disease situation by the collection of diagnostic samples during the normal course of visits and livestock treatments.

The Consultants believe that the proposals for range management as outlined in the Appraisal Document for the PADUs will require amendment. First it is impracticable to consider rangeland development for existing communities in terms of predetermined size and resource ratios indicated and, secondly, the highly complex relationships that exist between local and migrant livestock and the grazing areas adjacent to cropping land together with crop residue grazing, have to be understood. The fundamental amendment suggested is that instead of concentrating on identifying typical areas (i.e. PADUs) the emphasis should be changed to identifying receptive communities who could be persuaded to adopt practices which would lead to the achievement of project objectives. This would be achieved by the establishment of a communal grazing programme in which communities are gradually encouraged to adopt improved practices that are likely to be acceptable.

The establishment of a network of livestock and range demonstration farms is also recommended, these would be multifunctional in that they would provide facilities for staff training, extension, input supply (e.g. stockmen's remedies), monitoring rangeland livestock systems, and range and livestock trials. It is proposed that at least five centres be established by the Research Development of the Ministry of Agriculture as follows:

- two in Bur Acaba District; one on the grazing areas associated with the clays and the other on the coastal plain deposits;

- one in Dinsor District on the Basement Peneplain;

- one in Kansa Dere District on the limestone plateau;

- and one in Baidoa District on the limestone plateau.

1

Introduction

1.1 INTRODUCTION

The Bay Region is located in the central part of the Democtratic Republic of Somalia and includes the Administrative Districts of Kansadere, Dinsoa, Baídoa and Bur Acaba. Figure 1.1 indicates the approximate boundaries of these Districts. The exact boundaries of these Districts is not clearly defined on any existing map and the limit of survey selected is expected to enclose the greater part of these administrative districts.

1.2 GENERAL BACKGROUND AND AIMS OF THE STUDY

The potential of the Bay Region for development was first identified during the ICA studies of the Interriverine area in 1961. In 1972 a World Bank Identification mission indicated the potential for a project between the towns of Baidoa and Bur Acaba. A request for Coöperative Programme assistance to identify and prepare a project for the Region was carried out by a joint FAO/IBRD Identification Mission early in 1977 and this was followed by the World Bank Appraisal Mission in Mid 1979.

As a result of this appraisal the Bay Region Agricultural Development Project (BRADP) was established by agreement between the Government of Somalia and the Intnernational Development Association. The broad aims of the project are to aid the development of the Region through a programme of water conservation, drilling of boreholes, improved farming practices, and, where feasible, irrigation, to increase production of both crops and livestock.

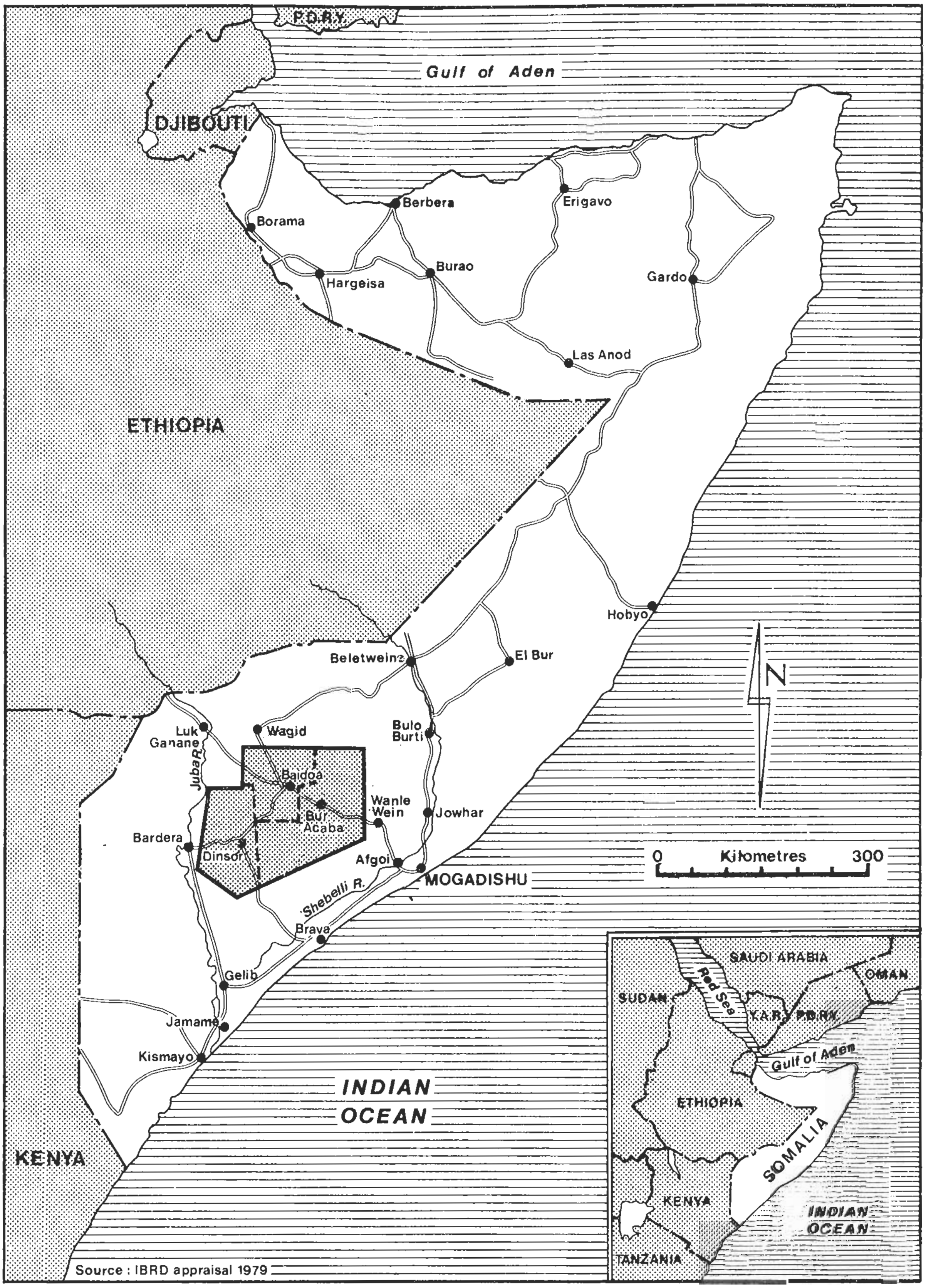
It was recognised that the existing data base was inadequate for the defining of strategies for development. The current study consisting of a report and maps on the existing resources of the area and a preliminary evaluation of this data have been prepared to satisfy this requirement. It was requested that as apart of these studies four pilot agricultural development units of 62 500 ha each should be selected, one within each of the four Administrative Districts. As far as possible these should be representative of the surrounding ecological zones in which they occur. In order to supplement the data collected in the field surveys of soils, range resources, livestock and agriculture, additional information which could be used for future development planning was collected. This took the form of an aerial census carried out by means of a statistical sampling and recording technique from a low flying aircraft.

As a result of these field studies a series of maps at 1:250 000 scale were produced depicting the following information.

Soils - Map 1 showing the soils of the area.

Vegetation - Map 2 showing major vegetation units and location of sample sites.

1.1 Location of the Project Area



Source : IBRD appraisal 1979

Land Use - Map 3 showing main cropped areas and grazing patterns.

Land Capability - Map 4 showing the land capability classification.

Base Map - Map 11 showing salient infrastructure and base map data.

In addition the TOR state "based on the above (thematic maps) a tentative master plan at a scale of 1:250 000 will be developed". It was not possible to carry out master planning at this stage of the study without considerably more additional information, designated to be provided after Phase I of the study is completed. However, outline planning with a designation of areas suitable for dry land cropping, rangeland and irrigation is possible (Map 5). Further maps were also produced at 1:100 000 and 1:50 000 scale to show salient features identified during the course of studies on the potential irrigation area and the Pilot Agricultural Development Units (Maps 6 to 10).

2

Climatology

2.1 CLIMATOLOGY

The Bay Region lies between the rivers Juba and Shebelli, the only two perennial rivers in southern Somalia, and has a tropical semi-arid climate. The location of the project area is shown in Figure 2.1. Climatic data for the Bay Region, which comprises some four million hectares, is quite scarce with only 4 climate stations ever having operated within the Project Area. The station at Baidoa has been operational periodically since 1922 recording maximum, minimum and mean temperatures, cloud cover, wind speed and direction, dew point, relative humidity, vapour pressure and daily rainfall. Rainfall records at Bur Acaba span intermittently over four decades but other climate data is very sparse. At Dinsor rainfall only was recorded and intermittent data is available for just 6 years. At Bonka agricultural research station a full climate station exists although it has only been operational for 4 years and the data is again intermittent. Both Dinsor and Bur Acaba stations ceased to function in 1958. Although Baidoa and Bonka are operational they are only five kilometres apart.

The climate of the Bay Region has been described previously in the Inter Riverine Agricultural Study (HTS, 1977). The dominant influence on climate is the annual movement of the zone of maximum insolation and the associated Inter Tropical Convergence Zone (ITCZ) where winds from both hemispheres meet in an area of low pressure and atmospheric instability. The position of the Bay Region with respect to the movement of the ITCZ creates two wet seasons: the Gu season in April and May, and the Der season in October and November, separated by the drier Haggai from June to September.

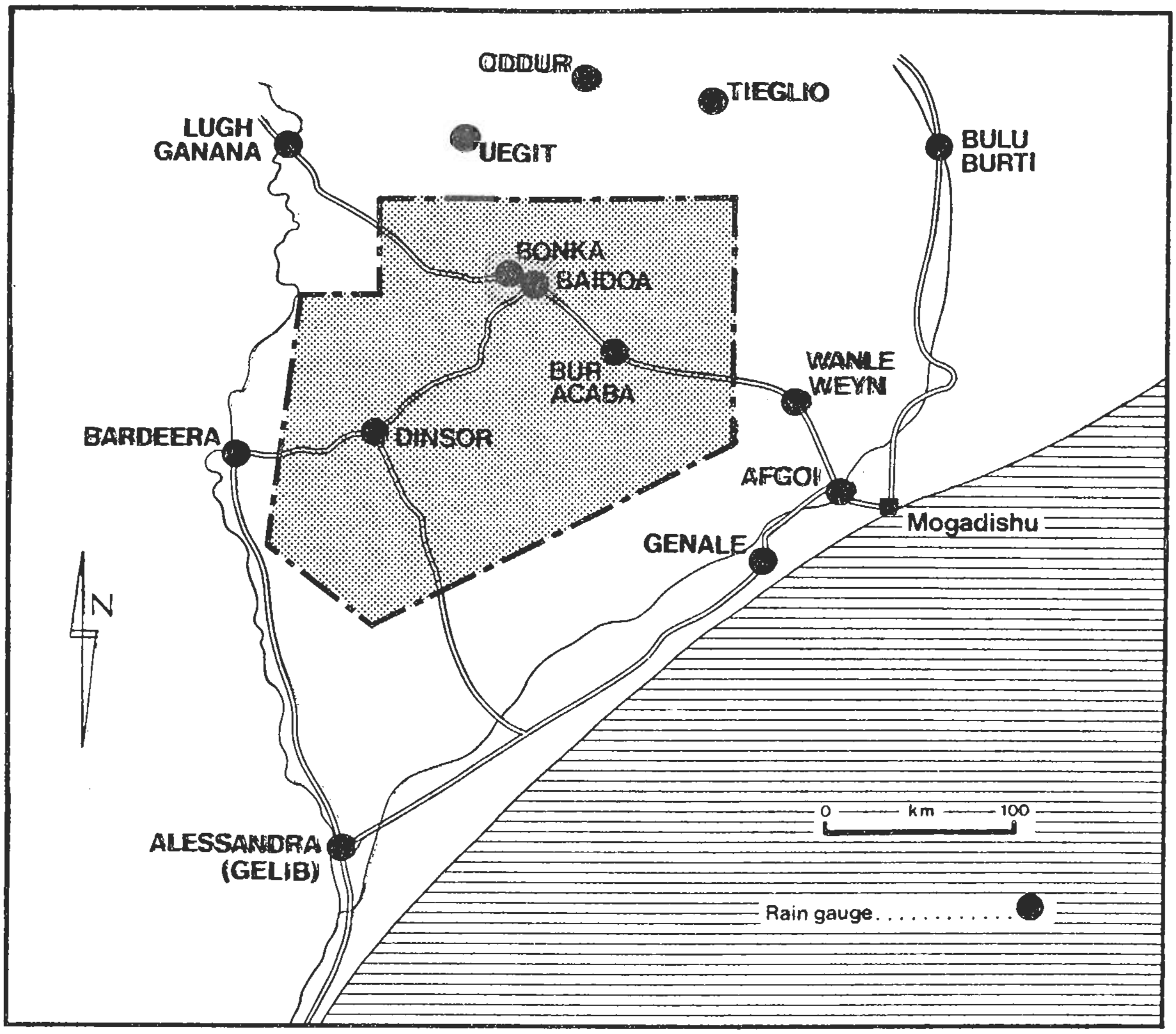
Monthly climatic norms are shown for Baidoa in Figures 2.2 and 2.3 together with 10 per cent and 90 per cent exceedance values determined on the assumption that the normal probability distribution is applicable. Values quoted also relate to Baidoa.

2.1.1 Temperature

The damping effect of the Indian Ocean and the proximity of the equator create a relatively small variation in mean monthly temperature of only 2° C each side of the mean annual temperature of 26.3° C. The highest daily mean temperatures occur in February/ March and the lowest in July/August.

However, the variation in temperature between day and night can be quite considerable being greatest in February when the mean of maximum daily temperatures is 35.5° C and the mean of minimum daily temperatures is 19.4° C, that is, a mean daily temperature variation of 16.1° C. The smallest variation is in July when the mean daily variation is 10.2° C corresponding to a mean maximum daily temperature of 28.8° C.

2.1 Rain gauge locations



2.1.2 Sunshine

Sunshine duration was not recorded in the Bay Region prior to the installation of the climate station at Bonka. However, initial 'teething' troubles and the short supply of recording cards have considerably reduced the amount of information available. Fortunately cloudiness observations were made at Baidoa for 23 years until 1958, with reading in tenths. Cloud cover averages approximately 45 per cent for much of the year rising to 70 - 80 per cent from December to March. However, the variation from day to day can be considerable.

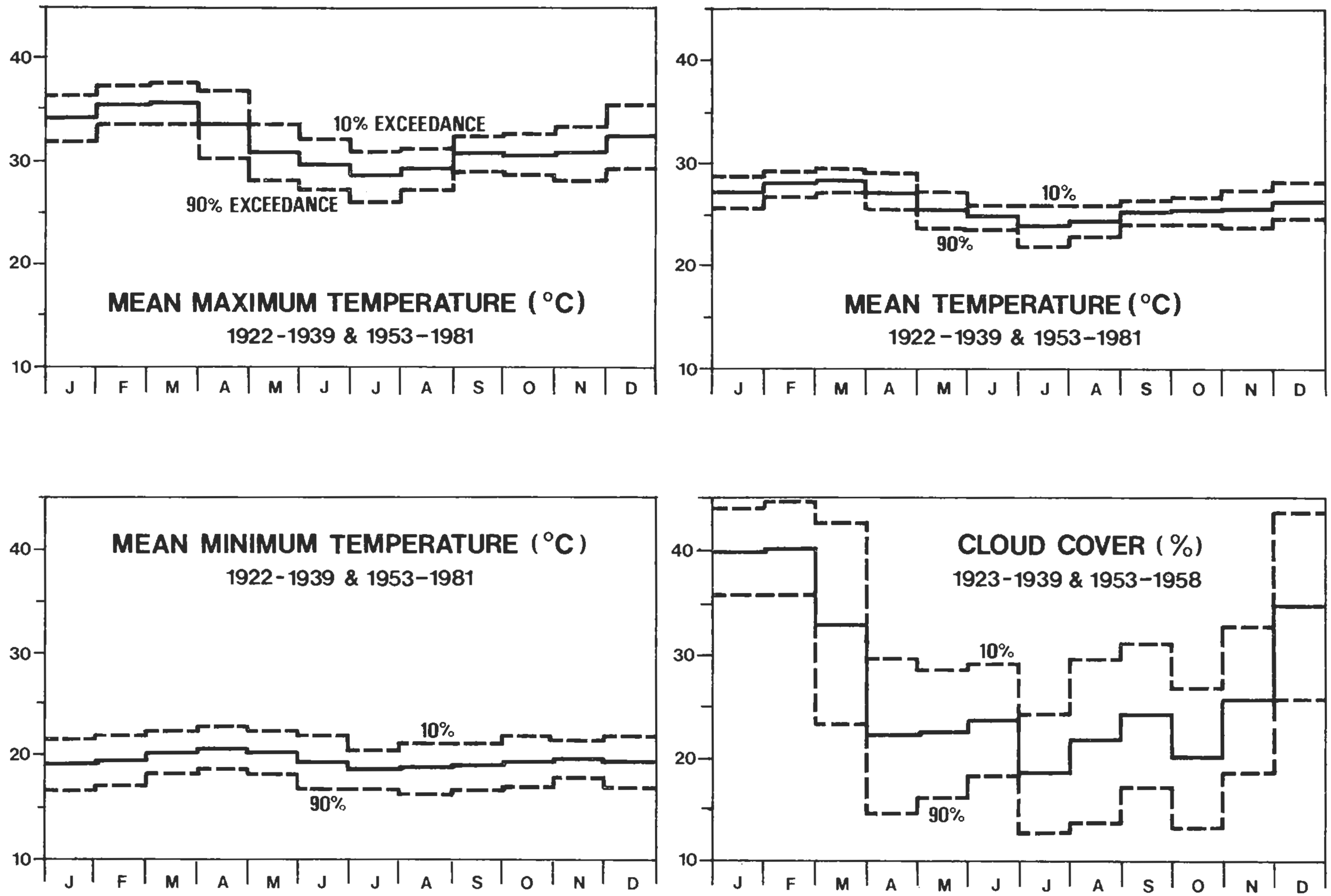
2.1.3 Relative Humidity

Relative humidity averages 65 - 75 per cent with the highest values in the Gu and Der season and the lowest in the period January to March. Humidity seems to decrease slightly travelling from Baidoa to Bur Acaba but then increases as the coast approaches. Humidity also falls off to the north west of the escarpment but decreases most rapidly to the north where the climate is arid.

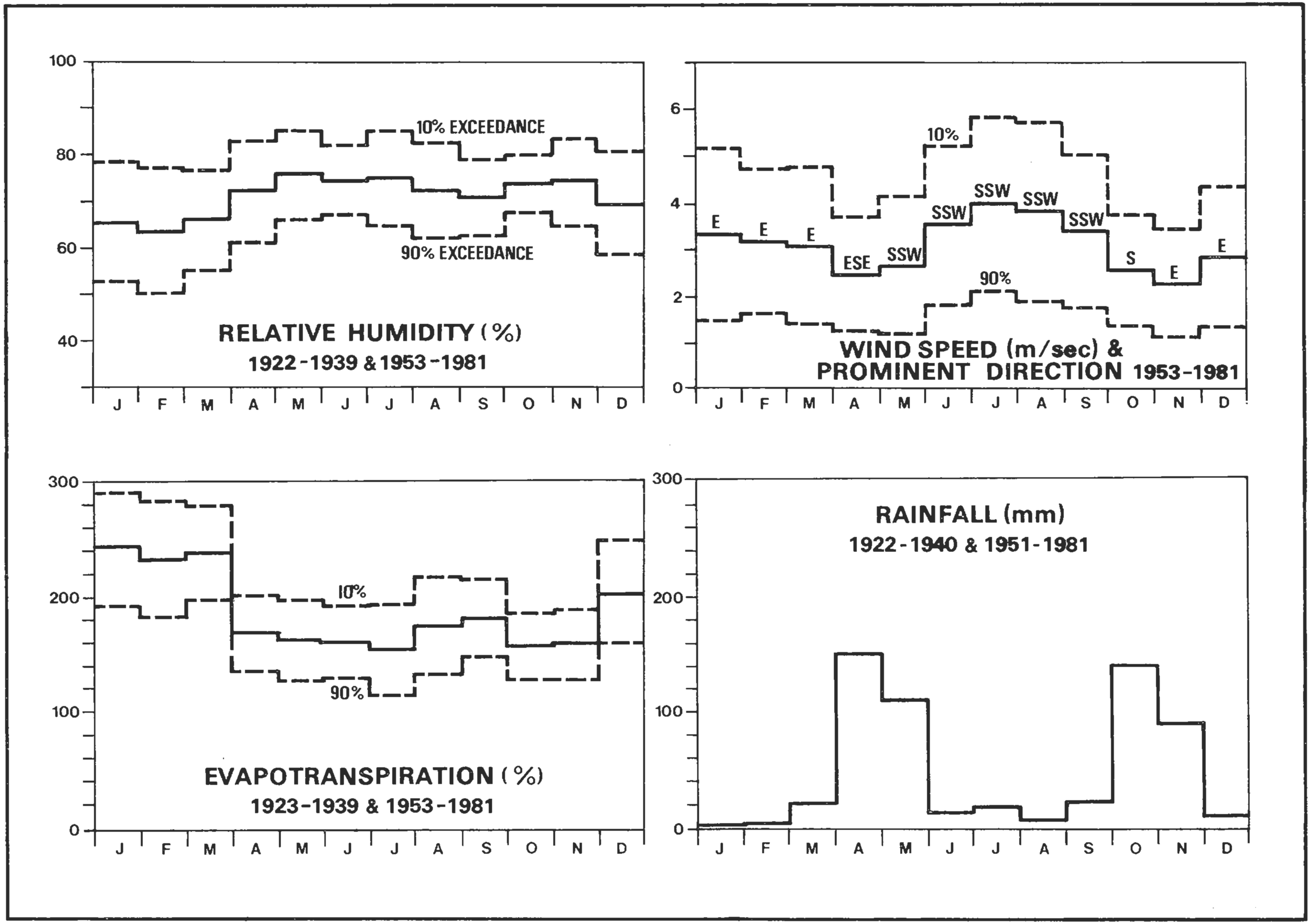
2.1.4 Wind Speed and Direction

Recorded monthly wind speeds show considerable variation. The mean monthly wind speed reaches a peak of 4 m/s (345 km/day) in June with a second minor peak in January.

2.2 Climatic norms; Baidoa



2.3 Climatic norms; Baidoa



The prominent wind direction is from the east during the period November - March and from the south-south-west during the period June - September. In the intervening periods the wind direction is more variable but usually from the south east quadrant. This variation in the prominent wind direction coincides with the onset of the Gu and Der rainy seasons.

Baidoa probably has above average wind speeds owing to its exposed position on the top of the escarpment. However, no other wind speed information is available.

2.1.5 Evapotranspiration

Potential evaporation reaches a peak in the period January - March with monthly values up to 290 mm, associated with high insolation, low relative humidity and elevated temperatures. For the remainder of the year potential evaporation is typically between 130 and 200 mm per month. Average annual evapotranspiration is 2 250 mm for Baidoa calculated by corrected Penman method (Doorenbos and Pruit, 1977).

2.2 RAINFALL

At present there are only fourteen rain gauges known to be operational in Somalia. Two of these (Afgoi and Bonka) report to the Ministry of Agriculture where the meteorology and hydrology sections are attached to the Department of Land and Water Use, and the remaining twelve report to the Ministry of Land and Air Transport where the meteorology section is attached to the Department of Civil Aviation. Unfortunately only two stations are situated inside the project boundary and these are located within five kilometres of each other (Baidoa and Bonka). Bonka was established recently (1976) and there is insufficient data to be able to include this station in the analysis. Nevertheless, this is a substantial improvement over the situation reported by HTS (1977) when only three rain gauges were operational in Somalia and none of these were inside the Bay Region.

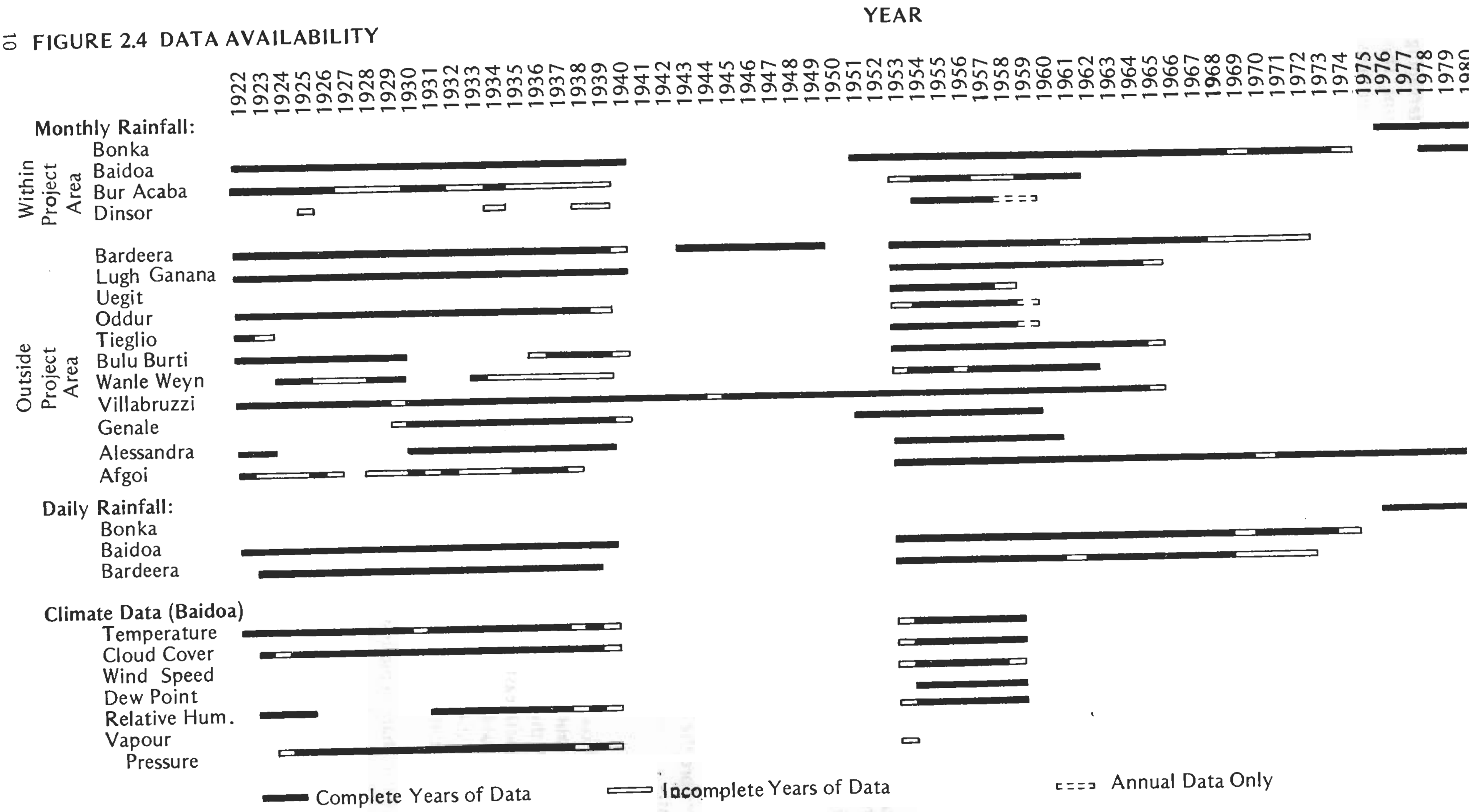
A substantially higher density network existed peviously although there has never been more than three rain gauges (Baidoa, Bur Acaba, Dinsor) within the project boundary. Furthermore the rain gauge at Dinsor has only 5 complete years of record. Had this been the only information available the derivation of an isohyetal map would be meaningless if not impossible.

The situation is somewhat alleviated by the past existence of several rain gauges within reasonable proximity outside the project boundary, thus permitting a tentative estimation of the aerial distribution of rainfall. Nevertheless, there has never been a rain gauge in the south-east quadrant of the Bay Region and those outside the south-east boundary are a considerable distance away close to the coast. It must be emphasised that isohyets presented for this portion of the Bay Region must derive almost entirely from subjective interpolation and must be treated with caution.

A bar chart depicting the period of record of each rainfall recording station, together with their respective distances outside the project boundary where appropriate, is presented in Figure 2.4.

All rain gauges used in the analysis are believed to be 400 mm diameter gauges set at approximately 1.5 - 2.0 metres above the ground, although some have now disappeared and it is difficult to check their past locations and exposure. Non-standard exposure is common due to the proximity of trees and buildings. The climate station at Baidoa, for example, is situated inside the compound of the Ministry of Transport within a few metres of two main buildings and close to a perimeter wall.

FIGURE 2.4 DATA AVAILABILITY



2.2.1 Annual Rainfall

Although some rainfall records cover quite long periods, Figure 2.4 demonstrates that others have short and rather intermittent observations. For example, Baidoa has 45 complete years of monthly data whereas Dinsor has only five. Bur Acaba has fourteen complete years of monthly data but a further twelve incomplete years. In order to maximise the amount of information used in the analysis it was necessary to infill the missing monthly data in the incomplete years of observations. Infilling was achieved by adopting the normal ratio method in which weighting coefficients are derived by determination of the ratio of the means of concurrent data for the station to be infilled and data for nearby stations. Thus a relationship is derived between estimated rainfall at the gauge under consideration and the recorded rainfall at several significant nearby gauges. Although it is usual to choose at least three significant adjacent records the sparseness of the rain gauge network reduced this to 2 records in some cases. Infilling was on a monthly basis with different coefficients derived for each month.

Mean annual rainfall, standard deviation, and coefficient of variation are shown for each gauge used in the analysis in Table 2.1. The statistics were derived using infilling data and adjusting all records to the standard 45 year period of the Baidoa sequence in order to reduce short term bias.

(a) Areal Distribution

The areal distribution of mean annual rainfall has been estimated previously in the form of an isohyetal map by HTS (1977). Although the increase in the amount of rainfall data available since the HTS (1977) study was undertaken is minimal, the total information available has increased in two respects: firstly by inclusion of the infilled partial years of record, and secondly by the availability of detailed topographic information which aids subjective interpolation of isohyets.

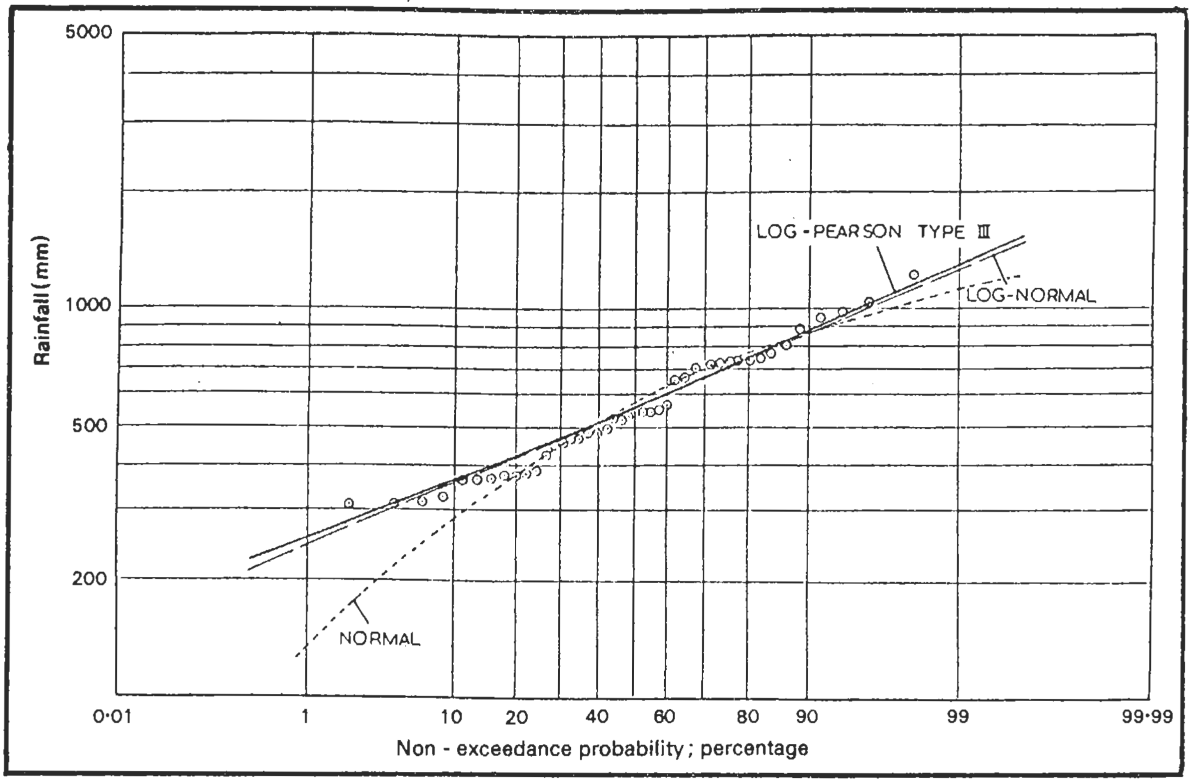
HTS (1977) mapped mean annual rainfall only, but recommended that rainfall at various probability levels should be included in any further study. Previous probability analyses have assumed annual rainfall to follow a normal distribution. However, annual rainfall in arid and semi-arid regions frequently has a slightly skewed probability distribution and a more appropriate and more general distribution in the Log Pearson type III which was fitted to each of the annual series by the method of moments using the first, second and third moments. Where a particular series covered a period of less than twenty years the series was extended again by the normal ratio method. Although this practice is known to lead to biased statistics the bias is small for the less extreme exceedance probabilities used here. Figure 2.5 shows a typical Log Pearson type III probability plot for Baidoa and Table 2.2 presents rainfall values at various probabilities of exceedance. Fifty per cent and seventy five per cent probabilities of exceedance, corresponding to rainfall values expected to be exceeded in 1 out of 2 years and 3 out of 4 years, were chosen for mapping. Figures 2.6 and 2.7 are the corresponding isohyetal maps. The isohyets were constructed by interpolation between point values estimated in the probability analysis. Where there is a significant difference in height between two rainfall stations interpolation is linear with respect to height difference, otherwise interpolation is linear with respect to horizontal distance. The isohyets were then adjusted subjectively to remove irregularities.

The isohyets show a fairly simple pattern with the highest values centred to the north west of Baidoa on top of the escarpment. This local maximum is believed to be due to orographic effects as the air masses rise over the escarpment as they move inland from the coast. Annual rainfall reduces in all directions from this centre with the most dramatic reductions to the north west towards Lugh Ganana and to the north towards Uegit and Oddur.

TABLE 2.1 ANNUAL RAINFALL STATISTICS
(Rainfall values in mm)

Statistics / Location	Baidoa	Bur Acaba	Dinsor	Bardeera	Lugh Ganana	Uegit	Oddur	Tieglio	Bulo Burti	Uanle Uen	Villabruzzi	Afgoi	Genale	Alessandra
Mean	589.5	442.0	543.5	442.2	313.4	345.2	360.9	249.0	319.5	521.8	501.9	545.0	539.2	626.9
Standard Deviation	214.2	176.7	187.6	1954	131.6	127.8	122.3	96.5	128.4	146.5	171.5	197.0	220.8	169.5
Coefficient of Variation	0.363	0.400	0.345	0.442	0.420	0.370	0.339	0.338	0.402	0.281	0.341	0.362	0.409	0.270
Location.	Within Project Area						Outside Project Area							

2.5 Probability plot; Baidoa Annual series



(b) Long Term Fluctuations

A number of statistical tests are available to detect long term fluctuations in hydrological series. To be conclusive such tests require a long unbroken period of values. The annual rainfall series are either too short or too intermittent for such an analysis and although 45 years of records are available at Baidoa the sequence has two significant breaks. The longest continuous period for Baidoa includes the 23 years from 1951 to 1973 and is the period used in this analysis.

Persistence is the grouping of events into wet and dry periods and two tests are used here for its detection. In the Median Cross Test the median is determined from the rank equalled or exceeded in 50 per cent of years when the data is ranked using the Blom formula as follows:

$$\text{Rank} = 0.5\ (n + 0.25) + 0.375$$

when n is the number of values in the sequence, 23 in this case. For significant persistence the number of median crosses must be outside the 95 per cent confidence limits of the expected value:

$$(n - 1)/2 = \pm\ 1.96\ (n - 1)/2$$

The median of the Baidoa annual rainfall series is 563.8 mm and is crossed 13 times, which is within the confidence limits of 11 ± 4.6. Thus there is no signficant persistence.

In the Turning Point Test the total number of maxima and minima must be outside the confidence limits of the expected value:

$$\frac{2}{3}\ (n - 2)\ \pm\ 1.96\ (16n - 29)/90$$

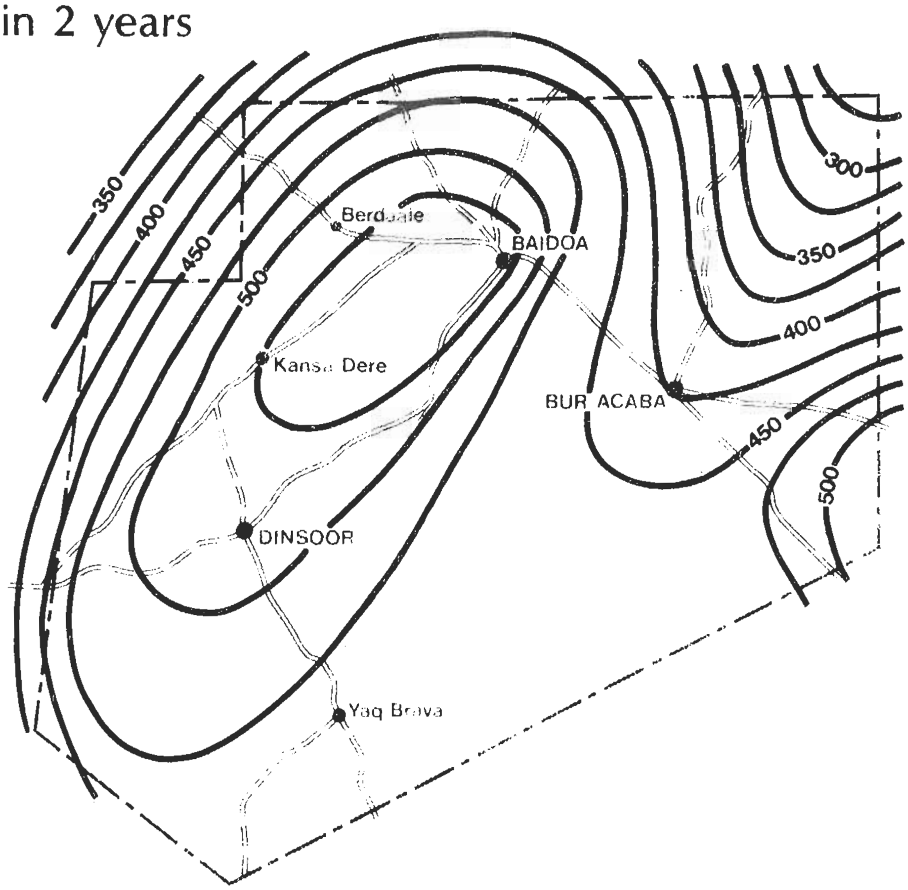
TABLE 2.2 ANNUAL RAINFALL PROBABILITY ANALYSIS (Rainfall Values in mm for given Probabilities of Exceedance)

Expected number of years value is exceeded	Probability of Exceedance %	Baidoa	Bur Acaba	Dinsor	Bardeera	Lugh Ganana	Uegit	Oddur	Tieglio	Bulo Burti	Uanle Uen	Villabruzzi	Afgoi	Ganale	Alessandra
9 in 10	90	360	228	353	233	138	149	223	136	162	349	313	323	264	352
4 in 5	80	413	284	386	284	182	204	252	161	206	408	363	392	329	436
3 in 4	75	441	305	416	303	203	228	265	176	227	434	389	419	355	468
2 in 3	67	476	349	449	339	234	261	284	192	253	468	421	463	393	505
1 in 2	50	547	420	507	406	295	330	327	230	313	540	484	530	473	591
1 in 5	20	740	595	675	581	433	459	440	322	454	684	653	682	641	741
Number Observations[1]		45	26	9 (+30)	39	31	5 (+18)	24	8 (+22)	22	17	33	34	21	20
Location			Within Project Area							Outside Project Area					

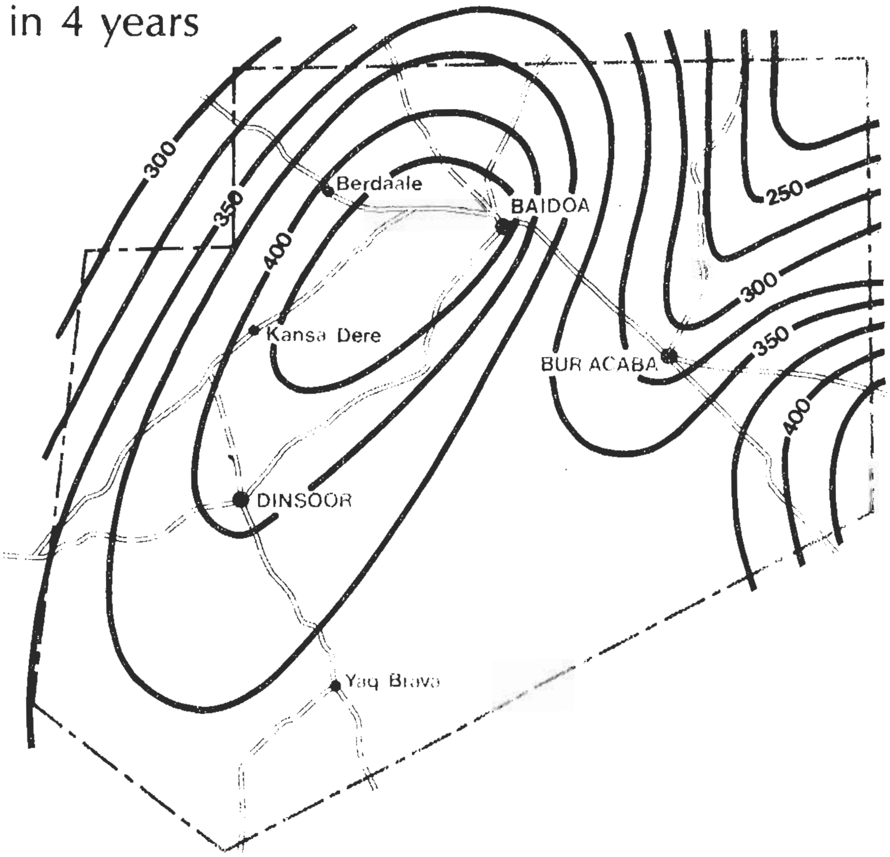
Note: [1] *Number in parenthesis indicates years of infilled data*

2.6 & 2.7 Annual rainfall isohyets (mm)

2.6 1 in 2 years



2.7 3 in 4 years



for significant persistence. The total number of maxima and minima in the Baidoa annual rainfall sequence is 17 which is within the confidence interval 14.0 ± 3.8, and again no significant persistence is detected.

2.2.2 Seasonal Rainfall

Annual rainfall in the Bay Region is distributed between two post-equinoctial rainy seasons: the Gu in April/May is generally more reliable than the Der in October/November.

Monthly average rainfalls expressed as percentage of the annual mean and their coefficients of variation, for the stations at Baidoa, Bur Acaba and Dinsor are shown in Figure 2.8.

Most of the rainfall occurs during the two rainy seasons. For Baidoa, for example, 45.1 per cent of the annual rainfall falls inthe months April and May whilst 39.2 per cent occurs in the months October and November and 8.9 per cent falls in the months June to September, in between the two rainy seasons.

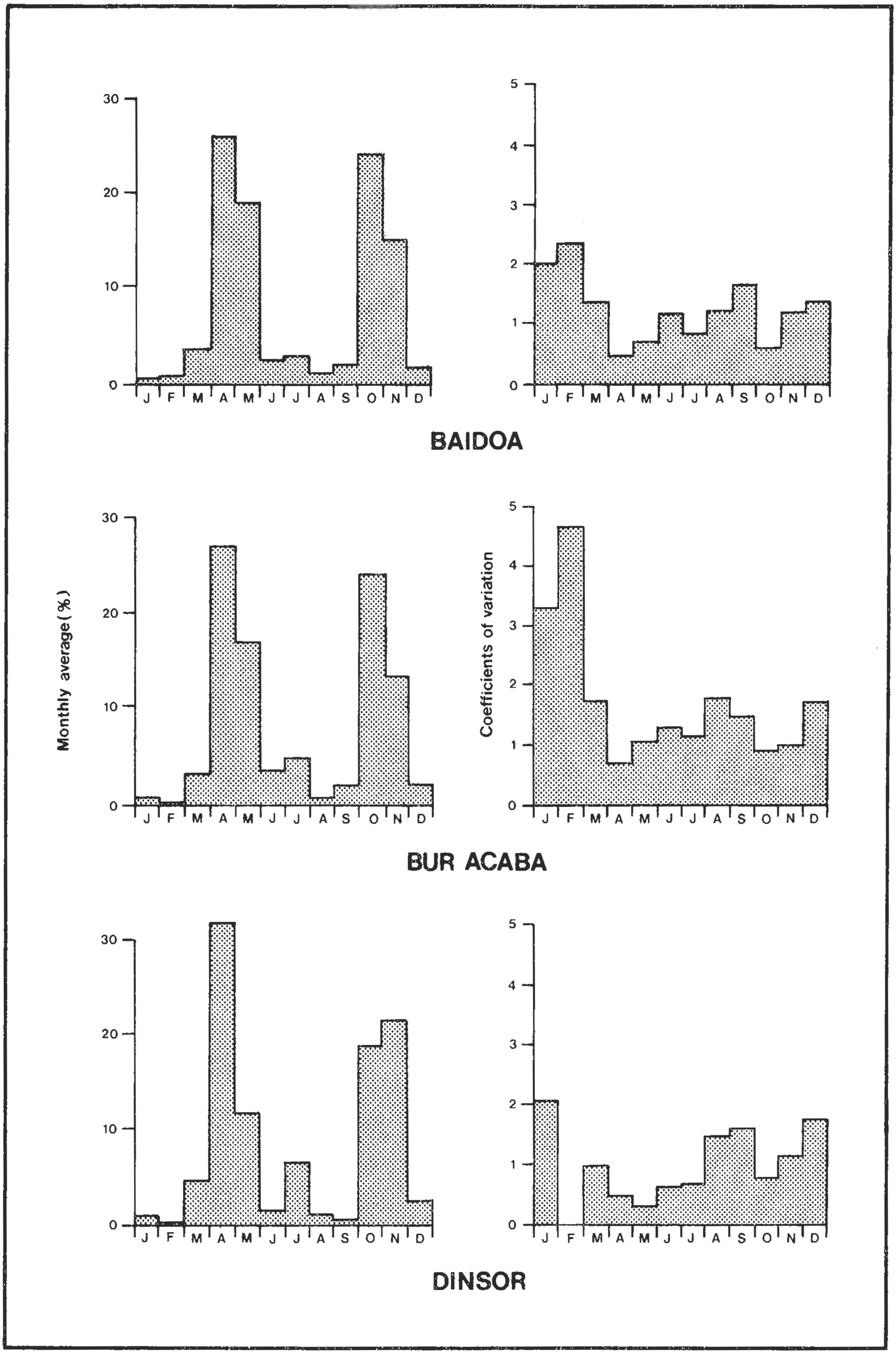
Although the annual rainfall shows considerable spatial variation throughout the region, the temporal distribution exhibits a similar pattern for all three stations. Higher monthly rainfall is experienced at the beginning of each rainy season in the respective months of April and October coinciding with the lowest coefficients of variation. Although little rainfall usually falls within the dry seasons the actual amounts show high variation, coefficients of variation being frequently greater than 2.0 in the period January/February.

To quantify the areal distribution of seasonal rainfall a probability analysis, similar to that for annual rainfall, was undertaken. Separate analyses were carried out for the Gu season and the Der season. The duration of each season was defined as the months April/May and October/November respectively. A more satisfactory delineation may be obtained using the first and last daily falls of, say, 10 mm or more to define the beginning and end of the season. Such a definition was adopted by HTS (1977) but cannot be used here since only monthly data was available for most stations. The procedure was to fit a Log Pearson type III probability distribution to each record by the method of moments, making use of the first three moments.

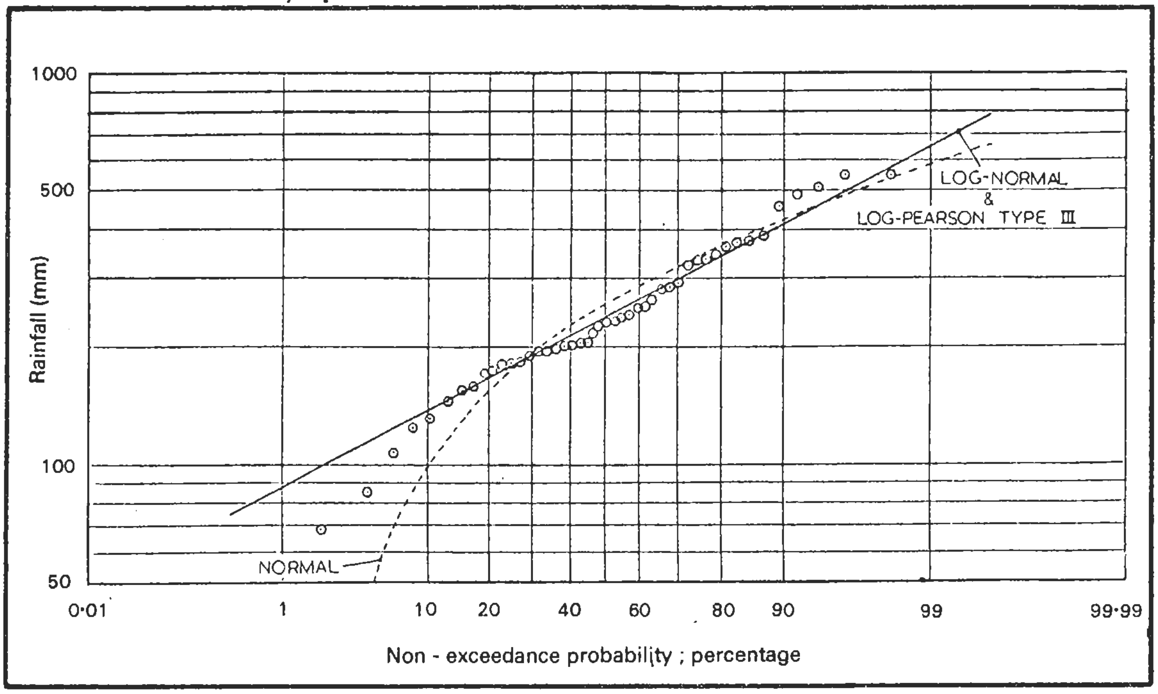
Figure 2.9 shows a typical probability plot for the Gu season for Baidoa, where the Log Pearson Type III is almost coincident with the Log-normal distribution. This distribution, however, is shown to provide a better fit to the series than does the normal distribution. Rainfall amounts relating to several probabilities of exceedance are presented in Table 2.3 for each station. Two isohyetal maps are presented for the Gu season, demonstrating the areal distribution of rainfall amounts expected to be exceeded one in every two years and three in every four years, in Figures 2.10 and 2.11 respectively. Similar information, but for the Der season, is given in Table 2.4 and Figures 2.12, 2.13 and 2.14. Interpolation between the estimated point values was by the same method as for the the annual isohyetal maps.

The pattern of the Gu season isohyets is very similar to that for annual rainfall: the highest rains fall in an area centred around Awdinle, to the west of Baidoa, with a trough detected with its axis in a north-east to south-west direction passing through Bur Acaba. A similar pattern unfolds for the Der season with a peak again centred just to the west of Baidoa, but, unlike the Gu season, rainfall continues to decrease towards the coast and a trough is not apparent.

2.8 Percentage monthly average rainfall



2.9 Probability plot; Baidoa. Gu season series



2.12 Probability plot; Baidoa. Der season series

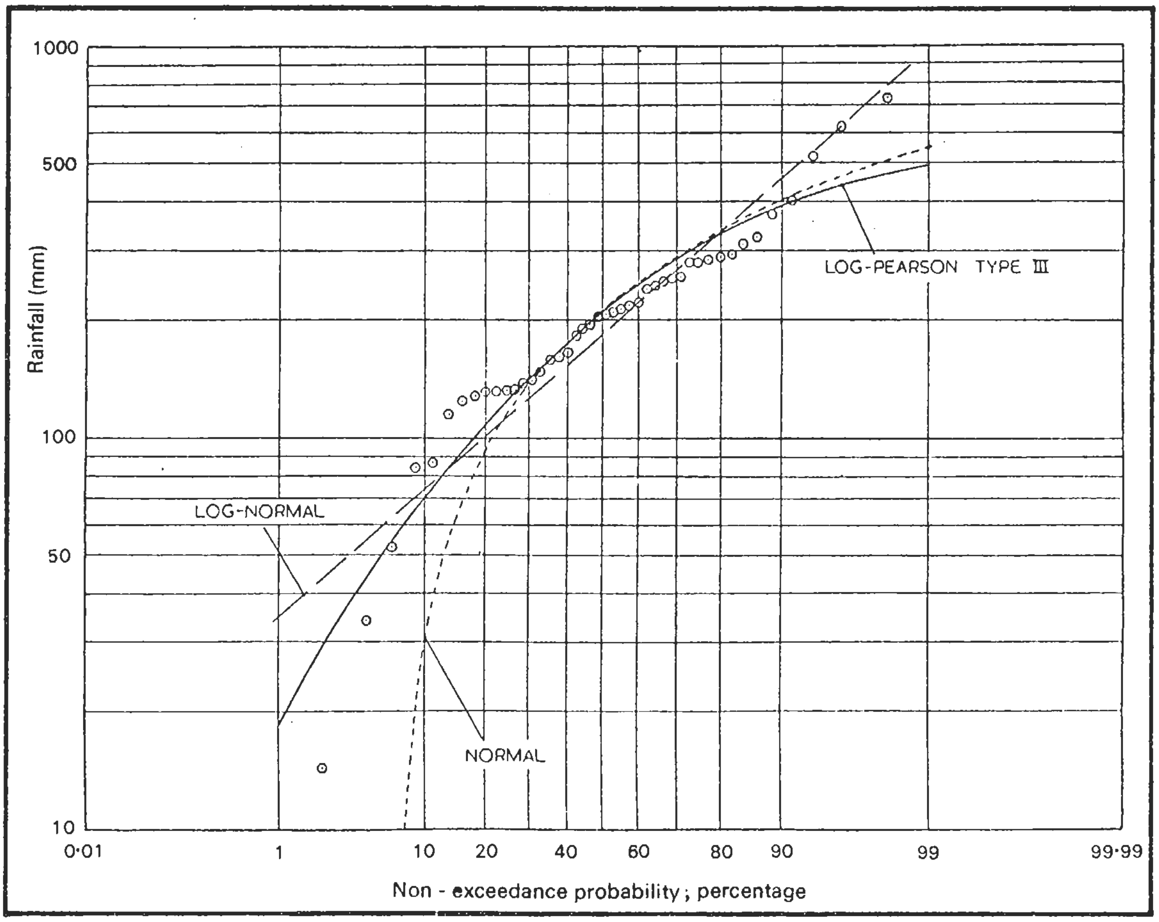


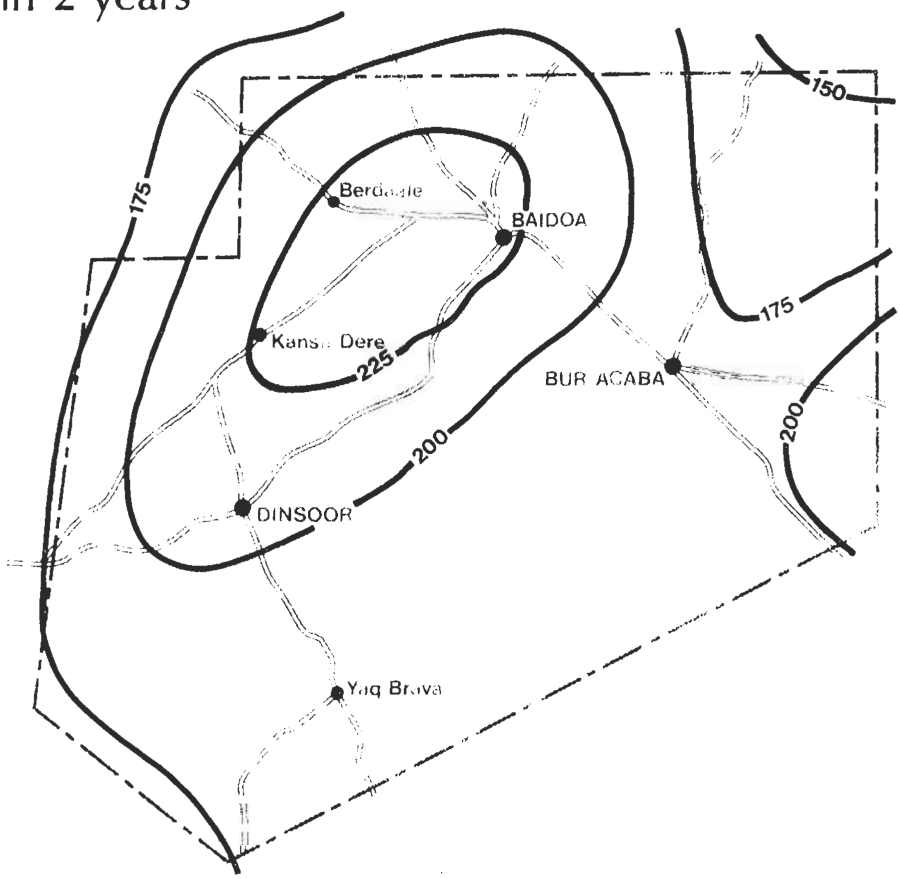
TABLE 2.3 GU SEASON RAINFALL PROBABILITY ANALYSIS (Rainfall values in mm for given probabilities of exceedance)

Expected number of years value is exceeded	Probability of Exceedance %	Baidoa	Bur Acaba	Dinsor	Bardeera	Lugh Ganana	Uegit	Oddur	Tieglio	Bulo Burti	Uanle Uen	Villabruzzi	Afgoi	Genale	Alessandra
9 in 10	90	139	48	118	73	54	73	93	64	51	113	94	84	53	149
4 in 5	80	168	82	146	97	83	87	111	78	71	160	112	107	71	174
3 in 4	75	181	99	156	108	93	93	120	84	80	177	122	118	80	186
2 in 3	67	199	125	172	124	109	102	133	94	94	202	134	133	93	202
1 in 2	50	240	134	205	158	147	119	160	114	128	248	161	167	123	235
1 in 5	20	344	310	279	262	219	159	232	173	188	314	224	249	212	312
Number Observation[1]		46	26	7 (+32)	39	32	5 (+18)	23	8 (+23)	23	18	33	39	23	20
Location		Within Project Area							Outside Project Area						

Note [1] *Number in parenthesis indicates years of infilled data*

2.10 & 2.11 Gu season rainfall isohyets (mm)

2.10 1 in 2 years



2.11 3 in 4 years

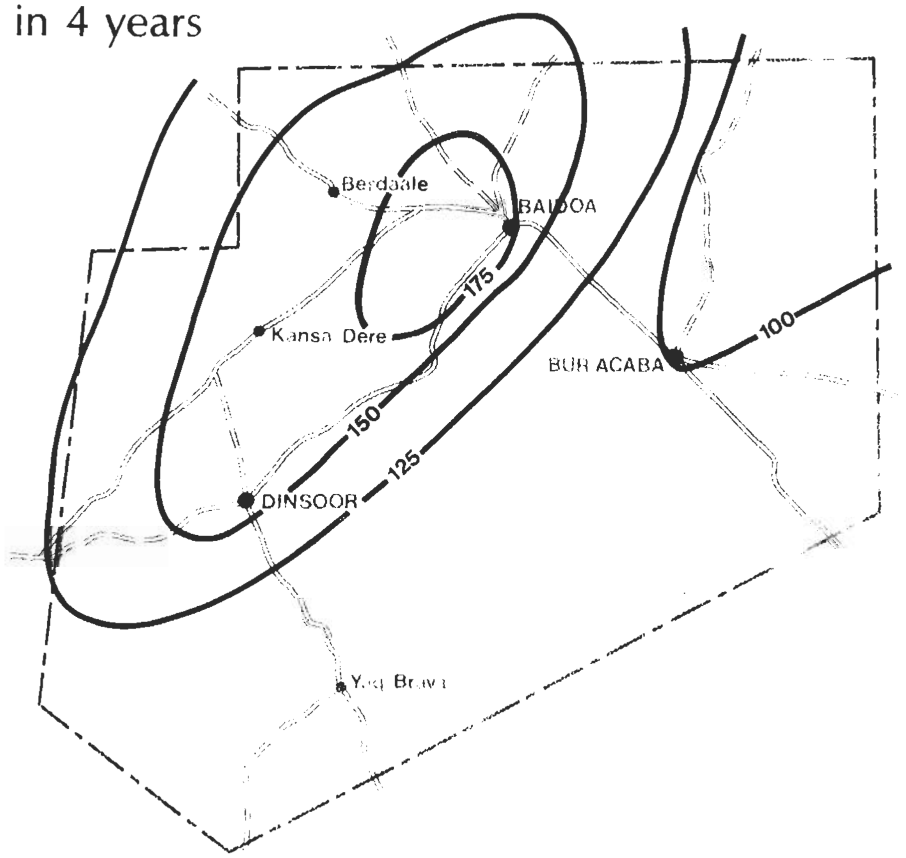


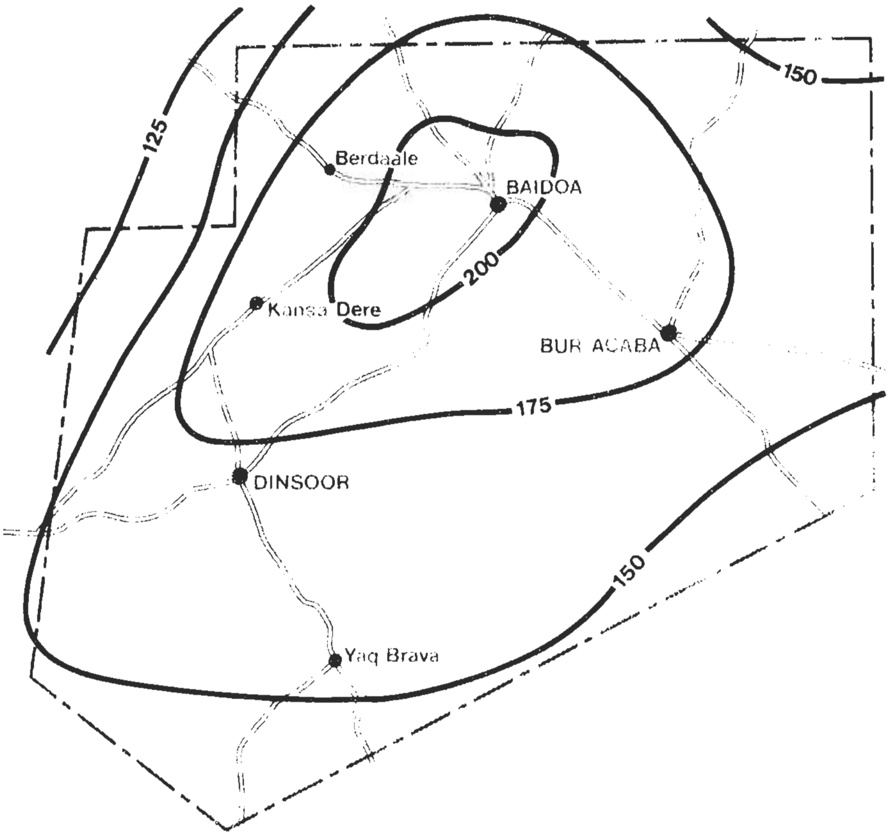
TABLE 2.4 DER SEASON RAINFALL PROBABILITY ANALYSIS (Rainfall in mm for given probability of exceedance)

Expected number of years value is exceeded	Probability of Exceedance %	Baidoa	Bur Acaba	Dinsor	Bardeera	Lugh Ganana	Uegit	Oddur	Tieglio	Bulo Burti	Unale Uen	Villabruzzi	Afgoi	Genale	Alessandra
9 in 10	90	74	45	69	35	15	55	67	39	34	62	44	21	15	19
4 in 5	80	112	83	95	56	27	69	83	52	55	82	75	44	30	34
3 in 4	75	129	99	107	67	34	76	90	59	66	92	90	55	37	43
2 in 3	67	156	124	126	87	46	86	102	69	84	107	114	77	50	54
1 in 2	50	215	182	169	133	76	113	129	92	125	144	176	132	83	99
1 in 5	20	344	272	281	261	172	198	201	160	234	253	311	281	148	229
Number Observations[1]		45	26	8 (+30)	39	31	6 (+17)	23	7 (+23)	21	21	33	40	23	20
Location		Within Project Area						Outside Project Area							

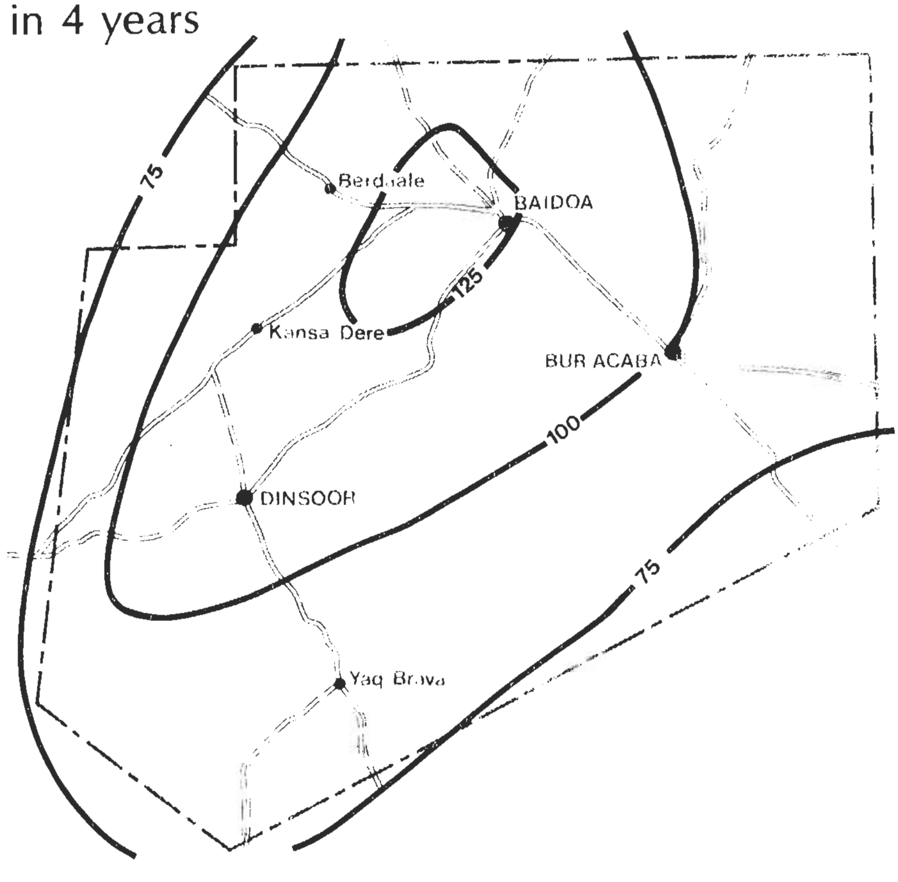
Note: [1] *Number in parenthesis indicates years of infilled data*

2.13 & 2.14 Der season rainfall isohyets (mm)

2.13 1 in 2 years



2.14 3 in 4 years



Sorghum is the main crop in the Bay Region and requires over 300 mm of rainfall for a good yield. Seasonal rainfall is nowhere greater than this value at the 50 per cent exceedance level. Only at a probability level of 20 per cent, that is once in every five years, are there significant areas where the seasonal rainfall is expected to be greater than 300 mm. Fortunately, Sorghum can be grown, albeit with a reduced yield with a rainfall of only 175 - 200 millimetres. At the 50 per cent exceedance level, once in every two years, the majority of the region experiences greater than 175 mm of rainfall in the Gu season (see Figure 2.11), as does approximately one third of the region in the Der season (see Figure 2.14). However, once in every four years less than 175 mm of rainfall is expected to occur over the majority of the region in the Gu season (see Figure 2.11).

Daily rainfall values are available at Baidoa and also at Bardeera, which is just outside the project boundary and an analysis of seasonal duration and start date is possible at these two locations. At Baidoa 39 years of daily rainfall data are available and 33 years of daily values are available at Bardeera.

The start and end date of each season is defined arbitrarily as the first and last daily falls of greater than 10 mm; single falls separated from the season by ten to fifteen days are excluded. Table 2.5 summarises the statistics relating to the start dates and durations of the two seasons, exceedance values being calculated assuming that the respective series of values fits a normal probability distribution.

TABLE 2.5 STATISTICAL DESCRIPTION OF RAINY SEASON PERIODS

Period		Baidoa	Bardeera
Gu Season			
Start:	1 year in 4	by 1st April	by 3rd April
	Average	9th April	10th April
	3 years in 4	by 17th April	by 17th April
Duration:	1 year in 4	49 days	37 days
	Average	38 days	27 days
	3 years in 4	27 days	17 days
Der Season			
Start:	1 year in 4	by 2nd October	by 14th October
	Average	10th October	24th October
	3 years in 4	by 18th October	by 3rd October
Duration:	1 year in 4	46 days	42 days
	Average	33 days	28 days
	3 years in 4	20 days	14 days

The start of the Gu season on average occurs at the same time for Baidoa and Bardeera although the season duration at the latter is some 11 days shorter. At Bardeera the Der season begins on average two weeks later than at Baidoa although the duration is similar.

3

Soils

3.1 METHODOLOGY

3.1.1 Aerial Census Stratification

A reconnaissance at between one and four thousand feet above the ground over the whole region was made to determine the criteria and approximate position of the geomorphic units or strata. These were draft plotted onto the 1:100 000 scale survey department maps. The boundaries were compiled using the Lockwood/FAO study maps as a guide in conjunction with the information available on the 1:100 000 scale maps. The boundaries were subsequently modified by reference to the 1:250 000 scale LANDSAT imagery. They were also modified during the flying programme for the census. The strata were described during the course of the census flying.

The major strata identified during these studies could be divided into 5 main geomorphic units:

(a)	clay plains subdivided into	- cultivated soils on limestone, strata 1, 5, 8, 20
		- cultivated soils on basement complex, strata 10, 12, 17, 21
		- uncultivated soils over coastal deposits, strata 19, 29
		- cultivated soils on mixed limestone and basement complex, stratum 24.
(b)	limestone plateau	- strata 2, 3, 4, 6, 15, 28
(c)	basement complex peneplains	- strata 9, 13, 16, 27
(d)	basement/limestone interface	- strata 7, 23, 26
(e)	coastal deposits	- strata 11, 14, 18, 22, 25

These are illustrated in Figure 3.1 and their characteristics summarised in Table 3.1

3.1.2 Geology and Geomorphology

The Bay Region includes most of the Upper Juba Region physiographic province. This represents a mature landscape with a gentle slope towards the coastal belt, except for the northern edge of the Bur subregion where the basal Jurassic sequence overlie the basement. This contact is clearly shown by a northeast trending escarpment that sharply borders the highland subregion. It is a retreating cuesta produced by the resistant basal Jurassic Baidoa suite over the less resistant metamorphic basement which includes scattered rounded hills of granite intrusions.

3.1 Aerial census strata

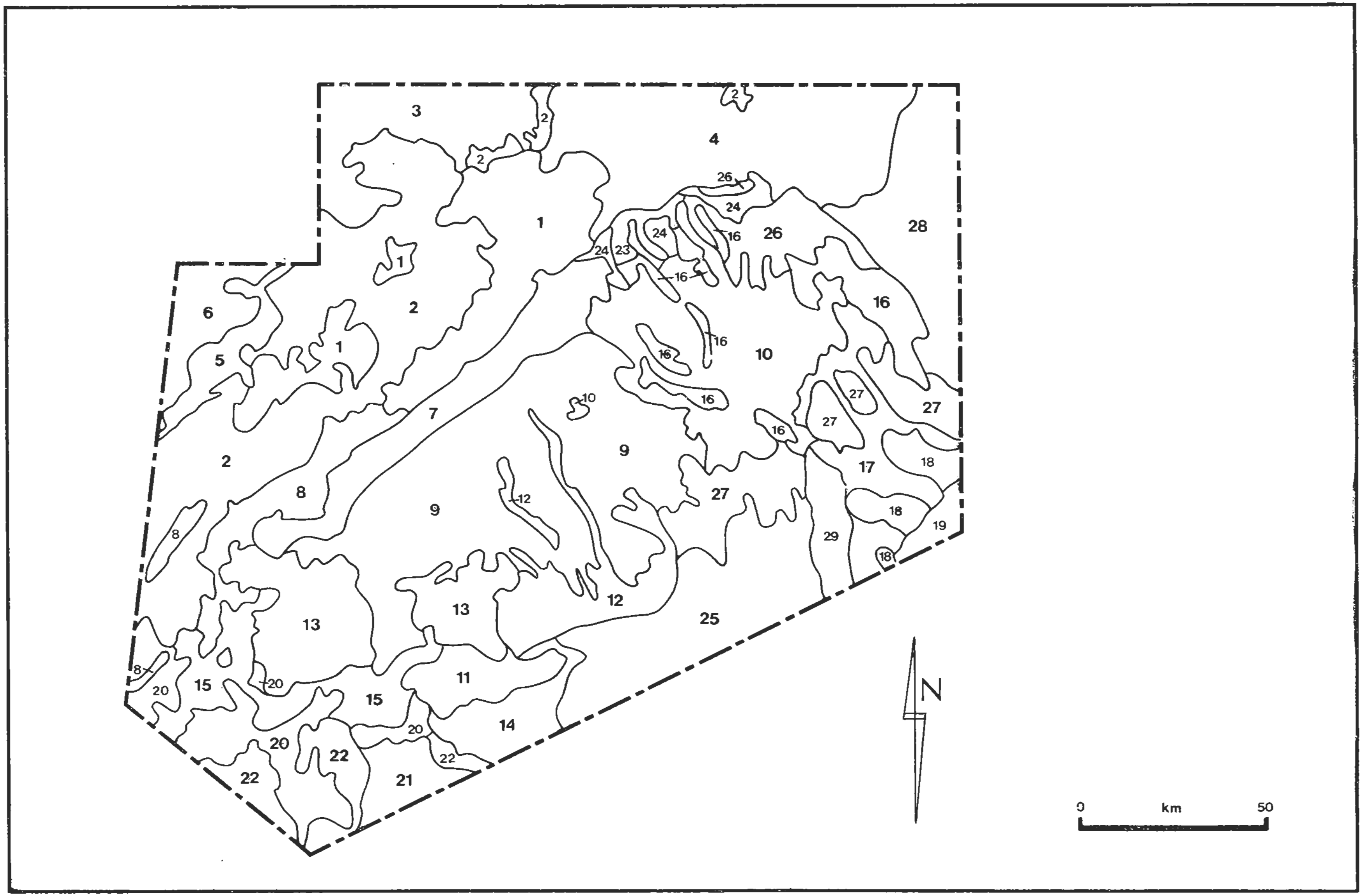


TABLE 3.1 AERIAL CENSUS STRATIFICATION

Geomorphological Class	Stratum Number	Physical Appearance	Soil Types	Vegetation	Cropping Pattern	Water Supply	Livestock Characteristics	Wood/Charcoal Production Features	Occupation/ Settlements
Clay Plains on Limestone	1	Plateau with slight slope NE to SW	Baidoa/Amin	Low shrubland many *Dobera glabra*	71.7 per cent cropped mainly sorghum	Waro	Moderate to heavily grazed 40/sq km	Local wood and poles	Many villages
	5	Nearly flat plateau	Amin	Dense *Acacia* spp.	8 per cent cropping	Very little	Low density 3/sq km	Nil	Local nomads, no permanent villages
	8	Clay plain on less resistant strata	Uiamo	Low shrubland	42.2 per cent mainly sorghum	Less dense waro	Moderate to heavily grazed 42/sq km	Local wood and poles	Many villages
	20	Nearly flat plain sloping N to S	Uiamo	Low shrubland	14 per cent mainly sorghum	Waro and local hand dug wells	Medium density 29/sq km	Widespread wood/pole cutting	Large villages Local nomadic settlers
Clay plains on Basement Complex	10	Gently sloping from north to south	Bur Acaba/ Modu mode	Low shrubland many *Dobera glabra*	52 per cent mainly sorghum	Waro	Moderate to heavily grazed 40/sq km	Local wood/pole cutting	Many villages
	12	Wide valleys and plains between granite burs	V.B./Issur	Dense low bushland	9-10 per cent increasing	Waro	High density 67/sq km	Local charcoal	Villages and nomads in the west
	17	Flat plains	Burei/Madamrodi	Medium density shrub bushland	Only local cropping	Waro, local balli	Low densities	Local wood/poles Little charcoal	Low densities of nomads
	21	Flat plain gentle N-S slope	Burei	Open bushland	Nil	Very little	Low densities	Nil	Low densities of nomads
Clay Plains on Coastal Deposits	19	Very flat plain	Dududmai	Medium density shrub bushland	Nil	Local waro and balli	Medium densities	Nil	Low to medium densities of nomads in east
	29	Alluvial fans	V.B.	Open bushed grassland	Nil	Local balli	Medium densities	Local charcoal, wood and poles	Low densities of nomads in the north
Mixed limestone and Basement Valleys	24	Flat valleys	Asharow	*Acacia Seyal* and *Acacia nubica* thickets	Local irrigation some crops in east	Local springs on escarpment edge	Low densities	Wood and poles in east	Main villages in east, low densities nomads
Limestone plateau	2	Gently undulating plateau sloping NW to SE	Amin/Berdaale	Medium shrubbed-bushland	Local cropping near Berdaale	Waro	Many camels, sheep, goats	Extensive charcoal	Many villages, nomads on margin with strata 1, 8 and 5
	3	Gently undulating limestone pavements	Regosols	Medium shrubbed- bushland	Nil	Little	Medium densities	Extensive charcoal	One village, scattered nomads and charcoal huts
	4	Gently undulating many ironstone gravels	Regosols (concretionary)	Medium shrubbed bushland	Nil (local abandoned fields)	Local springs	Low densities	Extensive wood/poles and charcoal in west	Small numbers nomads in west
	6	Shallow escarpments with limestone pavements	Regosols	Medium - dense shrubbed-bushland	Local small fields	Springs and hand dug wells in wadi	High densities of camels and goats	Nil	Many nomads
	15	Gently undulating stony landscape	Regosols/Uiamo	Dense shrubland	Local small abandoned fields	Shallow hand dug wells in wadi	High densities especially near water holes	Local wood/poles	Nomads near wadi some villages on edge stratum 15
	28	Flat to gently undulating	Regosols	Medium to dense bushland	Nil	Few wells in west of area	Low densities	Nil	Few nomads
Basement Peneplain	9	Weakly undulating plain with isolated burs	Dinsor	Open shrubbed bushland	Nil	Local balli, waro in the north and wells near burs and in the wadi	Medium densities	Wood and poles	Many nomads
	13	Extensive burs of granite/ granodiorite	Dinsor	Open shrubbed bushland	Nil	Wells near burs and in wadi some new waro	Medium densities	Nil	Many nomads in east
	16	Convex interfluvial peneplain ridges/remnants	Dinsor	Medium shrubbed bushland	Nil	Waro mainly in margins stratum 10	Medium densities	Nil	Villages on edge stratum 10, medium density nomads
	27	Flat to slightly undulating peneplain	Dinsor / Madamrodi	Open to medium density bushland	Nil	Small numbers dry waro/balli	Low densities	Charcoal near main road	Small number of nomads
Basement-Limestone Interface	7	Steeply sloping escarpment and footslope	Dinsor	Medium to dense wooded bushland dense shrubbed thickets in valleys	Some fields in wider valley floors	Many small springs	High densities	Many wood/poles extracted	Villages on edge of strata 1 and 8, medium to high density nomads
	23	Low ridges and limestone capped spurs	Regosols	Medium-dense wooded bushland	Nil	Shallow wells and springs on escarpment	High densities camels, medium densities others stock	Low levels wood/poles	Villages on edge of stratum 24, high densities nomads
	26	Gently undulating low escarpment	Regosols	Dense wooded bushland	Nil	Local springs on line of escarpment	Low to medium densities	Nil	Low densities
Coastal Deposits	11	Undulating plain	Issur	Medium bushland	Small fields locally	Hand dug wells in wadi	Large numbers of cattle grazing	Nil	Many nomads, local villages
	14	Slightly undulating plain	Issur/Burei	Medium-dense bushland	Small fields locally	Low density shallow wells	Large numbers of cattle grazing	Nil	Low densities nomads, local villages
	18	Flat Coastal plain	Burei	Medium density shrub bushland	Local mechanical cultivation	Waro	Low to medium densities	Nil	Few villages and low densities nomads
	22	Undulating plain	Issur	Medium density shrubland	Nil	Sandy wells	Low to medium densities	Nil	Medium densities nomads
	25	Very flat plain	Burei	Open-medium shrub bushland/ grassed bushland	Nil	Dry balli	None	Nil	Very low densities nomads

The oldest rocks occur in the Bur Region and consist of metamorphics with intrusives. The Bur Acaba granite intrusion has been dated as Lower Cambrian. The former include material of both sedimentary and igneous origin; amphibolites, mica-schists, gneiss, phyllite, quartzites, and marble. The central and southwestern parts have a higher concentration of intrusives mainly of granites and granodiorites and these are associated with complicated networks of aplitic and quartz dykes.

The present day basement peneplain has a very mature morphology mainly as a result of erosion which affected the area before the Jurassic ingression. It has been modified by later erosion cycles. The basement Bur area is overlain by the Jurassic sediments in a radial pattern in the north and northeast . Towards the coast these have gradually become covered with quaternary sediments. Although much of the Bur Acaba basement high was above sea level during the early Jurassic ingression it was eventually covered by a shallow sea in the Middle Jurassic or Callovian period. The evidence for this is found in the presence of remnants of the Baidoa Formation on the northern margins of the present basement.

The Baidoa formation rests unconformably on the basement complex. It consists of thick bedded oolitic and algal limestones interbedded with varicoloured shales. These are followed by a well bedded sequence of yellowish brown dense limestone and detrital limestones occasionally intercalated with calcareous shales, but generally oolitic with abundant shell fragments. The more easily weathered shales have produced broad clay basins separated by low cuestas formed in more resistant limestone.

3.1.3 Satellite Image Interpretation

The computer techniques employed in the enhancement of the imagery used in the Bay Region studies are described more fully in Appendix A. Three LANDSAT products were available during the course of the resource investigations. Black and white enlargements to 1:60 000 scale of Return Beam Vidicom (RBV) images; 1:250 000 scale photographic colour composite enlargements from standard NASA photographic products; and Hunting Image Process and Analysis System (HIPAS) processed colour composite enlargements from computer compatible tape (CCT) data. The principal advantage of the latter material over the former two products, for interpretative processes, is the greater amount of detail available. Film products are not as sensitive as the LANDSAT sensors and so the data recorded is degraded when recorded on film. The computer based digital image processing system, however, allows a full range of LANDSAT data to be analysed. The larger scale of the RBV imagery however, did allow some useful comparisons to be made especially in the area studied for possible irrigation development.

The computer enhanced 1:250 000 scale images were processed on HIPAS and the four scenes involved were geometrically warped to fit the existing 1:250 000 scale base map. The four scenes were also mosaiced into two sheets and a number of different enhancement techniques and enlargements applied to selected areas as case studies for the more detailed surveys carried out in the PADU's. These are described more fully in Appendix A.

3.1.4 Soil Survey Techniques

For the initial reconnaissance surveys soil survey observations were carried out to achieve an overall density of sites at 1:500 ha in the cultivable areas and 1:10 km^2 in the rangelands. The geomorphic unit stratification and LANDSAT interpretation was used as a guide in the location of these sites. Detailed traverse notes were made along all tracks used for access to assist the final mapping.

It was proposed in the Terms of Reference that four pilot agricultural development units (PADU's) of 62 500 ha would be slected for more detailed investigations. These areas would be representative of main soil types within each of the four Administrative

Districts and should consist of approximately 55 000 ha of rangeland and 7 500 ha of cultivable land. The more detailed studies would, however, be confined to only 10 000 ha of the range category.

At the time of the identification of the PADU's it was possible to procure 1:20 000 scale air photographs of these areas. These were used as a basis for the planning of the field mapping in two of these areas. The interpretation from these photographs was reduced to 1:50 000 scale for the final mapping.

The appraisal mission had identified an area of 100 000 ha with limestone parent materials, likely to yield groundwater and proposed that up to 60 000 ha of this land could be irrigated. However, it was apparent at the initial stage of the reconnaissance studies that there was a fundamental error in the basis of this assumption. Much of the land identified as comprising limestone parent materials consisted of very shallow limestone over deep basement complex strata. Also these materials were often eroded down to resistant strata, with very little soil development.

The area selected for reconnaissance investigations of the 60 000 ha was based on the aerial census stratification and a preliminary interpretation of the Lockwood soils data. This showed that more promising soils for irrigation development were likely to exist in the valley unit of stratum 24 and in the clay soils of stratum 10, in the south of the area. Elsewhere in the east of the area the soils were found to shallow, largely developed over basement complex strata in areas unlikely to yield sufficient groundwater for irrigation.

The TOR called for an overall density of one site per 500 ha for the PADU's and the reconnaissance irrigation studies. Where access was difficult it was necessary to bulldoze trace lines. In most areas, however, existing access was suitable for the needs of the study. Bore sites were described to a depth of 1.2 m and every third site was sampled from 0 - 25 cm; 25 - 75 cm and 75 - 120 cm. These depths were slected on the basis of an analysis of existing information on chemical changes in the soil profile (Lockwood/FAO 1968). Pit sites generally to two metres depth were sampled by natural horizons with about four samples per pit.

Additional studies on soils, soil moisture and soil physical characteristics were carried out at selected sites in the potential irrigation areas.

3.2 SOIL MAPPING UNITS

The soils of the Bay Region were classified and mapped following a similar system to that employed by Lockwood (1968). This enables a more rapid correlation with their reconnaissance units. They have been divided into four main groups based largely on parent materials:

- soils of the Limestone Plateau;
- soils of the Basement Complex;
- soils of the coastal Plain and;
- miscellaneous soil types.

In addition there is discussion on the range of variation found in these soil types from the more detailed sample investigation carried out in the Limestone Depression and PADU survey areas.

Table 3.2 summarises the main characteristics of the soils described in the following section.

3.2.1 The Limestone Plateau

(a) AMIN SOILS (Am)

The Amin soils rank alongside the Baidoa soils in terms of economic importance to the Bay Region. they occur mainly in a large (99,900 ha, gross) area around Ufurow and Kansadere and support a significant proportion of the regions grain agriculture.

The Amin soils are red-brown to brown vertisols associated with the softer marley beds of the Jurasic limestone plateau. They lie on fairly well drained sites at an elevation of 400-500 masl and under a current rainfall regime of 400 - 600 mm annual average precipitation. In these respects they are similar to the Baidoa soils described, although Baidoa sites are generally less well drained (Lockwood, 1968).

The surface horizons are non-saline red-brown clay loams or clays, whilst the sub-soil is typically brown clay often containing gypsum and calcium carbonate concretions.

The Amin soils in the Bay Region are cultivated almost entirely for Sorghum. Regrowth of natural vegetation on non-cultivated areas is normally an *Acacia* sp. dominated thicket formation. *Euphorbia* sp. hedging is a common feature of the Amin landscape, lining drainage lines and the perimeters of wara and villages. A heavy surface cover of limestone boulders occurs on the periphery of the Amin soil areas.

(b) BAIDOA SOILS (Ba)

Formed in situ within the deep mantle of the limestone plateau, the Baidoa soils are relatively fertile vertisols that predominate throughout the Baidoa Plains sub-region as far to the south west as Xabaab Barbar. These soils are normally deep (at least 120 cm) brown - dark brown (10YR 4/3 - 10YR 3/3) clay loams and clays exhibiting the large surface cracks, solution holes and slightly gilgaied micro-relief characteristic of vertisols. They are slightly alkaline (pH 7.5) but surfaces horizons are non-saline. Small (1-2 mm) manganeseous granules and land snail shell fragments are common features of the upper profile whilst calcium carbonate concretions and gypsum crystals are sometimes to be found at depths below 80 centimetres.

The Baidoa soils are amongst the most fertile in the Bay Region and are preferentially cropped for rainfed sorghum, occasionally intercropped with cowpeas.

Natural vegetation upon Baidoa soils is generally of a secondary nature, being regrowth from previous clearances. *Acacias* predominate in thicket formation, often with a fair cover of grasses beneath. Sorghum residues (stover) are increasinly utilised for dry season livestock forage. A gross total of 132 590 ha of Baidoa soils have been mapped.

(c) BARDEERA SOILS (B)

The Bardeera soils are in many respects similar to the Baidoa soils described above, being moderately deep Brown to Yellow-Brown fine textured vertisols. Their genesis is similar, formation occuring from Jurassic limestone parent material of the plateau, either in situ or from locally derived erosion products. They occur in areas of lower

TABLE 3.2 SOIL MAPPING UNITS - RECONNAISSANCE STUDIES

Geomorphics Unit	Soil Mapping Unit	Symbol	Physiography	Microrelief	Soils	Vegetation/ Land Use
Limestone Plateau	Amin	Am	Flat plateau	Weak gilgai	Red-brown-brown fine textured	
	Baidoa	Ba	Flat plain	Weak gilgai	Brown-dark brown fine textured	Extensively cultivated
	Bardeera	B	Flat plain	Even	Brown-yellow brown fine textured	Scattered cultivation
	Berdaale	Bd	Flat plateau	Smooth even	Dark-red to red brown medium textured	Scattered local cultivation
	Cor Cor/ Concretionary Regosols	RCr	Flat-weakly undulating plateau	Uneven rocky outcrops	Moderately shallow Dark red brown gravelly Sandy soils	Rangeland
	Regosols	R	Undulating plateau	Many limestone pavements	Shallow rocky red brown sandy clay loams	Rangeland
	Uiamo	Ua	Gently sloping	Weak gilgai occ. outcrops	Grey-grey brown fine textured	Cultivated
Basement Complex	Bur Acaba	Br	Basins	Weak gilgai occ. outcrops	Brown-olive brown fine textured	Cultivated
	Dinsor	Di	Nearly flat interfluves	Smooth even	Red brown sandy profiles	Rangeland
	Issur	Is	Nearly flat interfluves	Smooth even	Brown sandy profiles	Rangeland
	Modu Mode	Mo	Depressional	Weak gilgai-sink holes	Grey brown to Grey clays	Extensively Cultivated
Coastal Plain	Burei	Bi	Flat to concave slopes	Even	Brown to yellow brown clay solonetz	Rangeland
	Dudumai	Du	Flat to convex slopes	Even	Yellow brown to red brown carbonaceous clays	Rangeland
	Madamrodi	Mr	Gently sloping	Even	Red brown-brown sandy loams	Rangeland
Valleys	Valley Bottoms	VB	Weakly undulating	Even	Variable textured and coloured often stratified soils	Rangeland

current average annual rainfall, however, (3-400 mm.p.a.) and at lower elevations (150 - 300 ma.s.l.). The Bardeera soils do not occur extensively in the Bay Region, being confined to relatively small areas (6 445 ha, total) in the northwest of the region close to the present valley of the Juba River.

Surface textures are clay-loam to clay with brown to grey-brown clays beneath. The soils occur on level to gentle sloping or undulating ground and a slight gilgai is common. Large cracks and solution holes are often found in Bardeere soils during dry conditions.

The soils are fertile, but salinity increases with depth down the profile currently, the soils are cropped for sorghum on a rainfed basis.

(d) BERDAALE SOILS (Bd)

The Berdaale soils are essentially a deeper phase of the concretionary regosols. They occur principally around the town of Berdaale and comprise an area of 23 480 hectares.

They are moderately deep, dark red to red/brown medium textured ferrasols with a marked concretionary horizon. Limestone stones and boulders are a feature of the surface but in insufficient quantities to hinder cultivation. Cultivation is predominantly for sorghum. The Berdaale soils correspond closely to the Cor Cor soils described by Lockwood Corporation (1968).

(e) CONCRETIONARY REGOSOLS (RCr)

These soils are moderately shallow to shallow dark red to red-brown concretionary ferrasols often bearing limestone boulders and/or iron coated gravels on the surface. Within the Region, the concretionary regosols are most commonly found in the periphery of the cultivated clay basins of the limestone plateau, particularly around the Amin and Baidoa soils. They are developed on the more resistant iron rich limestone strata.

These regolsols are coarser textured than the nearby clays, being sandy clay or sandy clay loam in the surface and sub-surface. Soil colour is usually consistent throughout the profile, but the subsoil is characterised by a heavy concentration of cemented concretionary gravels. Carbonate concretions and gypsum crystals may also be found in the subsoil.

The concretionary regosols are slightly alkaline and generally quite shallow, with surface stones hindering cultivation. Nevertheless, some areas are utilised for growing sorghum.

(f) REGOSOLS (R)

Shallow, rocky Regosols predominate over the limestone plateau, accounting for a total mapped area of 1 010 735 hectares. These dark red to red-brown (2.5 YR 3/6) sandy loams and sandy clay loams are characteristically shallow (rarely deeper than 60 cm) and are subject to varying degrees of outcropping of the underlying limestone pavement. In some areas this outcropping may account for more than 75 per cent of the local surface area. Horizonation of the profile is not apparent, although textures generally became slightly heavier with depth. Salts of any kind are rarely present, the soils being quite well drained.

The regosols occur in the dryer areas of the region and are rarely cultivated. They bear a mixed shrub/bushland vegetation with a very variable ground cover of herbs and grasses. Land use of the regosols is almost entirely for graze and browse.

(g) **UIAMO SOILS (Ua)**

The Uiamo soils are the principal cultivable soils of the mantled limestone plateau in the west of the region. 273 005 ha of Uiamo soils have been mapped. They are grey to grey-brown vertisols of rather variable depth - deep to moderately deep - and are slight to moderately alkaline (pH range: 7.8-8.1). They occur on flat to gently undulating land and are generally associated with depressional tracts and basins.

The Uiamo soils bear the typical surface characteristics of vertisols - a slight but regular microrelief, large surface cracks delineating the master peds, and solution holes. Surface colours may range from 10YR4/3 to 10 YR 4/1 but generally became greyer with depth. Surface and subsurface textures are clay-loam to clay over a massive or weakly prismatic subsoil. Coarse sand grains appear throughout the profile to a depth of about 1.5 m., having been transported down drought cracks. Shell fragments and small black concretions are common features of the upper horizons, whilst calcium carbonate and gypsum may be found in heavy concentrations below about 80 centimetres.

The Uiamo soils are fertile and are cropped extensively for rainfed sorghum. Mechanised cultivation of these soils is currently being attempted in the Buulo Guudud area.

3.2.2 The Basement Complex

(a) **BUR ACABA SOILS (Br)**

The Bur Acaba soils are dark-brown vertisols derived from the products of the erosion of the basement complex granites and metasediments and drift materials derived from the limestone plateau. Whether the soils were formed in situ or have been transported is not entirely clear, but the majority of Bur Acaba soils now overlay the mixed granites and gneiss of the basement complex. Some 192 440 ha of Bur Acaba soil have been mapped. They occupy level, gently undulating, and sloping lands in the Bur Acaba plain.

The surface (dark brown, 7.5 YR 4/4) exhibits a slight microrelief, occasional gravel smears, and large cracks and solution holes during the dry season. Textures are clay loam to clay becoming heavier with depth. The soils are moderately deep to deep and are moderately alkaline (pH 8.0). Small, soft, concretions of calcium carbonate are often found at depth (around 100 cm).

Bur Acaba soils are extensively cultivated, mostly for sorghum, and farmers construct small rectangular basins to trap the early rains and improve moisture penetration.

(b) **DINSOR SOILS (Di)**

The Dinsor soils cover an area of 977 380 ha and are amongst the most extensive soil types in the Bay Region. They are formed within the crystalline materials of the basement complex and occur extensively in the Bur sub-region on level and gently undulating topography under a rainfall regime of 400 - 600 mm per annum.

The Dinsor soils are deep - moderately deep coarse textured, slightly acid latosols. Textures range from loamy coarse sand at the surface to coarse sandy clay at depth (200 cm). The soils are dark red (2.5 YR 3/5 - 3/6) throughout the profile, with no marked horizonation. A few soft calcium carbonate concretions may be found at depth.

Dinsor soils are latosolic and a hard surface capping often forms, particularly in relatively heavily grazed areas near tracks and villages. In these areas, infiltration rates are low, run-off is high and erosion rills and gulleys a common occurance. In valleys and local depresions, a coarse quartz grit smear accumulates, occasionally to a depth of five centimetres or more, which inhibits capping and improves permeability.

The Dinsor soils are rarely, if ever, cultivated. Natural vegetation is a fairly mature mixed shrub and bushland. Herb and grass communities are normally absent where the soil has become capped but grow well where permeability is better. Land use is almost entirely for graze and browse.

(c) ISSUR SOILS (Is)

The Issur soils are similar in many respects to the Dinsor soils described above, but occur in areas of slightly lower average annual rainfall (400-500 mm) and may have developed in more deeply weathered crystalline materials or be associated with a pleistocene deposit (Lockwood, 1968).

The Issur soils and deep, nearly neutral to slightly alkaline (pH 7.3) medium textured latosols and are confined in their occurence to areas southeast and southwest of Yak Brawe. Some 199 805 ha of this soil have been mapped. They have no realistic agricultural capability and are used currently as rangeland, largely by itinerant nomads.

Natural vegetation is an open mixed shrubland; *Terminalia* sp. and *Euphorbia* sp. are common components.

(d) MODU-MODE SOILS (Mo)

A total of 42 815 ha of these grey to grey-brown vertisols have been mapped. They are associated with the Bur Acaba soils described previously and generally lie to the north of them, and south of the current position of the limestone escarpment. The Modu Mode soils are derived from the weathering products of both limestone drift and basement complex sediments but like the Bur Acaba soils, generally overlie basement complex gneisses.

In terms of profile characteristics, the Modu Mode soils resemble to some extent the Uiamo clays, but may be found at slightly lower elevation (150 - 350 m. asl). The grey, clay loam to clay surface exhibits slight micro relief, drought cracks and sink holes. The subsoil is dark grey to dark grey brown, compact and may exhibit slickensides. Salts and soft carbonate concretions are often present in the subsoil.

The Modu Mode soils are extensively cultivated for rainfed sorghum, within small rectangular basins.

3.2.3 The Coastal Plain

(a) BUREI SOILS (Bi)

The Burei soils occur in the southeast of the study area and have been mapped over an area of 360 475 hectares. They have been derived from the mixed erosion products of the limestone and crystalline mantles to the north.

The Burei soils are solonetzic, brown to yellow-brown clay loams and clays. They exhibit a slight micro relief and are covered with a shallow soft mulch or sandy wash. Small black concretions are common throughout the profile and salts and soft carbonates may be present in the subsoil.

There is little agricultural potential for the Burei soils and because they occur in an area with limited water supplies they are severely limited in their use for rangeland development. Extensive construction of wara is taking place in the area to the west of the Wanle Weyne to Bur Acaba road, however, and this should raise the potential of the area for rangeland development.

(b) **DUDUMAI SOILS (Du)**

The Dudumai soils are fine textured red-brown to yellow-brown concretionary soils predominating in the extreme southeast of the study area. A total of 40 975 ha of these soils have been mapped.

The surface is generally a smooth or fine gravelly, yellow-brown or red-brown sandy clay over a dark red-brown clay containing hard and soft carbonate concretions (Lockwood Corporation, 1968).

The Dudumai soils are droughty and difficult to work and are not suitable for rainfed cultivation.

(c) **MADAMRODI SOILS (Mr)**

Madamrodi soils occur on level to gently sloping land in the southeast portion of the Region. They are medium to fine textured, deep, and moderately alkaline (pH 7.9) red-brown to brown soils, described by Lockwood as Terra Rossa. Surface horizons are sandy loam to sandy clay loam, slightly silty in local depressions. The subsoil is generally a brown sandy loam containing a few calcium carbonate concretions.

As for the Dudumai soils, which occur in the same general area, the Madamrodi soils have little or no potential for agriculture but carry a natural vegetation which is currently heavily utilised for graze and browse by local livestock.

3.2.4 Miscellaneous Soil Types

(a) **VALLEY BOTTOM SOILS (VB)**

A total of 278 990 ha of the Region is mapped as Valley Bottom Soils. The delineation and extent of this significant unit is based on the distinctive LANDSAT response to fine soil textures, associated soil moisture retention and corresponding vegetation condition. The soils themselves, however, may vary greatly throughout the unit, their nature being largely dependent upon that of the parent material eroded and subsequently deposited. The majority of valley bottom deposits are recently derived from the clay plains of the limstone plateau mixed with fine erosion products from surrounding soils of crystalline origin. Physical characteristics are very variable. Colour may range from olive through grey and brown to red-brown. Textures vary from sandy loam to clay, often overlain with sands in those river courses with only intermittent flow. Salts and carbonate concretions may be present in high concentrations and, where evaporation rates are high, gypsum crystals may be clearly evident in and on the surface (e.g. to the south of Ufurow).

In the middle and lower courses, the valley bottom soils may extend to considerable width, taking on the appearance of a flood plain. Here, the clays may be quite deep and exhibit vertisolic characteristics of gilgai and drought cracking. Such areas of worthwhile size are often farmed for rainfed sorghum, although rotations may be quite short.

The areas of these mapping units are shown in Table 3.3.

TABLE 3.3 SOIL MAPPING UNIT AREAS (hectares)

	Mapping Unit	Symbol	Hectares
Shallow soils over Limestones	Regosols	R	822 695
	Regosols - Concretionary	RCr	274 615
	Regosols >50% pavement	Rp>50%	190 135
	Regosols >75% pavement	Rp>75%	6 905
Shallow and moderately shallow soils	Uiamo/Regosols	Ua/R	2 300
	Regosols/Dinsor	R/Di	74 580
Moderately shallow to moderately deep cultivable soils	Berdaale	Bd	23 480
Moderately deep to deep cultivable soils	Amin	Am	99 900
	Baidoa	Ba	132 590
	Bur Acaba	Br	192 440
	Modu Mode	Mo	42 815
	Uiamo	Ua	273 005
Moderately deep soils on basement complex	Dinsor	Di	977 380
	Issur	Is	199 805
Moderately deep soils of the coastal plain	Burei	Bi	360 475
	Madamrodi	Mr	65 375
	Dudummai	Du	40 975
Miscellaneous soil units	Valley Bottom	VB	278 990
	Basalts	Bs	2 300
	Bardeera	B	6 445
TOTAL AREAS SURVEYED			**4067 205ha**

3.2.5 The Limestone Depression

The area covered by the study lies immediately adjacent and to the south of the limestone plateau and escarpment to the south and south east of Baidoa. It includes a number of tributary streams draining off the escarpment the most important of which is the Togga Shiikh Asharow. This river has a number of small irrigation schemes developed along its upper reaches. These valleys contain varying depths of alluvial/colluvial deposits generally of mixed limestone and basement complex origin and containing significant amounts of mica sand. Much of the remainder of the area is composed of rolling country developed on basement complex strata with localised thin residual cappings of hardened limestone which rarely exceed 10 metres thickness. Nearer to the escarpment there are local areas of deeper colluvial drift derived from weathering of the limestone on the plateau. Whilst in the south of the area under study somewhat deeper weathering of the basement granites over a long period of time has produced clay soils, often calcareous, up to two metres in depth.

The details of the initial reconnaissance studies are presented on Map No. 6 and the area measurements are summarised in Table 3.4. Figures 3.2 and 3.3 illustrate the range of variation found within the areas selected for more detailed soils investigation at the semi-detailed level. It was evident at an early stage in the soil investigations that there was unlikely to be sufficient groundwater available for any large scale extension of irrigated farming as envisaged in the IBRD appraisal document. As a result these more detailed studies were confined to investigating the properties of the soils developed on recent alluvium and semi recent alluvial terraces along the Togga Shiikh Asharow.

The major soil types identified in the area were as follows:

(a) valley bottom sites. Asharow soil;

(b) moderately shallow to shallow soils over limestone: Berdaale soil;

(c) moderately deep soils over residual limestone: Uiamo and Baidoa soils;

(d) moderately deep to deep clay soils over granites: Modu Mode and Bur Acaba soils.

Table 3.5 summarises the main characteristics of the soils described in the following paragraphs.

(a) Valley Bottom sites:

Asharow Soil
These soils occur most extensively along the Shiikh Asharow river valley and its main tributaries. It is characterised by its yellow brown (10 YR 5/4) surface colours and a high proportion of mica sand present throughout the profile, which imparts a silty texture to the soil. The semi detailed studies revealed a number of coarsely stratified profiles especially close to the main stream course.

Surface horizons range from strong brown, very fine sandy clay loams to yellow brown and dark yellowish brown, silty clay loams to clay loams. Subsurface and subsoil horizons are generally brown to yellowish brown, clay loams with increasing concentrations of powdery carbonates and nodules at depth. Profiles are moderately well structured, though with limited vertical cracking. Mainly medium prismatic breaking to fine subangular blocky structures are common below 30 centimetres Occasionally fine wedge structures were observed in the deeper deposits below 75 centimetres.

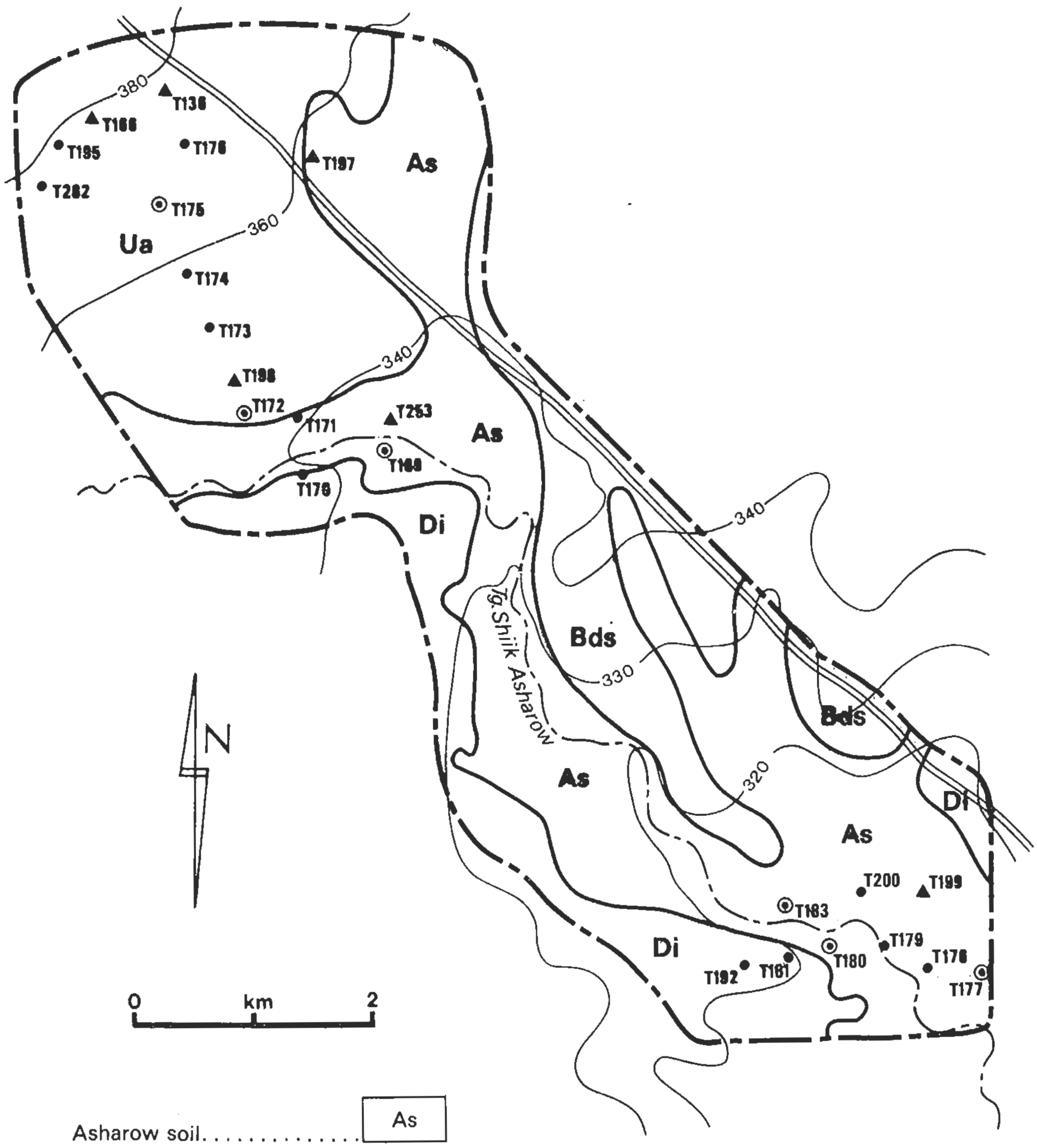
(b) Moderately shallow to shallow soils over limestone.

Berdaale Soil
These soils are developed in areas of limestone of shallow depth overlying basement complex strata. They are very similar to the red soils developed on the limestone of the plateau areas although here are occasionally mica sand inclusions in these soils. Although of a similar colour to the red brown soils developed on the basement complex interfluves they are normally moderately fine to fine textured, with shell fragments commonly occurring at some depth in the profile. These soils have little agricultural potential and rarely exceed 50 cm in depth.

TABLE 3.4 LIMESTONE DEPRESSION SURVEY AREA MEASUREMENTS

	Mapping Unit	Symbol	Hectares
(a) Reconnaissance Survey			
Shallow soils over Limestone	Berdaale moderately shallow	Bdms	37 990
	Berdaale deep	Bd	500
Moderately shallow soils over Basement Complex	Dinsor	Di	7 320
Moderately deep to deep soils over basement complex/ limestone	Baidoa	ba	1 827
	Modu Mode	Mo	3 570
	Uiamo	Ua	2 180
	Bur Acaba moderately deep	Brmd	2 300
	Bur Acaba deep	Br	12 830
Alluvial Soils	Asharow	As	8 220
		Total area	**76 737ha**
(b) Semi Detailed Survey			
Shallow soils over limestone	Berdaale	Bds	450
Soils over Basement Complex	Dinsor	Di	475
Moderately deep - deep soils over limestone	Uiamo	Ua	1 025
Alluvial soils	Asharow	As	1 900
		Total Area	**3 850ha**
(c) Detailed Survey			
Existing irrigation on Asharow soils			52
Asharow soils currently not irrigated			130
		Total Area	**182ha**

3.2 Asharow Valley Semi-detailed soil survey



Asharow soil . . . . As

Berdaale soil . . . . Bd

Dinsoor soil . . . . Di

Uiamo soil . . . . Ua

Shallow; less than 50cms . . . . s

Pit site sampled . . . . ▲

Bore site not sampled . . . . •

Bore site sampled . . . . ⦿

Limit of survey . . . . —·—

3.3 Irrigation areas in the Shiikh Asharow Valley

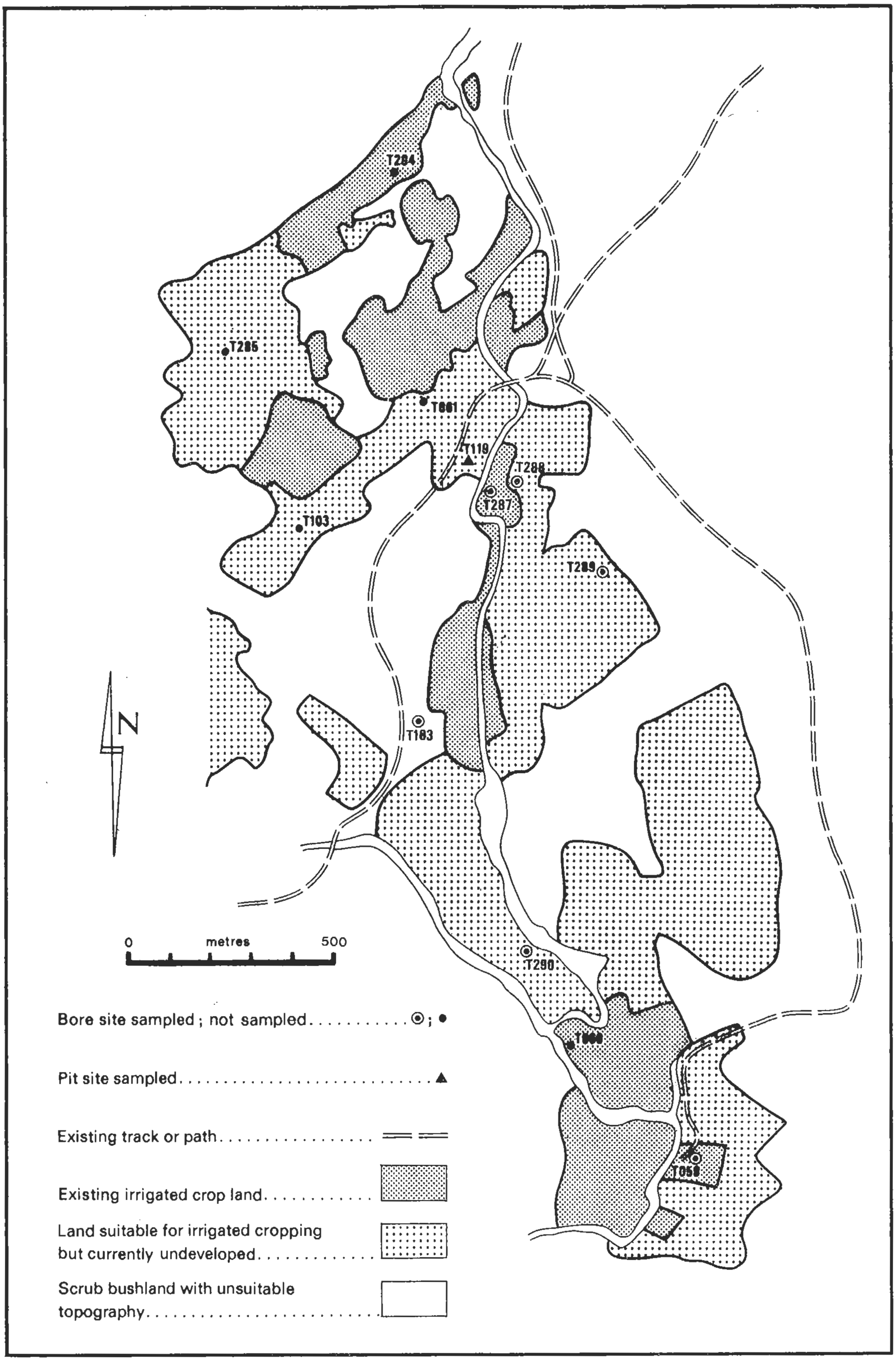


TABLE 3.5 SOIL MAPPING UNITS IN THE IRRIGATION STUDIES

Geomorphic Unit	Soil Mapping Unit	Symbol	Physiography	Microrelief	Soils	Natural Vegetation	Present Land Use
River Valley Bottoms	Asharow Soils	As	Slightly incised head waters with fans to south	Weakly undulating	Variable predominantly fine textured, yellow brown to strong brown colours	Open shrubland often cleared	Some irrigation much cropland
Ridges and Spurs	Berdaale soil	Bd	Rolling country with rounded convex hill tops	Undulating	Shallow moderately shallow medium textured soils often stony red brown colours	Dense thickets	Browse land
	Dinsor soil	Di	Low usually convex interfluves	Nearly flat	Moderately shallow generally sandy red brown latosols	Degraded open shrubland	Poor rangeland
Clay Plains	Bur Acaba Soil	Br	Generally concave flat plains	Weak gilgai	Moderately deep to deep brown clays	Local thickets	Extensive cultivation
	Modu Mode Soil	Mo	Generally concave flat plains	Weak gilgai	Deep grey brown to grey clays often calcareous	Local thickets	Extensive cultivation
	Baidoa	Ba	Generally concave flat plains	Weak gilgai	Moderately deep to deep brown calcareous clays	Local thickets	Extensive cultivation
Old Terraces	Uiamo/Bardeera	Ua/B	Very weakly sloping terraces below the escarpment	Nearly flat	Moderately deep to deep Yellow brown to grey brown clay loams often strongly calcareous	Dense thickets	Scattered clearings

Note: In addition the following depth phases have been identified:

s	*- Shallow*	*less than 50 cm*
ms	*- Moderately shallow*	*less than 75 cm*
md	*- Moderately deep*	*less than 100 cm*
d	*- Deep (where applicable)*	*less than 150 cm*
vd	*- Very deep*	*more than 150cm*

(c) Moderately deep soils over Limestone

Uiamo Soil

Locally, at the foot of the escarpment there are minor terraces occupied by more brown-grey brown coloured, moderately well structured, medium to fine textured soils. These are very similar to the Uiamo grey clay soils on the plateau. Surface horizons range from dark greyish brown to greyish brown sandy clay loams to clay loams. Subsurface and subsoil horizons are moderately well structured angular blocky to subangular blocky, silt clay loams to clay loams with increasing contents of carbonates. Silty weathered limestone fragments occur within 1.5 to two metres of the surface and hard limestone below this depth.

These soils have some characteristics in common with the Bardeera soils identified in small areas in the west of the Region. At sites examined during the semi detailed and detailed surveys surface horizons were usually brown (10 YR 5/3) clay loams and occasionally sandy clay loams with mica sand flake inclusions. The latter indicating the close proximity of basement complex derived products. Sub surface and subsoil horizons range from brown (10 YR 5/3) to yellow brown (10 YR 5/4) and are generally clay loam to silt clay loam in texture. Towards the foot of the terrace colours often become more grey brown, brownish grey and olive brown with clay loam and clay textures, shell fragments and carbonate nodules.

(d) Moderately shallow soils over Basement Complex

Dinsor Soil

These red brown coarse textured sandy soils are associated with laterite or laterised basement complex parent materials including presominantly quartz pegmatites, within 1.5 m of the soil surface.

Surface horizons are red brown, coarse sandy loams to loamy sands with frequent inclusions of pale quartz-pegmatite grits. There is often very little horizon differentiation with depth but occasionally deeper subsoil layers become more sandy clay loam in texture before passing into laterite or decayed parent basement rocks. These soils have little potential for cropland development even if irrigation water were available.

(e) Moderately deep to deep clay soils

These can be divided into three main soil types all of which have similar morphological characteristics but which have more significant variations in soil colour and probable parent materials.

Baidoa Soil

This soil occurs only locally in the Region. It is more extensive on the limestone plateau. A small area has been mapped by Lockwood (1968) to the south west of Baidoa south of the escarpment. The clay soils here have many similarities with those on the plateau and appear to be derived almost exclusively from erosion products from the limestone on the plateau. They are underlain by weathered limestone detritus which itself caps basement granites.

This soil is a brown to dark brown clay loam to clay with well developed blocky structures throughout the profile. Carbonate concretions and fine gypsum crystals are common in the deeper subsoil horizons.

Bur Acaba Soil
This soil occurs extensively over basement complex rocks in stratum 10. It is derived from deep weathering of granites and gneiss and is usually associated with convex freely draining sites.

Surface horizons are generally dark brown well structured clay loams with many fine rounded black haematite nodules. These overlie brown strongly structured heavy clay loams and occasionally silt clay loams. The subsurface horizons are associated with finely weathered quartz-pegmatite grits and black haematite nodules these are often concentrated along vertical crack lines. Subsoil horizons are dark greyish brown to brown heavy clay loams with well developed coarse wedge shaped structures. They are often associated with increasing concentrations of carbonate and gypsum salts and pass rapidly into weathered granite parent materials.

Mode Mode Soil
This is a grey clay soil developed on less freely drained sites on the basement complex plains of stratum 10. Surface horizons are dark grey sandy clays and clay loams. These have a strong, fine subangular blocky structure with a well developed surface crumb mulch. Fine black haematite nodules and fine quartz gravels were also noted at many sites.

The subsurface horizons are dark grey or occasionally dark greyish brown heavy, clay loams and sandy clays. Well developed strong, coarse to medium prismatic structures occur with coarse vertical cracking. Fine black haematite nodules and quartz grits are scattered throughout the profile.

The subsoil becomes more wedge structured at depth with similar textures and colours to the subsurface horizons. There is also a marked increase in salt concentrations below 75 cm with fine powdery calc-silcates, carbonate nodules, and gypsum crystals. These overlie the weatherd granitic parent materials.

3.2.6 The PADU Surveys

As a result of the reconnaissance soil investigations four representative sample areas were selected for more detailed study within each of the Administrative Districts in the Bay Region. These comprised some 17 500 to 20 000 hectares of land containing approximately 7 500 hectares of cropland surrounded by the balance of rangeland. Within each area more data, particularly on soil chemistry, was collected for the main agricultural soils. Table 3.6 summarises the areas of each soil mapping unit within the PADU survey areas.

In the Kansadere area the Amin soil has the main potential for agricultural development under rainfed cropping. Data from the aerial census survey indicated, however, that this area is already 72 per cent cultivated. There seems little opportunity to increase crop production in this area since the balance of non cultivated land is likely to be short term fallow, often associated with more stony phases of these soils. Alkalinity at depth is also a slight hazard for deep rooting crops. although rainfall is adequate in most years. In the surrounding rangeland area soils are stony, often concretionary, shallow members of the Berdaale soil. Although these soils are inherently fertile due to the constant breakdown of freshly eroded rock strata releasing new minerals they only support open bushland. Much of these areas has been extensively exploited for charcoal production which also reduces its range capability.

TABLE 3.6 SOIL MAPPING UNIT AREAS FOR PADU SURVEYS (hectares)

Mapping Unit	Symbol	Hectares
Map No. 7 KANSA DERE		
Amin	Am	5 582
Amin stony	Amst	1 075
Berdaale shallow-moderately shallow	Bds-ms	14 787
Berdaale	Bd	252
		21 696
Map No.8 SAYDHEELO		
Baidoa	Ba	6 740
Berdaale deep	Bd d	152
Berdaale moderately deep	Bd md	1 403
Berdaale shallow-moderately shallow	Bd s-ms	9 302
		17 597
Map No.9 BUULO FULAAY		
Valley bottoms	VB	7 106
Issur	Is	7 480
Dinsor	Di	3 009
		17 595
Map No.10 BUULO GUDUUD		
Berdaale Moderately shallow	Bd ms	2 836
Bardaale shallow	Bd s	1 281
Uiamo deep	Uad	274
Uiamo moderately deep to deep	Ua md-d	10 309
Uiamo moderately shallow-mod. deep	Ua ms-md	472
Uiamo shallow-moderately shallow	Ua s-ms	1 311
Uiamo shallow	Ua s	411
Valley bottom/Uiamo	VB/Ua	1 403
		18 297

The Saydheelo area contains the important grain producing Baidoa soils. These soils are very extensively farmed occasionally under mechanised cultivation. They are fertile, clay loams to clays with high water holding capacity. Locally, in slight depressions, some high exchangeable sodium values have been recorded but these are not severely limiting (<20%). The surrounding rangelands consist of Berdaale soils with a range of depth phases. These soils support rather poor stands of open to dense bushland which have been severely exploited, both for firewood near Saydheelo village, and for charcoal elsewhere.

The Buulo Fulaay area was selected because it is an area where some expansion of cropping and development was observed during the aerial census. This area had previously been regarded as marginal for cropping (Lockwood 1968, HTS 1977). The dark grey clay soils in the valley bottoms have previously been largely unexploited except in this area where clearing and expansion of cultivation is taking place. It was for this reason considered desirable to collect more information for the planning base in these areas. An analysis of this data indicates that the clay soils are very similar in many respects to the Modu Mode soils, though they have significantly higher sand contents. These appear to derive from recent weathering of the low granite peneplains developed on the interfluves. These soils are also characterised by high levels of exchangeable sodium in the subsoil, which have an effect on soil structure rendering these clays very hard and cloddy when dry, yet slaked and extremely dispersed when wet. Most of the rangeland occurs on the Dinsor and Issur soils. These support open bushland with a moderate potential for development.

The Buulo Guduud PADU contains larger areas of relatively underutilised Uiamo soils. These clay soils have a moderately high potential for rainfed agriculture, although in this area rainfall is more variable than on the plateau nearer Baidoa. Much of the area is characterised by long rotations with many areas of fallow soils supporting dense Acacia thickets. Areas with rangeland potential include both underutilised Uiamo clay soils and shallower red brown Berdaale soils developed on more resistant limestone strata. The former often contain dense inpenetrable thickets which would be difficult to develop for rangeland without some form of clearance. The latter support mainly open range though with considerable areas of surface rock outcrops which present a limitation.

3.3 SOIL PHYSICAL CHARACTERISTICS

3.3.1 Surface Infiltration

Table 3.7 shows the values obtained for the mean infiltration characteristics of the soils in the potential irrigation area. Optimum final infiltration rates for gravity irrigation purposes range from 7 to 35 mm per hour.

At both sites examined in this area rates, after seven hours of infiltration, show little levelling of values. The final mean values of 208 mm/hr and 60 mm/hr are well above the acceptable optimal levels for gravity irrigation. The existing system of irrigation which is characterised by the use of very small basins, often less than 3.m^2 confirms the view that intake rates are high on these soils. This factor also explains the water shortage phenomenon that results in the loss of some crops due to irregular water distribution on the fields.

Given these conditions it is likely that water applications on these soils will need to be at frequent intervals unless deep rooted crops are grown. Much of this area is developed under deeper rooting tree and fruit crops, probably for this reason, with vegetables grown as a shade crop to minimise evapotranspiration losses especially in the dry seasons.

TABLE 3.7 MEAN INFILTRATION CHARACTERISTICS OF TWO SOIL PROFILES

Profile No.	Approximate Initial Intake rate	Approximate Final (mm/hr)	Approximate time (hr.min) required for infiltration of 50 mm	100 mm	150 mm
T119	177	208	00 15	00 35	00 45
T136	133	60	00 25	00 50	01 20

Note all values estimated from graphs (Figure 3.4).

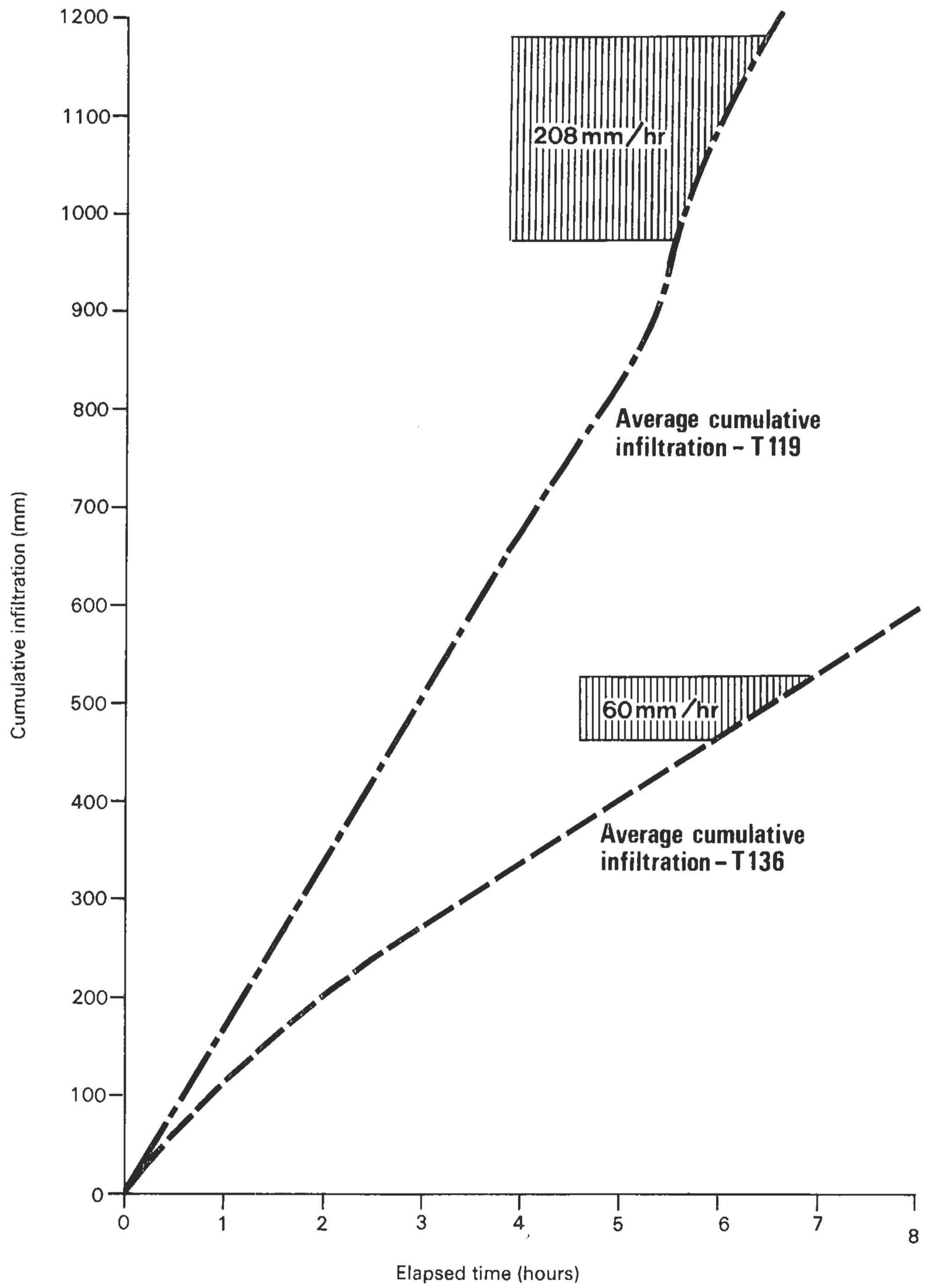
3.3.2 Soil Moisture Characteristics

Samples were collected at both sites of surface infiltration tests from natural horizons for soil moisture evaluation. The results of these tests are illustrated in Table 3.8

TABLE 3.8 DETERMINATION OF MOISTURE RETENTION PROPERTIES

Profile No	Depth cm	Texture	Bulle Density	Percent Moisture vol% 0	1/10 atmos	1/3 atmos	1 atmos	15 atmos	Available Moisture % by Vol	cm
T119	0-26	SCL	1.31	46.9	30.5	28.4	27.2	12.6	17.9	4.6
	26-54	SC	1.37	47.5	37.5	35.3	33.1	15.2	22.3	6.2
	54-95	SC	1.39	48.9	40.0	36.7	34.5	15.7	24.5	10.0
T136	0-20	CL	1.30	49.3	41.5	38.0	35.9	17.3	24.2	4.8
	20-45	CL	1.32	46.6	41.2	36.2	34.5	17.5	23.6	5.9
	45-130	C	1.37	44.3	37.9	34.6	32.5	14.5	23.8	20.2

3.4 Mean cumulative infiltration rates



The available moisture content of a soil is generally accepted as being the difference between the moisture content at field capacity and permanent wilting point. These values closely correspond to the moisture retained at tensions of 0.1 and 15 atmospheres. The difference between these two values when multiplied by the bulk density gives the percentage available moisture by volume. This is divided by 100 and multiplied by the thickness of the soil horizon in centimetres to give the available water in the whole horizon. Summation of the values for each horizon gives the available water for the whole profile. The figure obtained represents the thickness of the sheet of water which is available to the crop after the soil has been brought to field capacity. The moisture actually easily available to the plant approximates to 50 per cent of this value, often very similar to the moisture available between 0.1 and 1 bar tensions. The available moisture figure can be used to calculate the frequency of irrigation water application needed by a crop growing in that soil.

3.4 SOIL CONSERVATION

In many areas it is likely that the impact of rainfall (splash erosion) will result in fragmentation and scattering of soil particles particularly on gently sloping land over the basement complex strata. This will result in transport downslope in rills which may later form gullies on the lower slopes especially adjacent to existing channel courses. Many of these are incised and headward erosion was observed at many sites close to the escarpment. Splash erosion will be less effective in areas of soils with a high stone cover. However, in the main cultivated soils, textures are fine and surface sealing of unploughed field after initial rains occurs which aggravates surface run off. In the vertisols the vertical cracks will aid infiltration although ploughing before rainfall can seal the cracks and reduce infiltration. It is apparent that in many areas the farmers are aware of the need both to conserve soil moisture and the soil, since cultivation techniques practised i.e. small bunds, even of stones, will help to retain water in place,and prevent run-off except in the most severe storms.

4

Groundwater Resources

4.1 INTRODUCTION

The main objective of the groundwater studies undertaken as a part of the natural resources inventory of the Bay Region, was to identify any groundwater irrigation potential that might exist. This practically limits the area to be considered to the so-called 'Limestone Depression', located below the escarpment, to the south and east of Baidoa (see Figure 4.1). The Basement Complex rocks are generally not permeable enough to sustain well yields of the magnitude required for economically viable crop irrigation. In the case of the 'Limestone Plateau', even if the underlying strata were suitably transmissive, the depth to static water level would make pumpage for irrigation prohibitively expensive.

Thus most of the groundwater work in the region was concerned with the Limestone Depression. Areas outside it, particularly the Limestone Plateau have been considered mainly as far as their hydrogeology relates to that of the Depression.

4.2 PREVIOUS AND CURRENT WORK

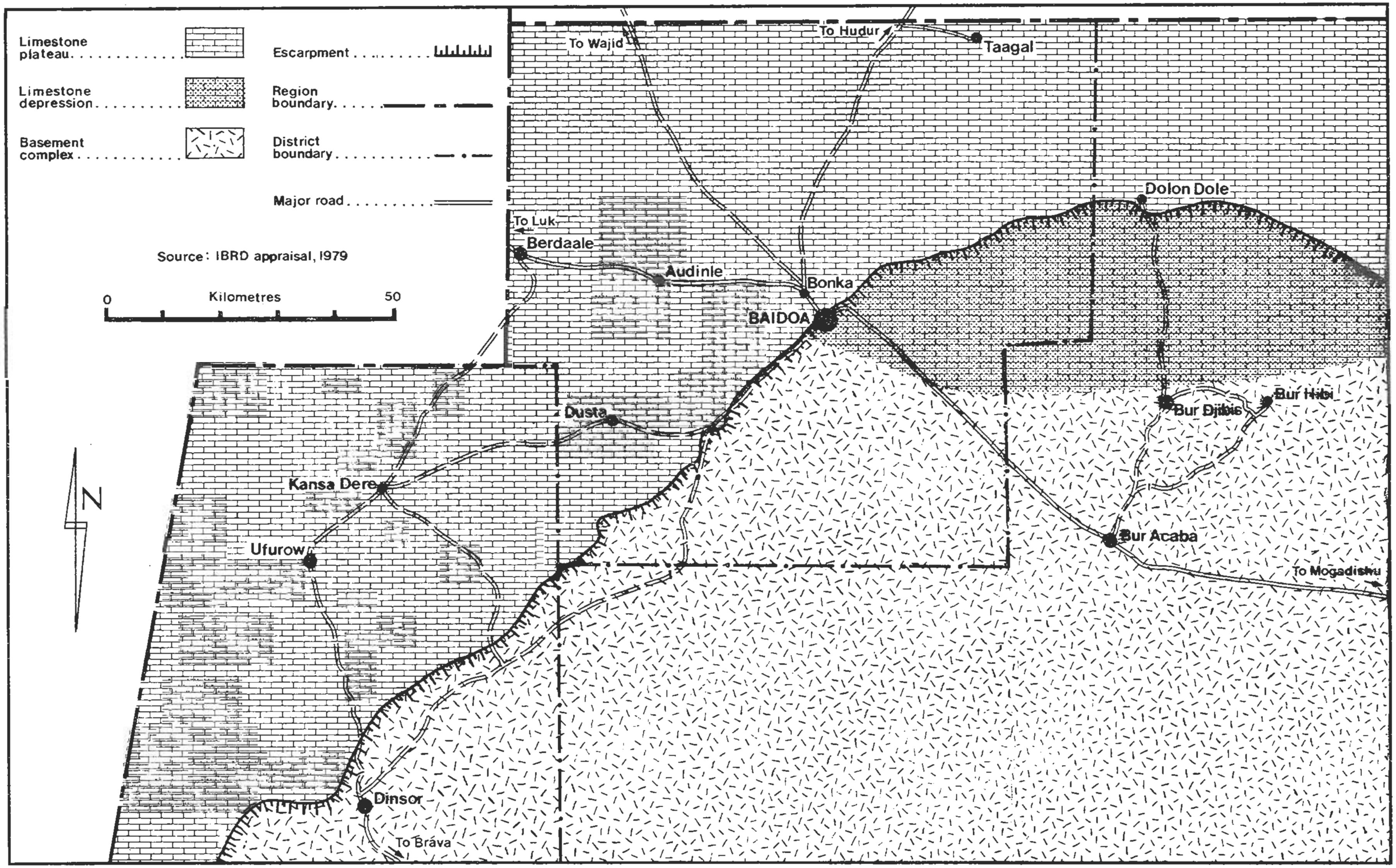
The hydrogeology of Somalia in general and of the Region in particular is not well documented. However there are several publications relevant to the subject.

Geology is reasonably well covered in existing literature. There are several papers discussing various aspects of stratigraphy and geological structures, such as those of Gubbins et al. (1952) and Beltrandi and Pyre (?). Geological maps are available at various scales up to 1:100 000, but most of them suffer from inadequate base maps.

Hydrogeology of the whole country is discussed by the Lockwood Corporation (1968), UNDP (1970) and Johnson (1978). Groundwater resources of the Bay Region are dealt with in more detail by FAO (1977a) and the World Bank (1979). Currently, exploratory drilling and well construction and testing are being undertaken by the Water Development Agency (WDA)/Louis Berger International, under a financing agreement with USAID.

It was FAO who first identified the limestone depression as an area of groundwater irrigation potential. This was done on the basis of existing pumped groundwater irrigation in the area, LANDSAT imagery analysis and hydrochemistry of water samples collected from existing wells. The wells in question are basically enlarged karst features in the immediate vicinity of the main drainage channel of the region, the Togga Sheikh Asharow. The satellite imagery was interpreted as showing sparsely developed surface drainage, suggesting possible high infiltration intake, and gypsiferous deposits to the west, near the Ethiopian border, taken as a groundwater discharge zone corresponding to the intake area mentioned above.

4.1 Geological map of the Bay Region



The chemical composition of the groundwater in the Depression was interpreted as a mixture of senile storage water and young recharge water.

In formulating the Bay Region Agricultural Development Project, the FAO/World Bank Cooperative Programme (1977) included a groundwater irrigation component in the development proposals. The World Bank Staff Appraisal Mission Report (1979) proposed that drilling investigations in the Limestone Depression would be necessary to test the hypothesis of groundwater irrigation potential; six exploratory boreholes and two test production wells were recommended. This was to be done as a sideline to the major groundwater component of the project which was to be the construction of drilled wells for potable water supply, mainly on the Limestone Plateau.

During negotiations for the Bay Region Project implementation, USAID agreed to finance the groundwater component. They engaged Louis Berger International as Consultants to procure all the necessary machinery, equipment and materials, and to train WDA staff in all aspects of groundwater exploration and development. Field work under this programme started early in 1982. So far six exploratory/training boreholes have been drilled in the Limestone Depression, of which one has been converted into a production well; in addition several new holes have been drilled on the Limestone Plateau.

Most of the Louis Berger International drillings have been sited in the extreme west of the Limestone Depression, an area of relatively easy access. Although the results of these make it most unlikely that any further groundwater irrigation development will be possible, there is still a need for exploratory drilling further to the east.

4.3 GEOLOGICAL SETTING

The Bay Region of Somalia is located near the junction of two major structural units: the Bur Region Horst and the Mandera-Lugh Basin. Apparently the emergence of the Bur Basement block during the early Jurassic, divided southern Somalia into two structurally controlled basins of deposition (Beltrandi and Pyre):

- Somalia Coastal Basin
- Mandera-Lugh Basin.

The south-eastern boundary of the Bur block is a major fault (the Coastal Fault of Somalia). No obvious structure is visible at the north-western boundary, but faulting is suspected.

The overall stratigraphic sequence of the region is as follows:

System	Series or Suite	Lithology
Recent	Superficial deposits	Mainly residual deposits and thin alluvium
Jurassic	Gabra Hare Suite	Bioclastic and oolitic limestone, dolomite sandstone and marl
	Uegit Suite	Coralline limestone and calcarenite
	Anole Suite	Clastic limestone with marl and calcareous clay

System	Series or Suite	Lithology
	Iscia Baidoa Suite	Sandstone, shale, conglomerate, limestone, marl and clay
Precambrian Basement complex	Bur Igneous Rocks	Mainly granitic intrusives
	Bur Acaba series	Gneiss, schist, amphibolite, quartzite and minor occurrence of marble.

From the point of view of groundwater development, the formations of interest are the Bur Acaba Series, the whole sequence of the Jurassic carbonates and clastics, and the Quaternary alluvium.

The Bur Acaba metamorphics occur in a large outcrop in the south-east of the Region; it is a virtual peneplain, occaisionally dramatically interrupted by spectacular inselbergs of granitic rocks. The lower members of the Jurassic sequence form a prominent escarpment (the Baidoa Escarpment) near Baidoa but this fades to the east and west into more subdued topography; the Jurassic outcrop stretches to the north of the escarpment forming the Limestone Plateau. There is also a thin remnant of limestone overlying the Basement, below the Escarpment to the east of Baidoa, forming the Limestone Depression (see Figure 4.1). The superficial deposits are mainly in the form of residual soils and thin alluvial along the major drainage channels.

Because of the scarcity and strongly seasonal nature of the rainfall, generally absorbent ground surface, high potential evapotranspiration and mainly small catchments, there are no perennial rivers or streams in the Bay Region. However, in some areas there is a well developed pattern of drainage lines, which may be indicative of sub-surface conditions.

A dense, dendritic drainage pattern can be seen on the outcrop of the Basement Complex particularly in the western part of the Region. This reflects the relatively high rainfall in that area as well as the largely impermeable nature of the underlying rock. On the Limestone Plateau there are few drainage channels except in the immediate vicinity of the Baidoa Escarpment; this is due to the very low land slopes, high infiltration intake of the soils and the availability of a sub-surface storage reservoir (the limestone aquifer). In the Limestone Depression, the drainage pattern is relatively dense in the west, with fewer identifiable drainage channels in the east; this may be indicative of better aquifers in the east (see Figure 4.2).

As already mentioned, most of the catchments are small. Only one of the channels draining the Escarpment, extends for any distance onto the Limestone Plateau. This is the Togga Sheikh Asharow which rises about 15 kilometres north of the Escarpment, passes through Baidoa and then down the scarp face and across the Limestone Depression (Figure 4.2). It has a well defined, incised bed, and in some sections, carries a substantial base flow up to two months following the rainy season. In the past it carried the flow of perennial springs on the Escarpment, but these are now diverted for irrigation.

4.4 OCCURRENCE OF AQUIFERS

The Basement Complex rocks, in an unaltered state, are virtually impermeable. Small quantities of groundwater can sometimes be obtained from systems of joints and fissures, and from the near-surface zone of weathering. In the Bur Acaba series of the Bay Region, none of these are well developed; thus groundwater is found only in small pockets isolated from each other by impermeable rock. Such groundwater as exists, is exploited for potable supplies by large diameter dug wells, often constructed in large numbers close together in areas of suitable conditions.

Some horizons within the Jurassic Formation are porous and permeable, at least locally. From the point of view of this Project, it is the Iscia Baisoa Suite which is of most interest. Hence its stratigraphy, lithology and water bearing properties are discussed here in some detail.

The details of the Iscia Baidoa succession are given by Beltrandi and Pyre, and by Johnson (1978). On the basis of surface exposures, the following sequence was identified, overlying the Basement Complex, in the vicinity of Baidoa town:

Lithology	Thickness
Detrital limestone	up to 650 m
Dense oolitic and lithographic limestone	c. 90 m
Varicoloured shales and marls with thin limestones	c. 120 m
Basal quartz sandstone and conglomerate	20 - 40 m

The current drilling investigations (Eckart, 1982) have established a more detailed succession for the lower part of the Iscia Baidoa Suite. In the limestone the drilling method has been direct rotary with air or foam circulation, which makes accurate formation sampling difficult, but geophysical logging has identified some strongly characterised marker horizons, which can be correlated between adjacent boreholes. The most striking of these is a thick shale layer with a single limestone layer, two or three metres thick; in Baidoa the base of this shale is about 45 metres above the top of the Basement (Figure 4.3).

The details of the basal Jurassic succession, established on the basis of the geophysical logs of several boreholes is as follows:

Unit No.	Lithology	Thickness
V	Massive, dense, brown and grey limestone with thin layers of brown clay, and black shale and marl	100+ m
IV	Intensely stratified sequence of thin, dark grey and brown limestones and dark coloured shales and marls; individual beds are seldom more than 1 m thick	c. 30 m
III	Massive, dense, brown, grey and white limestone, with beds of dark grey shale	c. 35 m

Unit No.	Lithology	Thickness
II	Dark grey and purple shale with a single layer of dark grey limestone; the limestone is 2 to 3 m thick and occurs about 1/3 of the shale thickness down	40 m
I	Intensely stratified sequence of dark brown and grey limestones, black and purple shales and marks, with greenish grey sandstone near the base; individual layers are usually less than 1 m thick, except for a major limestone layer at the top	c.45 m

In terms of water bearing properties, none of the strata described above look particularly productive; the best chances of reasonably high discharge wells, would be those tapping some of the massive limestones, provided these contain karst features. The hydrogeological interpretation of the sequence identified is given as follows:

Unit I. Low transmissivity aquifer; the sandstones can be expected to have a low intergranular permeability, unless strongly cemented; the limestones are probably virtually impermeable unless karstified; the intense stratification, with many shale layers, indicates that the aquifer would behave in a confined manner even in areas where Unit II has been eroded.

Unit II. Aquiclude.

Unit III. Probably low permeability aquifer; the dense, hard limestone layers are expected to be transmissive only along fractures, joints and karst features; the latter are probably restricted to the vicinity of the Escarpment, where this Unit is exposed and may be fractured by slumping caused by erosion and squeezing of the underlying shales; normally confined by the overlying Unit.

Unit IV. Very low permeability aquifer; the shales are impermeable but the limestones may be transmissive along joints and fissures; probably would behave in a confined manner due to the abundance of shale layers.

Unit V. Probably low permeability aquifer; the massive limestones may be karstified in some areas; they may also possess some joint and fracture permeability; probably unconfined in the vicinity of Baidoa and Bonka but of low storativity (about one or two per cent).

On the Limestone plateau the regional groundwater level is normally greater than about 50 metres below ground surface. However, in the immediate vicinity of the Escarpment, there is at least one perched groundwater body, held up by the shales of Unit II, with a much higher water level. There may be other perched water levels further into the limestone outcrop, overlying the shaly horizons of some of the higher Units. The topographically lower Limestone Depression has a regional water level much nearer ground surface; it is normally within 10 metres of the land level.

From the point of view of potential well yields, the geometry of the saturated limestone is of the utmost importance; Figure 4.4 summarises the situation in the vicinity of Baidoa. On the Plateau the thickness of the strata overlying the Basement Complex is about

100 metres at the Escarpment and increases rapidly towards the north-west; the regional dip is 1 to 1.5 degrees. Below the escarpment (in the Limestone Depression) the Jurassic strata, overlying the Basement are generally thin, as shown by the summary of the recent drillings given in Table 4.1; the locations of these are shown in Figure 4.2.

In addition to these drilling results, some evidence on the Iscia Baidoa Suite geometry is available from outcrop exposures in the Limestone Depression. These are also shown in Figure 4.2 and indicate that the Basement floor, on which the Jurassic sediments rest is highly uneven; this may be due to faulting or merely deposition on an uneven topography.

From purely stratigraphic considerations, it would be expected that the Jurassic of the Limestone Depression would be mainly Unit I, that is a low permeability aquifer. In fact the situation is somewhat complicated because of the proximity of this area to the margin of the basin of deposition, where some lithological irregularities coud be expected. The geophysical logs of boreholes in the Depression indicate an intensely stratified succession similar to Unit I; however the lack of permeability in four boreholes may not be typical of this Unit elsewhere.

Little is known about the nature and the geometry of the jurassic strata in the eastern part of the Limestone Depression. Again, general stratigraphic considerations indicate that the lithology would be that of Unit I, but its water bearing properties and thickness are unknown and require further investigation by drilling.

4.5 AQUIFER AND WELL CHARACTERISTICS

The lithology of the Jurassic Formation of the Bay Region indicates generally low permeability and porosity, with at least one major complete aquiclude (Unit II). Quantitative data on this subject are restricted to a few pumping test records for wells on the Plateau; further relevant information can be deduced from drilling and construction records of boreholes and wells.

Records of formal pumping tests are available for four water supply wells, located about 1.5 km to the north of the town. These have been analysed for aquifer and well characteristics. The results are shown in Table 4.2. In the case of other, older wells, only those within 50 kilometres of Baidoa were taken as relevant to the main objectives of this project and such data as are available from them, processed.

As can be seen, all the estimated transmissivities are very low; true permeabilities are probably somewhat higher than those listed (particularly for those wells which penetrate Unit II), as the sections include some completely non-productive layers, which should really be excluded from the calculations. Nevertheless none of the wells listed penetrate strata permeable enough to support irrigation wells, even if the static water level was much nearer to the ground surface (as it is in the Limestone Depression).

Most of the data available from the Limestone Depression support this conclusion. Of the six exploratory holes recently drilled there, four were dry (extremely low permeability), one produced a very small yield and only one is viewed as sufficiently productive to be completed as a permanent production well (Borehole 4); even this is viewed as a potable supply well, of relatively low yield. The one exception to this general picture of very low permeability of the Iscia Baidoa Suite, is some intensely karstified limestone just to the south of the Escarpment near Baidoa. Here, some of the karst features have been enlarged by digging and are pumped for irrigation. The reason for the advanced karst development in this particular area is probably related to the proximity of the main

TABLE 4.1 SUMMARY OF RECENT DRILLING

Borehole No.	Depth (m)	Depth to Basement (m)	Main Lithology	Water Bearing Properties
4	42	31	sandstone, limestone, marl and clay; Basement rocks highly weathered.	Produced good airlift discharge; SWL about 2m below GL; being completed as a production well.
5	42	18	Limestone and decomposed Basement Basement rocks	Very small airlift yield; SWL about 4m below GL.
6	80	64	Mainly clay and marl with a few thin limestones	Dry hole
7	40	30	Limestone and shale	Dry hole
8	46	38	Marl, silt, sand and limestone	Dry hole
9	35	<35	No lithological log	Dry hole

Source: *Louis Berger International (1982)*

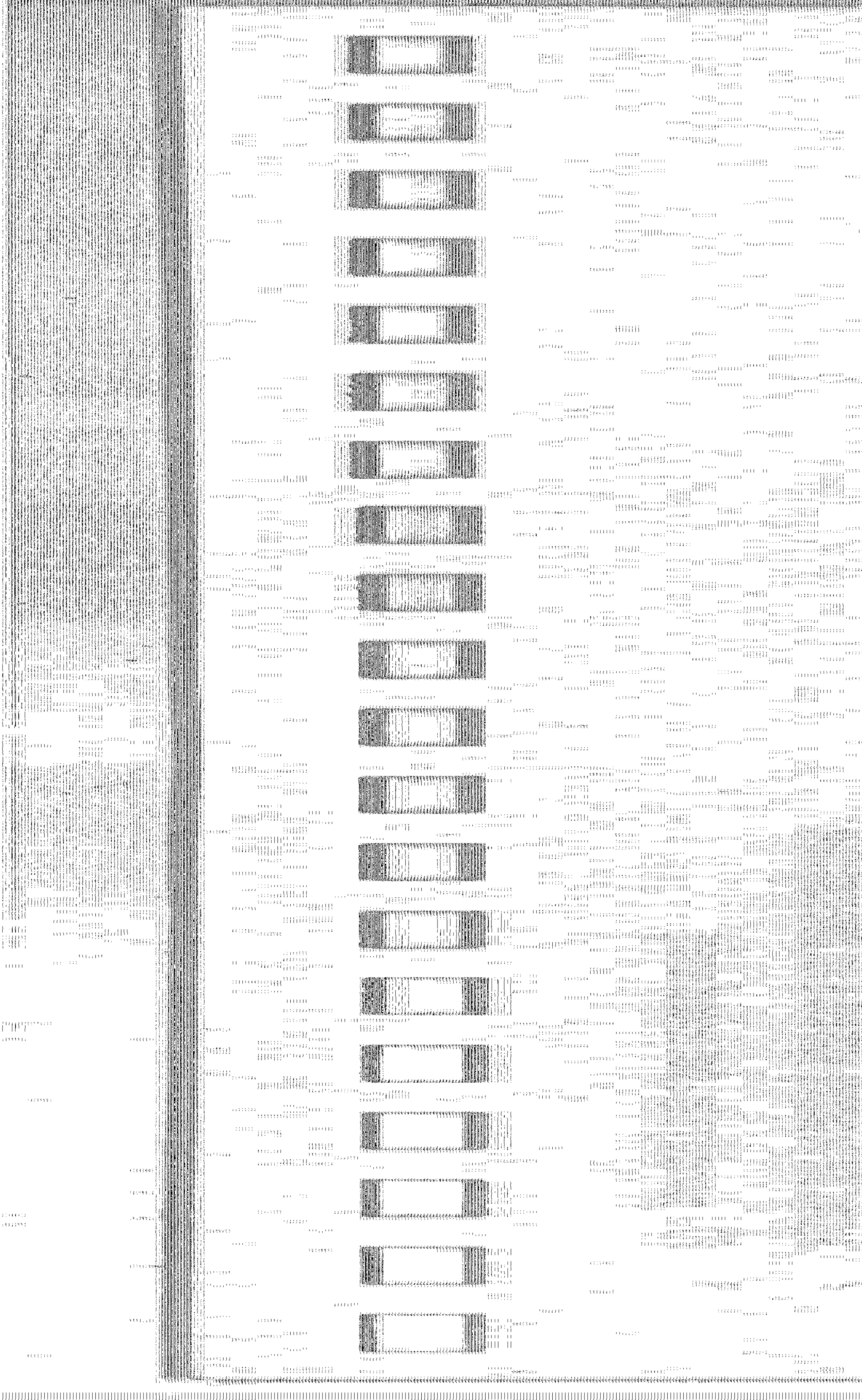


TABLE 4.2 PUMPING TEST RESULTS

Location	Well Ref. No.	Aquifer[1]	Well Depth	Pump Intake Setting	Engine Power	Static WL	Discharge Rate	Pumping WL	Drawdown	Specific Capacity	Specific Draw-down	Trans-missivity	Mean Section Feasibility[2]
			(m)	(m)	(BP)	(m)	(l/s)	(m)	(m)	(l/s/m)	(m/l/s)	(m^2/d)	(m/d)
Baidoa water supply well - 1.5 km north of Baidoa	1	IB (III - IV)	115.2	78	?	12.00	4.42	52.65	40.65	0.116	9.20	14.3	0.14
Baidoa water supply well - 1.5 km north of Baidoa	2	IB (III - IV)	111.4	96	?	10.65	4.20	63.00	52.35	0.079	12.46	14.7	0.15
Baidoa water supply well - 1.5 km north of Baidoa	3	IB (III - IV)	89.6	78	?	24.20	4.31	59.00	34.80	0.124	8.08	17.8	0.27
Baidoa water supply well - 1.5 km north of Baidoa	4	IB (III - IV)	92.4	?	?	21.83	1.75	59.86	38.03	0.046	21.73	6.6	0.09
Baidoa Town	1	IB (I - III)	120.0	80	15	C. 35.00	2.22	C. 70.00[3]	35.00	0.063	15.76	8.4	0.10
Baidoa Town	2	IB (I - III)	120.0	80	15	C. 35.00	2.22	C. 70.00[3]	35.00	0.063	15.76	8.4	0.10
Baidoa Town	3	IB (I - III)	130.0	80	15	C. 35.00	2.22	C. 70.00[3]	35.00	0.063	15.76	8.2	0.09
Saydheelo - 27 km from Baidoa towards Oddur	-	IB (V+)	70.0	-	-	-	Dry hole	-	-	-	-	Very low	
Baray - Basay - 45 km from Baidoa towards Uegit	-	IB (V +)	60.0	50	10	C. 20.00	1.11	C.40.00[4]	20.00	0.056	18.02	7.8	0.20
Audinle - 30 km from Baidoa towards Lugh	-	IB (V +)	70.0	40	10	C. 20.00	?	?	?	?	?	?	?
Gof Gadud - 27 km from Baidao towards Dinsor	-	IB (? III)	70.0	?	15	C. 63.00	P.D[4]	-	-	-	-	Very low	Very low
Dusta - 45 km from Baidoa towards Kansa Dere	-	IB (V +)	80.0	?	15	C. 50.00	P.D[4]	-	-	-	-	Very low	Very low
Wapdoro - 50 km from Baidoa towards Kansa Dere	-	IB (V +)	106.0	95	10	C. 70.00	P.D[4]	-	-	-	-	Very low	Very low
Day nunay - 25 km from Baidoa towards Bur Acaba	-	B	90	83	15	C. 20.00	2.22	C. 73[3]	53.00	0.042	23.87	7.1	0.10
Rooble Sheikh - 45 km from Baidoa towards Bur Acaba (well not used - salty water)	-	B	-	-	-	-	-	-	-	-	-	-	-

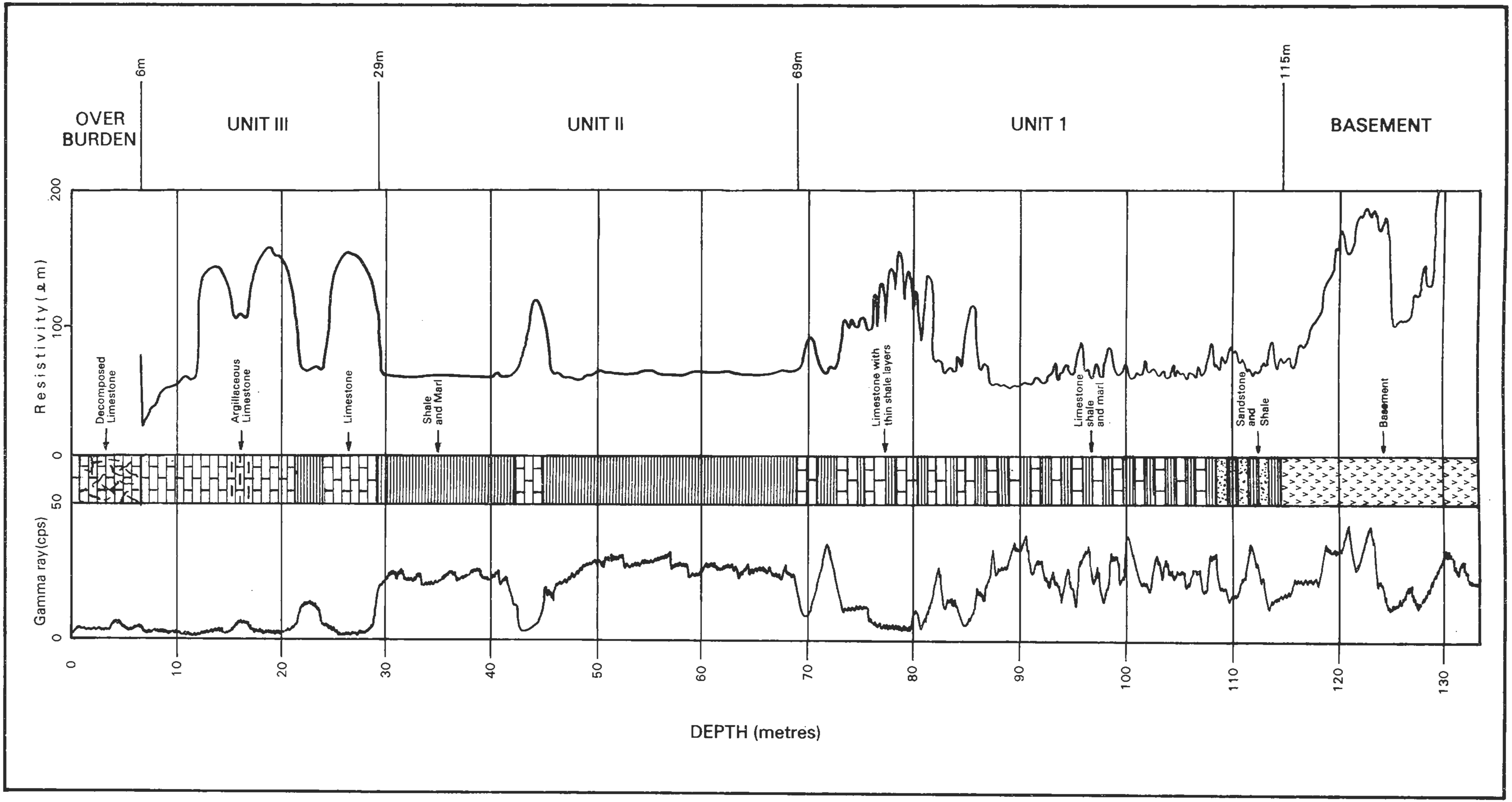
1 IB - Iscia Baidoa Suite B - Basement
(III - IV) - Units III and IV
(V +) - Units V or higher

2 Calculated using the Dupuit equilibrium equation

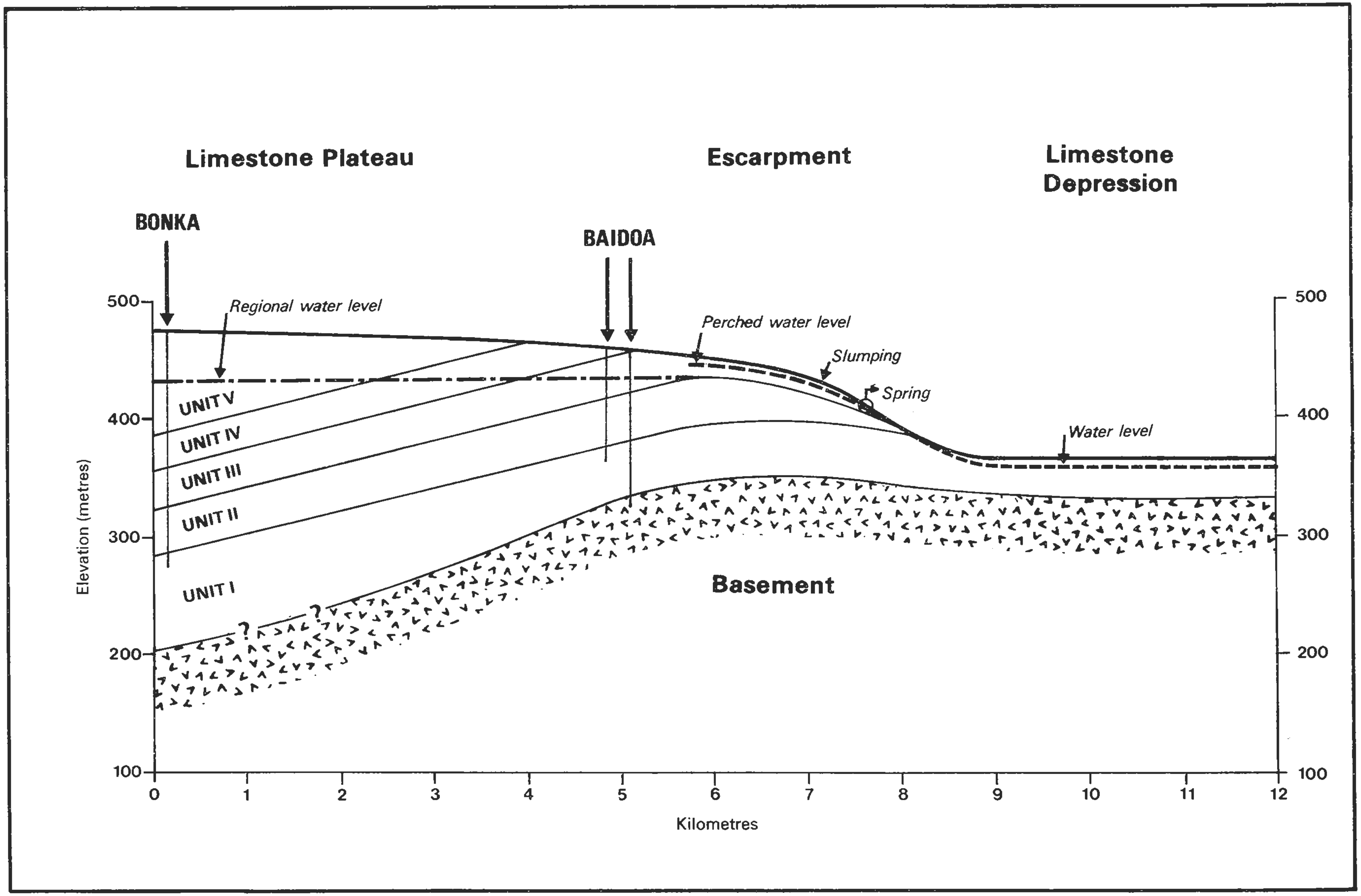
3 Assumed that the pumping water level is 10m above pump intake

4 PD - pumped dry after a short period of running

4.3 Composite log of Borehole 11 (U.S. Compound well)



4.4 Hydrogeological cross-section; Baidoa area



drainage line of the region, the Togga Sheikh Asharow. Though the general lithology of Unit I is not of the kind conducive to karstification, the existing pumpage is probably from an outlier of the limestone layer occurring at the top to this Unit. No similar karst features have been identified anywhere else in the Region.

The storativity of the aquifers has not been measured in any way, but can be expected to be low. Massive limestones with porosity dominated by joints, fissures and fractures, seldom have storage coefficients higher than 1 or 2 per cent in the unconfined state. In the confined aquifers the storage coefficient can be expected to be at least two orders lower. The low storage capacity of the aquifers is reflected by rapid changes in head in wells and boreholes, in response to natural recharge discharge and to pumpage. Very few observations of natural groundwater level oscillation are available, but it has been reported verbally (Eckart, 1982) that in the vicinity of Baidoa, the shallow aquifer water level rose about two metres, and the deep aquifer (Unit I under the Plateau) nine metres between April and June 1982. It is also reported by the well operators that, in the Limestone Depression, pumping of one of the irrigation wells almost immediately affects all the others.

The available data on drilled well performance are listed in Table 4.2. All the discharges are less than 5 l/s. Specific capacities range from 0.046 to 0.124 l/s/m; specific drawdowns are all greater than 8 m/l/s and range up to 22 m/l/s. It is reported that three dug wells are currently used for pumped irrigation in the Limestone Depression; their discharge rates are between 5 and 20 l/s and drawdowns are apparently of the order of one metre.

Summarising, both lithological evidence and such pumping data as are available, indicate that the non-shale members of the Iscia Baidoa Suite form low transmissivity aquifers, which, when saturated, can yield small amounts of water to drilled or dug wells. High yields, sufficient for irrigation, have been obtained only from enlarged sink holes in one small area of the Limestone Depression, where these karst features are particularly well developed; it is thought that this area is unique and that such favourable conditions do not exist anywhere else in the Region.

4.6 HYDROCHEMISTRY

In groundwater development planning the chemistry of the water is usually viewed from the following points:

(a) Its suitability for the intended use

(b) Its general hydrochemistry, which normally reflects its history and may help in the understanding of natural groundwater movement patterns

(c) Its corrosion and/or incrustation potential, particularly with respect to materials used for well and pump components.

All the available chemical analyses of groundwater samples from the Bay Region are listed in Table 4.3; the exact location of some of the sources is not known, except for their relation to the major physiographic units of the area.

In terms of the US Dept. of Agriculture (1954) irrigation classification based on electrical conductivity (EC) and sodium adsorption ratio (SAR), the groundwaters of the Limestone Depression are mainly of the C3 - S1 class, that is high salintiy and low alkali hazards (see Figure 4.5), Such quality is considered suitable for irrigating most crops on free draining soils. The quality of the spring water on the Escarpment is similar. In the case of

TABLE 4.3 CHEMICAL ANALYSES OF GROUNDWATER SAMPLES

Ref. No.	Source of Sample	Physiographic Unit	Depth (m)	EC x 10^6 @ 25°C	TDS (ppm)	Milliequivalents per litre							NO_3 (ppm)	B (ppm)	SAR
						Ca	Mg	Na	K	C1	SO_4	HCO_3			
43	DW	BC	2.2	1 756	1 124	2.4	1.3	11.4	-	1.2	1.9	12.0	-	-	8.38
44	DW	BC	17.5	3 356	2 148	1.2	1.2	26.3	-	8.6	5.5	14.6	-	-	24.01
45	DW	BC	16.0	5 600	3 584	18.0	21.6	18.8	-	44.3	6.9	7.2	-	-	4.22
46	DW	BC	2.4	1 638	1 048	2.0	0.8	10.8	-	2.4	3.4	7.8	-	-	9.13
47	DW	BC	11.3	3 944	2 524	6.8	2.8	25.5	-	10.4	14.5	10.2	-	-	11.64
48	DW	BC	11.7	3 794	2 428	6.4	13.2	17.6	-	23.4	3.4	10.4	-	-	5.62
49	DW	BC	15.1	1 381	884	2.4	3.2	9.7	-	1.2	1.5	12.6	-	-	5.80
50	DW	BC	12.1	6 450	4 128	5.2	11.6	23.7	-	7.1	25.4	8.0	-	-	8.18
51	DW	BC	9.8	55 963	35 816	5.6	66.3	30.2	-	51.1	42.6	8.4	-	-	5.04
52	DW	BC	20.4	1 200	768	3.6	2.0	4.2	-	0.6	0.9	8.2	-	-	2.51
56	DW	BC	7.2	4 666	2 986	11.2	12.0	30.6	-	27.6	5.4	20.8	-	-	8.98
57	DW	BC	7.5	3 138	2 008	10.8	1.6	12.2	-	14.4	1.4	9.2			4.90
VI	BH	BC	-	2 000	1 590	2.7	5.2	12.1	0.2	11.6	4.7	3.5	115.0	0.3	6.08
16	BH	LP	80.0	4 706	3 012	31.1	15.2	2.3	-	8.8	34.2	5.6	-	-	0.48
19	DW	LP	5.1	3 106	1 988	6.4	9.6	17.8	-	14.4	2.6	16.8	-	-	6.29
20	BH	LP	78.0	1 531	980	4.8	6.4	7.0	-	1.6	2.2	14.4	-	-	2.96
32	DW	LP	10.1	1 419	908	6.0	2.0	5.9	-	8.6	1.3	4.0	-	-	2.95
35	BH	LP	103.0	1 218	780	2.8	1.2	9.4	-	7.0	2.4	4.0	-	-	6.65
53	BH	LP	?	2 969	1 900	6.8	3.2	19.7	-	20.6	2.1	6.9	-	-	8.81
33	SP	ES	-	981	628	4.7	2.3	4.0	-	5.4	1.2	4.6	-	-	2.14
34	SP	ES	-	1 641	1 050	4.8	3.6	10.3	-	9.0	2.1	7.6	-	-	5.03
36	SP	ES	-	1 006	644	3.2	0.8	7.4	-	2.4	0.8	8.2	-	-	5.23
38	SP	ES	-	859	550	2.8	1.6	5.1	-	3.2	2.5	3.8	-	-	3.44
39	SP	ES	-	1 931	1 236	4.8	2.4	10.0	-	4.8	1.2	11.2	-	-	5.27
40	SP	ES	-	2 338	1 496	8.8	1.3	12.8	-	8.0	2.1	12.8	-	-	5.70

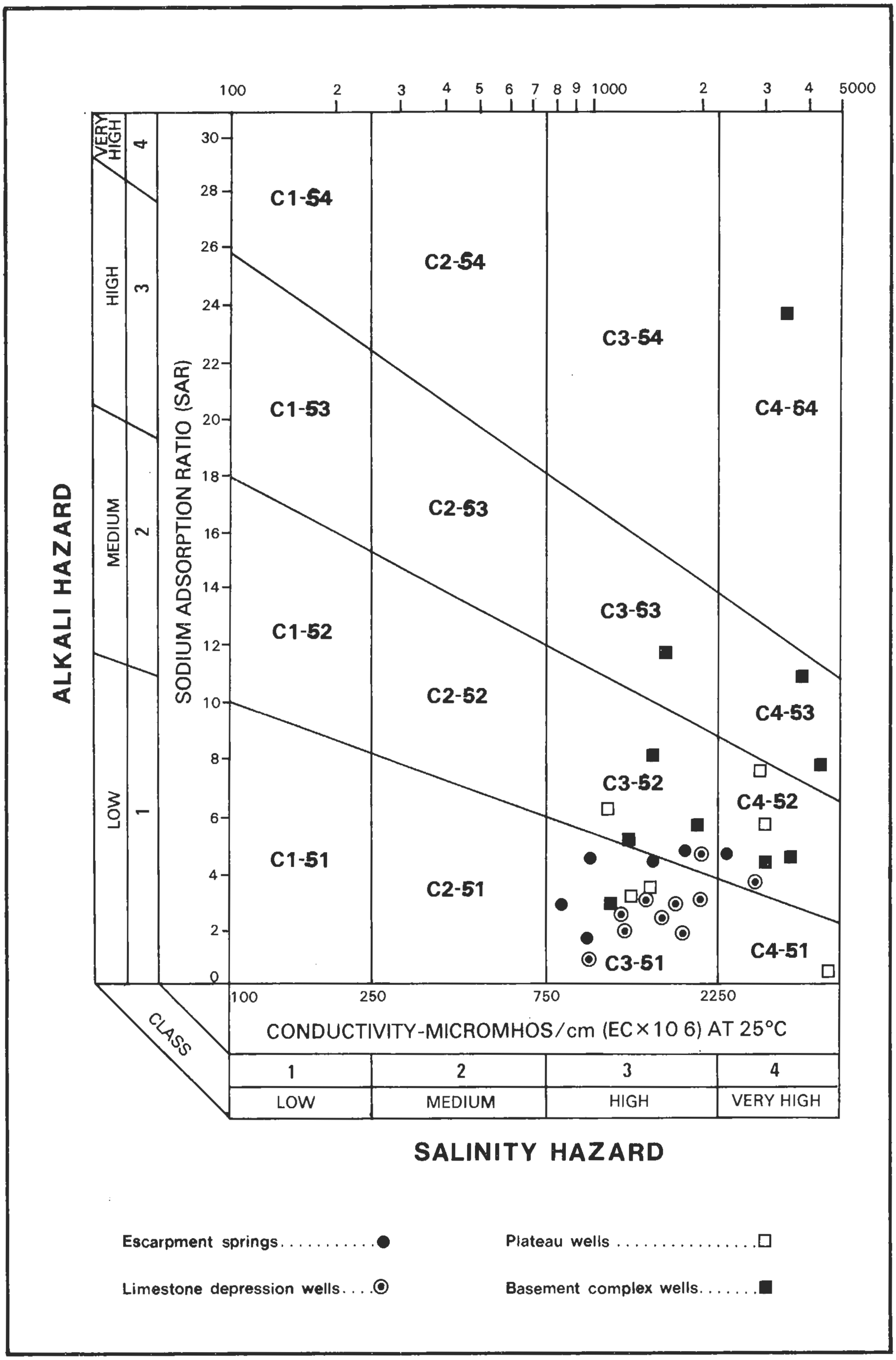
DW - Dug well BH - Borehole SP - Spring
BC - Basement complex LP - Limestone plateau ES - Escarpment

TABLE 4.3 Continued

Ref. No.	Source of Sample	Physiographic Unit	Depth (m)	EC x 10^6 @ 25°C	TDS (ppm)	Milliequivalents per litre Ca	Mg	Na	K	C1	SO_4	HCO_3	NO_3 (ppm)	B (ppm)	SAR
37	DW	LD	16.3	994	636	3.6	2.4	1.7	-	1.4	0.9	5.4	-	-	0.98
59	DW	LD	?	2 934	1878	12.6	4.6	11.4	-	17.5	1.4	6.1	-	-	3.89
60	DW	LD	?	2 041	1 306	6.9	3.9	9.0	-	9.8	2.0	5.2	-	-	3.87
61	DW	LD	?	1 781	1 140	5.8	4.5	4.6	-	5.9	3.3	5.6	-	-	2.03
62	DW	LD	?	1 694	1 084	7.1	2.5	6.0	-	7.7	1.9	5.0	-	-	2.74
63	DW	LD	?	2 131	1 364	7.7	3.0	12.6	-	11.2	2.0	5.1	-	-	5.45
I	DW	LD	?	1 500	1 280	5.3	2.4	7.0	0.2	9.3	2.6	2.4	49.5	0.2	3.59
II	DW	LD	?	1 160	920	3.1	2.3	4.6	0.2	7.5	2.0	1.7	53.4	0.2	2.72
III	DW	LD	?	1 300	1 052	4.0	2.5	4.3	0.2	7.6	2.0	2.7	52.0	0.3	2.36
V	DW	LD	?	1 850	1620	4.3	6.8	8.0	0.1	8.5	6.7	4.0	28.0	0.9	3.41

DW - Dug well
LD - Limestone Depression

4.5 Irrigation water classification



both the Limestone Plateau and Basement groundwater, the range of quality is very wide.

For potable water, the World Health Organisation (WHO, 1977) have laid out two sets of standards stating the desirable and the permissible limits for all chemical constituents commonly found in natural waters. The available analyses of groundwater samples cover but a few of these constituents, but even in terms of total dissolved solids (TDS) none of the groundwater samples from the Bay Region are within the WHO desirable limits; samples from the Escarpment springs and Limestone Depression wells are mainly within the permissible limits (or just outside them), but some of the groundwater from the Limestone Plateau and particularly from the Basement Complex has quality well outside the permissible standards.

The general hydrochemistry of the groundwater of the region was examined with the aid of a Durov diagram (Figure 4.6); this graphically represents the composition of the water and places it in a field related to its origin and history.

As it moves through an aquifer system, groundwater undergoes a series of ordered chemical changes. The most obvious of these is the general increase in salinity in the direction of flow. Thus the freshest groundwater is normally found near the recharge zones and the highest salinities occur close to the discharge areas, or in regions of stagnant water. The overall patterns are seldom simple because of the presence of preferential flow paths in most groundwater basins. Along such paths groundwater tends to be less mineralised than elsewhere in the vicinity.

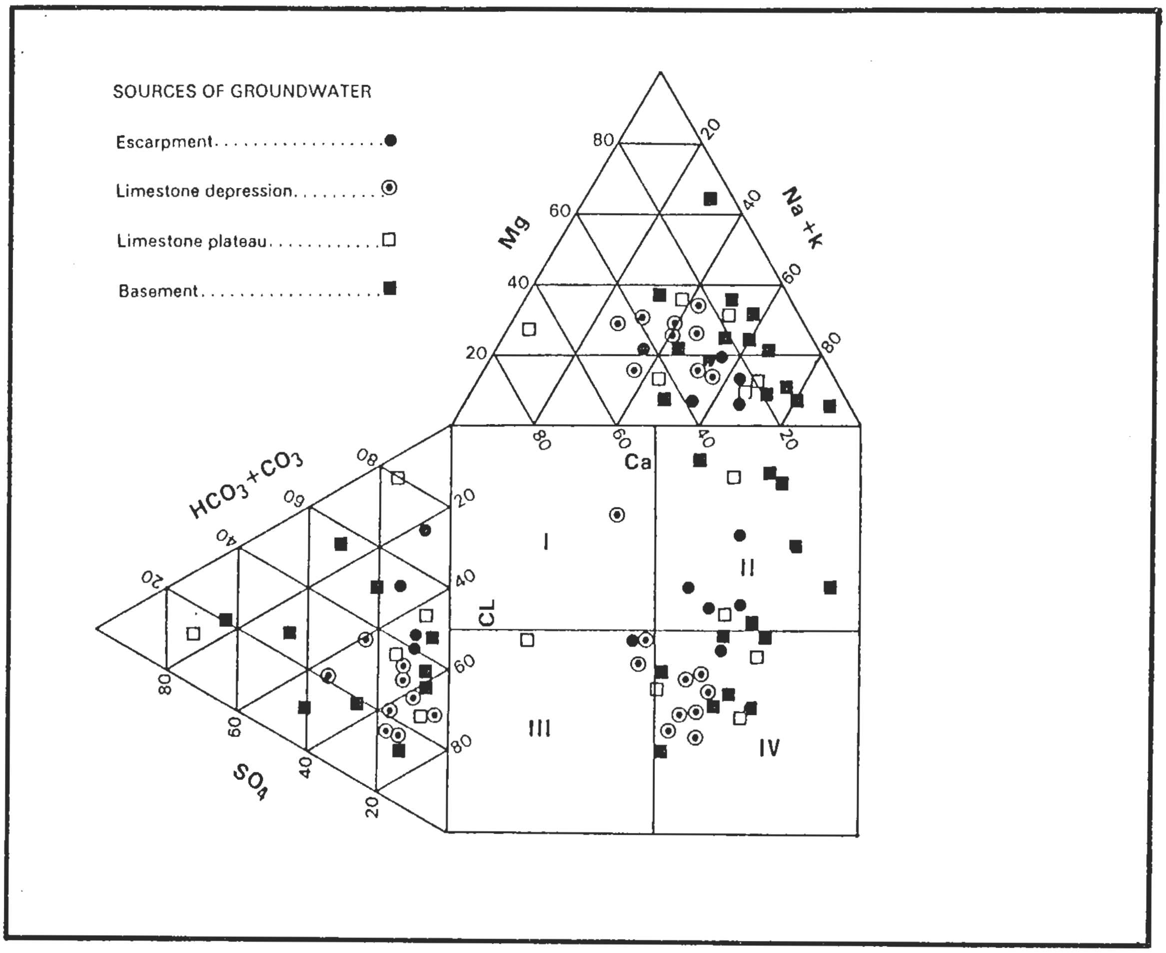
In terms of chemical composition recharge waters are usually similar to rain water and the dominant ions are calcium, magnesium and bicarbonate, although if the source of recharge is a surface water body such as a stream this composition may have become considerably modified before reaching the aquifer. Throughflow groundwaters are typically of the sodium bicarbonate type and stagnant or storage groundwaters are invariably dominated by chloride and/or sulphate.

As can be seen in Figure 4.6, no clear pattern emerges with respect to the relation of groundwaters of the major physiographic units. Little recharge water of the standard calcium/magnesium bicarbonate (plotting in quadrant I of the Durov diagram) can be identified. Most of the groundwater samples from the Limestone Depression are sodium/calcium chloride, but with sufficient bicarbonate present to suggest that the analysed samples are mixtures of storage, throughflow and recharge waters. The discharge of the springs on the Escarpment has the Hydrochemistry mainly of the throughflow type. The Limestone Plateau and especially the Basement groundwaters have a highly variable composition, but mainly of the throughflow and storage type (quadrants II and IV).

In summary, general hydrochemical considerations offer little help in understanding the groundwater flow regime of the Region. It appears that the Limestone Depression receives some recharge both directly from rainfall and from infiltration of water from springs on the Escarpment. However it also contains hydrochemically senile water of the long term storage character. Certainly, there is little hydrochemical evidence to support the hypothesis (Johnson, 1978) that the Limestone Depression is a major intake area for the aquifer system underlying the Limestone Plateau.

The chemistry of the groundwaters of the region, suggests that incrustation rather than corrosion may be a problem with well components. However, the history of the few wells that have been in operation in the area for several years, indicates that such problems are unlikely to be severe.

4.6 Groundwater chemistry–Durov diagram



4.7 RECHARGE AND GROUNDWATER MOVEMENT

Practically no direct piezometric evidence is available for any part of the Region. Therefore groundwater movement patterns have to be inferred from basically circumstantial evidence concerning physiography, geology, climate, hydrochemistry and surface hydrology.

Apart from the Baidoa Escarpment the whole Region has subdued topography with low land gradients. In the Limestone Depression and on the Basement Complex outcrop, the gradients are generally towards the south-east; on the Plateau the situation is more complex with almost radial gradients from a topographic high to the north of Baidoa. The soils of the region are mainly brown and grey vertisols (swelling clay) and coarse grained red soils; the latter have a high potential infiltration intake.

Overall annual rainfall in the Region is low (less than 600 mm average everywhere), but tends to occur in high intensity showers; consequently run-off and/or infiltration to the groundwater reservoir can be expected. Dense drainage systems exist only on the Basement and in the western part of the Limestone Depression. Elsewhere, the absence of surface drainage channels could be interpreted as occurrence of high infiltration and recharge of the groundwater reservoir. Some of the streams may themselves be sources of recharge, where they pass through areas of high infiltration capacity surface material.

Thus, recharge of such aquifers as underlie the Bay Region is expected to take place either as direct infiltration of rainfall or as seepage from seasonal streams. Because of the arid climate and generally very low vertical permeability of most of the strata concerned, this recharge is certain to be low. It can be independently deduced that the underflow (aquifer throughflow) in all parts of the Region is low, the transmissivity of the aquifers is normally small and the generally flat land gradients are reflected in low groundwater gradients.

The direction of the underflow is thought to follow that of surface drainage; that is, in the Limestone Plateau zone, part of the aquifer drains towards the Escarpment and part (much the greater) moves down-dip away from the Escarpment. Groundwater discharge is by springs on the scarp face of the Plateau, and by evaporation and evapotranspiration, either in the recharge zone itself, as in the case of the Basement and the Limestone Depression, or at a distant discharge zone, such as the gypsiferous beds near the Ethiopian border where the Plateau underflow gets too near the land surface and evaporates.

It has been claimed (Johnson, 1978) that it is only the higher units of the Jurassic aquifer in the Escarpment zone that contribute to the springs, from perched groundwater bodies; it is further argued that in the basal beds the direction of the underflow is reversed and that the Limestone Depression forms the intake zone for the underflow of the Plateau. In view of the lithology and the hydraulic properties of the basal units of the Iscia Baidoa Suite, even if this intake zone hypothesis is right, the underflow from this source must be small.

It is clear from the above discussion that aquifer recharge in the Region is expected to be low but is difficult to quantify. By analogy with other regions of similar climate it is estimated that recharge might be about 1 to 5 per cent of the average annual rainfall. Using these kind of figures for the Limestone Depression and a gross surface area of about 1500 km^2, the recharge is estimated as between 10 and 40 Mm^3 per annum. Although run-off from the escarpment may contribute a little more to the aquifers the overall indications are that it is the lower estimate that is more likely to be correct.

4.8 SUMMARY AND CONCLUSIONS

The geology of the Bay Region is dominated by two major stratigraphic units:

- the Precambrian Basement Complex
- the Jurassic Limestone Formation

The former comprises a suite of ancient crystalline metamorphics with younger granite intrusions. The latter consists of limestones, shales and marls with basal sandstones and conglomerates.

The Basement rocks occur in a large outcrop forming a low lying plain in the south-east of the Region. The Jurassic outcrop is mainly in the form of a retreating cuesta with a prominent southwards facing escarpment; however, in the east a remnant of the Jurassic occurs in an outcrop below the Escarpment, with ground elevation approximately the same as that of the Basement Complex forming the so-called 'Limestone Depression'. It is this Limestone Depression that has been the focus of the present investigations as the only possible source of groundwater for irrigation. Crystalline Basement rocks, even if fractured and weathered are extremely seldom, if ever, permeable enough to support wells with discharges large enough for economically viable irrigation. In the case of the Limestone Plateau the problem is with the depth to static groundwater level which is normally greater than 50 metres; even if the aquifers there were reasonably permeable, pumping from wells for irrigation would be prohibitatively expensive.

The recent drilling programme undertaken by WDA/Louis Berger International/ USAID has provided some new valuable information on the lithology and the hydraulic properties of the Jurassic strata of the Baidoa region, including those of the Limestone Depression. All these results indicate that the basal units of the Jurassic, which occur under the Plateau and outcrop in the Depression, are low permeability interdigitations of thin limestones, sandstones, shales and marls or more uniform predominantly shaly beds. Borehole pumping test data, admittedly very scarce, indicate very low permeability for all units of the Jurassic; drilled well yields range from nothing to 0.124 litres per second per metre drawdown; even the best of these are not high enough for successful irrigation.

The only exception to the prevalance of low aquifer permeability and consequently low well yields, are three large diameter dug wells in the Limestone Depression, just to the south of Baidoa; however these are thought to represent a unique condition of a particular limestone layer, intensely karstified, partly by flooding from the largest drainage basin in the area; in fact at least some of these wells are considered to be artificially enlarged karst features (sink holes).

Groundwater quality in the Region is variable. Least mineralised water in the region is that discharged by springs on the Escarpment and by some of the wells in the Limestone Depression. Highly saline groundwater (up to 35 000 ppm TDS) occurs in parts of the Basement Complex. As a rule, water from the Jurassic aquifer is suitable for irrigation and much of it is within the WHO permissible limits for drinking water.

The general hydrochemistry of the groundwater is consistent with a low permeability system of low recharge and slow underflow. Pumped sample analysis and the history of wells, which have been in operation in the area for several years, indicate that no serious problems with corrosion and/or incurstation of well components are likely to occur.

Thus, there is overwhelming evidence that none of the aquifer systems of the Bay Region are suitable for large scale development for irrigation. None of the wells drilled anywhere in the Region have produced yields large enough for economically viable field irrigation. This is true of the Limestone Depression as well as the other physigographic units, and it is most unlikely that any boreholes drilled in the future will be any different. The only doubt that exists relates to the eastern part of the Limestone Depression, for which no direct drilling evidence is available at present. This difficiency should be corrected by the construction of two exploratory boreholes, but it should be understood that the chances of success are very small.

5

Vegetation And Range Resources

5.1 INTRODUCTION

The Bay Region falls within the Ethio-Somalian Sector of the Afro-Oriental Biogeographical Domain identified by Ibrahim (1974). The vegetation is predominantly Semi-Arid wooded Savanna. Some 11 per cent of the area consist of cropped land and associated fallows, the remaining area (excluding towns and villages) is considered to be rangeland representing some 3.5 million hectares. These rangelands were found to carry an average biomass of 5 100 kg/km^2 in February - March 1982. The importance of the Bay Region as a livestock production centre is well recognised.

The Rangeland survey set out to:

a) Identify and delineate the ecological formations.
b) Provide a reconnaisssance level map showing physiognomy and gross species distribution of the rangelands. (1:250 000 scale)
c) Provide information on relative use of the rangelands. Proximity to villages and permanent water sources, and identify any under used areas.
d) Provide information on the range plants; preference, palatability, and seasonality.
e) Provide a checklist of plants found in the Bay Region with local names.

These data are expressed cartographically on Map Sheet Nos. 2 and 3 and in Appendix D.

5.2 SURVEY METHODS

5.2.1 Ground Survey

The ground survey was carried out between January and April 1982. Although isolated showers did lead to some new vegetation growth, most of the vegetation was in a dormant stage and difficult to identify. Local plant names were collected for unidentifiable plants in readiness for the emergence of new growth and thus accurate identification. The problem was particularly compounded in the grass species. Dry remains of the grasses from the previous 'Der' season were often the only available material for identification. The most common grass species, *Tetrapogon tenellus* did not have persisten spikes whereas several of the *Aristida* species drop their seed quickly. Despite these contraints it is felt that few species have been overlooked and that an accurate picture of the species composition and distribution has been built up.

5.2.2 Continual Traverses

While travelling along selected existing tracks, foot paths and old trace lines information was collected on species distribution and associations. Changes in soil surface geomorphology, and physiognomy were noted and transfered to a field map. The location of the continual traverses appears on Figure 5.1.

5.2.3 Sample Sizes

Once plant associations had been identified, sample sites for each association were described, in all 46 sites have been described. The location of the sample sites appears on Map Sheet No. 2. At each site the following information was collected:

Species present with local names.
The relative abundance of the species present (Dominant, Abundant, Frequent, Occasional or Rare).
The state of growth of these species. (In leaf, flower or fruit.)
The extent to which the species have been grazed (Heavy, Medium, Light or not grazed).
The Physiognomy of the vegetation using the characters described in the map legend.
The ease of penetrability for cattle, sheep, goats and camels as being either good, fair or poor.
The topography and soil type at each site.
The erosional status; gullying, rilling or surface compaction.
An assessment of the range as either Excellent, Good, Fair or Poor.

A site proforma is reproduced as Figure 5.2. This proforma was designed to fit the particular requirements of vegetation physiognomy, species components, seasonality and and palatability. Observations on surface soil condition were also made. This description of erosion status is a good indicator of degrading conditions and is particularly relevant for short duration survey where unfamiliarity of the typical and indicator species make estimates of trend difficult. Emphasis was placed on the collection of local plant names. This record will hopefully allow locally trained staff, without an in depth knowledge of plant taxonomy, to monitor species changes at particular sites.

Additional observations on main vegetation species were collected at all soil survey bore and pit observation sites.

5.2.4 Aerial Census

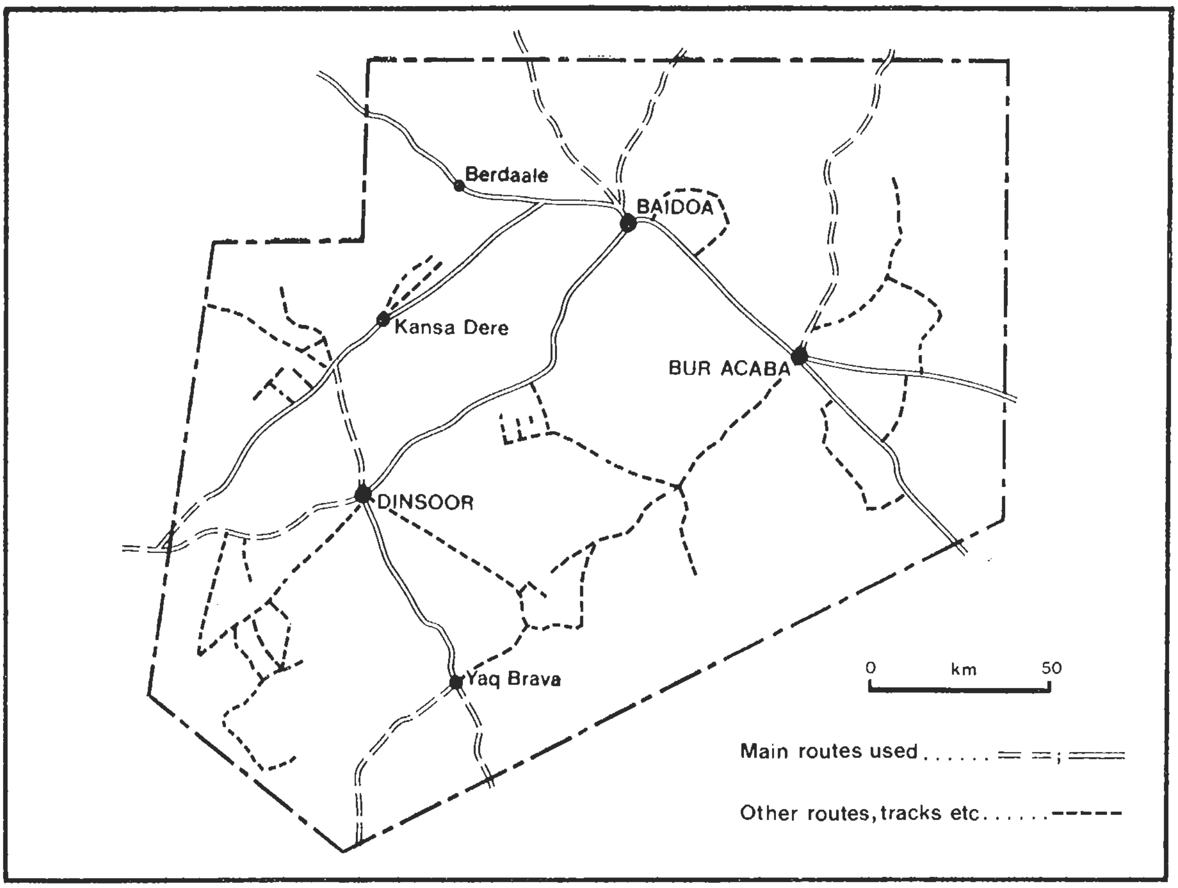
Details of the aerial census are described in Appendix C. While the aerial survey was principally used to count livestock numbers and their type and distribution, the observer in the aircraft also noted vegetation type, changes in density and canopy cover and land use. This information has been used in conjunction with the more detailed ground survey data in the mapping process and was particularly useful when mapping the more inaccessible areas.

5.3 MAPPING

Comprehensive interpretation of remotely sensed imagery was carried out during and after the ground survey. The following imagery was used:

a) 1960 Photomosaics at 1:60 000 scale
b) RBV imagery at 1:60 000 scale
c) 1973 and 1975 precision processed LANDSAT imagery or 1:250 000 scale
d) 1982 Air photo cover at 1:20 000 scale (for PADU areas only)
e) 1:100 000 scale topographic maps based on 1973 Russian air photographs.

5.1 Traverses used in vegetation survey



These remotely sensed images have helped increase the accuracy of mapping but, because of a wide difference in type and form of imagery, little could be deduced about the dynamics of the range resources.

It was proposed in the Terms of Reference that four pilot agricultural development units (PADU's) of 62 500 ha would be selected for more detailed investigations. These studies would be confined to approximately 10 000 hectares of rangeland in each PADU. The Range survey of these four separate areas, mapped at 1:50 000 scale, provided a useful check on the purity of the reconnaissance mapped units. In addition new 1:20 000 scale air photographs of these areas were made available for mapping purposes. An acceptable agreement between the reconnaissance and PADU maps was found. The same mapping units at the reconnaissance level were applied in the PADU areas. At 1:50 000 scale it was possible to map areas of differing density and grass cover with more precision.

5.4 CLASSIFICATION

5.4.1 Introduction

The 1956 conference at Yangambi (Zaire) set out to standardise physiognomic vegetation descriptions for Africa (CCTA/CSA 1956). This classification system was used by Lockwood (1968). The uniformity of vegetation type in the Bay Region renders the Yangambi classification (designed as a continent wide, and therefore generalised, system) unsuitable even at 1:250 000 scale. Lockwood recognised only four units:

1. Semi-Arid tree and shrub steppe.
2. Thicket and Wadi thicket.
3. Woodland.
4. Agricultural Land.

FIGURE 5.2 VEGETATION SITE PROFORMA

ASSOCIATION: AREA: DATE:

LOCATION: SITE NO:

SPECIES	COVER AB.	CONDITION

REMARKS

TOPOGRAPHY: SOILS:

SURFACE FEATURES:

	G	S	G	C
G				
F				
P				

EROSION:

	Dry	Wet
Excellent		
Good		
Fair		
Poor		

Using this system some 70 per cent of the Project Area would appear as unit 1 Semi-Arid tree and shrub steppe. In order to provide information that would include characteristics more appropriate for assessing the range a revised system of classification was developed for the current study.

The characters used in this classification are of two types:

a) Physiognomic:
This is expressed in terms of the life forms of the vegetation components. The major type of vegetation is taken as the primary criteria i.e. shrubbed, bushed etc., and the secondary growth form follows e.g. shrubbed bushland, or bushed woodland; where the predominant growth form (shrub, bush etc.) is used as the primary descriptive factor. This dual classification system is supplemented by a density index of open, medium or dense. In addition a subjective assessment of the grass cover is made as being poor, fair, good or excellent. These characteristics cannot directly be related to use or capability, they merely represent the gross vegetation description. Information on species components are required to relate the vegetation to capability and potential.

b) Specific:
A generalised system of species component mix was devised. Units identified were:

Acacia: here *Acacia* species (particularly *A. zanzibarica, A. stulmanii* and *A. paolii* and the allied genera of *Caesalpinia* and *Dichrostachys*) provide 70 per cent or more of the existing plant cover. This very characteristic species mix is found on the heavier textured soils of the cultivated clays and valley bottom soils. This unit is typical of the abandoned and fallow land.

Mixed **Acacia:** here *Acacia* species (particularly *A.bussei, A.senegal, A.mellifera* and *A.reficiens)* provide more than 30 per cent of the existing cover. A wide variety of other perennial species are found in this unit. Typically this species mix is found on the red soils that overlie limestone in the north and west of the Project Area.

Mixed: here the vegetation is typically non-thorny, although *Acacia tortilis* is often locally common. This species combination, which includes many of the palatable non-thorny species such as *Dalbergia microphylla, Grewia tenax Ochna inermis* and *Cordia ovalis* typifies the vegetation on the lateritic basement complex soils in the southern and central parts of the Project Area.

This system of vegetation description provides the basis of the map legend and is summarised in Table 5.1. A comparison between the units used in the current study and those used by Lockwood (1968) is given in Table 5.2., Map Sheet No.2 at 1:250 000 scale where the broad distribution pattern of the vegetation units are identified and mapped in this study. Table 5.3 summarises the areas of these units.

5.4.2 Indicator species

During the course of the field work the distribution of several species was found to closely follow soil type and/or edaphic conditions. One species in particular, *Dobera loranthifolia,* was found to be an accurate indicator of the deep clay soils. Other soil/plant relationships are indicated in Table 5.4.

Grazing pressure also affects the species components found in a unit. Dyksterhuis (1949) proposed the increaser/decreaser/invader approach towards a dynamic classification of site description. This envisages the livestock selecting the most palatable species in a given assemblage of plants. These preferred species are under greater pressure from grazing than the less palatable species and are called decreasers, as their importance as components within a plant association is likely to decrease with increasing pressure from livestock. Similarly the less palatable species with less grazing pressure are likely to increase in number (the 'increasers'). Under heavy grazing pressure over time a change in the species components can be expected as species not found in the climax vegetation appear. These species, the 'invaders', are usually non-palatable species or species of low palatability. This system is generally applied to the grass/herb layer and is a useful monitoring principal but of little use in a survey of this nature where the climax vegetation (especially the grass/herb climax vegetation components) is unknown. However, it is possible to identify some 'invader' species. These species represent visible signs of misuse. Table 5.5 lists some of these species and the situations in which they were noted to occur.

5.4.3 Ecological Units

During the ground survey ecological units were identified based on geology, soils, topography, species components and vegetation physionomy.

Five main geomorphological/ecological units were recognised:

a) clay plains
b) limestone plateau
c) basement complex peneplains
d) basement/limestone interface
e) coastal deposits.

These are illustrated in Figure 5.3.

TABLE 5.1 PHYSIOGNOMIC VEGETATION DESCRIPTION

Density Index	Species	Primary Vegetation Growth Form (1)	Secondary Vegetation Growth Form
Open	*Acacia*	Grassed	Grassland
		Shrubbed	Shrubland
	Mixed *Acacia*		
Medium			
		Bushed	Bushland
	Mixed		
Dense			
		Wooded	Woodland

Annotation of grass cover: Poor
Fair
Good
Excellent

Footnote: 1)Where Shrubbed = less than one metre
Bushed = one - three metres
Wooded = more than three metres.

TABLE 5.2 VEGETATION CLASSIFICATION : COMPARISON WITH PREVIOUS STUDY (Lockwood 1968)

Mapping Unit and Symbol				Lockwood/FAO (1968) After Yangambi
Mixed *Acacia*) Mixed)	Open) Medium) Dense)	Shrubbed Bushland or Bushed Shrubland		Semi-Arid Tree and Shrub Steppe
Acacia	(Medium) (Dense)	Thicketed Bushland Thicketed Shrubland Shrubbed Bushland Bushed Shrubland		Thicket and Wadi Thicket
Agricultural land or *Acacia*	Open	Shrubland	(recent fallow)	Agricultural Land
Mixed	Open) Medium) Dense)	Bushed Woodland		Woodland

TABLE 5.3 VEGETATION UNIT AREAS (hectares)

Mapping Unit	Area
Mixed Species	
Open shrubbed bushland	1 170 625
Medium shrubbed bushland	74 580
Open grassed bushland	206 305
Open bushed grassland	76 250
Dense bushed woodland	10 000
Mixed Acacia Species	
Open shrubbed bushland	230 475
Medium shrubbed bushland	967 380
Dense shrubbed bushland	152 740
Acacia Species	
Medium grassed bushland	211 875
Dense thickets with cultivation	966 975
Total area	**4 067 205 ha**

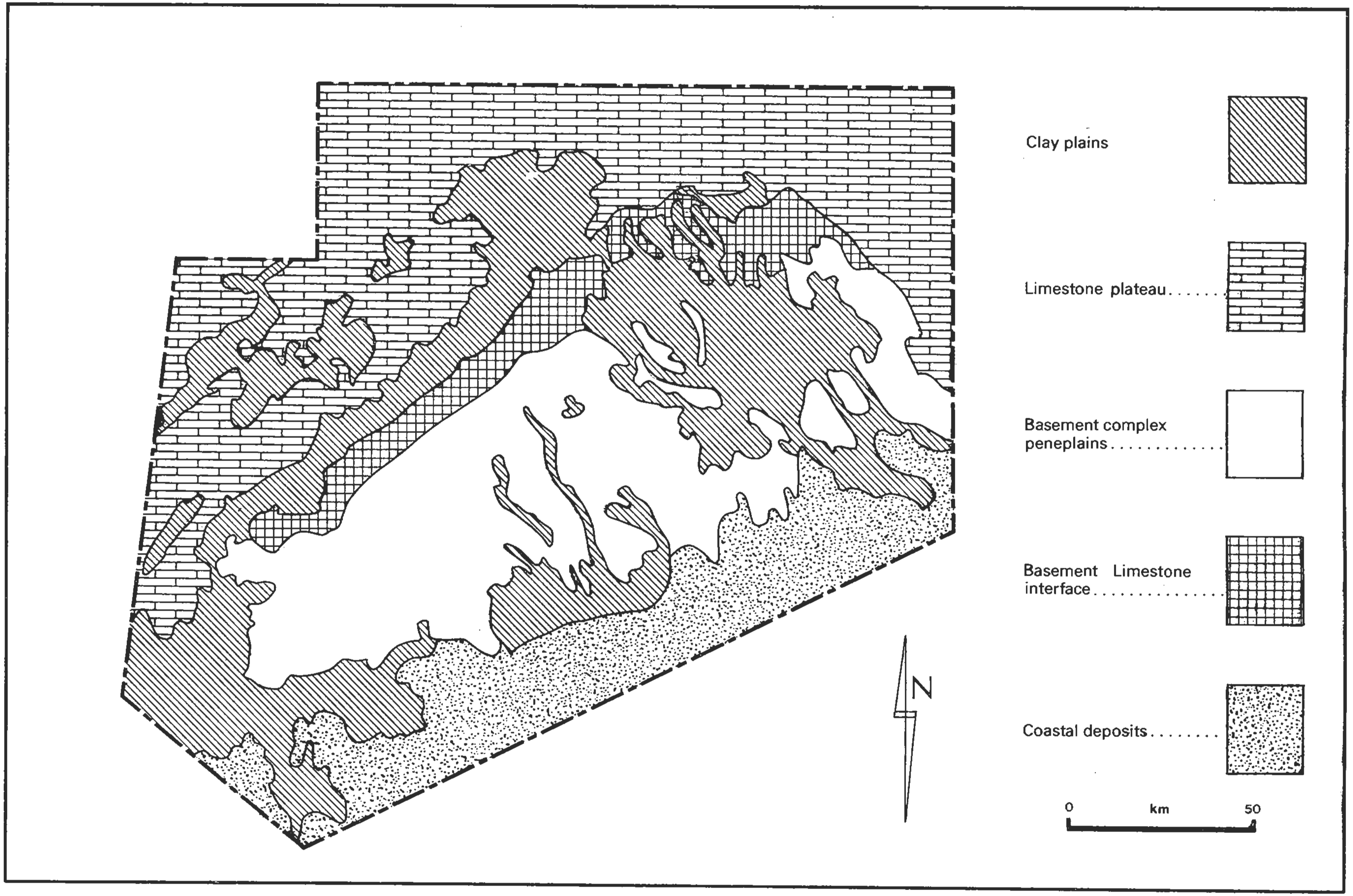
TABLE 5.4 SOIL/PLANT RELATIONSHIPS : INDICATOR SPECIES

Species	Local Name	Soil/Type Texture
Dobera loranthifolia	Garas	Deep clay soils, often cultivated
Acacia zanzibarica	Fulaay	Clay soils, valley bottoms and fallowed areas
Euphorbia cuneata	Dirindir	Rocky
Albizia anthelmintica	Reidub	Soils associated with limestone parent materials
Lawsonia inermis	Alan	Seasonally wet areas
Uvaria denhardtiana	Osman Doy	Sandy Soils
Acacia nilotica	Tougaar	Seasonally wet areas, uars, and escarpment footslope
Platycelyphium voense	Saby Saydi	Soils associated with limestone parent materials

TABLE 5.5 PLANTS CHARACTERISTIC OF OVERGRAZED AND DISTURBED AREAS : INVADERS

Plant Name	Local Name	Comments
Acacia nubica	Goumer	Found on disturbed ground, old trace lines, road edges. Particularly in areas where soil textures are light to medium.
A. zanzlbarica *Ipomoea sp.*	Fulaay	On disturbed ground with medium to heavy textured soils. In overgrazed situations on lateritic soils.
Abutilon fruticosum	Balambal	An unpalatable species increasing in number on the lateritic soils.
Indigofera sp.		As above and also along road edges in the red soils over limestone.
Euphorbia robbechiii	Darkain	
Euphorbia grandicormis .	Galaliyo	
Dichrostachys cinerea	Detair	On cultivated land now regenerating or abandoned. Can withstand periodic burning.
Caesalpinia trothae	Gorgor	
Mundulea sericea	Neerga fijis	Increasing in number on thered lateritic soils, possibly as a result of overgrazing.
Aloe sp.		
Commiphora species	No	

5.3 Ecological units



a) Clay Plains

Two sources of fodder are derived from the cultivated land on the clay plains. These comprise the stover and the fallowed vegetation. The cultivated areas have continually large numbers of stock throughout the year. The lowest density of stock can be expected in the dry season when the owners frequently move into the range areas. For most of the wet season and harvesting period when labour requirements are high, the stock and the stock keepers are to be found in and around the cultivated areas. During the growing season the stock graze and browse the fallow vegetation as well as the immediate range around the cultivation. Once the harvest begins stover is collected and fed to the stock and when whole fields have been harvested the stock are turned in to graze the stover as well as any palatable weed species. After the harvest is complete the stock owners move out with their animals into the range lands. As a result of artificially high stock numbers (stover being available as a supplementary feed) these areas of vegetation - particularly those surrounding the cropped land are in a very poor condition. Apart from annual grasses, the vegetation consists of thorn shrub or tree vegetation (*Acacia zanzibarica, A. horrida, A. nubica, Caesalpinia trothae,* and *Dichrostachys cinerea*). All these species are of low palatability eaten only by camels and goats, and even then low in preference. While this type of range is degraded the role of the thorny vegetation should not be overlooked. The thorny vegetation by restricting access to stock protects grasses and herbs from grazing and acts as a seed bank ensuring propagation of grass species in areas where the grasses might otherwise be grazed out completely.

b) Limestone Plateau

These areas of predominantly uncultivated shallow often stony soils, have a medium to dense vegetation cover, often providing good to fair grazing. These areas are frequently too dense for adequate penetration by grazing camels and cattle and sometimes goats. Typically the vegetation consists of a fair to good grass layer of *Tetrapogon tenellus,* and *T. cenchriformis,* a medium shrub layer and a medium to dense bush layer. *Delonix elata* and *Albizia anthelmintica* often reach tree size. There is little evidence of erosion in this unit, with wet season grazing being relatively good. Much charcoaling activity is carried out.

c) Basement complex peneplains

This ecological unit covers some 920 000 ha in the central part of the Bay Region. It shows dramatic examples of overgrazing, and associated erosional and degradation features. It is thought that these areas are fragile and readily susceptible to overgrazing. The present vegetation is generally an open shrubbed bushland formation with a poor grass cover. There is much evidence of gullying, rilling and surface compaction. In the vicinity of villages the condition of the range is generally very poor. This large unit is one that requires remedial action and associated careful management if it is to be returned to a more productive state. Natural recovery of these areas is likely to take many years even if stock are immediately excluded; natural reseeding will be hampered by the now compacted surface. Infiltration rates are reduced by this capping and surface runoff evident after even small rain showers. Some areas, particularly in the vicinity of the inselbergs, do have a good grass and shrub cover. This is thought to be the result of a combination of two factors:

- Runoff from the inselberg surface providing a better moisture regime for plant growth and

- the presence of erosional products from the inselberg giving rise to a localised band of unlaterised coarse textured surface materials which allow rainwater to infiltrate the soil.

Hand dug wells are often found near these inselbergs giving further indication of the higher moisture status associated with these land forms.

d) Basement/limestone interface
This unit marks the transition between the basement complex peneplains and the limestone plateau. It consists of a mixture of limestone outcrops and laterised sandy soils. The vegetation is predominantly the same as the basement complex (open mixed shrubbed bushland) but also contains patches of medium mixed *Acacia* shrubbed bushland, more typical of the limestone derived soils. Similar species are found to those recognised on both the limestone plateau and the basement peneplains.

e) Coastal deposits
This unit occurs on the edge of recent marine activities. It represents a transistional zone between the flat alluvial marine plain and the basement complex. These areas are perhaps the most under-utilised of any rangelands within the Bay Region. Few tracks and hardly any permenant sources of water are to be found in this area. Nomadic and semi-nomadic families migrate through this area and it is also crossed by stock being transfered to Mogadishu on Kismayo for export. The vegetation is variable, often classed as grassland, but it is predominantly open bushland with sometimes an excellent grass cover. Other parts are medium (and occasionally dense) bushland but still with an excellent to good grass cover. The bush species include *A. bussei* and *A.reficiens,* as well as localised shrubs of *Dobera loranthifolia* and *Combretum hereroense.*

5.5 GRASSES OF THE BAY REGION

FAO (1960) indicate that the Bay Region is an area where *Chrysopogon aucherii var quinqueplumis* dominates the grass cover. However, this particular species was found on only two occasions growing in the same vegetation unit during the current studies. It is thought the FAO conclusion is based on extrapolation of data into the relatively undescribed Bay Region.

The dominant grass of the Bay Region is *Tetrapogon tenellus.* It is an annual species normally growing to about 40 cm but in protected areas *Acacia* thickets it may reach 70 centimetres. Little can be deduced about the relative palatibility of this species, since it is often the only grass species found in many units.

Another annual species *Tetrapogon cencriformis* is also frequently found. This species often occurs on the poorer range land soils (those of coarse texture). In the seasonally wet areas *Sporobolus helvolus,* and *Andropogon kelleri* are frequently found. In areas of active water movement, e.g. edges of uars, wadi sides (and along the irrigation canals south of Baidoa) *Dicanthium annulatum* and occasionally *Cynodon dactylon* are encountered.

The annual grass *Eragrostis ciliariensis* is one of the first annual grass species to appear on the sand dune ridges in the south of the area. *Dactyloctenium aegyptiacum* and *D.scindicum* appear commonly on the limestone soils especially in areas where recent charcoal burning has taken place. The presence of this species in large numbers within this unit is primarily due to two factors:

- the clearing and thinning effect that the charcoaling practices have on the vegetation

- the ability of this species to colonise favourable sites quickly.

Several *Aristida* species including *A. adscensionis* are frequently found throughout most vegetation units.

5.6 CHARCOAL PRODUCTION

Charcoal production and collection by the Mogadishu based charcoal co-operative has a considerable effect on the rangelands of the Project Area. The Bay Region is by far the most heavily utilised region for charcoal production in Somalia with 86 of the 112 official camps presently in the Project Area. Each camp consists of 10 to 15 people engaged in wood collection and kiln preparation together with a guard from the forestry section of the National Range Agency. Total charcoal production is estimated at 30 000 tonnes/year. On a pro-rata basis this represents some 23 000 tonnes/year from the Bay Region.

Official annual production figures (from the cooperative alone) show a shortfall of 6 000 tonnes/year against estimated requirements for Mogadishu. It is likely that demand for charcoal in Mogadishu will continue to rise, and that the Bay Region will continue to be a very important source of charcoal. At present, work is being carried out on improving the local technology of charcoal production and also the use of agricultural by-products for charcoal briquettes. Officially only dead wood is allowed to be used for charcoaling, but in practice most woody species are used with *Acacia bussei* and *Terminalia polycarpa* being the prefered species.

The main areas of charcoal production in the Bay Region occur on the limestone plateau. The visible effects of the charcoaling practices include:

- a network of well defined tracks wide enough for a large truck and trailer to deliver water to the sites and collect the charcoal.

- areas of relatively open land with often a good grass cover.

- areas of uniform thicket and dense stands of regenerating bush.

Overall the initial thinning of the woody vegetation gives rise to an improved grass cover, especially in areas where *Acacia bussei* is an important component in the upper layer. However regeneration of the thorny vegetation is rapid and dense thickets of *A.bussei* soon develop. These stands are likely to be of little use for further charcoaling since the high density of the regenerating thorn leads to considerably slower groth rates than in a natural, evenly spaced stand.

It is difficult to put a time scale to the process of regeneration but the steps which occur in a mixed *Acacia* community are as follows:

Initial (pre-charcoal)	Medium Mixed *Acacia* Shrubbed Bushland
Charcoaled	Open Mixed *Acacia* Bushed Shrubland
Post Charcoal	Open Mixed *Acacia* Shrubbed Grassland
Early Regeneration	Open Mixed *Acacia* Shrubland (thicket)
Later Regeneration	Dense Mixed *Acacia* Bushland (thicket)

5.7 LAND USE CHANGES

Assessments of changes in the land use/vegetation over longer periods of time were attempted by making use of the 1960 aerial photomosaics for the region. However a number of problems were encountered. Widely different signatures are recorded for the same features on LANDSAT, RBV or air photographs. Although geomorphic features can readily be distinguished and correlated on these images,changes in land use or vegetation are much more difficult to detect. In addition, although the quality of the 1960 photomosaics was sufficient for landform identification and comparison (and incidently correlated strongly) with the RBV imagery, at the same scale, it was not possible to easily identify vegetation characteristics. Although erosion features are a good guide to changes in the landscape often reflecting an increased degree of over use or misuse. These features are often the end point in degradation and not a stage in the degradation process.

It is also very dangerous to draw conclusions from comparisons of year to year changes in vegetation especially in areas with such variable rainfall distribution. This latter factor can lead to great year to year variations in primary biomass production and range conditions which do not reflect any long term trends. The time of year when the imagery was acquired will also have a strong influence on the characteristics interpreted.

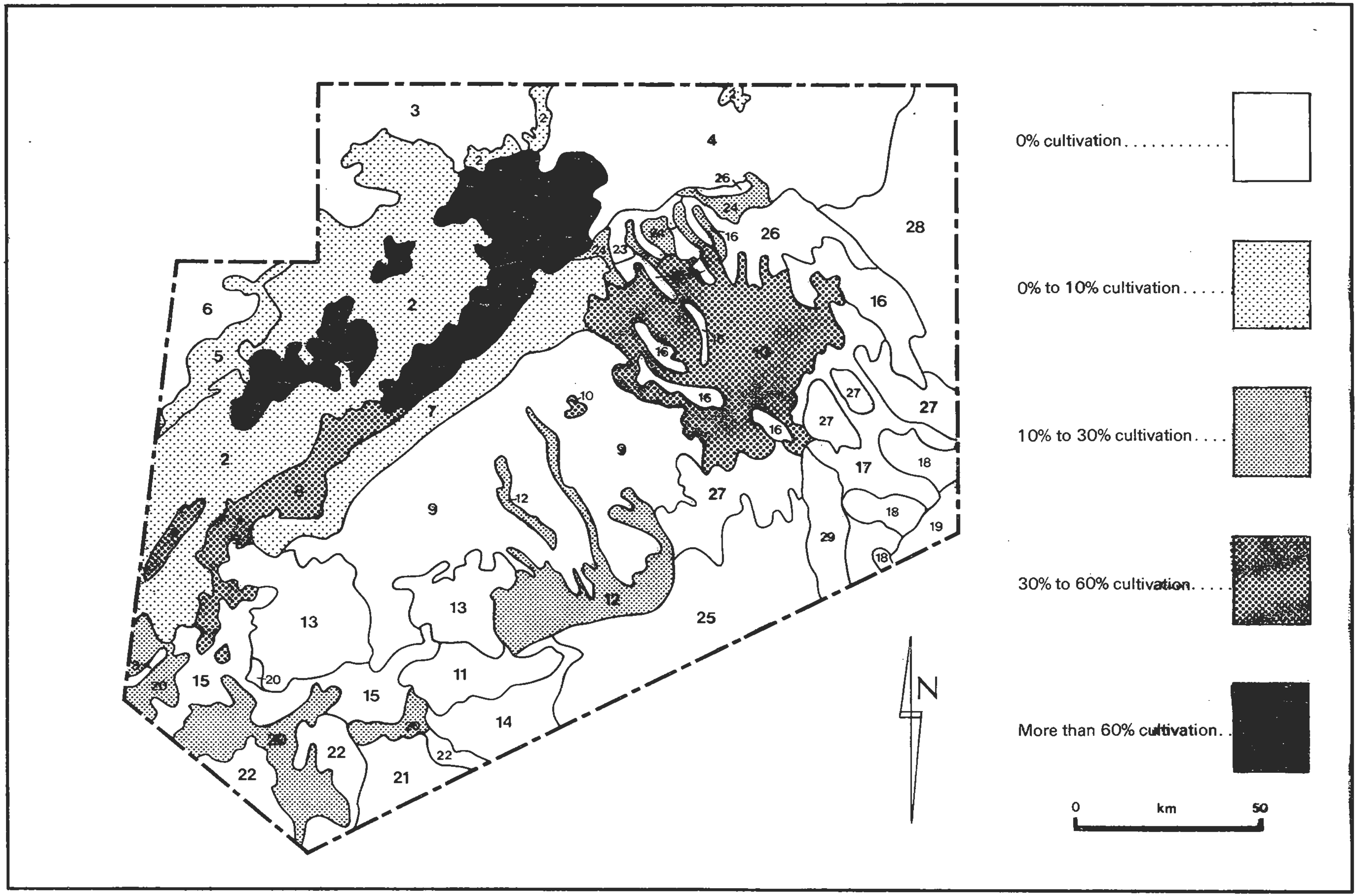
Figure 5.4 illustrates the per cent cultivated land by strata as derived from the 1982 aerial census.

Figure 5.5 illustrates the per cent changes in areas of cultivated land between 1973 and 1982, in the strata identified during the aerial census. These strata contain the main areas of cultivable land. There appears to have been only a small net increase in crop land over the period. The category of crop land includes recently abandoned land. There has been no major change in the distribution of cropping by strata although, locally, more obvious changes have taken place in small areas, with decreases of cultivation (in Stratum 2 for example) and increases (in Stratum 12). Changes in the extent of cultivation between 1960 and 1982 were also examined by reference to the earlier 1960 photomosaics. However, for the areas selected no significant changes were recorded.

Water sources which were recorded during the aerial census showed the most marked increase over the period in the cultivable lands in Strata 1, 2, 7, 8, 10, 12, 13, 16 and 20.

Although the observations made from the 1973 aerial photographs and presented on the 1:100 000 scale survey department topographic maps are not strictly camparable with the aerial census recording it is possible to draw a number of conclusions on changes in village size or structure. A selection of villages were completely counted for comparison with the 1973 map data. These data summarised in Table 5.6 reveal a general trend of increase in village size. It also appears that there is a cyclical trend at some sites with abandoned compounds re-occupied temporarily by nomadic graziers who place aquallo in the old compounds. The data for non nomadic houses showed a uniform increase over the period which relates closely to the population increase over the period.

5.4 Percentage cultivated area by strata



5.5 Significant changes in cultivated area by strata; 1973–82

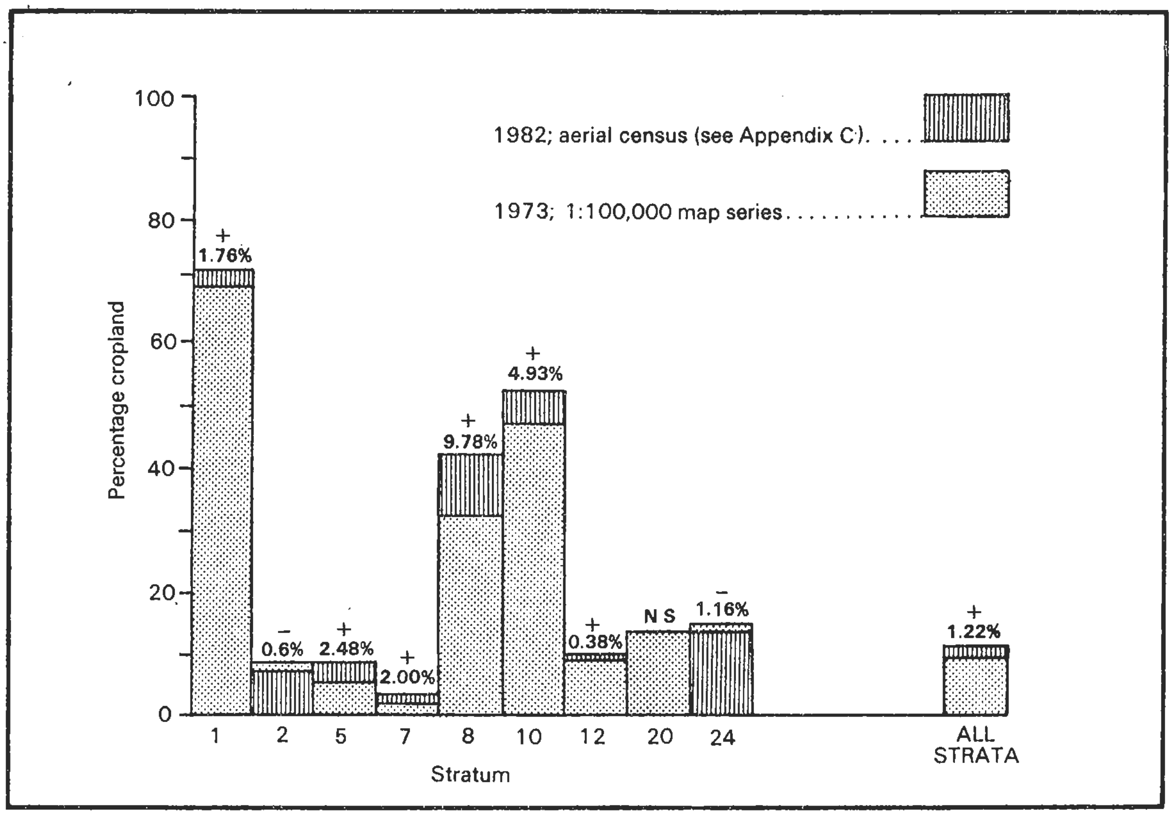


TABLE 5.6 CHANGES IN VILLAGE SIZES

Existing Village				New Village		Average Size			
Sample				Sample		All Samples			
Permanent		Nomadic		Permanent	Nomadic	Permanent		Nomadic	
Houses				Houses		Houses			
+	-	+	-	Average	Increase	1973	1982	1973	1982
35	18	16	20	32	21	26	39	21	21

6

Livestock Inventory

6.1 INTRODUCTION

Although the Bay Region comprises only 6.4 per cent of the total land area of Somalia, it directly supports 8.9 per cent of the human population, is a major grain producing area for the nation and carries the highest livestock density in the country (National Range Agency Technical Note No. 3). The higher than national average rainfall and its existing resources favour the region as one with a high potential for agricultural and livestock development.

A prerequisite to any development action is the collection and collation of information on the level and distribution of these natural resources and their relationship in socio-economic terms with the human population who exploit them.

The partial or complete dependence upon livestock for their livelihood, by the majority of people, and the important contribution of the livestock industry to the regional income necessitate a fuller understanding of the extent of the industry and the manner in which it functions. A survey of both the livestock numbers maintained and their distribution throughout the region is the starting point towards this understanding.

The main purpose of the livestock input of this resource survey was to carry out this basic census of livestock numbers and their distribution, the results of which are documented in Section 6.3 and in Appendix C. The data collected are based upon the situation as it existed in February 1982 at the end of the main Jillel dry season. As the livestock population of the region is influenced by the level of livestock movement between the regions and the within region distribution varies according to season, a single census provides only a limited working basis and does not enable a fuller description or planning proposal to be undertaken in detail.

The corrobative and alternative estimation of the numbers, movement or utilisation of livestock based upon the extrapolation of supportive data normally available, although usually unreliable, was not possible due to either lack of this information or the information being in a format that would not permit analysis. Sources investigated were:

(i) Licenced buyers, market sales and taxes
Market and buyers returns are not maintained and details of sales tax receipts, based upon a 5 per cent levy on market sale value were only available in a consolidated form at the District Council Offices. Sales are not classified by numbers, species, size, sex or area of origin.

(ii) Veterinary records
Since the cessation of the Rinderpest Eradication Programme (Project J.P.15) vaccination activities have severely declined in terms of frequency and coverage of definable areas, campaigns having been small scale, ad hoc, or on a 'fire fighting' basis only. This precludes any estimation of previous regional or localised livestock populations. Similarly no stock movement or quarantine controls are practised within the area.

(iii) Hides and skin sales
The marketing of hides and skins in the Region is not controlled, the National Hides and Skins Agency is not operational in the area and therefore sales emanating from the Region cannot be quantified.

(iv) Slaughter figures
Statistics available are limited to animals slaughtered by butchers and cafe proprietors at the four District Headquarters and the data reliability is in question due to the haphazard manner in which they are collated by the Veterinary Department.

(v) Watering point fees
The 19 waro , part of the former EEC Livestock Scheme for the interriverine area, currently administered by the Range Development Agency, together with 23 of the boreholes maintained and controlled by the Water Development Agency, supply domestic and stock water facilities on a fee paying, per head basis, with rates varying according to livestock type. Other than monthly or quarterly returns of receipts produced by the Agency's regional offices, no written records are maintained. The utilisation of these facilities in terms of species, flock-herd sizes or total numbers therefore cannot be determined. It is evident that cash receipts obtained have little relationship to the actual utilisation.

It became apparent at the commencement of the study that livestock owners were aversed to cooperation with a formal questionnaire programme particularly with questions related to livestock numbers, i.e. total herd-flock sizes, sales and mortality figures, together with a reticence to discuss, in front of others, issues that may have a political connotation, notably land use in respect of communal land tenure and grazing and water use control.

Answers to direct questioning on livestock numbers were either politely refused, avoided or had little credence when corroborated by physical counts. To avoid antagonism it was necessary to count and sex livestock surreptitiously without the owners knowledge.

Cooperation, subject to avoiding the contentious issues above, is generally high and for this reason and the fact that the various interpreters made available had had no previous relationships with the stock owners, together with the extensive coverage of questioning required, that an informal interview method was chosen and conducted at random mainly at watering points.

The study was carried out at all major centres of human population and of livestock in each of the four districts where, in addition to livestock owners, discussions were held with members of staff of the administrative and technical departments of the central and local government and with livestock traders. The interview programme was phased into two main areas, run concurrently, with initial emphasis placed on the more extensive aspects viz. livestock movements, nomadism and marketing channels and with 'within herd' aspects viz. ownership, husbandry, productivity, being dealt with increasingly towards the latter stages of the study.

The shortfall of information on the regional human resources, social patterns and agricultural systems together with the limited scope of this study, enabled only a general overview of the livestock industry to be undertaken. This review does, however, permit the pinpointing of those areas which require further study in depth, either by specific intensive surveys or through a continuous monitoring programme.

6.2 LIVESTOCK NUMBERS

The estimated livestock populations of the Region as determined from the aerial survey are shown in Table 6.1 together with that of the 1975 census, both censuses having been enumerated during the late Jillel long dry season.

TABLE 6.1 THE LIVESTOCK POPULATION OF THE BAY REGION (head)

	Camels	Cattle	Sheep	Goats	Donkeys	Horses
Feb. 1982	321 722	368 065	36 193	353 173	495	84
(Standard Error of estimate)	± 7 482	± 6 690	± 2 801	± 6 937	± 422	± 146
1975[1]	361 500	255 000	55 000	192 000	-	-
Charge (No.)	-39 778	+113 065	-18 807	+161 173		
Charge (%)	11%	+44%	-34%	+84%		

Source: Hunting Technical Services 1982

[1] *Statistical Department, Ministry of Planning.*

The apparent charges during the seven year period between censuses are: some decline in the camel population, a reduction by one third of the sheep flock and substantial rises in the cattle and particularly in the goat numbers. The relative contribution and charges of the individual species populations to the total livestock numbers are shown in Table 6.2.

TABLE 6.2 PROPORTION OF LIVESTOCK SPECIES TO TOTAL LIVESTOCK NUMBERS

	Percentage of total livestock numbers		Ratio between species	
	1975 (%)	1982 (%)	1975	1982
Camels	42	30	6.6	8.9
Cattle	30	34	4.6	10.2
Goats	22	33	3.5	9.8
Sheep	6	3	1.0	1.0

The paucity of demographic and productivity information at the time of both censuses and during the intervening period inhibits the identification of causes that have brought about these changes. However, it appears that:

(i) Since 1975 the absence of major endemic diseases and the climatic conditions have been generally favourable towards an increase in livestock numbers. Forage production has benefitted reproductive rates and lowered mortality levels and crop yields have been adequate to lower the level of subsistence dependency upon livestock products and sales.

(ii) The apparently increasing trend towards a more sedentary or less extensive way of life is reflected in the rise of cattle and goat numbers.

(iii) Regional ownership of camels is also likely to have increased. As there had been less movement in and out of the region this particular year due to the favourable previous rainy seasons, the 1982 census figures are more representative of regional ownership.

By comparison the 1975 census figures were possibly boosted by extra regional herds passing through and by those which had remained since entering to escape the previous drought, the effects of which had been relatively less severe in the Bay Region than in most other areas.

Any measure of variation or trends within the livestock population are dependent upon comparisons with a reliable statistical baseline. The only baseline available are the 1975 census data and it is now argued that the population estimate at that time was an overcount (Ministry of Planning, March 1981). This argument is based upon:

(a) the only previous reliable cattle estimate was that determined during the J.P.15 Rinderpest Campaign 1970-71 since which the reported heavy mortality of cattle, some 30 per cent, during the 1973-75 drought, would have made the increase of cattle numbers between 1971 and 1975 seem unreasonable;

(b) the aerial surveys carried out during 1979 in the Central Rangeland Development Area showed a substantial reduction of livestock numbers from the 1975 census, notably a reduction of 80 per cent in camels and 68 per cent in cattle;

(c) the national stocking density obtained from the 1975 census was three times the estimated carrying capacity of the rangelands based upon the National Range Agency calculation of the mean seasonal availability of natural forage. The favourable years of rainfall since 1975 are likely to have resulted in some increase of livestock numbers above this.

The overcount argument applies to the natural livestock population in general and may or may not be equally applicable to the Regional figures; however, the mean annual increase of cattle at 6 per cent per annum and of goats at 12 per cent per annum would appear to be an acceptable rate of increase over the period during which favourable conditions generally prevailed.

6.3 LIVESTOCK DISTRIBUTION AND STOCKING DENSITIES

6.3.1 Livestock Species Distribution

The major influences which determine the distribution of livestock within the region are the supply of stock watering facilities and forage availability. The distribution of livestock is closely related to the grazing areas in the proximity of the all year round water sources. The availability of forage resulting from the combined effects of rainfall and soil type, is influenced also by competition between flocks and herds and also by the supply of crop residues. Other factors which to a lesser extent influence livestock movement and hence their distribution are the type of stock or stock mix owned, traditional and family preferences and a localised effect of water levels on passable river crossings in the south west.

Although the livestock distribution can never be considered as static there are normally two distinct times of year when movements are at their lowest and some level of temporary stability can be recognised. These times being when stock have reached their principal grazing areas for the long Jillel dry season and for the remainder of the year i.e. in February and late June-July respectively.

During the less severe short 'Haggar' dry season (July to September) there is generally very little extensive livestock movement and, in other than exceptionally dry years, any movement at that time tends to be localised.

With a situation of both seasonal and yearly variation in livestock distribution the value of a single season enumeration is limited. The minimum requirement of two counts, one in each of the two main seasons, would have greatly enhanced the understanding and working value of distributional charges but were not included within the terms of the study. However, as the single enumeration was carried out during February the information obtained can be considered to be a good estimate of the general distribution and of the densities for a Jillel grazing season.

The distribution of livestock enumerated during February 1982 within each stratum is detailed by species totals and by their densities (herd/km^2) in Appendix C and the distribution densities of camels, cattle, sheep and goats are shown in Figures 6.1, 6.2, 6.3, and 6.4 respectively.

The Jillel Dry Season

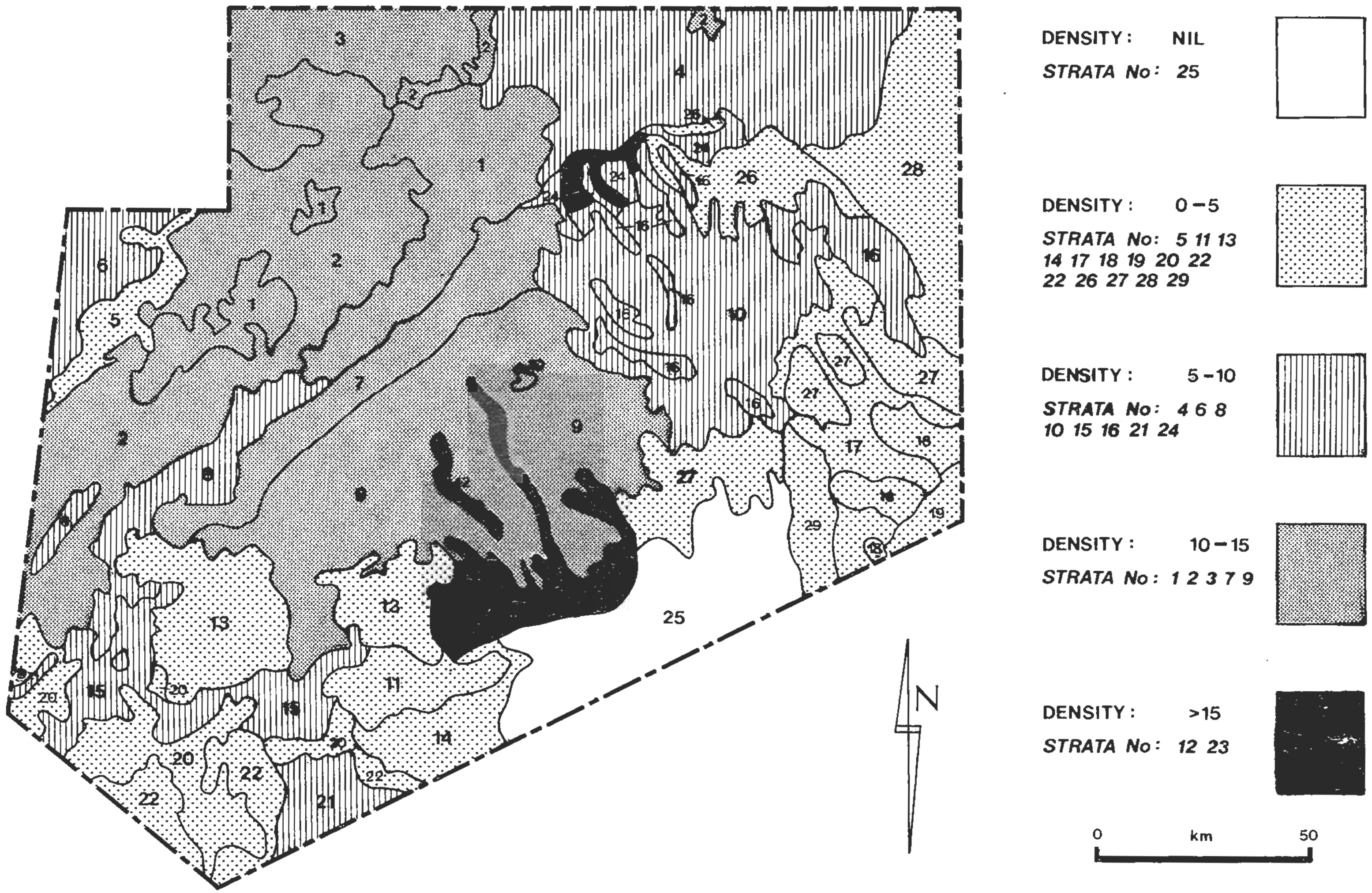
During this season there are increased movements of stock, in a generally southerly, south westerly direction, to 'traditional' Jillel grazing areas and/or passing out of the region towards the Shebelli and Juba rivers, the migration being greater in years of poorer rainfall.

Increasing concentrations of stock occur at the more reliable or permanent water sources as the dry season progresses, this raises the stock densities within the more favourably watered strata. Also of considerable significance are the movements within some strata creating localised areas of very high livestock densities around the vicinity of the watering points.

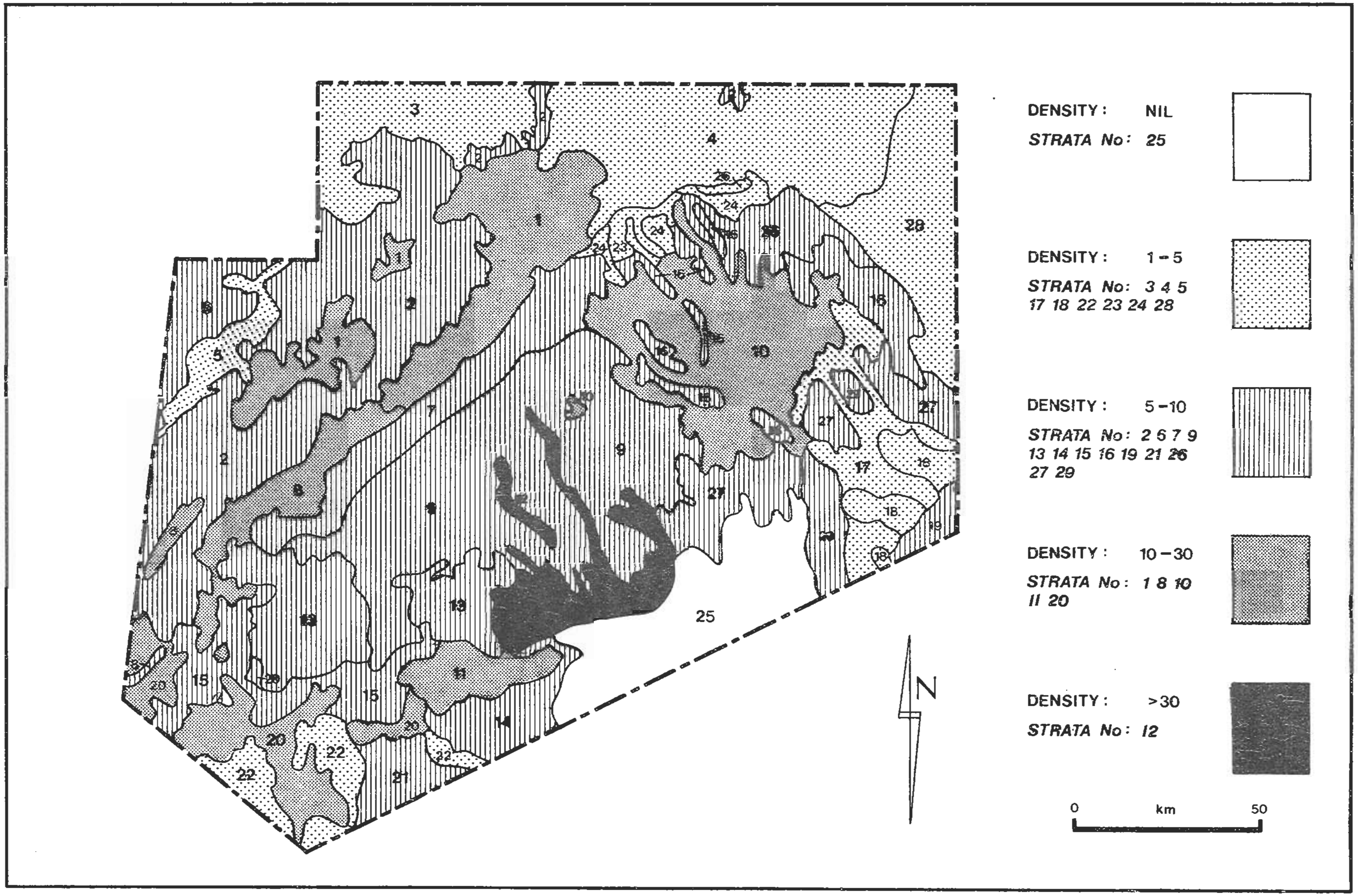
There is an increased concentration of livestock towards the larger units of heavier soils which due to their greater water retention properties, support a higher density of waro which retain water for long periods.

These clay soil areas are also characterised by their greater forage potential since they are the principal crop producing areas, the residues being an important source of dry season feed particularly for cattle and household stock. They are more productive in total and for over a longer growing period than other regional soil types, and their condition underfoot is dry. Their propensity for stickiness means they are often deliberately avoided during the wetter times of the year.

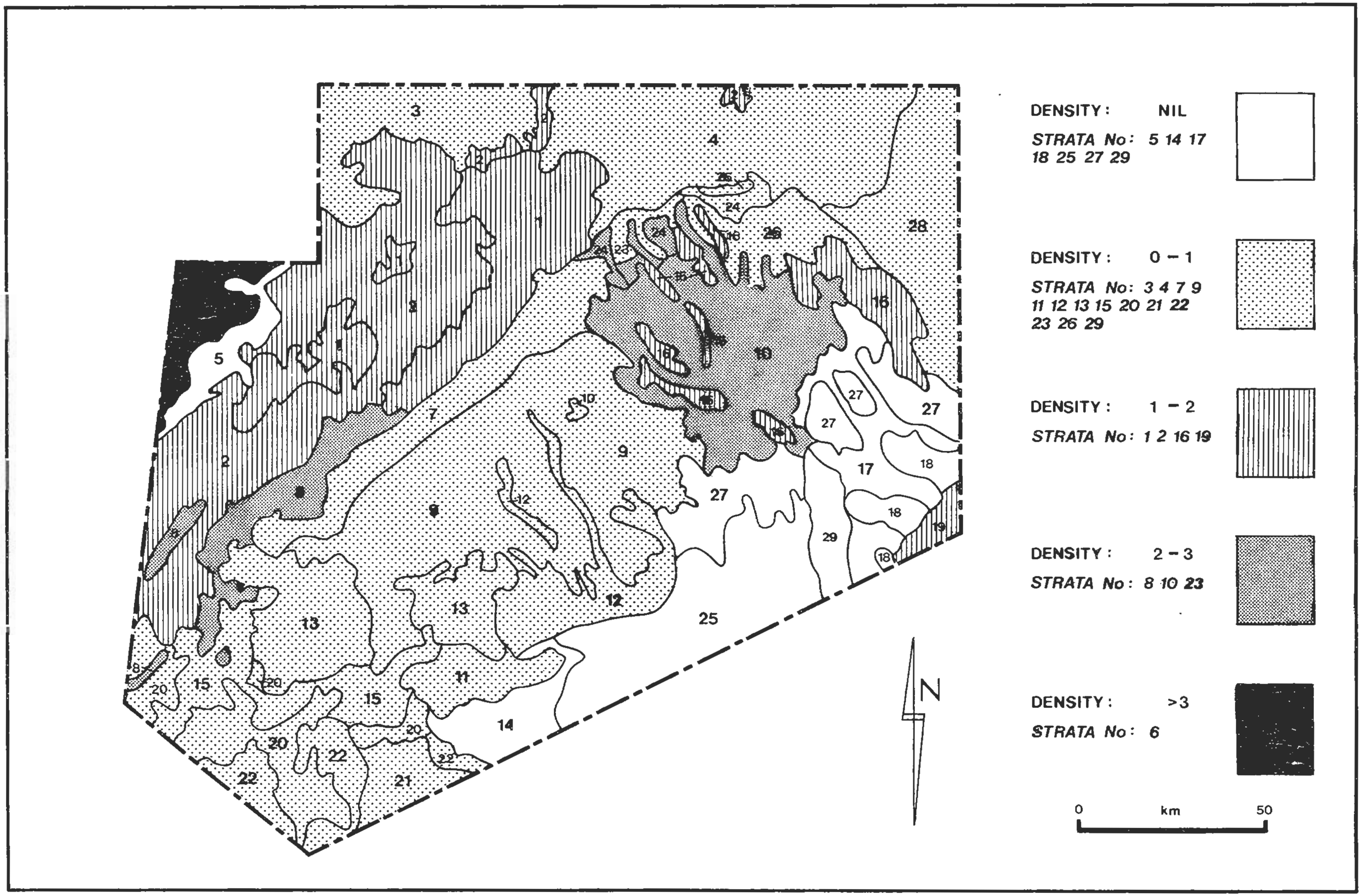
6.1 Distribution of camels (head/km.)



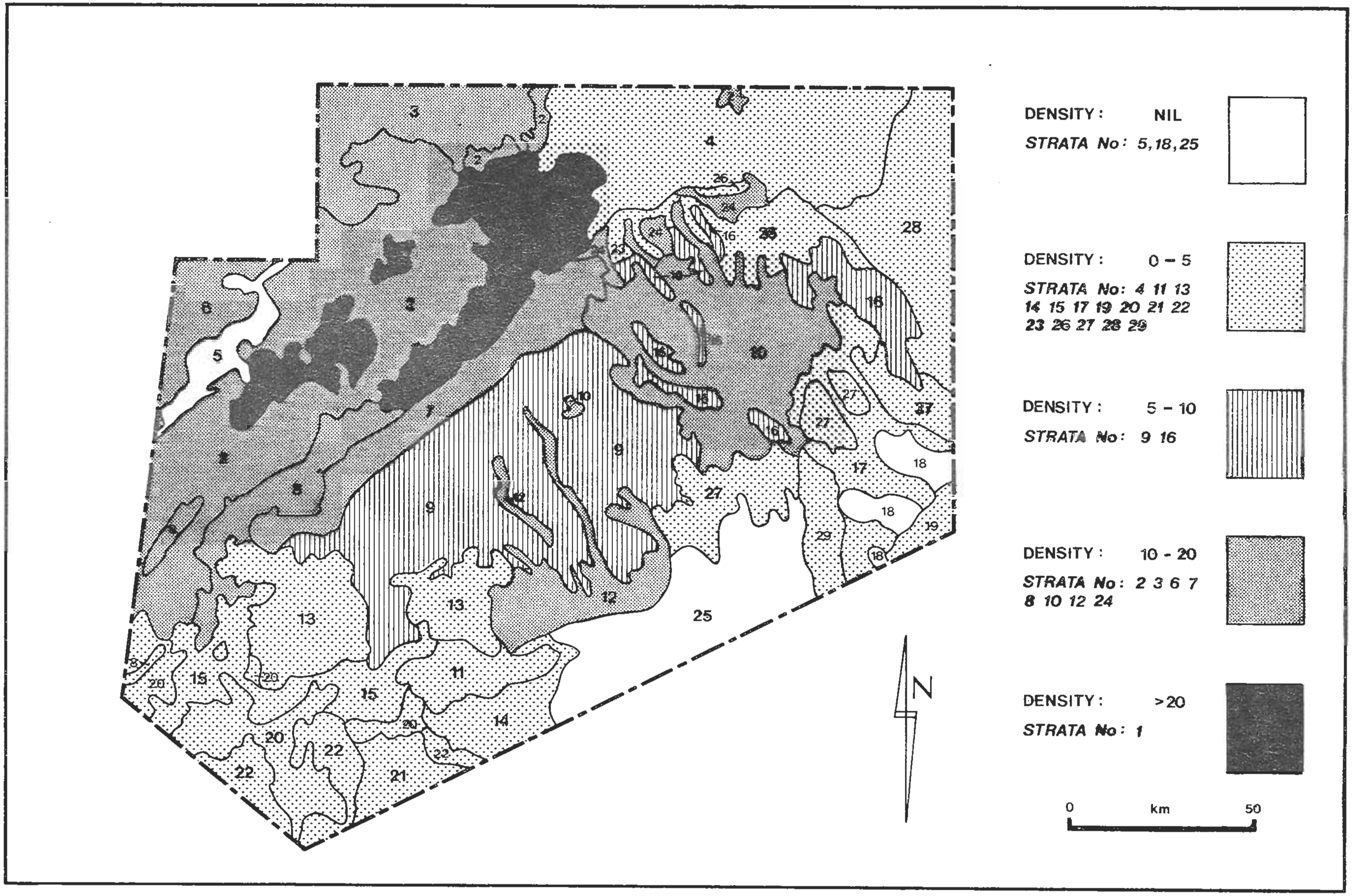
6.2 Distribution of cattle (head/km)



6.3 Distribution of sheep (head/km)



6.4 Distribution of goats (head/km)



The Gu Rainy Season

With the commencement of the main Gu rains the opposite trends prevail i.e. a reverse migration, not necessarily direct, from the Jillel grazing areas; stock are moved away from the cropping areas as replanting takes place; where possible, heavy soils underfoot are avoided in preference for the red, red-brown and areas which also commence regrowth earlier.

The increasing availability of surface and temporary stored water enables stock to be herded further afield which has the effect not only of dispersing stock over a wider area, overspilling into the previously less accessible strata but also reduces localised concentrations at the all year round watering points causing a more even distribution within the stratum.

The higher densities and increased proportion of all stock species supported on the clay soils relative to other soil units is shown in Table 6.3. The densities of cattle and small stock are particularly high whereas camels due to their greater ranging ability are more evenly distributed.

The important relationship between livestock and the cropping areas during the Jillel season is shown by the relative high numbers and greater densities of stock maintained within the five most heavily cropped strata (Table 6.4). These strata represent approximately 20 per cent of the Regional land area and support 54 per cent of the cattle and 48 per cent of the goat populations.

6.3.2 Biomass

A knowledge of the livestock densities, *per se*, of the individual species within each stratum does not permit a satisfactory estimation of stocking rates, grazing pressure or carrying capacity relationships due to the variation in body size between species but also within species due to the age and sex structure. As feed intake and body size are highly correlated, biomass densities and their distribution are preferred coefficients for descriptive and working purposes.

The biomass of a species is the product of the population mean liveweight of the species and the species population size. Total biomass (in kg) by the summation of biomass for all species, provides the biomass density when related to land area (kg/km^2).

The mean population liveweight was estimated by applying the appropriate mean liveweight for each species, classified by sex and the approximate age-size, determined during physical herd and flock counts. Enumeration of the following broad classifications was carried out.

Sale herds	-	Mature male herds maintained independently.
Mature males	-	All breeding males and mature castrates.
Breeding females	-	All females of breeding age-size.
¾ grown	-	Camels aged 24-48 months; cattle 18-36 months; small stock 12-24 months.
½ grown	-	Camels $<$ 18 months; small stock $<$ 12 months.
Very young	-	Recently born, at foot.

The computation of species mean liveweights based upon this classification is shown in Table 6.5. Sample sizes ranged from 0.85 per cent (goats) to 1.66 per cent (cattle) of the regional populations.

TABLE 6.3 LIVESTOCK AND BIOMASS DENSITIES BY LAND FORM CLASSIFICATION

Soil unit	Stratum No.	% of Region	Camels		Cattle		Goats		Sheep		Biomass	
			No/km^2	%	No/km^2	%	No/km^2	%	No/km^2	%	Kg/km^2	%
Clays	1, 5, 8, 10, 12, 17, 19, 20, 21, 24, 29	27.2	10.1	35	19.4	58	15.8	50	1.3	40	8 418	45
Limestone Plateau	2, 3, 4, 6, 15, 28	31.3	8.5	34	4.2	15	8.0	29	1.1	37	4 330	26
Basement Peneplain	9, 13, 16. 27	22.6	8.0	23	6.9	17	5.2	14	0.7	19	4 674	21
Basement Limestone Interface	7, 23, 26	5.1	9.9	6	7.3	4	12.2	7	0.4	2	5 241	5
Coastal	11, 14, 18 22, 25	13.8	1.2	2	3.9	6	0.7	1	0.1	2	1 302	4
Total Region	**1-20 inclusive**	**100**	**7.9**	**100**	**9**	**100**	**8.7**	**100**	**0.9**	**100**	**5 150**	**100**

Source: Hunting Technical Services 1982.

TABLE 6.4 CATTLE AND GOAT POPULATIONS IN RELATION TO ARABLE CROPPING

Stratum No.	Regional area %	Stratum cropped %	Cropped area km[2]	Cattle No. (head)	Cattle Density (head/km[2])	Cattle Density[1] ranking	Goats No. (head)	Goats Density (head/km[2])	Goats Density[1] ranking
1	6.3	67.9	1 751	70 130	27.2	2	97 668	37.9	1
10	6.5	39.1	1 036	51 173	19.3	4	38 231	14.4	6
8	2.8	37.7	422	17 220	15.4	6	17 828	15.9	4
20	2.5	11.2	113	21 220	21.1	3	4 100	4.1	12
12	2.5	7.6	76	40 631	40.8	1	10 220	10.3	9
Total mean	**20.6**	**40.7**	**3 398**	**200 374**	**24.0**	-	**168 047**	**20.1**	-
Regional total/mean	**100**	**9.2**	**3 727**	**368 065**	**9.1**	-	**353 173**	**8.7**	-

Source: Hunting Technical Services 1982

1 *Rank position within all strata 1-29.*

TABLE 6.5 POPULATION MEAN LIVEWEIGHTS BY SPECIES

Species	No. of herds/ flocks	Livestock Category (Proportion - Mean Wt.) Sale herds		Mature males		Breeding females		¾ grown		½ grown		Very young		Population mean wt.
		%	kg	%	kg	%	kg	%	kg	%	kg	%	kg	kg
Camels	138	4.6	490	11.9	480	57.9	430	9.7	310	11.2	160	4.7	50	379
Cattle	253	4.9	270	3.6	300	64.2	250	11.3	190	14.1	70	1.9	30	216
Sheep	72	-	-	7.2	32	65.9	25	15.5	16	9.6	9	1.8	4	22
Goats	129	-	-	4.0	34	69.2	25	12.6	16	12.9	9	1.3	4	22
Donkeys	-													Estimated 125
Horses	-													Estimated 280

Source: Hunting Technical Services 1982.

The total biomass of domestic livestock in the region is estimated at almost 210 million tonnes or approximately 5 150 kg/km^2, with a range from nil, in stratum 25, to 19 270 kg/km^2 in stratum 12. The contribution to total regional biomass by individual species being:

Camels	59 per cent
Cattle	38 per cent
Sheep and goats	4 per cent

The influence of equines and wild game is insignificant.

The biomass densities and the species contribution for each stratum is detailed in Appendix E and the density distribution throughout the region is illustrated in Figure 6.5.

6.3.3 Carrying Capacity

Forage production figures were calculated over a ten month field period by Lockwood (1968).

These figures were calculated from air dried samples collected in one season's growth. In the Bur Region production was estimated at between 267-984 kg/ha varying according to ecological formation. Only the grass/herb layer production was used to calculate these figures and they do not contain any measure of the production of the browse species. This approach was justified 'by the fact that cattle are of major importance in the economic development of the livestock industry in Somalia' (Lockwood, 1968).

In the Bur Region forage production was estimated at an average of 30.9 metric tonnes per km^2. Lockwood *et al* use the livestock consumption figures provided by Nelson (1964) of 3.6 metric tonnes per mature cow per year. Several criticisms can be levelled at the interpretation of these figures and the conversion of primary biomass production to carrying capacity. They include:

(1) The generally accepted dry matter requirements for a cow of 250 kg is 6.25 kg dry matter/day, representing 2.3 tonnes/year.

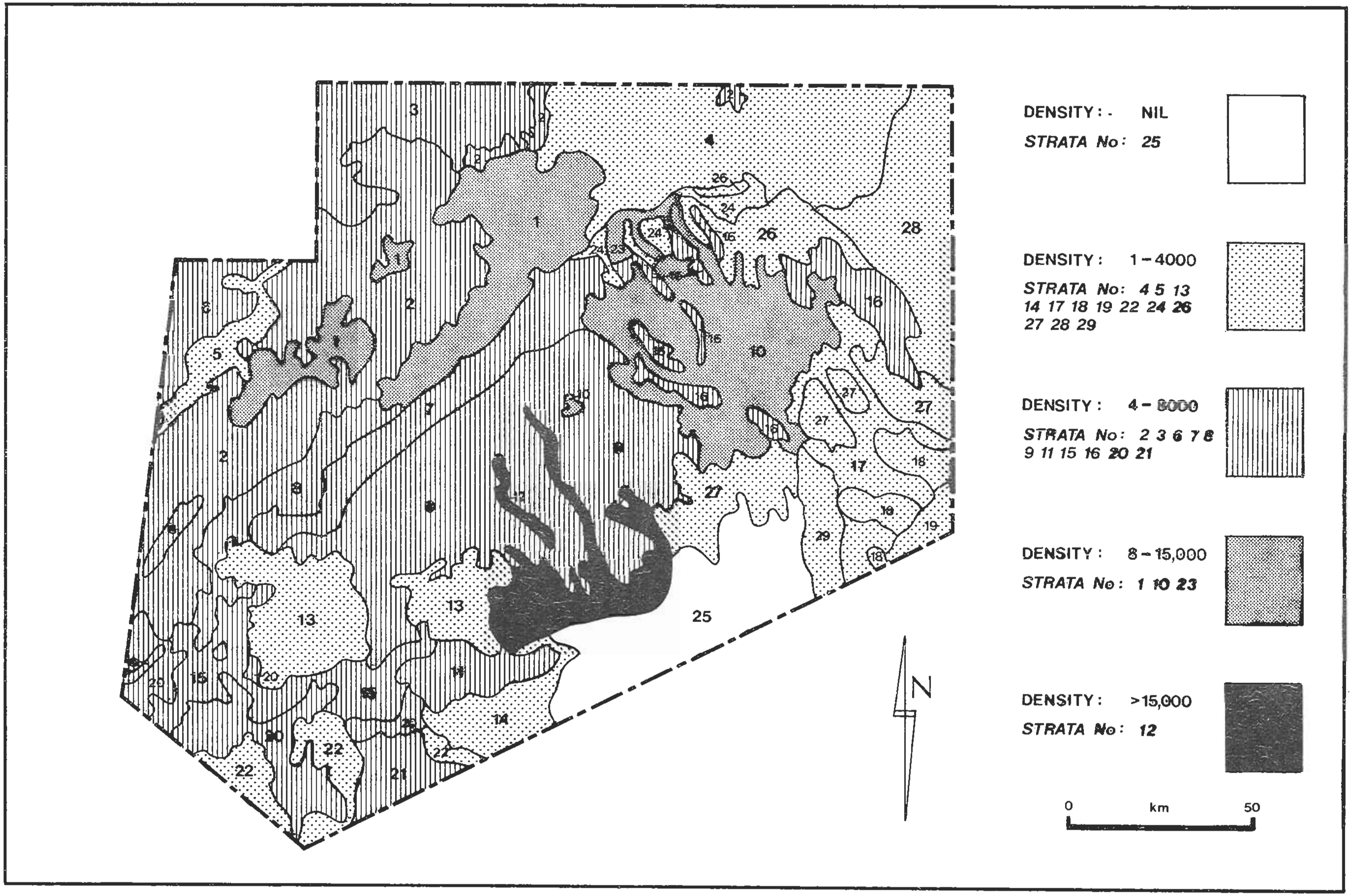
(2) Lockwood *et al* stress the importance of cattle, but in the present survey camels represented more than 50 per cent of total domestic stock in liveweight terms. Browse, an important food source for camels and goats, is not estimated by Lockwood.

(3) Lockwood *et al* give carrying capacity for cattle, and compare this theoretical value with the observed rate. No allowances were made for sheep, goats or camels, or the browse components.

The Lockwood report also indicated that because of the relatively small number of samples taken over a large area for just one year's production the figures obtained could be regarded with some scepticism.

The duration of the present survey was too short to attempt the collection of material to calculate carrying capacity or biomass production. In the ideal situation several years of data collection are required. In practice there are two principal limitations to the value of carrying capacity figures:

6.5 Distribution of biomass (kg/km)



(a) There are very great spatial variations in rainfall distribution and related primary biomass production.

(b) There is a considerable variation in annual rainfall totals.

As a result of these limitations there is a great variation in the amount of primary biomass production both from year to year and from place to place. Under present conditions it is unlikely that workable management strategies could be maintained to prevent overgrazing. It is also difficult to accurately assess carrying capacity under such conditions. Carrying capacity is defined as the number of livestock that can be supported per unit area on a sustained yield basis. In this instance the actual number will vary considerably from year to year depending largely on the annual rainfall. An extremely flexible management system needs to be adopted to meet these conditions and prevent overgrazing.

Estimate of likely biomass production can be calculated using the methods of Le Houerou and Hosle (1977). In this example, which is based on data collected from a variety of Sudanian and Sahelian zones, 45 rainfall/production figures have been used in the regression equations:

Total dry matter (TDM)	$y = 105.42 + 2.58\ x$
Consumable dry matter (CDM)	$y = 42.17 + 1.03\ x$

where y is production kg/ha/year
x is annual rainfall in mm
$n = 45$
$r = 0.83$

When the average annual rainfall totals 500 mm, the production figures are:

TDM - 1 395.42 kg/ha/year
CDM - 557.17 kg/ha/year

On the assumption that dy matter requirements are 2 300 kg/250 kg liveweight per annum, the average figure represents one 250 kg animal per 4.2 hectares or 23.8 x 250 kg animals per square kilometre. The optimum theoretical level is therefore 5 950 kg liveweight per square kilometre which approximates very closely with that calculated from data provided by the aerial census and livestock studies.

It is not possible to make direct comparisons with the Lockwood survey data which are based entirely on cattle grazing the grass and herb cover. The present ground survey indicates that there are significant variations in stocking density within the rangeland which is often reflected in the condition of the range.

6.4 LIVESTOCK OWNERSHIP AND HERD STRUCTURES

6.4.1 The Human Population and Livestock Resources

No human population census has been carried out since 1975 but the estimated number of people inhabiting the region may be deduced from the count of occupied houses and the mean number of occupants. From the aerial survey the number of houses under occupation was estimated at 94 749 and classified as 'non-nomadic' permanent 30 143, temporary 15 620 and nomadic 48 986. With occupancy factors, determined from a small corrobarative sample of 6.8, 2.8 and 3.3 persons respectively, the regional rural population is approximately 410 400 persons of whom 39 per cent are residing in temporary nomadic accommodation.

With the inclusion of the estimated urban population, principally Baidoa, the approximate human population of the Bay Region is 440 000 which is an acceptable estimate in relation to population growth since the 1975 census (Table 6.6).

TABLE 6.6 THE REGIONAL HUMAN POPULATION AND POPULATION DENSITY

		Bay Region		National
	1982	1980[1]	1975[2]	1975[2]
Population	440 000	450 986	393 153	4 417 445
Per cent of national population	-	8.9	8.9	100
Density (persons/km^2)	10.8	11.1	9.7	6.9

[1] *Stat. Dept. Estimated 3.1 per cent annual growth rate on 1975 base*
[2] *National census 1975*

No human demographic information on the Region is available which restricts the knowledge of family unit size to the small random sample obtained during the study, and which is based upon livestock owning families only. Confusion can exist in the definition of a family unit, i.e. the individual household unit of man, wife and children or the more extended family made up from several household units. The mean household size found was 4.8 persons and that of the extended family, where persons herded their livestock together, was 13.6 persons. This latter definition and size being preferred as the number of households found maintaining their livestock independently was less than 2 per cent. On the assumption that family size of arable only farmers is similar and 95 per cent of families are dependent upon agriculture the number of farming families within the region is estimated at 30 7.35.

The livestock and cropland resources available, per capita and to each family, are shown in Table 6.7.

TABLE 6.7 LIVESTOCK AND CROPLAND AVAILABLE PER CAPITA AND BY FAMILY

	Total population	Population 95% dependency	Farming family
Camels (herd)	0.73	0.77	10.5
Cattle (herd)	0.84	0.88	12.0
Sheep (herd)	0.08	0.09	1.2
Goats (herd)	0.80	0.84	11.5
Cropland (ha)	1.01	1.07	14.5
Potential cropland (ha)	1.19	1.25	17.0

Camel herds tend to be in larger groups than cattle and have a greater range. This is to be expected due to the higher proportion of the non-agricultural families owning camels and their increased dependence upon livestock for subsistence. Over 50 per cent of the cattle and goats are maintained in groups of 20 or less and sheep, being more widely distributed between owners, with 64 per cent of flocks being 5 animals or less.

The inequality of ownership distribution is demonstrated by Table 6.8 in which the proportions of the livestock population within the lower 25, 50 and 75 per cent levels of total herds and flocks and their inverse relationships are shown.

TABLE 6.8 PROPORTIONAL RELATIONSHIPS BETWEEN LIVESTOCK NUMBERS AND HERD-FLOCK NUMBERS

	Proportion (per cent) of livestock numbers			
Proportion of herds/flocks	**Camels**	**Cattle**	**Sheep**	**Goats**
Lowest 25 per cent	7.1	5.8	10.3	6.5
Lowest 50 per cent	21.6	21.7	20.7	17.4
Lowest 75 per cent	47.4	46.8	40.2	46.4
	Proportion (per cent) of herd/flocks			
Proportion of livestock numbers	**Camels**	**Cattle**	**Sheep**	**Goats**
Lowest 25 per cent	54.0	54.2	60.5	54.7
Lowest 50 per cent	77.0	77.2	82.9	77.5
Lowest 75 per cent	91.6	91.7	95.6	91.5

6.4.2 Herd - Flock Sizes and Ownership

The ownership of livestock throughout the region cannot be fully determined from this overview and requires a more intensive survey which would enable zonal differences to be examined and would include an estimation of the non-livestock owning rural population present.

From random herd and flock counts made throughout the Region, mainly at water points, the livestock patterns observed show a distinct skewness in a similar manner to other pastoral-agricultural communities on the continent.

The size range and frequency of livestock herds and flocks is shown in Table 6.9.

The disproportionate ownership pattern is very similar for all of the four livestock species particularly with camels and cattle, in all cases half the livestock owners own approximately 20 per cent of the stock and over 50 per cent of the livestock numbers are in the hands of 25 per cent of the livestock owning families.

As indicated previously the lack of information on the human population does not permit a regional statistical study to be undertaken. However, during the study certain trends were observed in the relationships between the numbers of livestock owned, cropping activities and the size of the family. These resources influence the form of agricultural management system practised. The mean family size and livestock numbers owned according to whether the family carries out arable cropping and the system of livestock herding practised i.e. on a seasonal movement or permanent split family basis, are shown in

Table 6.10, which is further classified according to the principal type of livestock kept. The main indications being:

- that livestock owners who do not cultivate crops each year own larger herds, which may be because, particularly in the case of the larger camel owners, their subsistence needs are met from livestock sources and there is less need, or no desire, to crop;

- that owners who practise a permanent split family system of herding do so because their livestock numbers are too large to be supported all the year round in the cropping areas and/or their family size is large enough to release labour to enable them to carry this out.

TABLE 6.9 PROPORTION OF HERD AND FLOCK SIZES WITHIN LIVESTOCK TYPES

	Camels	Cattle	Sheep	Goats
No. of herds/flocks(n)	135	248	72	129
Herd/flock size	%	%	%	%
1-10	16.3	24.2	87.5	21.7
11-20	28.1	29.0	6.9	32.5
21-30	16.3	19.9	2.8	19.4
31-40	15.6	10.5	1.4	8.5
41-50	8.9	10.1	1.4	7.0
51-100	12.6	7.2	-	10.9
101-150	2.1	-	-	-
Mean size of sample	**29.9**	**23.4**	**6.3**	**24.1**

TABLE 6.10 LIVESTOCK NUMBERS OWNED AND FAMILY SIZE ACCORDING TO MANAGEMENT SYSTEM

	Management System			
	Livestock only	Livestock and crop production: Seasonal	Split family	Both systems
(a) Camel owners (38 families in sample)				
Camels owned (Av. No.)	41	14	32	19
Cattle owned (Av. No.)	4	4	6	5
Small stock (No.)	14	22	28	24
Family size (Av. no. persons)	11.0	10.5	16.0	12.1
(b) Cattle owners (92 families in sample)				
Cattle owned (Av. No.)	39	19	28	22
Camels owned (Av. No.)	4	2	<1	<2
Small stock (Av. No.)	18	22	33	26
Family size (Av. no. persons)	10.1	12.9	18.6	15.0

Whilst recognising the fact that the ratio of predominantly camel owners to predominantly cattle owners within the sample may not be representative of the regional situation, the relationship of both herd and family unit sizes to the agricultural system practised follows a similar pattern.

Within the limitations of the study it was not possible to assess or quantify the numbers and types of livestock owned. However, based upon 148 family interviews, made at random throughout the Region, of the livestock or livestock mix owned, indications are that 30 per cent of livestock owners maintained a single species herd or flock with 70 per cent owning two or more herds of stock. The ratios of livestock mix owned are shown in Table 6.11.

TABLE 6.11 RATIOS OF LIVESTOCK TYPES AND LIVESTOCK MIX OWNED

Livestock owned	Ratio of all herds-flocks %
Camels	7.4
Cattle only	12.8
Small stock only	10.1
Cattle and camels	6.8
Cattle and small stock	33.1
Camels and small stock	14.2
Cattle, camels and small stock	15.5

Source: Hunting Technical Services 1982.

Overall, 44 per cent of livestock owners maintained some camels, 68.2 per cent some cattle and 73 per cent some small stock. Of the small stock flocks 5.5 per cent were sheep only with 64 per cent of flocks containing only goats.

6.4.3 Herd Structures

The sex and age structure, determined from physical counts, is shown by livestock type in Table 6.12.

These data, if extrapolated, only give an indication of the structure of herds and flocks maintained and preclude an accurate statistical computation of the regional situation due to:

- the incomplete data on the total number or relative proportions of herd and flock types;
- the size and frequency of separately maintained sale herds of male camels and cattle which are unknown;
- the use of camels, usually males, as pack animals which is a likely cause of undercount;
- the counts having been made at watering points, during grazing or whilst on

TABLE 6.12 HERD AND FLOCK STRUCTURES BY SEX AND AGE (rounded per cent)

Age[1]	Camels			Cattle			Sheep			Goats		
	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)	Total (%)
Mature	12.5	60.7	73.2	3.8	67.5	71.3	7.2	65.9	73.1	4.0	69.2	73.2
¾ grown	3.1	7.1	10.1	2.3	9.6	11.9	1.5	14.0	15.5	1.0	11.6	12.6
½ grown	5.2	6.6	11.7	6.8	8.0	14.9	2.8	6.8	9.6	3.0	10.0	12.9
Very young	2.5	2.5	4.9	1.0	0.9	2.0	0.9	0.9	1.8	0.6	0.6	1.3
Overall	**23.2**	**76.8**	**100.0**	**13.9**	**86.1**	**100.0**	**12.5**	**87.5**	**100.0**	**8.6**	**91.4**	**100.0**
Herds-flocks (No.)		**135**			**248**			**72**			**129**	

Source: Hunting Technical Services 1982

[1] *Age classification as described in Section 6.4.2.*

transit which may have resulted in an undercount of very young stock remaining at the homestead and of a proportion of in-milk females which are being maintained elsewhere;

- the aerial survey and physical counts being undertaken during the late long dry season prior to the main birth period of the Gu rains, the proportion of young stock is therefore likely to be at its seasonal lowest or conversely the ratios of other age groups at their highest. This seasonality similarly affects the total livestock numbers which would also peak during this period.

The herd and flock breakdowns show a relatively high proportion of breeding females which together with the higher proportion of female stock relative to males in the immature categories confirms that the overall aim of most livestock owners is to increase the livestock numbers by retaining and rearing as many females as possible.

The herd and flock sex ratios show that, overall, breeding male to female ratios are adequate at:

Camels 1:17
Cattle 1:18
Sheep 1:9
Goats 1:17

However, some variation does occur within the breeding flocks as shown by the proportion of them that do not contain a mature male viz:

Camels 40 per cent
Cattle 46 per cent
Sheep 68 per cent
Goats 33 per cent

However, this may reflect the practise of herding mature males separately during the non-breeding dry-season - the period of this survey.

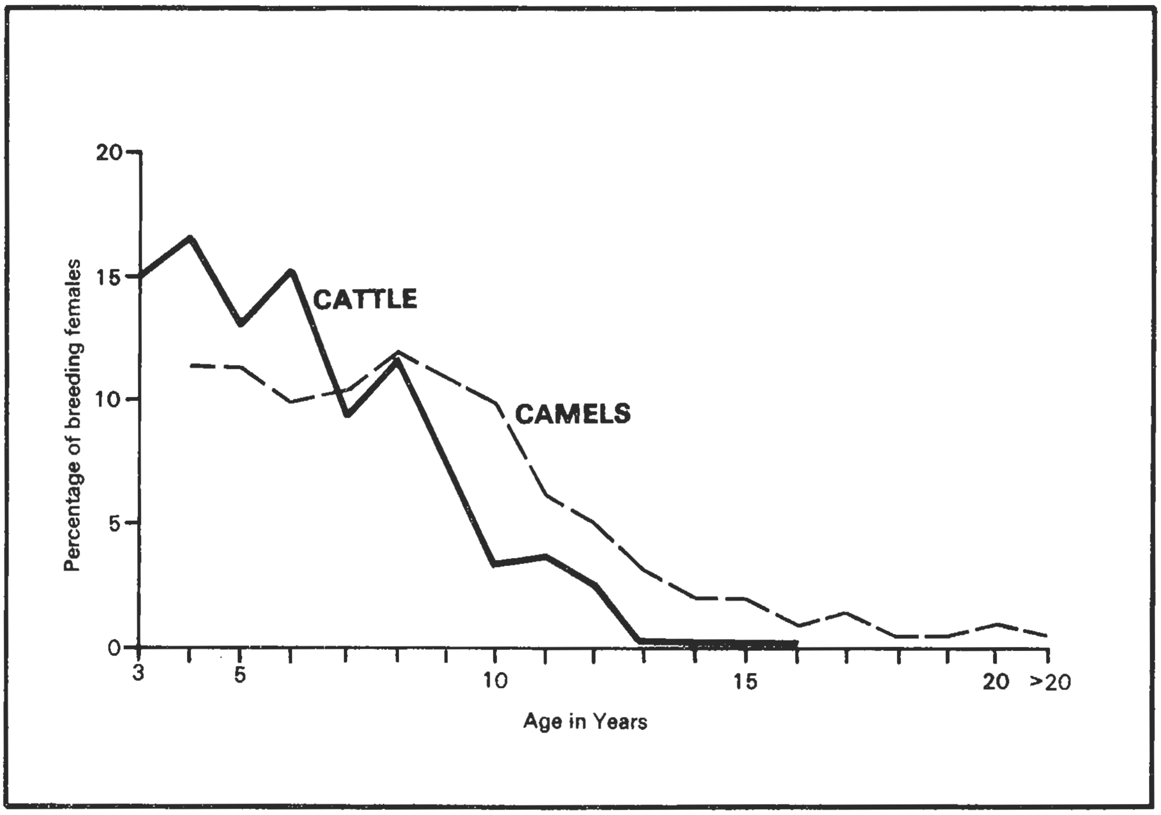
This shortfall tends to be limited to the smallest flocks and herds but does not impose a serious problem. In the case of camels, use is made of males owned by relatives or neighbours, this also applies to cattle, sheep and goats but the use of young males prior to sale, home slaughter or castration is common, particularly with small stock, where precocious ram lambs and kids can be active before six months of age.

The age structure of breeding females within the herds shows that there is a tendency to retain females to a considerable age, well beyond normal commercial limits. It is accepted that reproductive performance and milk yields decline with age after reaching a peak, usually 7-9 years in cattle. Camel owners interviewed were aware that the productivity of their camels similarly declined when they had reached the age of 11-13 years. The reluctance to cull older stock from the owner's point of view of understandable, in that his concern is to expand his herd and milk output. The number of young females joining the herds each year is inadequate to meet an expansion and to enable culling for the majority of owners, who have not yet reached an adequate subsistence self-sufficiency level. The low 'cost' of production incurred by retaining the aged animals relative to the return is to the immediate advantage of the individual owner although this may be disadvantageous to the total and potential production from the region as a whole.

Within the present ownership structure and the inherent need for security it is unlikely that the majority of livestock owners would be capable or willing to practise a rational culling programme of female stock. If the natural population balance were to be disturbed by an increased reproductive performance and/or a reduced mortality rate, the reluctance to remove the less productive animals would bring about serious consequences.

The age structure of breeding females determined in ten cattle and six camel herds is shown in Figure 6.6. The mean age of cattle from three years old upwards, was 6.3 years and for camels, aged four or over was 8.6 years. Within the herds 29 per cent of the cattle were aged 8 years or over and 24 per cent of the camels aged 11 years or more.

6.6 Breeding females; camels and cattle



No comparable information was collected from sheep and goat flocks but from sporadic age determination by mouthing and from interviews, it is apparent that although the culling rate of females is slightly higher, similar attitudes prevail, as the higher reproductive rates of small stock are offset by the higher levels of mortality and their relatively greater contribution to domestic meat supplies.

7

Livestock Management System

7.1 INTRODUCTION

The systems under which livestock are maintained have evolved through the need of livestock owners to provide adequate feed and water supplied for their stock. Both these basic requirements are subject to considerable fluctuation between seasons and between years and also to variations between ecological areas. The majority of stock are managed within a semi-nomadic system which follows patterns of movement that vary primarily according to the rainfall and to a lesser extent, on a more localised basis, to the competition between herds and flocks for a limiting forage resource. The objective of the systems practiced is to sustain the maximum number of animals that are available to the owners. The role of livestock in the rural economy is principally one of supplying milk, meat and pack animals for subsistence. The attitude towards "commercialism" is limited in most cases to the sale of livestock and livestock products in order to supplement their domestic needs or after their subsistence needs have been fully met. This attitude, in common with pastoral societies elsewhere, possibly evolves from a long history of experience on survival and means that maintaining and increasing livestock numbers is the major concern of the owners. This is necessary not only for the immediate subsistence needs of the owner but also as an insurance for the expected losses during periodic droughts and as a means of accumulating wealth and its associated prestige.

The systems evolved are generally an efficient way of maximising the use of resources within the constraints of climate and distance. However, without some changes towards the increase of productivity per animal together with some form of land use control, this efficiency could be detrimental in terms of overstocking and resulting in a long term decline in carrying capacity associated with it. Except for localised areas this point has not been reached throughout the region since some areas are seasonally "protected" due to the lack of water but as water extraction and water storage facilities are expanded these areas are declining. It is therefore now evident that the present management systems have to be gradually adopted, through education and land use programmes, if the level of livestock productivity is to be expanded to meet the needs of an increasing human population and to raise their standard of living whilst conserving the natural resources.

7.2 LAND TENURE AND ATTITUDES

The land and its availability for use is the cornerstone of pastoral and agricultural societies. Prior to the establishment of central and local government authorities, land was occupied, controlled and protected through a tribal system through which family rights to cropping land were regulated and social relationships maintained with other tribal groupings over grazing and water rights.

At the present time all land ownership is vested in the State. Individuals or groups cannot own land but rights to the sole use of cropping land are established. Except for a number of government approved cooperatives and associations, none of which are established in the region, all grazing land is held in trust for the nation, remains communal and is, in theory, available to any citizen who wishes to graze livestock.

The state can commandandeer land, compensated usually by the allocation of an alternative land area, and has compulsory take over powers for any central or local government needs e.g. roads, public institutions etc.

Security of occupancy is, however, normally guaranteed in regard to cropland in which case the occupants and their descendents have a claim in perpetuity. Although localised land pressure is beginning to become apparent with instances of continual mono-cropping there is as yet no evidence of fragmentation of holdings. There are still small areas as yet unused and some underutilisation in others.

All other land that is not held for cultivation is regarded as grazing area and is for communal use only no individual rights to the exclusion of others is permissable. However, within the communal areas individual water rights at developed sources i.e. home dug wells and war, are acceptable.

The exception to exclusive rights to grazing areas are the concessions made to the registered grazing cooperatives and associations. The cooperative system has been encouraged by the Government under its policy of "scientific socialism" and is supported with grants and priviledges. Although the establishment of cooperatives in the region has been active they are concerned with crop production and non agricultural activities only, none are involved directly with the use of grazing land.

The lack of land tenure or exclusive rights of occupancy within a sedentary and semi-nomadic situation is a severe constraint to any long term rangeland programme aimed at increasing livestock productivity whilst conserving and improving the range resources. It cannot be expected that livestock owners will understand or cooperate in rational use of rangeland unless they have some responsibility for that resource. Responsibility cannot be encouraged in a situation where individuals are unable to control any of the external influences that affect their livelihood.

An understanding of the various attitudes and levels of awareness held by the rural population on livestock-range relationships and the need to exert some control over live-stock numbers is of prime importance prior to the commencement of any range control or improvement programmes. The highly complex and variable social, economic and political interrelationships requires an in depth survey well beyond the scope of this study, together with a continuous extension programme geared to the basic concepts of land use and the options of control open to livestock owners.

Obtaining the opinions of livestock owners is arduous and restricted due to the political aspects of a very sensitive and deeply entrenched issue. Answers to questions were often restricted or avoided in an obvious attempt to be disassociated with any suggestions or ideas that maybe contrary to the present political policy.

Livestock owners are generally aware of excessive stock numbers in the short term but do not appear to comprehend the long term implications. The interest in the need to restrict livestock numbers was demonstrated by:

- the frequent statements that the local grazing was utilised by others from outside, although this was not liked it was tolerated;

- the rejection of suggestions to increase water availability by the provision of a borehole since this would only encourage further stock movement into the area;

- wanting "non resident" traders to maintain their sale herds elsewhere;

- two instances where villages had requested the Range Development Agency to assist in the protection of part of their grazing area and water supply;

- the ready acceptance of the suggestion that one or more small areas of grazing could be set aside and protected for specific communal use, such as dry season grazing for horse, cows or young stock paddocks.

In situations where no outsiders were involved, some form of authority or protection to prevent them entering in the future was acceptable. However, in some heavily stocked localities although incoming stock was not particularly welcome it was tolerated and residents were against means of control. The underlying reason for this being that the numbers of local stock was high and seasonal movement out of the area common, so that owners did not want to be barred from other areas on a reciprocal basis.

From the guarded opinions expressed it is apparent that many livestock owners are on the brink of becoming aware that the competition and pressures from livestock maintained within the traditional land use system is becoming disadvantageous to their own and to a lesser extent their communities interest. However the response is variable and the desire and possibility of encouraging modifications to the system is different according to the particular needs and situation within an area. The responses to suggestions and the awareness demonstrated, augurs well as a starting point for the introduction of localised extension programmes.

7.3. LIVESTOCK MANAGEMENT SYSTEMS

The management systems practiced within the Region can be categorised according to the temporary or permanent residence status of the stock owning family and by the relationship of livestock enterprises to cropping activities viz:-

Fully Nomadic	-	livestock only, regular home base, seasonal movements.
	-	livestock and crops, regular home base; seasonal movement.
	-	livestock and crops, regular home base; split family herding.
Sedentary	-	livestock only, permanent homestead.
	-	livestock and crops, permanent homestead.
	-	crops only, permanent homestead.

Evidence from interviews with livestock owners, officials and residents within the Region shows that there are probably no true nomadic families within the Region. There is no indication that livestock, other than from the adjacent regions, utilise the grazing and water resources, even during the exceptional times of drought. Semi-nomadic systems predominate.

The area has a higher potential for arable farming activities and can support high livestock densities because of numerous dry season watering points, a high range production potential and the presence of crop residues. This has reduced both the desire and need to move stock regularly over great distances and has brought about the evolution of sedentary and partly nomadic grazing systems. It is also evident that the desire by families to live in close proximity to social services such as clinics and schools is influencing the trend towards a more sedentary way of life.

The systems practised by 157 interviewed families, shown in Table 7.1 is indicative of the high levels of transhumance and involvement with crop production.

TABLE 7.1 LIVESTOCK SYSTEMS PRACTISED (157 families)

	Nomadic	Semi-Nomadic			Sedentary	
		Stock only	Stock and Crops	Stock and Crops Split family	Stock only	Stock and Crops
No. of families	Nil	21	71	38	8	19
%	0%	13.4	45.2	24.2	5.1	12.1
Overall	0%		82.8%		17.2%	
Livestock only systems	18.5%		Livestock and Cropping Systems 81.5%			

Families who maintain livestock and also grow crops regularly follow one of two systems, readily interchangable, which enable them to participate in both activities. The choice of system is the combined function of competition for grazing and water, the livestock numbers owned and the family size which in turn influences the dependence of families and also their priorities, more on crops or on livestock.

The more common practice is for livestock to be maintained at or in close proximity to the homestead and cropping areas with movement ot the long dry season grazing area after completion of the harvest. In cases where the whole family moves this is normally, subject to water availability, after the grazing off of crop residues. More usually, in over 70 per cent of cases some family remains generally the elderly people and children. In this case part or all of the crop residues are left to sustain those stock that remain to meet the families milk, meat or transport needs.

The alternative to this is the split family system whereby the family effectively maintains two management groups. One remains at the permanent homestead undertaking domestic and cropping activities and the second is based permanently away from the homestead herding the livestock. To meet the varying subsistence needs and labour requirements of each group, livestock and family members are interchanged as necessary. Herding duties are usually the responsibility of the young men.

From a sample of 130 families, of which details are shown in Table 6.10 indications of the influence of livestock numbers and family size upon the system practiced are:-

- that a lower livestock to family size ratio is generally associated with a higher dependence upon crops;
- that livestock owners who do not normally crop tend to own more livestock than families who carry out both activities;
- that families which are permanently split also tend to be larger and own more stock than families who manage both enterprises together.

The patterns are similar, whether families are predominantly camel owners, or predominately cattle owners.

Also during the study it was reported, but not witnessed, that within some larger herds' or combined herds some division of stock by species and or by state of production is carried out so that stock which require less frequent watering, can be ranged further. The watering frequency requirements of species are:

Camels <goats < sheep < cattle and equines but in practice during the dry seasons camels are watered every 6-10 days and other stock on alternate days.

Other than a very small proportion of purely livestock owners, sedentary families are in general dependent more upon crop production and either own no livestock, or usually very few. These are maintained throughout the year around the homestead or the crop growing area. Herding is usually only practiced to protect crops and during watering. However, those families with larger livestock numbers may herd regularly.

Although the numbers of livestock owner per family is small, their combined effect within the more densely populated crop and adjacent range areas is a cause of serious localised overgrazing. Some normally sedentary families have in the past been forced to move or remove their stock temporarily during extreme localised droughts.

Within Baidoa and some of the larger villages the keeping of one or two in milk house cows is common. Feed sources, mostly sorghum stover are purchased and a professional herder may be used. He is paid on a monthly per head basis, and each day collects, tends and returns the animals belonging to each of the families who use his services.

The husbandry practices carried out do not vary greatly between the management systems adopted with all stock maintained under an extensive communal grazing system. There are no commercial ranches, feedlots, dairy or poultry enterprises within the region.

7.4 LIVESTOCK MOVEMENT

7.4.1 The Need for Transhumance

The underlying need to provide livestock with adequate grazing and water throughout the year and their unequal availability throughout the region and adjacent regions, makes it necessary for livestock to be moved to meet this need. The inequality in the distribution of population and resources are primarily related to:

- the larger proportion of the human population and livestock owners being concentrated in and around the main cropping areas, principally in the northern half of the region and roughly within the inverted crescent running from Dinsoor through Ufurow, Kansa Dere, Baidoa to Bur Acaba;

- the shortage of all the year round water supplies along the north and north-eastern boundaries and over a large area along the southern boundary, particularly in the southeast;

- the ecological variation - with the vegetative cover becoming increasingly more suitable for cattle towards the south and south west, with the less penetrable areas in the north and northeast more suitable for camels and goats;

- to soil differences, with the clay areas supporting the arable sector and a generally higher level of range productivity;

- the differences between the livestock species in their abilities to forage and browse and in their drinking frequency, this enables camels and to a lesser extent goats, to be herded over a greater variety of range types and all greater distances from water;

- the variable rainfall throughout the region between seasons and years as well as between localities. Rainfall, with its variability and unpredictability, is the dominant influence in determining livestock movements and trends.

Movement to and from the dry season grazing areas in terms of time of departure, distances moved and to a lesser extend the direction of travel, is influenced by the extent of the previous Gu and Der rains and the time of commencement, intensity and distribution of the subsequent Gu rainy season. Considerable movements take place each year and their magnitude and intensity increase relative to a declining rainfall pattern, i.e. the lower the rainfall the greater the increase in:

- the livestock concentrations at water points;

- earlier starts towards the dry season areas;

- the number of families and herds on the move;

- the frequency of movement during the dry season;

- the distance of movement and

- the migration of families out of the Region.

The extent to which the livestock movements occur tend to fall into three broad categories,:

Localised There are short movements not usually more than 30 km and can be regarded as within area movements, adjusting the stock towards the viable water sources and crop areas. This is the most common form of movement and possibly involves more families, but not necessarily more livestock, than the other categories.

Intra regional: This is the largest category in terms of livestock numbers with longer movements often up to 100 kms and occasionally 150-200 kms, generally in a southerly direction and usually towards the same vicinity each year.

Inter regional: this movement is outside the region towards the Juba and Shebelli rivers. Families who carry out this each year tend to be larger livestock owners and have little or no dependence upon crops. Migration towards the rivers becomes increasingly more important in years of low rainfall.

Any movement during the shorter Haggai dry season are usually of a local nature but maybe increased in the years when the Haggai rains are adequate to bring on a flush of green growth.

The return from the dry season grazing area is similarly influenced by the rainfall but also by other factors particularly the need to meet the planting dates for the next sorghum crop and to avoid long movements with new born animals at foot the majority of which are born during the early Gu season.

The direction of travel is usually as direct as possible in times of early and more widespread rain. Where the rains are late the return is delayed, and if localised, movements will tend to be diverted to pass through these areas receiving the rain first.

With the onset of the rains, camel herds tend to be more active than cattle. This is an endevour by the camel herders to utilise the camels ability to cover longer distances in an attempt to supply green feed to raise the level of milk production upon which they are dependent. Cattle on the other hand are less mobile and mostly in a cyclic period of lower productivity prior to the onset of the calving season.

7.4.2 Livestock Migration Routes

The unpredictability of livestock movement within and through the region, the period over which they occur and their widespread flow makes a full assessment of their extent and their relative magnitude on extremely difficult task.

The localised movements are in particular extremely numerous and diverse but are in general a gradual build up of additional stock, as the dry season progresses, in to the more favourable strata from the less favourable adjacent areas. Such as into the crop residue areas of strata 1 and 10; the clay soil areas of stratum 12; the Juba riverine area of stratum 6 and the browse "overspill" areas from the cropland-stratum 23.

The longer intra - and inter regional movement routes used in the Jilaal season corespond broadly to traditional stock-marketing routes and their alignment is largely dictated by reliable watering points. Only perfunctory grazing takes place between watering points but herds may stay for some time in the vicinity of these points to graze. Between watering points, stock movement takes place within relatively wide corridors.

Routes are therefore more easily identified when the flow of stock tends to converge at the main water sources used in transit and the principal routes now established are as a result of the siting of these sources with the wars developed for the E.E.C. Inter River Livestock Project playing an important role.

The general flow of livestock for theJillel dry season grazing period is, in most cases, in a southerly or south westerly direction. The exceptions to this are:

- Bur Acaba District: a north, north westerly movement towards the limestone escarpment, of stock, particularly camels, normally resident to the north and east of Bur Heybo.

- Kansa Dere District; a small movement of mixed stock in a north westerly direction from Ufurow to the area bordering the Juba River.

- Dinsor District: a minor easterly movement, mostly of cattle, from Dinsor and Yak Brawe localities towards Ganana, Buulo Fulaay and Bur Galway.

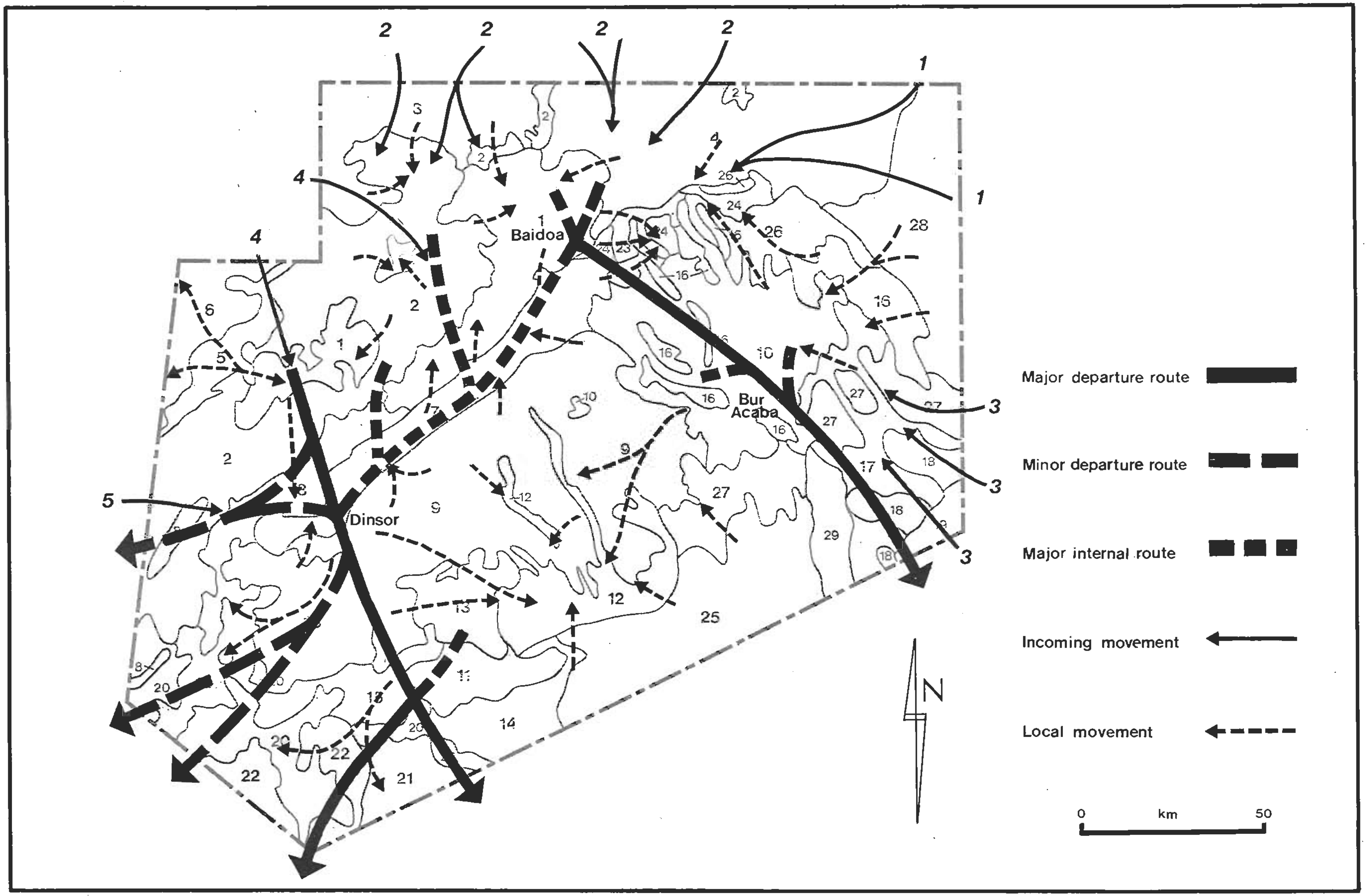
The principal routes can be broadly categorised as:

1. Directions of movement into the Region by stock from neighbouring regions and which normally remain for the period of the dry season.

2. Within region movements, mainly inter district and which link up with.

3. External routes passing out of the region towards the Juba and Shebelli Rivers and used by both regional stock and by stock in transit from the Bakool and Geddo Regions.

7.1 Principal livestock movement routes for Jillal season



The direction of livestock flows for the principal movements within each category are shown in Figure 7.1.

Livestock moves into the Bay Region from five principal directions during the Jillal dry season, and these movements are described below. Entry into the regions occurs within wide corridors - too wide to allow the identification and monitoring of stock concentrations during the short period of this study. Consideration should be given to conducting a comprehensive monitoring study to provide a basis for health inspection and quarantining programmes. The principal immigration movements are:-

- Hiran Region (Routes 1). Camels from the Buulo Berti and Jalalaski Districts, with movement, which did not take place in 1982, usually restricted to years of poor rainfall and is directed towards the natural springs on the limestone escarpment.

- Bakool Region (Routes 2). Mostly camels from the Wajid and Hudda Districts which graze mainly in strata 3 and 4. Local cattle vacate this area due to the poor availability of water. Livestock in transit destined for the riverine areas also enter here and link up with the two main external networks - route A mainly camels towards the Juba river, route B predominantly cattle to the Lower Shebelli Region and a minor movement also to the Lower Shebelli along route C through Bur Acaba District.

- Lower Shebelli Region (Routes 3). Small groups of mixed stock from the Wanle Weyn and Qoryole Districts which normally reside close to regional boundary.

- Geddo Region (Routes 4). Camels and cattle from the north east of the Geddo region, the majority of which pass through the region on route to the Lower Shebelli. Other Geddo stock by-pass Bay Region to the middle Juba.

- (Route 5). Small numbers of mixed stock from the Bardeera District during the years of low rainfall.

The within region movements form two distinct networks of flow. The major one emanates from the Baidoa and Kansa Dere Districts converging towards Dinsor from where routes diverge throughout the south west and spread towards the rivers outside the region. The main flows are closely associated with the wars on the Baidoa - Dinsor and Dinsor-Yak Brawe roads.

A second route on the eastern side of the region links the Baidoa and Bur Acaba Districts and continues out of the region to the Lower Shebelli.

The routes used by livestock leaving the region are utilised by all species of farm stock but there are generally a higher proportion of camels in the flow towards the middle Juba, (Routes A), predominantly cattle to the Shebelli through Yak Brawe (Route B) and approximately similar numbers of cattle and camels along the eastern route. (Route C). Livestock that leave the region by the westerly routes are more exposed to a possible risk of trypanosomiasis at the riverine grazing areas.

8

Livestock Husbandry, Productivity And Health

8.1 INTRODUCTION

The livestock owners of the Bay Region have in common with pastoralists elsewhere a deeply entrenched relationship with their livestock. Livestock are not only a main source of livelihood and wealth but are the focal point of a way of life and influence the social behaviour and relationships both within the family and with others.

Over many hundreds of years the close involvement with livestock has led to a deep understanding of the relationship between livestock and the environment and has resulted in the evloution of management and simple husbandry practices around which the lifestyle of the livestock owning community revolves. The difficult and occasionally severe environment has through natural selection produced adapted types of stock that have developed some resistance to nutritional hardship and endemic diseases. The production levels of the stock are optimised within the constraints of the environment to ensure survival and furtherance of the species. Higher production levels, for example of reproductive performance, would be detrimental unless a corresponding improvement in the environment took place. It can be assumed that the present levels of productivity are at their maximum within current environmental management and husbandry practices carried out. This does however not preclude that the genetical potential of the stock is a limiting factor as has been demonstrated elsewhere in Africa where the production levels of indigenous stock, for example, Boron cattle and Blackhead sheep, have been raised considerably through an improved management of the environment and by selection.

8.2 LIVESTOCK TYPES

8.2.1 Camels

The multifunctional ability, the extensive ranging and browsing ability and the capability to endure or survive periodic droughts makes the camel an important factor in the subsistence economy and social structure of the region. Milk production is their primary function, milk being the main dietary component of the semi-nomadic population and together with sorghum supplies the main dietary needs of much of the population. Milk sales form a high proportion of the cash income for the herds adjacent to or passing by the main trading centres. Camels milk is highly valued by non camel owners as a food and for its laxative effect, a requirement for the otherwise costive Somali diet.

As pack animals they are the principal transporters of goods and water in the rural areas but are not ridden. The meat production is secondary in that home slaughtering is not common, usually reserved for social occasions or from casualties. The sale of stock for slaughter is usually of mature males surplus to breeding or if castrated, surplus to pack animal requirements. The sale of females is normally limited to culls that are considered incapable of breeding through sickness or old age. The hides are used for the manufacture of houshold items but occasionally sold. The hair is not utilised.

Although genetically similar throughout Somalia, being single humped dromedaries *(Camelus dromedarius)*, the camels within the region and in the south generally are larger than those in the more arid areas to the north. No specific breeds are identified but a descriptive classification is used based upon the hair and skin colour tone of the animal. No production differences between the types are known but some livestock owners are of the opinion that the "Somal" type tends to be smaller and produces more milk and that "Dah" and "Mai" types tend to be larger and are better pack animals.

The six colour types commonly described are:

"Fil" - white,	"Somal" - off-white, cream,	"Dah" - dun, grey beige,
"Gof" - red-beige,	"Gurdud" - red-ginger,	"Mai" - grey to black.

A further largely northern, classification also exists, adding a degree of confusion to the locally applied nomenclature. In this case, the commonly found camel types are classed as follows:-

Siif Daar	- Heavier and darker
Eydimo	- Heavy but less dark than Siif Daar
Somal	- Small and off-white, with more milk
Hori	- Smallest and darker than Somal.

Size of mature animals is variable with ranges generally quoted at:
Breeding males 500 - 550 kg; mature castrates 450 - 500 kg; females 425 - 500 kg.

8.2.2 Cattle

The cattle of the region fall within the type classification of the East African shorthorn Zebu. They posses the typical thoracic hump which attains a good size in some mature males, have short horns or are occasionally polled and can be found with a large range of colours and markings. Several sub types are still identifiable although transhumance has caused some intermixing to occur particularly in the northern part of the region and along the major trade routes. The origins of these sub types are cattle developed by selection for certain features within the old tribal areas and the nomenclature now used to describe the types refers usually to the tribe of origin or occasionally according to colour or markings.

The major inter river type is the "Surka" which is dominant in terms of total numbers and almost the exclusive type in the south west including Dinsor District, southern Kansa Dere and southwest Bur Acaba. The colours are red with speckled white, roan, red with a white spiral ridge and a colour variation known as "Machen" which is a colour reversal form, i.e. white with red spots or patches. The muzzle colour is pale or flesh coloured, horns usually present (4 per cent polled), more rarely lyre shaped horns ("Bowro type") are to be found, usually in bulls. Mature cows are relatively fine boned, often deep bodied and have a slightly sloping tailhead. Udder attachment is firm even in aged cows.

The type is dual purpose, milk and meat and it is reputed to be more drought resistant than other recognised types in the region. Mature bulls range from 320 - 350 kg.

Smaller numbers of the "Gasara" and "Dawara" types are present, they are smaller than the Surka and both surpass it as milk animals. Of the two, the Dawara, originally from the Lower Shebelli Region, is the larger and better milking animal and otherwise physically very similar. They are self-coloured reds, dark reds to almost black in colour, very fine boned, lightly fleshed, a prominent sloping tail head, lop ears and loosely skinned with skin folds on the neck and brisket. Bulls have a pendulous prepuce and cows show a tendency to pendoulous udders and large teats. Horns are small and some polled animals occur. The approximate weights of mature bulls is 280 kg for Gasara and 300 kg for Dawara.

The influence of the "Boran" type from northern Kenya is evident more in the central and north of the region and this has a reputation for faster growth and a better flesh covering but is inferior to other local types in milk yield and drought tolerance, soon losing condition. Colours are mostly white or selfed pale colours, cream, yellow and light reds. Mature bulls, rarely seeen in the region, reach 340 - 360 kg. The "Lahdi", also white or pale in colour is similar, physically and in production traits, to the Boran but slightly smaller.

8.2.3 Sheep

Sheep play only a relatively minor role in the livestock industry of the region usually maintained as a small ancillary to the goat flocks or as small scavenging flocks in towns and villages. Only small quantities of sheep meat are eaten locally and animals are either sold out from the region or slaughtered principally for the medicinal properties of the sheeps head and for the fat. Milking is not practiced.

The sheep are intrinsically the Somali Blackhead type being haired, polled and fat rumped with a well defined black head and white body, with occasional all white, all black and dark brown variants. Most are relatively nondescript and maintained in flock sizes too small for owners to carry out selection programmes. The phenotypic variation is considerable ranging from the longer legged finer bodied desert form to the more common, blockier, shorter legged type. Mature body weights range from 27 - 40 kg in rams and 25 - 34 kg in ewes.

8.2.4 Goats

The regional goat flock tends to be rather mixed in type which results from considerable intermixing of types originating from other regions and the stabilisation of types from selection at local level.

The main influence is from the dual purpose White Somali, the typical goat of the northern areas which is short eared, has smooth short hair, and all males and most females with horns. A second influence is the larger Southern Somali goat with its greater variation in colour but particularly reds and browns with lop ears and a reputation for better milking qualities.

The intermixing and localised selection has resulted in a predominantly medium size goat, short eared (or Deg Yar) dual purpose type of variable colours and markings, the more common being black (Ariamadow), red (Ariassan) and white or white with coloured head (Ari ad). The less common long-eared goat (Deg weyn) is equally variable in colour pattern and supposedly has good milking qualities. Small numbers of the "Arab Goat" (Ari Arbed), a medium size, lean, long haired milk goat, are kept in the towns and are a source of "medicinal milk for children".

8.2.5 Equines

Donkeys are commonly used in the vicinity of villages and urban areas as pack animals and for pulling two wheeled carts. Generally associated with sedentary families they are rarely used for migratory movements. Donkeys are not ridden except by children. The total donkey population is small and unimportant on a regional level but their hardiness and capacity for work enables some urban families to supplement their income as hauliers, particularly of water, firewood and building materials.

Horses within the region are very few in number and serve no utilitarian function. The cost of maintenance is high and they are kept primarily for pleasure and prestige purposes.

8.2.6 Poultry

Many families, including some semi-nomadic groups, possess a few head of poultry. Ownership rarely exceeds 5 - 6 adult stock. The birds are nondescript as a result of natural selection within a relatively harsh environment. Some influence of past importations, believed to be from Rhode Island Reds, can be found in the main villages. Production levels are low due to the lack of husbandry and to heavy losses from predators and disease outbreaks. Feed supplies are usually from household scraps, insects and spoilt grain. Despite the low production of 25 - 30 small eggs per annum or two or three small clutches reared, poultry with no production costs does supplement the diet and income.

8.3 HUSBANDRY AND MANAGEMENT PRACTICES

The extensive nature of the management systems, the seasonality of feed resources, communal land use and the generally small herd and flock sizes impose limitations to the level at which management practices can be carried out. A simple system of husbandry has developed to meet the needs of livestock owners within the level of their capabilities.

8.3.1 Grazing, Watering and Herding

Livestock movement is controlled by herding and is, subject to an adequate family labour supply, directed towards:

- maintaining animals in the best possible areas of feed supply;
- protecting growing crops;
- protection against predators;
- prevention of straying and theft;
- prevention of herd-flock mixing (fighting, unwanted breeding);
- the occasional sub division of livestock to prevent suckling and ensuring all stock are watered regularly.

Herding is carried out throughout the year with the exception of small groups, usually suckling stock, family milk animals or small family units, which are retained or kept at the homestead. Pack animals are often hobbled to avoid herding and enable easy capture.

Cattle and camels are usually herded by the male members of the family while sheep and goats for which the women are normally responsible are tended by children.

At night stock are held within thorn or pole enclosures or within the family compound. In the more extensive areas, the tractability and docility of the livestock, enables adults to remain unenclosed but temporary brush enclosures are constructed for the protection of small stock and the younger animals and to enable the separation of offspring from dams to prevent suckling. Unenclosed adults rarely stray at night as females will not desert their offspring and it is reported that the stock do not graze willingly during the hours of darkness. To prevent straying and to assist in locating animals in the dense vegetation it is common practice, particularly in camel herds, to fit bells to the necks of the natural herd leaders.

Watering, under normal conditions, is carried out every 6 -10 days for camels and on alternate days for other stock. Watering of stock more frequently, even if readily available, is not practiced in the belief that too frequent watering reduces an animal's ability to survive in times of restricted availability. The hard work involved and the instances where water has to be paid for may also influence the drinking frequency.

8.3.2 Supplementation

Feed supplements are not generally available and rarely fed. Although sorghum stover is a major seasonal feed source, livestock are allowed accesss to it more as a substitute for grazing rather than as a supplement. There are minor exceptions and the storage of stover by stacking in the field or removal to the homestead is reputed to be on the increase. It is used primarily to maintain the homestead milk and pack animals and is occasionally sold. The availability of stover during the two dry seasons, at a time when range grazing and browse has declined or become less accessible, is a major factor in maintaining livestock numbers and in influencing management systems. The overall contribution of the sorghum crop residues as a feed source is considerable and possibly supplies a quarter to one third of the mean, annual total of the forage produced in the region. (Based upon the range forage production estimates of the Lockwood/FAO 1968 Report). From two seasonal crops on the estimated 3725 km^2 of cropped land, under very favourable conditions, yields of over 15 million tonnes of stover are possible. Taking into account the incidence of crop failure and wastage due to trampling, wind and termites, estimates of the yield of forage dry matter available for grazing during the two dry seasons are shown in the following Table 8.1.

TABLE 8.1 THE ESTIMATED PRODUCTION OF CROP RESIDUES (Sorghum)

	Gu Rains Production	Deyr Rains Production
Planting date	Mid April	Mid Oct. (mainly ratooned)
Grain yields[1]	350 kg/ha	250 kg/ha
Grain residue ratio[2]	1:6	1:6
Yield of forage	2 100 kg/ha	1 500 kg/ha
Crop failure	1 year in 4	1 year in 3
Mean annual forage	1 575 kg/ha	1 005 kg/ha
Estimated wastage	30%	40%
Dry matter content	90%	90%
Period of availability	Mid Aug. - mid Oct.	Mid Feb - Mid April
Approx. days available	60	100
Dry matter available	16.5 kg/DM/ha/day	5.4 kg/DM/ha/day
Dry matter intake	2.5% of body wt.	2.5% of body wt.
Biomass capacity	661 kg/ha/day	217 kg/ha/day
Cow equivalent (300 kg)	2.2 cows/day	0.7 cows/day

Source: [1] *Agricultural Extension Project*
[2] *Bonka Field Station Annual Reports.*

The sorghum stover production, whilst providing a source of dry matter that enables higher stocking densities to be maintained, is in terms of feed quality when the sole dietary component, little more than a source of roughage, being high in crude fibre with a resultant low metabolisable energy and digestible crude protein content.

The total quantities of other crop residues produced is insignificant although the planting of groundnuts, cow peas and mung beans is on the increase and being encouraged through intercropping and crop rotation recommendations.

Other than the occasional storage of sorghum stover, no other feed conservation practices are carried out, neither are forage crops grown although this too is reported to be actively encouraged by the extension service. It is feasible to expect that arable farm yields will be increased through improved cultivation practices and pest control, in that response to an extension input in the arable sector is likely to be more rapid than with the activities directed towards livestock husbandry.

Forage cropping and its integration into the present farming systems has yet to be backed up by an appropriate testing and field monitoring programme.

The deliberate fattening of animals with additional feed is not commonly practiced and grain or "porridge" is only occasionally fed to assist sick animals.

During droughts additional feed may be provided by the lopping of trees particularly *Dobera* and *Salvadora* spp. which are traditionally protected for this purpose.

The mineral status of the natural diet is unknown but although no apparent deficiencies have been observed it is likely that some imbalance may occur. No stock owners interviewed fed salt although several were aware of the need and permitted their stock to lick termite mounds, a source of salt in some areas. This may indicate that a supplement could be beneficial, particularly in sweet water areas, if only for its condiment effect upon feed and water intake. Phosphorus deficiency, common in many similar semi arid environments, is also unreported but the typical symptoms of pica and excessive hoof growth were observed.

Raising the level of nutrition to increase productivity is the primary function of management and husbandry practices. It is therefore necessary that attention is paid to intensifying this level by investigating the need, value and implementation of supplementary feeds i.e., improved utilisation of sorghum stover, other crop residues, forage crops, minerals and possibly fat soluble vitamins which are occasionally deficient in dry season feed sources.

8.3.3 Breeding Practices, Selection and Castration

With the exception of camels where the males come normally into a twice yearly musth, cattle, sheep and goats have a potential to breed at any time of the year. This is, however, usually restricted due to a temporary nutritional anoestrus and results in a tendency towards a natural bimodal breeding cycle with birth periods peaking during the Gu rains, the main season, and in the Deyr rains. These birth peaks result from breeding during a period of improving body condition brought about by the influence of the previous rainy seasons. This natural regulation of the breeding cycle optimises the time of parturition for most stock and therefore no practices have evolved to control breeding with males being allowed to run with the breeding females all the year round. This often results in first time breeding females being undersize and which is compensated for by the higher mortality of progeny from this group and a reported extended period between first and second parturitions.

No deliberate selection is carried out on the female side as in general most females are reared and retained for breeding being culled only when their useful breeding life is over, usually aged, or if chronically sick. Selection amongst males is common and the principal selection criterion amongst cattle and goats is based upon the dams milk production.

Forty five out of forty eight farmers interviewed stated that milk production was the main factor of production that they wished to improve. The dams milk production is also an important selection characteristic in camels but size is also taken into consideration. With the exception of camels, the culling of males not required for breeding is usually by sale or more rarely by home slaughter. Castration is practiced but is less common with small stock and in cattle and is often delayed until puberty.This is particularly common with the smaller herd and flock owners who partially depend upon the young males for breeding. Castration is more common in camel herds where large tractible males are often retained in addition to breeding males for use as pack animals.

8.3.4 Milking and Weaning Practices

Milk is the principal livestock product in the subsistence economy being a main component of the diet and to a lesser extent a source of cash income. The milk of camels, cattle and goats is drunk fresh with camels milk being generally preferred, goats milk is mostly consumed by children and cows milk used in the production of butter and ghee.

Milking does not commence until at least seven days after parturition which enables the new born to take advantage of the colostrom. The period over which animals are milked varies but is generally excessive and is usually terminated naturally due to pregnancy or occasionally intentionally when pregnancy is determined, a practice that is generally limited to herds of a size that are adequate to maintain some milk supply throughout the year.

Milking is facilitated by restricting the opportunity to suckle and normally carried out by separation both overnight and whilst grazing during the day through penning or herding separately. The suckling of camels is often prevented by enclosing the udder in a bag or access is limited by applying a "marak" or string tie to one or two of the teats. Milking, by hand into a milk pot or "cadeys", is carried out once per day, occasionally twice, with camels usually milked by the male members of the family and cattle and goats by women and children. The tractable nature of the local stock enables most of them to be milked without restraint but when necessary the use of hock ties, a rope ("marak sar") around the withers for camels or the hand holding of goats is practiced. Milk cows usually require the presence of a suckling calf to stimulate milk let down.

Maintaining a balance between the quantity of milk obtained and enabling the offspring to be reared is a skill which owners have developed through experience and their knowledge of the individual animals. However, the need for milk is such that the generally small herd size and the reduced supply during the dry seasons results in overmilking both on quantity and for over protracted periods. The higher nutritional requirement of milk production forces a demand on body resources and, exacerbated by seasonal declines in feed quality and quantity, is detrimental to reproductive performance through the lengthening of parturition intervals. Reduced milk availability and prolonged suckling frequencies particularly when very young, results in reduced growth rates of offspring and increases their susceptability to disease. Indications from interviews made are that all in-milk animals are milked at some time during their lactation.

Deliberate weaning is rarely practiced and suckling allowed to continue subject to the milk requirements of the family and the onset of pregnancy.

8.3.5 Livestock Identification

Livestock owners and herders have a propensity for the identification and the background knowledge of each animal in their care. Occasionally herd mixing or straying takes place and restitution of ownership is more readily ascertained when stock have been marked to simplify ownership identity. Marking of stock is more common in herds and flocks that migrate regularly and, where practiced, is usually in the form of ear slitting or notching, in the case of cattle and smallstock, and by branding in the camel herds. Ear notching is according to a family pattern whereas due to the traditional attitude of regarding camels as being held in trust for the tribe, camels are branded with a "somat" or tribal marking on the cheek or neck. Temporary paint marks are used by livestock traders to identify their stock while in transit and with some cooperation from traders this could be a possible means whereby the marketing movements and sources of origin of livestock could be monitored.

Although during the J.P. 15 Rinderpest Project all vaccinated stock were ear notched, the overall attitude to livestock marking is generally antagonistic and a considerable educational programme would be necessary if livestock owners are ever required to cooperate in any programme that entails the identification of livestock as in for example, zonal or livestock movement controls.

8.3.6 Animal Health Practices

Livestock owners demonstrate some awareness of the symptoms and effects of diseases prevalent in the region but through a lack of understanding of the aetiology of such diseases and the limitations in preventative and curative procedures, fatalistic acceptance of sickness and mortality has developed. Although there is an increase in the demand for assistance in treatment of stock by the Veterinary Authorities the more important aspects of preventative medicine are regarded with suspicion. As a result, with the present capabilities of stockowners, the measures carried out to improve livestock health are very limited.

Some knowledge of natural medicines exists, mainly costive or laxative agents, and firing is commonly used often erroneously for ailments that do not necessarily respond to induced inflammation.

The presence of trypanosomiasis in the riverine area is understood and measures are sometimes taken to avoid this area. It is reported that some stockowners have actively encouraged the spread of low virulence foot and mouth disease to reduce the possibility of a protracted outbreak and to maintain a resistance.

8.4 LIVESTOCK PRODUCTIVITY

8.4.1 Introduction

The essential characteristics of meat producing or dual purpose livestock maintained under extensive range conditions are:

- Reproductive performance
- Growth rates
- Variability - Longevity
- Product yield and value.

Quantifying these parameters within an extensive system cannot be achieved by means of a short survey, not only because of seasonal differences but because some of the factors themselves can only be measured over time. The questioning of owners relying upon memory and uncorroborated responses is an unsatisfactory method and cannot supply all the information required. A knowledge of the performance of the indigenous stock and an understanding and evaluation of the system within which they are managed are essential if the problems and weaknesses of the system are to be pinpointed and they are to act as a baseline from which improvements can be tested, evaluated and implemented. It is therefore necessary that a continuous extensive monitoring of the livestock systems practiced is established which could include not only a facility to relate overall production on an economic and land use basis but would also enable performance to be related to environmental effects and to the influences of the dam - offspring relationship *viz* age of dam, previous breeding record, sex and period of birth.

8.4.2 The Parameters of Livestock Production

(a) Reproductive Performance

A high reproductive rate is one of the basic requirements of a livestock enterprise for without a regular production of offspring there are less stock for sale, expansion or replacement and a reduced milk supply.

Reproductive performance is a measure of the combined effects of frequency of reproduction and the number of offspring produced at each parturition and is usually expressed as the number of offspring produced per year as a percentage of the breeding females available for breeding. The age at which breeding commences will also influence output in terms of total herd or flock productivity.

Ascertaining the number of offspring produced in relation to the number of breeding females maintained, over time, could not be carried out satisfactorily from a single interview with livestock owners. The estimation of lifetime reproduction rates from a smaller sample was considered to be more indicative of the real situation. The lifetime performance of a sample of individual females from a number of herds of varying size distributed throughout the region was determined from:

- an estimation of the reproductive age i.e. age in years, less mean age at first parturition and the pregnancy period, and less the period of time since the last parturition, and the number of parturitions achieved so far.

The age at first parturition of each species was estimated as:

Cattle	47.9 months
Camel	62.9 months
Sheep	25.6 months
Goat	25.8 months

The best estimate of the mean lifetime parturition interval was ascertained, after weighting and summation, from the number of parturitions that occurred for each individual during the period of the reproductive activity. The mean parturition interval and annual parturition percentages for each species is shown below:-

	Parturtion interval	Annual parturition %
Cattle	22.5 months	53.3
Camel	34.0 months	35.3
Sheep	12.5 months	96.0
Goats	13.5 months	88.9

The percentage annual birth rate is affected by the frequency of multiple births. Twins are rare in camels and cattle, being less than 1 per cent of all parturitions, and within the constraints of the environment a high twinning rate is probably undesirable.

The best estimates available of multiple births in sheep and goat flocks is 3 - 4 per cent and 6 - 7 per cent respectively. This would indicate an annual lambing percentage of approximately 103 per cent and a kidding percentage of 102 per cent. The multiple birth potential of small stock is, particularly in respect to goats, much higher than this as there is considerable variation between flocks and reportedly between years. The relative difference between the parturition intervals of sheep and goats is probably attributed to the very high incidence of milking that is carried out, the indications being that all animals are milked sometimes during their lactation.

(b) Growth Rates

There are no records or information available within the region on livestock weights or weight changes and any assessment of such values can only be determined from estimates emanating from considered opinions and experienced judgements. Such figures are crude, providing only a very general indication of the real situation which can only be determined through an adequate monitoring programme when the precise ages and weights can be determined and the influences of season of birth, sex and maternal effects assessed. Some estimates are provided in Table 8.2.

TABLE 8.2 APPROXIMATE WEIGHTS FOR AGE BY SPECIES (ESTIMATED)

	Age in months			
	12 months (kg)	24 months (kg)	36 months (kg)	48 months (kg)
Cattle	70	150	220	250
Camels	135	200	265	310
Sheep	12	24	30	-
Goats	12	24	30	-

Irrespective of the accuracy of the estimates the rate of growth from birth to mature weight is slow and below potential. Although no comparative performance of stock maintained under an improved nutritional level is available it is regarded that the weight gain of "weaned" growing stock as achieved during only seven to eight months of the year.

(c) Viability

In a similar manner to other parameters that are measured over time, estimating from interviews is unsatisfactory. The responses are exaggerated resulting in an under estimate due to the reluctance of stock owners to be completely truthful on matters which affect their pride and may reflect their stockmanship. No corroboration of answers is possible and the difficulties in relating the stock mortality numbers given, to the overall livestock numbers and to the previous years birth rate is considerable.

The best estimate for the mortality rates form the twelve monthly period from the beginning of the Gu rains 1981 to the end of the Jillel Dry season 1982 (April '81 - March '82), a year regarded by the local Veterinary personnel as being well below the norm, is shown in Table 8.3. The figures for sheep were unobtainable due to the very small flock sizes but their mortality rates are regarded as being considerably higher than for goats, particularly with young stock.

TABLE 8.3 THE ANNUAL MORTALITY RATE (%)

	No. of herds	Age < 12 month	Age < 12 month	Overall	Abortions[1]
Cattle	26	7.8	0.9	2.2	1.4
Camels	18	7.9	1.1	2.3	2.5
Sheep/Goats	15	17.1	3.8	4.3	2.4

Notes: [1] *Abortions as a percentage of breeding females.*

Source: *Hunting Technical Services 1982.*

(a) Productivity

Overall productivity cannot be assessed from the data base currently available and this shortfall further emphasises the need to establish a comprehensive monitoring programme.

The best estimate of live weight yield that can be obtained is the weight of twelve months old stock produced by a breeding female in one year. This estimate, calculated from the parameters obtained during the present study, is considered to be an over-estimate of birth rates which have also occurred over a period that is not representative of the climatic cycle. The live weight yield of yearling stock produced per breeding female per annum is shown in Table 8.4.

TABLE 8.4 LIVEWEIGHT YIELD OF 12 MONTHS OLD STOCK PER BREEDING FEMALE PER ANNUM

	Camel	Cattle	Goats
Annual birth rate (%)	35.3	53.3	102
Mortality to 12 months (%)	7.9	7.8	17.1
Reared to 12 months (%)	32.5	49.1	84.5
Mean 12 m liveweight (kg)	135	70	12
Mean liveweight yield per breeding female per annum (kg)	43.9	34.4	10.1

Source: *Hunting Technical Services 1982.*

Information on milk yields is not available but estimates made in 1973 by the FAO and quoted by Singh (1982) indicate that the annual yields, whilst rearing offspring, are Camels 350 litres; Cattle 150 litres and Goats 50 litres. Corroborative information supplied by livestock owners tends to confirm these levels. On the basis that camels are generally milked for up to two years, cattle for one and goats for less than one, the estimated yields per annum for the period of the mean breeding cycle is:

Camels 247 litres   Cattle 133 litres   Goats 44 litres

The inability to obtain information on livestock sales and details of home slaughtering prevents the reliable estimation of offtake from herds and flocks. Figures quoted in the past, on a natural basis, expressed as a percentage of the livestock population show the following ranges.

Camels 0.8 - 5.7% Cattle 3.9 - 11.0% Sheep and Goats 4.6 - 36.7%

Source: Livestock and Range Sector Study. Min. of Planning, March 1981.

From the herd structure and production parameters data obtained, the annual increment in livestock numbers within the region is estimated at:

Camels 17.7% Cattle 30.6% Sheep and Goats 54.7%

These increments are indicative of the stock available for sale, home slaughter, herd replacement and expansion on an annual basis but cannot be quantified. These increments are a considered over estimation due to the very favourable climatic conditions during the last few years and which does not make allowance for drought or severe dry periods which occur from time to time. These increments can possibly be regarded as approaching the maximum and indicative of the potential.

8.5 ANIMAL HEALTH

8.5.1 Introduction

Maintaining an acceptable standard of animal health is a major contributor to increasing the levels of productivity not only by lowering the mortality rate but more importantly the reduction of stress and debility which affects all production traits from which the combined losses of productivity greatly exceed the losses from mortality alone.

The provision of an efficient disease control programme is a basis for any livestock development activity and the role of the Veterinary Authorities is crucial in protecting the livestock on a regional basis and in raising the standards carried out at the on farm level.

Within an extensive situation the initial activity directed towards developing the livestock resource is the establishment of a Veterinary Service not only due to the need for these services but also because it is relatively easier to organise than other development activities in that it is more specific and its activities have an immediate and effective response.

At the current time the Veterinary Service is the only agency that is concerned directly with livestock and being solely concerned with disease control measures there is a void of activity in the area of animal production. Livestock management and husbandry are integral components of a health programme and as such their improvement has to run in parallel with it. This is an area for which extension activities are urgently required.

The principal and continual aim of the Veterinary Service has to be the protection of regional stock and export markets from the major epizootic diseases of economic importance that can only be dealt with on a zonal, national or even international level, e.g. rinderpest and foot and mouth disease.

The second priority are diseases that are more readily and effectively controlled by large scale programmes organised on a regional or zonal basis e.g. anthrax, blackquarter.

To provide an adequate cover within the priority areas requires a considerable expansion of the existing Department in terms of staff and facilities and if the third main area of within flock and within herd requirements are to be met, i.e. parasite control, footrots, first aid etc, an even greater expansion is necessary with a strong extension bias. The involvement of field staff from other agencies, particularly those of the Agricultural Extension Service Project, should be considered.

Development of the Veterinary Service; in addition to shortcomings within its infrastructure and which are to be improved through the BRADP there are several other major constraints which have to be eventually overcome if a regional animal health programme is to function effectively. These are:

- A fundamental constraint to the successful planning and execution of vaccination programmes is the current lack of understanding of the incidence and seasonality of disease and its economic importance. In this context importance may not necessarily be purely in terms of health. For example it is possible that the economic importance of tick control is overstated and the resources required to maintain a centrally run control service may be more efficiently utilised, in terms of financial return, if employed in other activities. However, ticks, from the farmer's viewpoint, are important as they are visibly obvious and as such a control programme which can be seen to work has a valuable spin-off effect in that it can build up confidence and faith for other activities of the Veterinary Service.

- Inability to control stock movement. The considerable movement of stock entering or returning to the region is widespread and can cross the regional boundaries at any point. The region is therefore under a continual threat at all times from all sides. Movement within the region is also irregular and uncontrolled and creates similar problems in that routine preventative measures cannot be efficiently or continually carried out.

- General uncooperativeness and suspicion of livestock owners towards vaccination programmes. The general attitude of livestock owners is that only animals known to be sick require treatment. Preventative programmes through vaccination are not generally understood and the past occurrances of fatalities and injury during vaccination programmes has hardened this attitude. This attitude also extends to the refusal to permit diagnostic samples to be collected.

8.5.2 The Disease Status

The overall disease status within the regions is generally unknown both in terms of their recurrence and seasonability and relative importance.The major epizootic diseases are rinderpest and foot and mouth disease both of major economic importance seriously affecting productivity and if not controlled would seriously affect the economy of the region due to the inability to maintain exports to external markets.

Occasional outbreaks of rinderpest occur but the present virus strain is believed to be of low virulence. During the period 1970-1975 the JP.15. Pan African rinderpest programme carried out a vaccination programme which was to be reinforced by the annual vaccination of all young stock. Regrettably this has not been carried out regularly and the cattle population can now be considered as non immune. The risk of an epidemic is now high particularly if a strain of high virulence is introduced. The updating and maintenance of the vaccination programme heads the list of priorities.

Foot and mouth also occurs spasmodically, types O, A and SAT II have been identified. Fortunately, due to the level of resistance in the indigenous stock or to the low virulence of the strains, the disease invariably runs a mild course and is generally considered of minor importance. Livestock owners have been known to encourage its spread to maintain resistance within their stock and reduce the period of the outbreak. Routine vaccination is not practiced but if this continues to be the case then particular vigilence is necessary to be able to keep the disease incidence well monitored as it is in the national interest to eventually establish an internationally acceptable disease free zone.

Two Mycoplasmic diseases occur regularly within the region, contageous bovine pleuro pneumonia (CBPP) is more prevalent in areas adjacent to the Middle Juba and Shebelli Regions. The extent of the disease is not fully known but the severe debilitating effect of the chronic form is well recognised by stock owners and vaccination programmes are normally acceptable when outbreaks occur. It is recommended that vaccination of the bovine population should become routine and stock owners encouraged to destroy known chronic cases. Contageous Caprine Pleuro Preumonia (CCPP) is considered to occur regularly within the goat flock and is not related to any specific time of year. Locally produced vaccine is now available but has yet to be used regularly in the region. The current opinion is that CCPP is of relatively minor importance and treatment is attempted by the use of broad spectrum antibiotics and by recommendation to slaughter the severe cases. A serious aspect of both pleuro-pneumonia types is the presence of undetected carrier animals which proliferate the diseases, the introduction of a comprehensive vaccination programme would eventually reduce this problem.

Trypanosomiasis:- Tsetse fly does not occur in the region but with the exception of the Bakool Region to the north it inhabits localised areas in all other neighbouring regions which includes the important grazing areas of the Shebelli - Juba valleys and the Shebelli flood and marine plains. Four *Glossina* species have so far been identified, *Glossina brevipalpis, G. longipennis, G. austeni* and *G. pallidipes.* of which the latter is more widespread. The more common trypanosomes transmitted by tsetse fly are *Trypanosoma viva* and *T. brucei* whilst *T. evansi* which affects camels is believed to be more widespread in its distribution due to mechanical transmission by biting flies.

The incidence of trypanosomiasis in the region is restricted to stock that enter from the tsetse infested riverine areas in the course of the dry season migration. Considerable expense is incurred in the provision of drugs for treatment although due to poor communications and the uncontrolled stock movement the treatment cover available is only partially effective. It is expected that the trypanosomiasis problem will decline and possibly disappear as the tsetse fly clearance programme of the MLFR proceeds.

Tick Borne Disease: The incidence of tick borne diseases, both within the region and at national level, requires considerable study. As yet, insufficient information is available on the importance of tick borne diseases that have so far been diagnosed and on the occurrence and distribution of vectors.

Heartwater, causal agent *Cowdria ruminatum,* may occur as it has been recorded elsewhere in Somalia and at least two proven vectors, *Amblyomma lepedum* and *A. gemma* are common within the region.

Anaplasmosis, causal agent *Anoplasma margenale,* is known to be present as are the potential vectors, *Rhipicephalus* and *Hyalomma* spp. The occurrence of anaplasmosis is however not likely to be a serious problem due to the high levels of innate resistance normally characteristic of indigenous stock maintained in endemic areas. The incidence of *A. ovis* in small ruminants has not been ascertained. Babesirosis (Redwater) exist in cattle and small ruminants but it is unlikely that Babesia infections cause significant disease problems in the local breed types.

It is suspected but not confirmed that some forms of *Theileria* are present within Somalia but no evidence exists to suspect the presence of East Coast Fever (*T. parva*) neither has the normal vector *Rhipicephalus appendiculatus* been identified. One proven vector of *T. mutans* of cattle, the tick *Ambylomma variegatum* is present in the country but is limited in distribution and not yet identified within the region.

Nairobi Sheep Disease caused by a virus is reportedly common within Somalia but its importance within the region is not known. The vector, *R. pulchellus*, is the commonest tick in the region and the occurrence or introduction of the disease would not be unexpected.

A common condition found in camels and suspected, though not confirmed, as being of tick borne origin, is a form of posterior paralysis which occasionally results in death. Firing of the joints is commonly practiced to try to alleviate the condition. The frequency and distribution of this syndrome would appear to justify an investigation into its cause.

Other diseases known to occur regularly are blackquarter, anthrax and haemorrhagic septicaemia, all of which can be prevented easily by routine vaccination programmes once their relative economic importance is ascertained. Occasional cases of botulism and pasteurellosis have been reported but are considered as unimportant.

Sheep pox is known to exist but is of little importance compared with other regions, it is sporadic and a locally produced vaccine is available if epidemic proportions are reached. A similar situation occurs with Camel pox.

Other conditions that occur regularly are contageous pustular dermatitis in young lambs and kids; foot rot in small ruminants, possibly exacerbated by interdigital infestation of ticks; mastitis and opthalmic conditions which usually lead to blindness.

There are several diseases which due to the geographical situation and the environment can be expected to occur. These would include the viral diseases, Bluetongue and Rift Valley Fever; tuberculosis and the diseases associated with reproduction Vibriosis, Brucellosis and Enzootic Abortion.

Endoparasites:- although considered as important and the sales of anthelmentics are increasing, the lack of information on the helminth species precludes the recommendation of specific control programmes. Heavy nematode infestations are common throughout the region and their importance is enhanced during periods of low nutrition. Tapeworms are common in lambs and kids. Fascioliasis is reported to exist in stock that visit the riverine areas. *Echinococcus* and *Cycticerus bovis* are regularly observed during meat inspection at the slaughter houses.

Ectoparasites:- tick infestations occur on all livestock becoming heavier, often reaching massive proportions during the onset of the rainy seasons. Stock owners know of their association with some diseases and aware of and welcome control measures. Minor cases of goat and camel mange are known to occur but are unimportant. The incidence of bots, nasal and other myiasis causing flies is not known.

8.5.3 Veterinary Service and Facilities

Of all the Government Agencies that have responsibilities within the rural areas, the Veterinary Services have the most comprehensive support facilities. The organisation of this service is shown in Figure 8.1.

These include:-

- an extensively equipped but under-utilised diagnostic laboratory with capabilities in virology, bacteriology, parasitology and serology.

- A vaccine serum producing institute currently producing nine vaccine types enabling self sufficiency in the main vaccine needs except for Foot and Mouth Disease.

- Training facilities for veterinary assistants and laboratory staff.

- Links with the University Veterinary Faculty in the areas of research and the training of Veterinary Practitioners.

The administration of the Veterinary Service is vested in the MLFR and is channelled through a regional to district network which follow the Central and Local Government Administration boundaries. However during the six year period of the BRADP, the regional service is to be directed from within the Project but linked to the natural service through two officers responsible for the administrative and the technical coordination.

An objective of the project, to increase the effectiveness of the regional veterinary service, will be through additional support to the existing administrative organisation, with an increase of field staff to man the dispensaries, two mobile units and the provision of materials and livestock handling facilities in the field. A sound organisational structure is a necessary base from which activities can be instigated as the overall effectiveness has in the past suffered through a shortfall of experienced and trained personnel and logistical support. Past activities have centred primarily around the sale of drugs and medicants from the dispensaries and district offices; a limited attempt to carry out vaccination programmes and in the public health duties with meat inspection at the municipal slaughtering facilities.

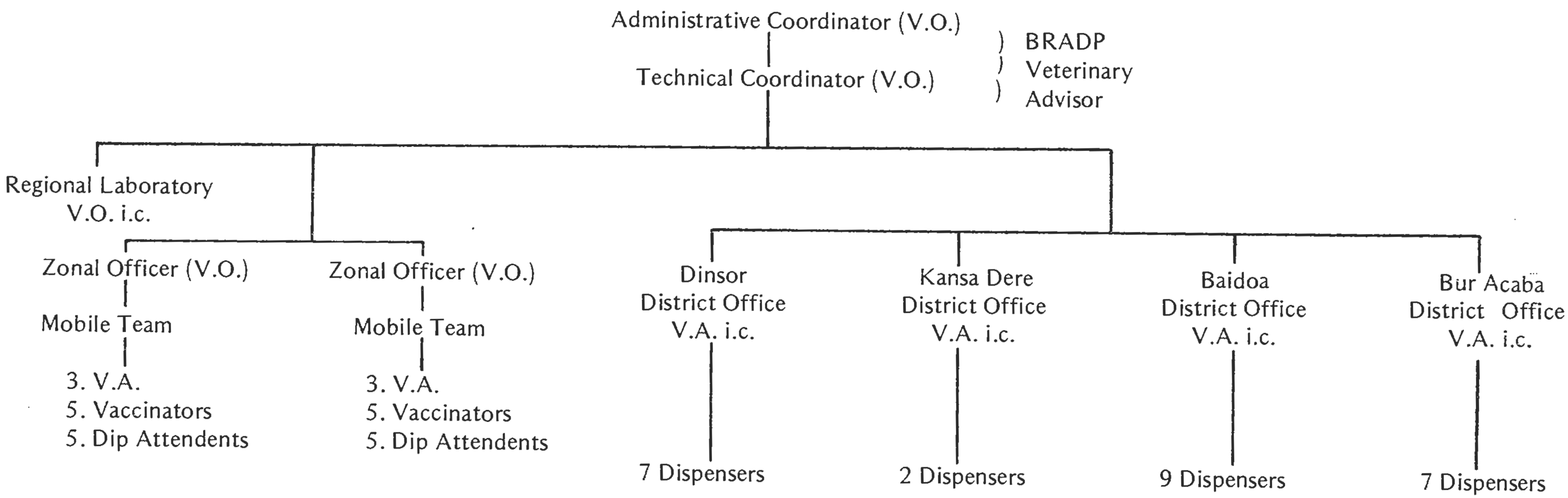
The sale of animal health medicants is a popular service and is much in demand. Sales during 1981 were valued at nearly half a million Somali Shillings of which half was for the purchase of trypanocidal drugs. It is reported that the demand for antibiotics far exceeded the limited supply that was made available.

TABLE 8.5 VALUE OF DRUGS AND MEDICANTS SOLD DURING 1981

	S.Sh	% of total
Trypanosomiasis control	223 810	50
Antibiotics	104 374	23
Acaricides	95 499	21
Anthelmentics	25 208	6
Total	448 891	100

Source: Bay Region Veterinary Monthly Reports.

FIGURE 8.1 THE DEPARTMENT OF VETERINARY SERVICES - BAY REGION



V.O. Veterinary Officer - Professional Vet. Practioner
V.A. Veterinary Assistant - Certificate 2 year Formal Training.

The sale of drugs to the general public presents several problems when carried out in the present manner. It is known that some drugs are used for human treatment and improper use of toxic materials could be a health hazard. However, the principal danger is the dévelopment of drug resistance particularly to antibiotics and acaricides. Most drug sales are carried out by relatively untrained staff who prescribe medicants often without seeing the stock which require treatment. Even if the correct medicant is prescribed there is little guarantee that effective dosage rates, in terms of quality and timing, are carried out. The situation is in fact quite alarming particularly with antibiotics which tend to be sold when available as a general panacea. It is strongly recommended that the availability of drugs on sale is reviewed and emphasis placed upon a broad range of simpler stockman's remedies that can be sold with instructions and guidelines for their use.

The extent of the use of drugs cannot be satisfactorily assessed. The information, within the monthly reports of the Veterinary Department, of the treatments carried out is based upon the quantity of drugs sold to which some factor is applied to relate it to possible usage. The reported figures can be considered to be a considerable over estimate.

Vaccinations carried out during the years 1977 - 81 are shown in Table 8.6.

TABLE 8.6 VACCINATIONS CARRIED OUT 1977 - 1981

	1977	1978	1979	1980	1981
Rinderpest	81 539	116 240	45 640	N/A	43 000
CBPP	-	-	45 089	N/A	-
Blackquarter	30 350	-	4 600	N/A	106 950
Anthrax	19 374	31 360	56 560	N/A	21 124

Source: GOS 1979 Statistical Abstracts Veterinary Monthly Reports

The basic infrastructure within the region, to enable routine programmes to be established, has been lacking. This and the generally poor response by livestock owners to the acceptance of prophylaxis concepts has relegated vaccinations to "fire fighting" exercises. The lack of recognised treatment centres throughout the region exacerbates the problem. There are only two livestock handling facilities throughout the entire region, at Yak Brawe and Ufurow, which were constructed in 1973 as marketing centres for the EEC Livestock Project. Due to the poor design they are unused and require replacement. A crush building programme is required with the eventual aim of having a simple animal restraint facility at every market and major water source.

8.6 MARKETING

8.6.1 Introduction

The marketing system within the region has been enhanced by a viable export market but has evolved through normal economic principles with little involvement by Government Agencies. Within the region the presence of livestock traders and a network of village livestock markets provide facilities that enable producers to have access to regular market outlets. The ability of producers to sell as and when they want is not a constraint.

In addition to the regional internal trade of slaughter and breeding stock, the principal market outlets are to the Mogadishu Municipality and the export trade to the Middle East via Mogadishu and to a lesser extent from Kismayo.

Quantifying the sales within and from the Region are currently not possible as the means to collect such information are not established. As all livestock sales are, for tax collection purposes, meant to be through recognised channels, the tax recording system could be amended to partially meet this need.

8.6.2 The Marketing System

The livestock production systems based upon self contained family herds and flocks have not become stratified with the result that most animals offered for sale by the producers are generally mature and go straight into the slaughter trade. Except for the small numbers that are purchased directly by local butchers and cafe proprietors the majority pass into the hands of traders who market directly to Mogadishu or who more commonly act as middlement selling on to the larger dealers who supply the export trade. To meet the export contract requirements, Government permits the export of mature males only (whether castrated or entire). The export of all female stock and immature males is prohibited.

Throughout the region there are 21 livestock markets (Souks), the distribution by districts being Baidoa 7; Bur Acaba 9; Kansa Dere 2 and Dinsor 3. Selling is carried out through Mediators (Dallal or Wakil) who negotiate bids between prospective purchasers, a sale being made on the final bid if the seller consents. If sold the seller pays the Mediator four per cent of the sale price for his services. A five per cent municipal tax is also payable by the purchaser. The District Councils have the power to levy additional taxes to meet specific Development or Self Help Schemes. Currently only the Dinsor District Council imposes any additional levies. An example of a sales transaction for a young camel sold for S.Sh 1 000-00, at Dinsor, would be as follows:

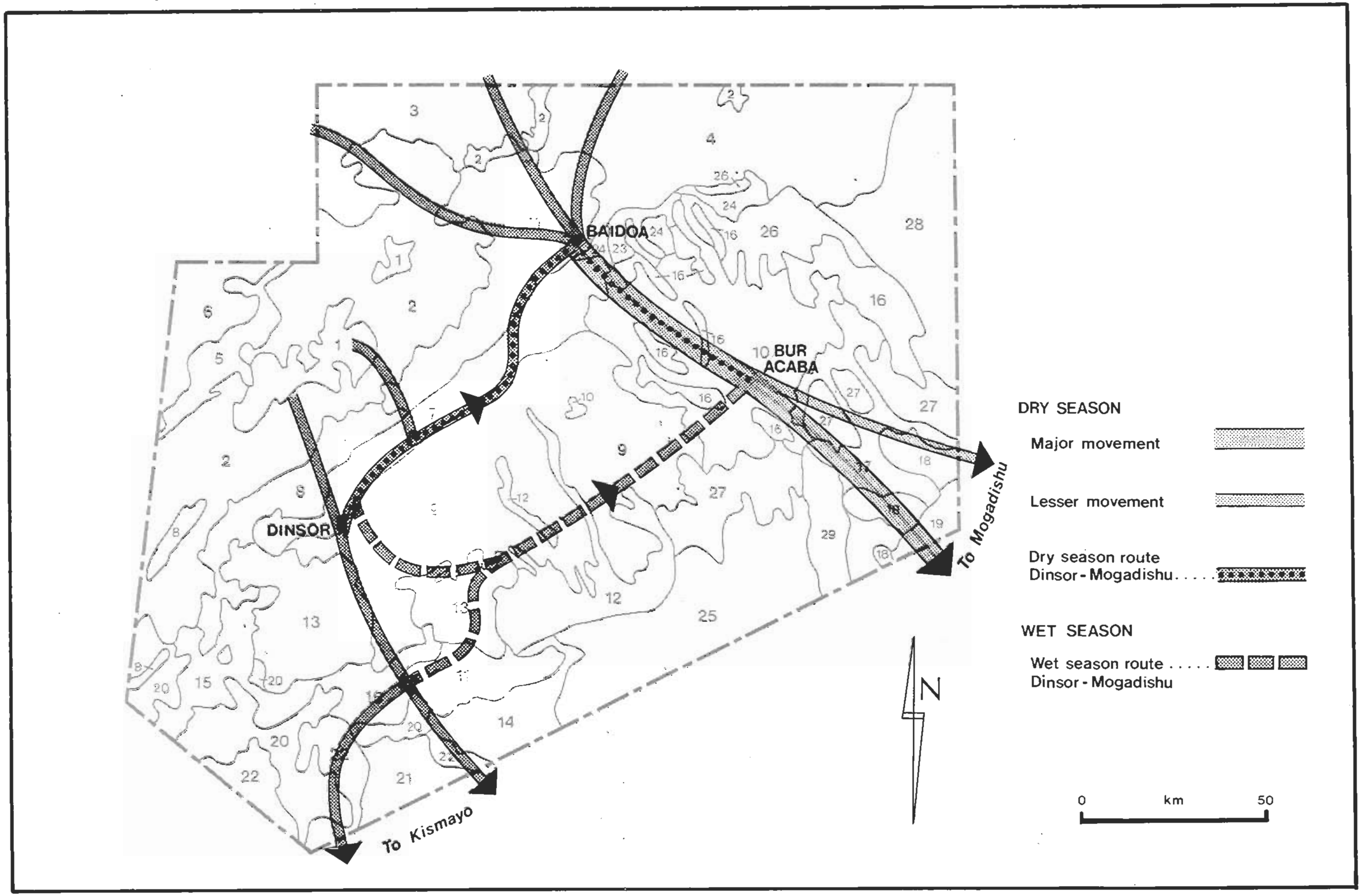
Agreed price S.Sh 1 000-00	Price	1 000-00	Price	1 000-00
	Sales Tax plus 5%	50-00	Dev. levy less	10-00
	Self Help plus	8-00	Mediator less 4%	40-00
	Buyer pays S.Sh	1 058-00	Seller receives S.Sh	950-00

Livestock are sold throughout the year but the main sales are during the early rains with traders particularly active as livestock move northwards after the Jillel dry season. It is reported that occasionally farmers will exchange stock with traders, receiving females to expand their herds, for unwanted male stock.

Baidoa market prices tend to be more favourable than other markets and this does encourage some movement from the west of the the region to benefit from the extra price received but also to supply traders who are active just to the north of the town at Bonka where the trade routes from the north and north west meet. The range of prices for various categories of stock as at February 1982 are shown in Appendix E.

The principal market routes and destinations are shown in Figure 8.2. The routes follow alignments to known reliable watering points. These are not shown at this scale of presentation, but their location may be found by reference to Map Sheet No. 5 in Volume 3 of this report.

8.2 Principal livestock marketing routes



9

Engineering

9.1 WATER SUPPLY

Water supply for domestic consumption or watering of livestock derives from two sources: surface water where storm run-off during the rainy seasons is collected in reservoirs called 'wars'; and groundwater where water is abstracted from hand-dug wells or tube wells constructed in water bearing strata.

9.1.1 Surface Water

Wars are artificially constructed depressions which collect water from surface run-off during periods of intense rainfall. There are two types of war: the first takes its water supply from a natural water course via a small excavated diversion channel or by construction of a bund across the water course; the second type is situated in a natural depression or on a mild slope and frequently has a series of bunds or artificial drains to gather run-off into the war.

In addition to wars many of the Burs, which are large intrusions of hard igneous rocks which project from the otherwise flat basement, have high run-off coefficients. The water which runs off from their impermeable surface is frequently impounded behind small hand-built dams which are often constructed from stone and mortar.

War depths are usually from one to seven metres most often dependent upon the depth of the soil. Capacities vary from a few hundred cubic metres up to 14 000 m^3 in one or two instances. War construction is often by hand although many use bulldozers, hired from the state owned company ONAT, which are also frequently employed to remove sediment deposits. For communally owned wars each man from the community takes his turn in removing sediments. Most wars have no ancillary equipment and livestock are more often than not watered directly from the war.

War water is usually turbid and generally of a very poor quality, although it is adequate for livestock and frequently used for human consumption. Livestock are not usually restricted from entering wars and often wade in,increasing the turbidity of the water and increasing the risk of pollution.

Wars are the major source of water in the wet seasons although the majority dry up a few weeks into the dry seasons.

There are many wars in the Bay Region and their density is such that it is almost impossible to map them individually at a 1:250 000 scale. However, many are included in the base maps produced from the 1:100 000 scale Survey Department Sheets.

An important source of water in the dry seasons are the wars along the main stock routes which were established in 1973 with EEC funding. There are 21 such wars in or very near to the boundary of the Bay Region and their locations are shown in Figure 9.1. The layout of these wars is standard, a typical example being shown in Figure 9.2. They have a small stilling basin with a weir in front of the intake which has a 100 mm iron grill to prevent debris blocking the 750 mm diameter intake pipe. A diesel driven pump supplies water from the reservoir, the capacity of which varies between 22 000 and 34 000 cubic metres, to a 70 cubic metre concrete domestic supply tank from which water is drawn by hand. From the tank 50 mm diameter plastic pipes feed eight concrete water troughs, each of three cubic metres capacity, either by gravity or by hand pumps situated one at each trough. The main reservoir has a barbed wire fence and the domestic supply tank has gated railings to prevent livestock contaminating the water. The main reservoir is lined with heavy duty PVC sheeting to reduce seepage losses.

Of the 21 wars 11 had no pump, or the main pump was not functioning, and most of the hand pumps were broken or the PVC pipes feeding them were broken or had been stolen. The PVC lining to the sides of the wars was badly damaged and much had been stolen although presumably the base lining was in better condition. Thus watering of animals is frequently direct from the domestic supply tanks or water has to be man-handled out of the main reservoir and over the fence at the top of the embankment. Seepage loss is increased where the plastic sheeting has been removed. Occasionally the steel railings surrounding the domestic supply tank had been trampled underfoot and in a few cases livestock were drinking directly from the main reservoir. Otherwise, these types of wars, with their high depth to surface area ratio, provide a much more reliable water source than the traditional shallow wars. Approximately 80 per cent of EEC wars had less than one metre depth of water (total war depth is seven metres) at the time of visiting in late February 1982 towards the end of the dry season and three were empty.

Two large wars are in operation at Bur Acaba with approximate capacities of 100 000 and 140 000 cubic metres. As with EEC wars one of these, the larger, has a pump, supply tank, and three water troughs. There is also a 100 mm diameter supply line, with flexible couplings, which leads into the town of Bur Acaba, although this was disconnected at the time of visiting. However, these two wars have a high depth to surface area ratio and must loose much water through evaporation. Open water evaporation is in excess of 2 000 mm per annum whereas the maximum depth of water is approximately four metres. Assuming the war fills completely twice per year, the 25 per cent of the water must be lost through evaporation.

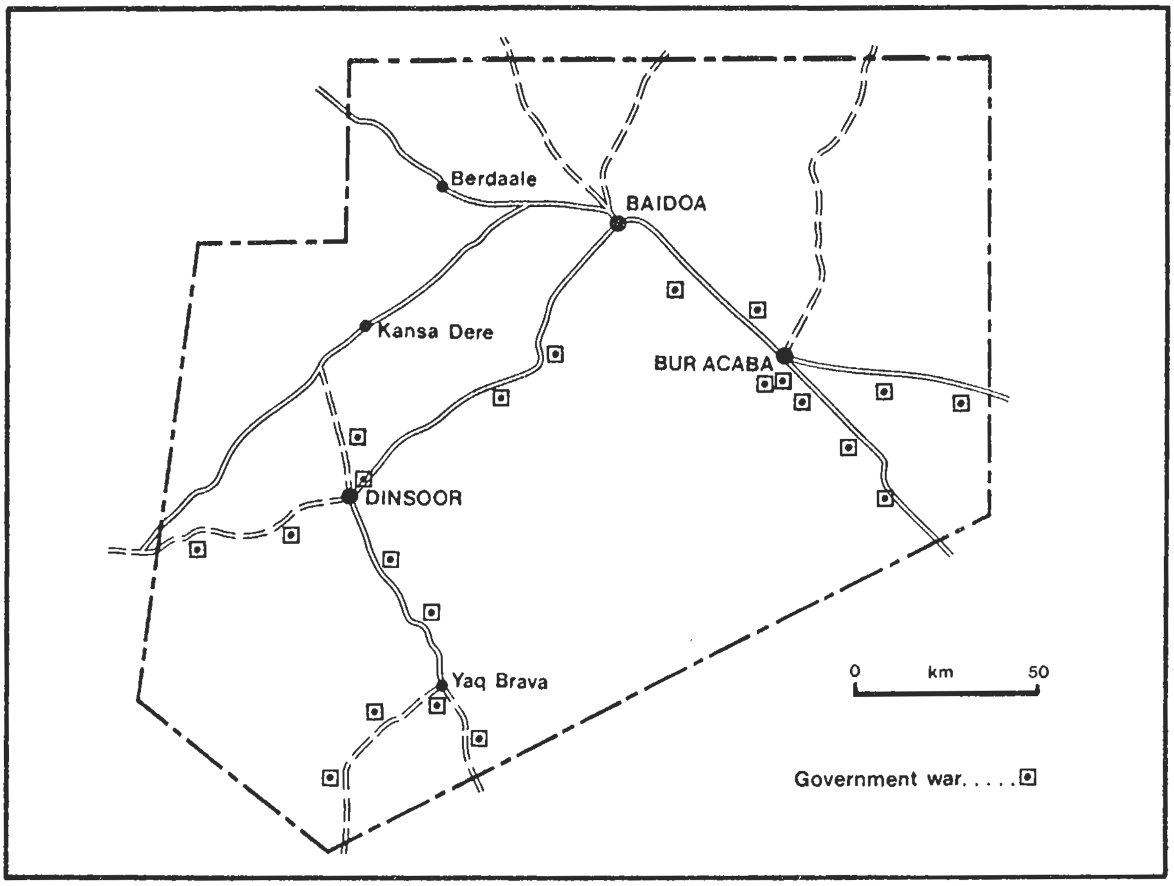
9.2 INFRASTRUCTURE

9.2.1 Communications

The efficient administration and commercial development of any region require the provision of an adequate communications network. Lack of transport infrastructure limits accessibility, restricts the supply of goods and dampens the incentive for expansion of economic activities. Impassability of roads during rainy seasons leads to a high rate of suppressed transport demand, particularly for passenger traffic.

Although there are graded air strips at Dinsor and Kansadere and a two and a half kilometre paved runway at Baidoa, air communications are not well developed. Since there are no railways in Somalia virtually all transport is by road. The main features of the road network in the Bay Region is shown on the 1:250 000 scale base map (Sheet No. 11).

9.1 Location of Government wars

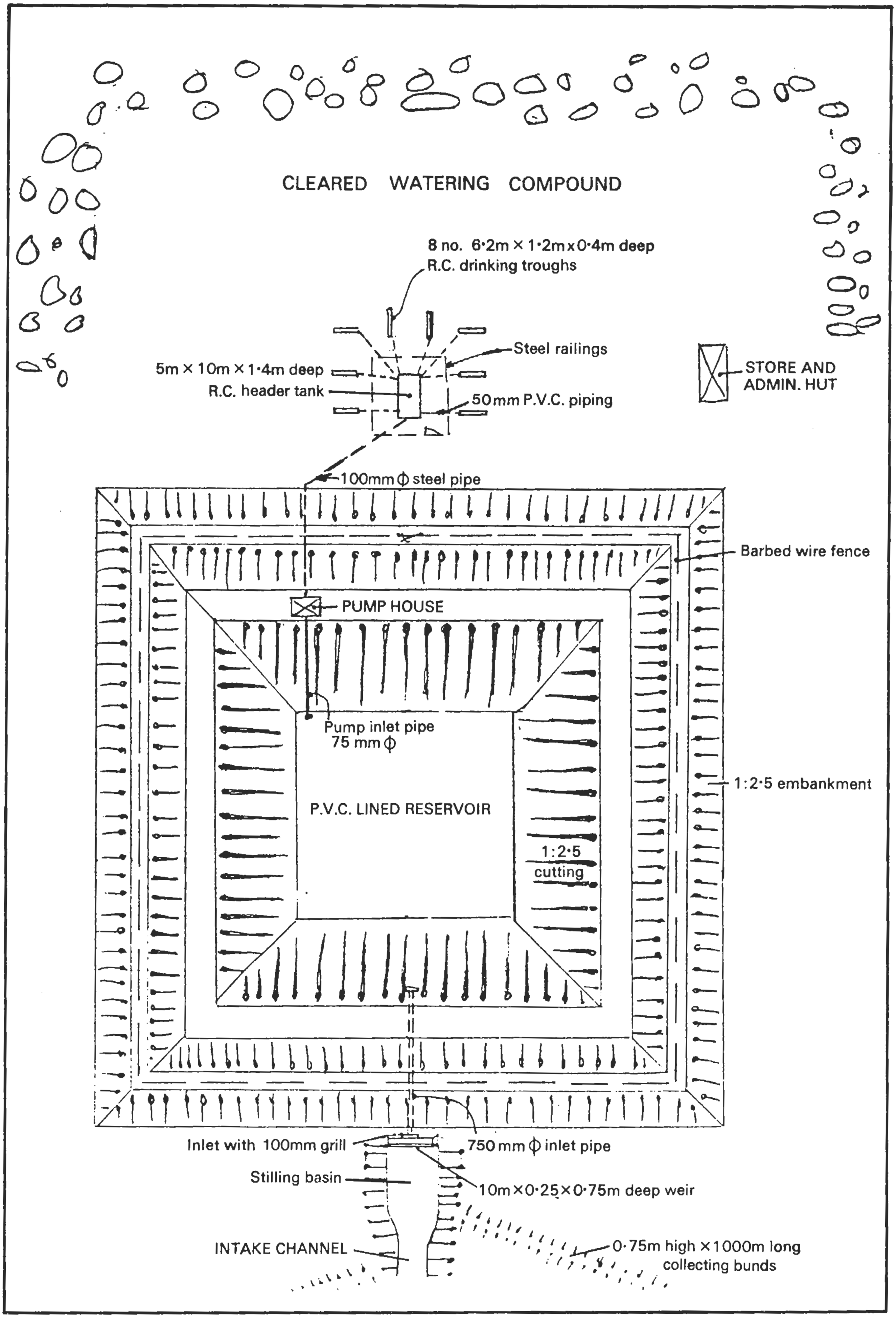


9.2.2 Existing Road Network

The only paved road within the region leads in from Mogadishu on the coast, through Afgoi on the Shebelli river, and through Bur Acaba in the project area to Baidoa. Three paved feeder roads, out of Baidoa towards Lugh Ganana, Dinsor and Uegit, were proposed in 1972 through the EEC food help programme, although only the Lugh Ganana road is now completed as a paved road.

The Afgoi to Baidoa road was constructed in 1971 with assistance from the International Development Agency and the European Development Fund. The road is 6.3 m wide and the finished surface 700 m above surrounding ground. The paving consists of 400 mm of asphalt concreting on a 300 m thick base of clay-sand-gravel mixture. The 7 year design life of the pavement has now elapsed and although the design wheel load was 4.5 tonnes the heavy trucks using the road frequently have wheel loads in excess of 6 tonnes. Much of the road is in a satisfactory condition although there are extensive sections suffering from undulations, pot holes and cracking of the surface. Surface cracking is particularly noticeable between Bur Acaba and Baidoa and the pavement has not been resealed since construction. (Details taken from Dorsch Consult, 1980). The road crosses extensive areas of black clay soils which have a very high expansion potential under wet conditions. Longitudinal cracks appear in the pavement and there is frequently excessive deformation under wheel tracks. Dorsch Consult (1980) recommend design CBRs of 7 for black clay soil, 5 for the red soils and 4 for alluvial soil for future developments in the region.

9.2 Commission for European Communities constructed well



The remaining road system consists of an extensive network of dirt tracks of varying condition. In general these tracks are in poor condition and for extended periods during the two rainy seasons they are impassable. For only half of the months in the year can one rely on unhindered transport. The supply or export of goods is very unreliable in the rainy seasons when more sensitive goods cannot be conveyed at all. Improvement to the tracks will accrue benefits in reducing overall transport costs, in reducing damage to goods and avoiding loss of weight of livestock trucked. Dorsch Consult (1980) estimate that improvements to the Dinsor-Gelib road, for example, would reduce transport costs to about 60 per cent for a gravel road and to about 50 per cent for a paved road. Road improvements would also allow the development of private transport and extension of bus services which at present only exist on the paved roads from Afgoi to Lugh Ganana.

The soils of the tracks are basically of three types: black soils, red clays and debris material. The transition from one to the other is frequently very fast providing a whole range of conditions, along the same track, which vary from rainy season to dry season. In dry seasons quite reasonable conditions prevail for relatively long distances but are interspersed with extremely bad conditions where the track is deeply rutted or is strewn with boulders, particularly along the limestone escarpment. The track from Dinsor to Ufurow for example, is very slow, crossing rough limestone pavement. In contrast the track from Dinsor to Yak Brawe crosses black soils and red clays which are quickly traversed in dry weather but are badly rutted in short sections. In wet conditions the reverse is true: the rocky roads are slow but usually passable and the clay soils are more often than not impassable. The black soils remain muddy for long periods and are by-passed by rough detours.

The Ministry of Public Works (1978) have given priority to the improvement of 3 280 km of road in Somalia. 1 120 km of these radiate from Baidoa:

Baidoa - Lugh - Dolo	230 km
Baidoa - Bardeera - Gelib	500 km
Baidoa - Uegit - Belet Uen	390 km

In particular the connection to Bardeera is seen as very important to development with the proposal to construct a hydro-electric and irrigation dam at Bardeera. Phase one of the construction of this road is now underway with base laid from Awdinle on a straight wide track which now extends beyond Ufurow. This road will improve access to the good rainfed agricultural land on the top of the escarpment.

9.2.3 Project Roads

A considerable portion of funding for the Bay Region Agricultural Development Project has been allocated to improvement of the existing road network. The original proposal included 558 kilometres of gravel road with an additional 250 kilometres of new tracks to provide access to areas capable of development. However, construction costs have increased and the programme of road improvements has been reduced. Project roads are now proposed as in Table 9.1 and are shown on the planning map (Sheet 5).

TABLE 9.1 PROJECT ROADS

Road Number	Location	Type[1]	Length (km)
2	Bonka - Uegit	C7	27
2	Bonka - Uegit	A6	43
4	Baidoa - Goof Gadey	C7	35
4	Goof Gadey - Dinsor	A6	60
4	Goof Gadey - Dinsor	B6	23
4	Dinsor - Yak Brawe	A6	50
6	Bonka - Tagaal	A6	40
6	Bonka - Tagaal	B6	20
7	Goof Gadey - Kansadere	A6	20
7	Goof Gadey - Kansadere	B6	30
9	Dinsor - Kansadere	A4	30
9	Dinsor - Kansadere	B4	10
10	Bur Acaba - Dolon Dole	A4	30
10	Bur Acaba - Dolon Dole	B4	20
10	Bur Dijis - Bur Heybo	B4	15
Total			**453**
Access tracks	To be decided	T3	250

[1] *A6 = 6 m gravel on good subsoil* *Class II*
B6 = 6 m gravel on black soil *Class II*
C7 = 7 m regravelling existing road

The road from Awdinle to Kansadere is currently under construction providing access to Bardeera dam and is not now to be funded from the BRADP allocation. A gravel road from Baidoa to Dolon Dole was originally proposed but is now considered to have low priority.

The design/construction procedure at the time of this survey was at the alignment stage. Construction equipment was expected to begin to arrive in mid-1982 and alignments were being agreed for the first sections from Goof Gadey to Kansadere. Quarry sites were located ready for the crushing plant to commence work. The first construction was to be regravelling of the Class II road from Baidoa to Goof Gadey.

The design specifications of these low cost roads seem to be adequate although no engineering soil analysis results were available for confirmation. The majority of the roads are to be 6 metre wide gravel on an 8 metre wide formation. Type A roads are to have 500 m embankment of good subsoil with 200 mm (compacted depth) of gravel top layer. Type B roads were to have a 400 mm embankment of poor subsoil with 300 m (compacted depth) of imported fill and laterite top layer.

The lack of provision of drainage was noted but the Project highway engineer indicated his intention to provide drainage ditches on the high side of all Project roads and camel tracks on the low side. Much of the existing track scheduled for improvement will be realigned since it is often sunken below the surrounding agricultural land due to compaction and erosion. The tracks thus act as drainage channels during periods of heavy rainfall and erosion is increased. The 700 mm high embankments together with the drainage ditches recommended should overcome this hazard. Stone and mortar fords are cheap and adequate for the small number of stream crossings, although attention must be given to detailing to alleviate erosion both upstream and downstream of fords.

Although the provision of further paved roads is desirable, for the level of funding available the proposed gravel roads would be adequate.

The choice of roads selected by the project for improvement is logical. The increase in accessibility will enable transport to operate throughout the whole year and will reinforce Baidoa as an agricultural and administrative centre for the whole region. However, once the road improvements are complete adequate provision must be made for maintenance.

The land units identified as suitable for expansion are located in the west and south west of the region. We recommend that the majority of the 250 km of 3 m wide access tracks are allocated to these areas. Suggestions for preliminary alignment of these tracks are indicated on the Planning Map Sheet 5, although adjustment to these preliminary alignments would obviously be required at the construction stage.

The Pilot Agricultural Development Units are each located on existing tracks and no specific allocation of project funds is envisaged for road improvements or building of new roads in these areas other than those already proposed.

9.3 IRRIGATION

9.3.1 General

In the absence of adequate perennial surface water resources in the Bay Region FAO/IBRD (1977) turned attention to groundwater resources and claimed to have identified a major extension of the Jurassic-Baidoa suite of the escarpment onto an area to the east of Baidoa previously mapped as basement complex. The resource was identified mainly from interpretation of satellite imagery and was believed to form a recharge area where large quantities of good quality water at shallow depth would be available for irrigation purposes.

However, HTS (1977) cast doubts on the assertions of FAO/IBRD and concluded that although the resource could exist there was insufficient evidence to guarantee the availability of large quantities of water for irrigation. Investigations up to the time of writing this report by the Bay Region Agricultural Development Project have been confined to the drilling of several trial boreholes in the west of the 'limestone depression' area. A detailed discussion of the hydrogeology of the area based on currently available information is presented in Chapter 4. As would be expected in this area of transition between basement complex and the overlying beds of the escarpment the geology is much more variable than FAO/IBRD originally implied. Permeabilities are generally quite low and areas with a sufficient yield for irrigation purposes are confined to more localised limestone deposits. Although there is an obvious danger in extrapolating the results of these investigations in the west of the 'limestone depression' to the whole area it seems unlikely that the geology will be any less varied. In short there is a high probability that such groundwater resources which do exist are insufficient to permit the economical development of any major irrigation scheme. Furthermore the present reconnaissance soil study suggests a substantial reduction in the area of land suitable for irrigation. The 60 000 hectares estimated as suitable by Lockwood/FAO (1968) is thus reduced between 10 and 15 thousand hectares immediately adjacent to the escarpment. In the river Asharow valley itself about 130 hectares adjacent to existing schemes could probably be developed.

Since no extensive irrigation development is likely, the attention of irrigation studies was directed to a review of existing small scale irrigation schemes which grow fruit and vegetables for local consumption particularly for Baidoa. It is envisaged that any future irrigation development would probably be restricted to similar small scale schemes. However, it must be stressed that the development of such schemes would be severely restricted by marketing constraints. In view of transport costs and the difficulty in transporting easily damaged fruit and vegetable crops the export of such goods to markets outside the Bay Region would not be economically viable. There is also a limit in the extent to which the local markets could be developed since supply for existing small schemes seems almost adequate, and the development of even such small new schemes is therefore unlikely.

9.3.2 Existing Irrigation Schemes

There are no extensive irrigation schemes in the Bay Region, existing irrigated areas being restricted to a few small schemes which draw water from springs issuing from localised perched aquifers on the edge of the escarpment to the north east of Baidoa, and to small schemes in the valley of the Togga Shiikh Asharow. Water is frequently drawn by hand and most irrigated areas are no bigger than garden plots.

The most significant of irrigated areas situated on the edge of the escarpment is Habare, some twenty five kilometres to the north east of Baidoa. There are approximately twenty hectares of arable land at Habare of which no more than one fifth is currently under irrigation. In 1980 a 4-horse power diesel driven pump was installed followed by a 3-horse power back-up the following year. These acquisitions have allowed an expansion of the area under irrigation which is currently continuing. Irrigation water derives from two shallow hand-dug wells which tap a local perched aquifer. The main well is approximately three metres square, hand-dug in limestone, and the static water level is two metres below ground level. Basin irrigation is practised with crops typically including paw-paw, coffee, onions, tomatoes, citrus, groundnuts, dates, mango and custard apple. The ground is undular and basins are not usually larger than five metres square. Water is distributed through 100 mm diameter flexible hosing which overcomes the problem of undulating land and also reduces distribution losses. There is little drainage problem in the shallow soils (typically 300 mm depth) which overlie limestone. Considering the adverse conditions of shallow soils, undulating land and small water supply the layout is of necessity irregular but the scheme is operated with acceptable efficiency.

The most extensive irrigation scheme is situated in the valley of the Togga (river) Shiikh Asharow immediately to the south of Baidoa. A map of the area has been compiled using aerial photographs and a ground (tacheometer) survey. The map is included as Figure 9.3. Parts of this irrigation scheme are reputedly well over half a century old.

The primary water source in the dry seasons derives from a spring which issues from below a seasonal waterfall in the bed of the Togga Shiikh Asharow. Below this spring a small reservoir feeds three shallow irrigation channels which are approximately 500 mm wide and lined with clay. Each channel feeds a small irrigated valley, one separated from the next by a small hill covered with dry scrub. In the dry seasons water issues from the spring at a rate of approximately 30 lites/sec. and supplies the northern half of the main irrigated area although an extensive network of small channels allows spring water to be distributed over the whole scheme. The secondary water source derives from a series of hand-dug wells which are 10 to 12 metres deep, on average, with a typical depth to static water level of 8 metres. These wells are sited in limestone conglomerates which presumably derive from limestone beds which dip into the escarpment. Only two of the wells in the main irrigated areas have pumps and the plots supplied by them are well managed. Pumping rates from these two wells are approximately 25 litres/sec. Two other wells appeared to provide a reasonable supply of water although they have no pumps at present and water drawn by hand is mainly for drinking. There are eight dry hand-dug wells, five of which are shown on the map. The locations of the remaining three were not accurately ascertained but are situated in the area marked 'A'. The wells are dry due to collapse of the side-walls just below the stone and mortar linings, probably after a period of heavy rainfall. Consequently the seepage faces are buried and it was not possible to assess their utility as a water source. However, at least one of these wells had provided significant quantities of water in the not too distant past.

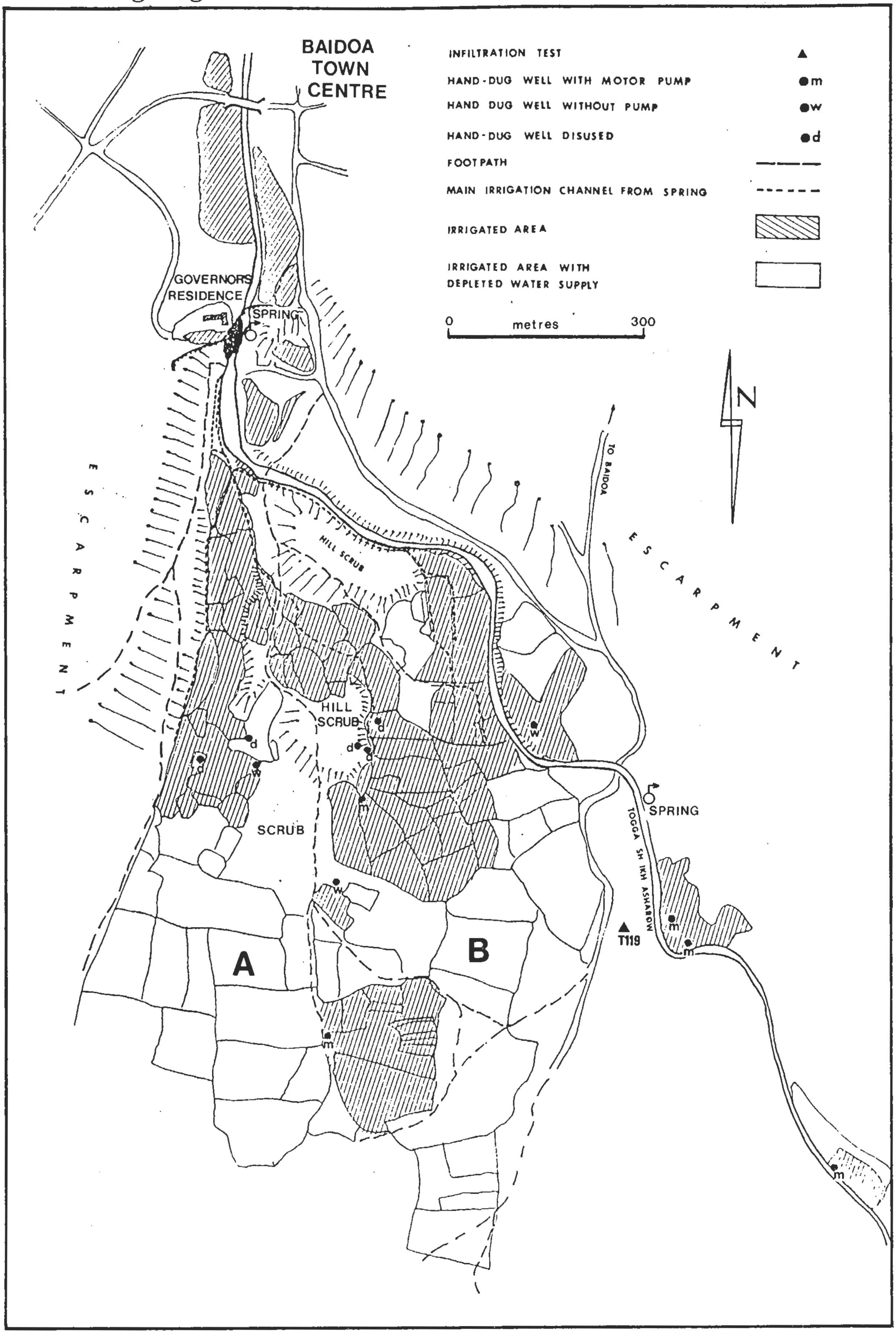
The ground slope is very steep over all, but the most southerly sectors of the schemes. Terraces are cut into the sides of the valleys and basin irrigation is practised. Infiltration rates are very high (an infiltration test undertaken at pit site T119 on Figure 9.3 gave a final infiltration rate of 208 mm per hour) and the basins are of necessity small, in most cases less than five metres square. The main irrigation channels follow contour lines with drops of up to two metres formed as stone cascades when the ground slope is too severe. The most eastern of the channels is cut into the steep western banks of the Togga Shiikh Asharow.

The crops include a wide variety of vegetables and fruits, including tomatoes, squash, chillies, onions, paw-paw, mango, banana, guava, citrus, bread fruit and sugar cane and supply the local market in Baidoa.

Further to the south along the banks of the Togga Shiikh Asharow there are several more irrigation plots, mostly of area less than one hectare. The locations of two such plots are shown in Figure 9.3. In this sector the Togga has water which issues from a perennial spring although the flow is often less than thirty litres per second. These irrigation plots abstract water from hand-dug wells very close to the Togga and diesel motor driven pumps lift water over the river banks into small distribution networks. Some of the main channels are constructed of stone and mortar. Water is abstracted at a peak rate of approximately 40 litres per second.

The total area of land which is laid out for irrigation, as shown in Figure 9.3 is approximately 52 hectares. Of this land an estimated 27 hectares (shown shaded) receive an adequate water supply from the spring below the Governor's residence and from the wells with motor driven pumps. The remaining 25 hectares appear to suffer from a depletion of water supply in the dry seasons. The scheme is remarkably well constructed and managed considering the adverse conditions which prevail: the terraces are neatly tailored to the contours of the land and main channels wind tortuously, passing along the sides of ravines and even beneath the roots of a large Ficus. Levelling of terraces has been laboriously

9.3 Existing irrigated area at Baidoa



achieved by hand and the whole scheme seems to have grown as a natural development rather than by a specific design. It is difficult to imagine a scheme better suited to this situation than the one which currently exists. Although initial distribution 'losses' may be considerable, since the clay lining to the main channel quickly cracks whilst not in use, these 'losses' are compensated for by growing fruit trees, particularly bananas, close to the channel, such that an automatic furrow irrigation is applied at the same time as the basins are watered.

The main requirement for any development is for improvement of the water supply to the area. Areas 'A' and 'B' in Figure 9.3 were suffering from inadequate water supply. It is possible that groundwater in this river valley is adequate to supply the whole of the area currently layed out for irrigation all the year round: the Togga Shiikh Asharow drains approximately 150 square kilometres of land on the escarpment which has the highest rainfall in the Bay Region. It is the largest catchment which drains southeastwards off the escarpment and although the Togga was not seen in flood spate the flow is said to be considerable. Recharge in the valley immediately below Baidoa into permeable local limestone beds may be quite significant. However, since most of the hand-dug wells had collapsed it was not possible to assess the extent of the groundwater supply. A trial borehole and pumping test in the area would help to determine whether or not development of this small resource is feasible though vehicular access to the area is difficult.

10

Land Capability

10.1 INTRODUCTION

The agricultural potential of the Project Area is variable and may be divided into:

- land suitable only for grazing;
- land potentially cultivable by rainfed cropping;
- land cultivated by rainfed cropping;
- land potentially suitable for irrigation subject to assured water supplies.

To a greater extent the land potential is controlled by the soil as modified by topography and parent materials. In general the land on the basement complex has a greater potential for grazing than for cropping and the reverse is true for the limestone plateau area, though there are important exceptions to this rule.

The purpose of the land capability assessment was therefore to identify the specific parameters of soil, terrain and range which affect land utilisation and to set limits to these parameters which would affect the sustained production of various agricultural crops and cropping systems or rangeland management; and at the same time, identify the needs for soil conservation measures.

Land is classified according to the USDA (1961) land capability classification system. This has, however, been modified in an important respect to meet local conditions especially with regard to rangeland capability. In order to accommodate the capability ratings for the rangeland a dual classification system has been employed on Map Sheet No. 4 at 1:250 000 scale. This indicates firstly the capability for rainfed cropping (including general rangeland potential) and secondly, it indicates the range capability based on an assessment of the vegetation map information. Rainfed cultivation would include sown pasture and forage crops. Rangeland is defined initially as only suitable for its current use of grazing by migrant livestock or capable of improvement by some form of controlled grazing. The degree to which this latter potential can be realised is indicated in the second capability rating for range.

The classification takes account of rainfall for rainfed cultivation but it does not take account of availability of irrigation water or ease of command.

Class I Land

Class I land is suited to a very wide range of cultivated crops. Topography is level. Soils are deep, generally well drained, easily workable, have adequate moisture holding capacity, are well supplied with plant nutrients, and reasonably homogeneous. The upper 100 cm should have no salinity and sodium hazards may occur between 100 and 150 cm. Class I (rainfed) land must receive at least 500 mm average annual rainfall.

Class II Land

Class II land is suited to a wide range of cultivated crops. Topography is level, and soils are deep and easily workable, but they exhibit certain deficiencies which may require fairly minor reclamation measures. The soils certainly require careful management for maintenance of good yields in the long term. The deficiencies may be impaired drainage, a tendency to show wide textural variations over short distances, or moderate salinity or sodium levels in the lower profile. Salinity levels must be nil or low above 50 cm, and may be moderate between 50 and 150 cm. Sodium levels must be nil above 50 cm, but they may be low between 50 and 100 cm, and moderate between 100 and 150 cm. Class II (rainfed) land must receive at least 500 mm average annual rainfall.

Class III Land

Class III land is suited to a limited range of cultivated crops. Topography is level and soils are normally deep, but they suffer from at least one deficiency which it is difficult to correct, and which reduces yields. Such deficiencies include poor moisture holding capacity, or severely impaired internal drainage due to an impermeable concretionary layer or massive clays in the subsoil. The latter may be a product of moderate to high alkalinity levels in the lower profile. Class III soils may suffer from mild deficiencies of plant nutrients, but they are not inherently infertile. Salinity levels are low or moderate above 100 cm, but may be high between 100 and 150 cm. Sodium levels are nil or low above 50 cm, but they may be moderate between 50 and 100 cm, and high between 100 and 150 cm. Class III (rainfed) land must receive at least 450 mm annual average rainfall or lie in the below 450 mm coastal strip. It includes land which in other respects qualifies for Classes I and II, but receives only 450 to 500 mm rainfall.

Class IV Land

Theoretically Class IV land can be reclaimed. In the context of this study, the very high cost of reclamation makes them unsuitable for the development of cultivation at present. In the project area, large areas of Class IV land coincide with fine textured, poorly drained saline-alkali soils. If they are brought into production in the future, rice cultivation appears to offer the best prospects.

On Class IV land the choice of crops is strictly limited, and it is termed marginal. Normally topography is level and the soils are deep, but they suffer from a combination of major deficiencies which are difficult to correct. These reduce yields and may lead to greater risk of crop failure. Deficiencies include very low inherent fertility, high erosion hazard, high salinity, high sodium levels and very severely impeded drainage. Salinity and sodium levels are moderate to high throughout the profile, and salinity may be very high between 100 and 150 cm. Class IV (rainfed) land must receive at least 450 mm average annual rainfall.

Class V Land (rainfed only)
This is a special land class. It is suited to a limited range of shallow rooting crops, but only under special systems of management. Topography is normally level. Soils are deep, easily worked, and inherently fertile. Average annual rainfall is less than 450 mm, but this can be overcome by the use of intensive cultivation methods in a mixed agricultural economy (involvement in livestock production counterbalancing in some measure the greater risk of crop failure owing to inadequate rainfall). Class V (rainfed) land is not suitable for large scale mechanised agriculture. In the non-mechanised sector, it is unsuitable for cultivation by people who own no livestock, or who are unfamiliar with intensive cultivation methods.

Class VI Land
Class VI land is unsuitable for arable cropping, normally because of non-level topography, shallowness of soil, high erosion hazard or a combination of these. Deep soils on level topography may be downgraded to Class VI if they are medium to coarse textured and inherently infertile. Similar soils containing (high) concentrations of gypsum or combining very high salinity and sodium hazards are Class VI.

This land has a moderate potential for development as rangeland, and a good potential for forestry development. Class VI includes soils on level topography which receive less than 450 mm average annual rainfall except soils whose favourable tillage characteristics qualify them for Class V (rainfed).

Class VII Land
Class VII land is unsuitable for cultivation. It has a low potential for development as rangeland, and a moderate potential for forestry development. Soils are shallow. Normally topography is undulating, and there is a low to moderate erosion hazard (by wind and/or water). Class VII land is particularly susceptible to overgrazing and requires frequent resting to avoid a decline in livestock carrying capacity.

Class VIII Land
Class VIII land is unsuited to cultivation and rangeland development. In favourable sites, it has a low potential for forestry development. Most Class VIII land is best set aside for wildlife or for grazing by migrant livestock such as camels and goats. Topography is undulating, rolling or hilly, soils are very shallow, and there is a high erosion hazard.

The range capability classification has not been applied to the main areas of cultivated land. In general existing cultivated land has priority for development over rangeland. The cultivated land units consist of presently farmed land, short and long term fallow, and abandoned land. The present range of the long term fallow and the abandoned land is poor due to the development of Acacia thickets. The short term fallow prior to thicket development is often of good quality but rapidly becomes ungrazable. Such localised and dynamic changes cannot be mapped successfully.

In the range capability classes vegetation physionomy and species component are the major limiting factors.

Class 1 Land
Excellent rangeland with high potential for development. Good physionomy, open stands of woody species with good penetrability, good cover and inherent species components. Few non-palatable species.

Class 2 Land
Suitable rangeland with potential for improvement at low cost by careful bush clearing or thinning. Medium to dense woody vegetation, with reduced penetrability, good inherent species components, few non-palatable species.

Class 3 Land
Marginally suitable rangeland requiring reseeding or prolonged exclusion to upgrade the range. Good physionomy, open stands of woody species with good penetrability but poor species composition, with a number of non-palatable species.

Class 4 Land
Land with little potential for improvement except at considerable cost. Medium to dense woody vegetation with reduced penetrability, poor inherent species components and a number of non-palatable species.

Class 5 Land
Land with little or no range development potential. Variable physionomy, high proportion of non-palatable species many of low preference, often overgrazed and misused.

10.2 CHARACTERISTICS THAT AFFECT LAND CAPABILITY CLASSIFICATION

10.2.1 Texture

Soil texture is the most commonly limiting factor, land is downgraded if the soil is excessively coarse or excessively fine textured: soils with coarser textures have low water holding capacities and excessive infiltration rates which severely restrict their use for rainfed cropping or reduce their irrigation efficiency. Fine textures adversely affect aeration and root penetration for most crops though in the case of soils with high contents of montmorillonitic clays, deep cracking and strongly developed structures are alleviating factors.

Soils with loam or friable clay textures are preferred and where significant depths of medium textured horizons occur within the top 120 cm they are generally placed in Class I. When fine sands and silts occur as a high percentage of the soil fraction especially in the surface horizons these have important implications for surface capping. This was observed to be widespread on the red soils developed on basement complex strata. To what extent this capping was also influenced by excessive trampling and overgrazing by cattle was not known but it severely restricts seedling emergence, plant growth and moisture penetration during rain showers.

Excessively stony soils are also limiting for crop growth and can seriously affect tillage operations for rainfed cropping. Concretionary and stony areas with extensive rock outcrops and limestone pavements are generally placed in Classes VI or VII and because they limit the vegetative ground cover have a low potential for rangeland.

10.2.2 Structure and Consistence

Many of the soils assessed as potentially cultivable and, in many cases already under cultivation, have features attributed to vertisols. These soils have a distinctive morphology which influences their tillage characteristics, soil-water relationships, chemistry and fertility. The expanding lattice (montmorillonite) clays of the vertisols have the capacity to expand and contract on wetting and drying respectively. In the dry state the soil develops a shallow friable surface mulch and vertical cracks to a depth of at least 0.5 m. These cracks separate the prismatic structural units and some of the friable surface washes down the cracks. When the soil is rewetted and expands pressure develops in the lower horizons giving rise to churning effect in the whole profile. This churning is reflected in the development of slickensides or slip faces, wedge shaped structures in the subsoil, gigai microrelief, and the presence of ferromanganese concretions scattered over the surface. Observed structure in these clay soils is largely a reflection of the soil moisture content at the time of survey. Structural development is best expressed in the dry state but in this condition the soils are very hard. When wet the clays slake causing the disintegration of structural aggregates producing a soil which is sticky and plastic.

These variations have important implications for tillage practices. The range of moisture contents within which tillage is feasible are limited, in the dry state cultivation is difficult due to the hardness producing cloddy surfaces and if mechanical cultivation is used a high demand for power. Tillage under wet conditions results in a puddled and massive soil with the attendant risk of clogging up wheeled equipment, so tracked equipment is preferred, although most tillage is carried out in the dry state in much of the area at present. These soils have a self-mulching property, that is the capacity to form a friable surface layer some 200 to 300 mm thick. This effect achieved under conditions of alternate wetting and drying can be used to reduce the need for tillage. It produces a fine seed bed through which water can move freely and enables the rapid development of the initial root system. It was noticeable that the local population preferred cultivating soils with this phenomenon rather than soils with a hard surface crust. In many areas the seeds are planted directly into this mulch and the only disturbance of the soil surface that takes place is restricted to the construction of shallow water conservation bunds or basins. Expansion forces at work in the subsoil can have an adverse effect on root development causing compression and splitting of individual roots. However, this phenomenon was not so strongly developed in the clay soils of this area.

10.2.3 Gypsum and Carbonates

(a) Gypsum

Gypsum occurs mainly in the subsoil horizons. Amounts and distribution varied significantly between sites but an examination of the data provides no real statistical significance. It takes two main forms:

(i) fine to very fine crystals;

(ii) fairly large lenticular crystals with dull faces.

The latter occur predominantly in the deeper subsoil layers.

Levels of gypsum in the soils of the main cultivable areas are not sufficiently high (range 1-10 per cent) to constitute a hazard and cause problems to crops or to effect significant subsidence in the subsoil.

(b) Carbonates

Calcium carbonate commonly accumulates in soils developed under arid and semi-arid climates. In the soils of the study area it was noted to occur in four main forms:

(i) small hard rounded whitish concretions up to 2 mm in diameter;

(ii) medium hard round whitish concretions up to 6 mm in diameter, occurring in only a few profiles;

(iii) very small crystals occurring as streaks or distributed throughout the soil profile. In certain profiles carbonates were found in fine crystalline form throughout the soil matrix;

(iv) very hard dark grey ferromanganese coated concretions up to 5 mm in diameter.

In general the presence of calcium carbonate affects both the physical and chemical characteristics of a soil. Discrete particles of carbonates can affect moisture characteristics and create an unfavourable environment for plant roots. However, carbonate concretions or nodules such as are found in the current survey area are less active than similar concentrations in a diffused form especially when the majority are larger than the critical size (0.02 mm).

The presence of carbonates in the soil reduces the ability of the soil to retain moisture especially at high tensions. It is noticeable that the moisture retention curves of highly calcareous soils, regardless of texture, are similar to those of coarse textured non-calcareous soils. These characteristics imply more frequent irrigation applications at relatively low moisture tensions (less than 1 atmosphere). Massoud (1973) has also noted that increased percentages of calcium carbonate in the soil result in the precipitation of carbonates in the pore space thus reflecting diffusivity.

Though capping is often severely developed on the sandy soils of the basement complex (Dinsor and Issur soils) it is likely that this is caused by a combination of binding by heavy rain drops and trampling during grazing. There do not appear to be any serious crusting problems with these soils due to high carbonate contents.

10.2.4 Soil Salinity

High salt contents in soils affect plant growth in different ways. One effect of high salinity is to increase the osmotic pressure of the soil:water solution. This effectively increases the tension with which water is held in the soil against the extraction effort of plant roots. This effect is most critical at tensions representing the upper limit of easily available water. At a conductivity value of the soil saturation extract of 4 mmhos/cm the osmotic pressure of the soil solution is increased by 2.4 atmospheres above one having only very small amounts of dissolved salts.

The second major effect of high salinity concerns the direct toxic effect of the individual constituents of soil:water solution. There is some evidence to suggest that for root crops, chloride is rather more harmful than sulphate. Within this area the dominant soluble salts are calcium and sodium sulphates.

In evaluating the soils for sustained irrigation the importance of the initial level of salt varies according to the ease with which salts can be leached from the root zone. The presence of high salt contents in permeable easily leached soils has much less significance than a much lower salt content in soils of limited permeability which are difficult to leach.

For the optimum yield for a wide range of crops it is desirable that the ECe of the root zone should not exceed 4 mmhos/cm. Two major factors control the equilibrium salt content that may be expected to develop under irrigation, the quality of the irrigation water, and the amount of water that can be expected to pass through and out of the profile as deep percolation losses.

The quality of the irrigation water used in this area at present is unlikely to cause any serious hazards to crops.

Salinity values for the routine samples analysed during the current study have been summarised in Table 10.1. Salinity classes have been adopted from FAO standards. 54 per cent of samples have a negligible salinity class with a value of 1.9 mmhos/cm or less, only 14 per cent of samples fall in the low salinity class with values of less than 3.9 mmhos/cm. A small percentage of samples have moderate and high salinity values. Figure 10.1 indicates the average salinity values in the different sample depths examined in the study for the main soils with agricultural potential.

TABLE 10.1 SUMMARY OF ECe (MMHOS/CM) VALUES BY SALINITY CLASSES AND SOIL MAPPING UNITS

Salinity class (after FAO)	Maximum ECe value	Per cent observations in main agricultural soils						
		All samples	Am	Ba	Br	Ua	Mo	VB
I Negligible	1.9	54	39	63	51	44	41	46
II Low	3.9	14	19	15	11	14	17	27
III Moderate	7.9	24	34	22	20	37	25	27
IV High	16	8	8	0	18	5	17	0
V Very high	>16	0	0	0	0	0	0	0

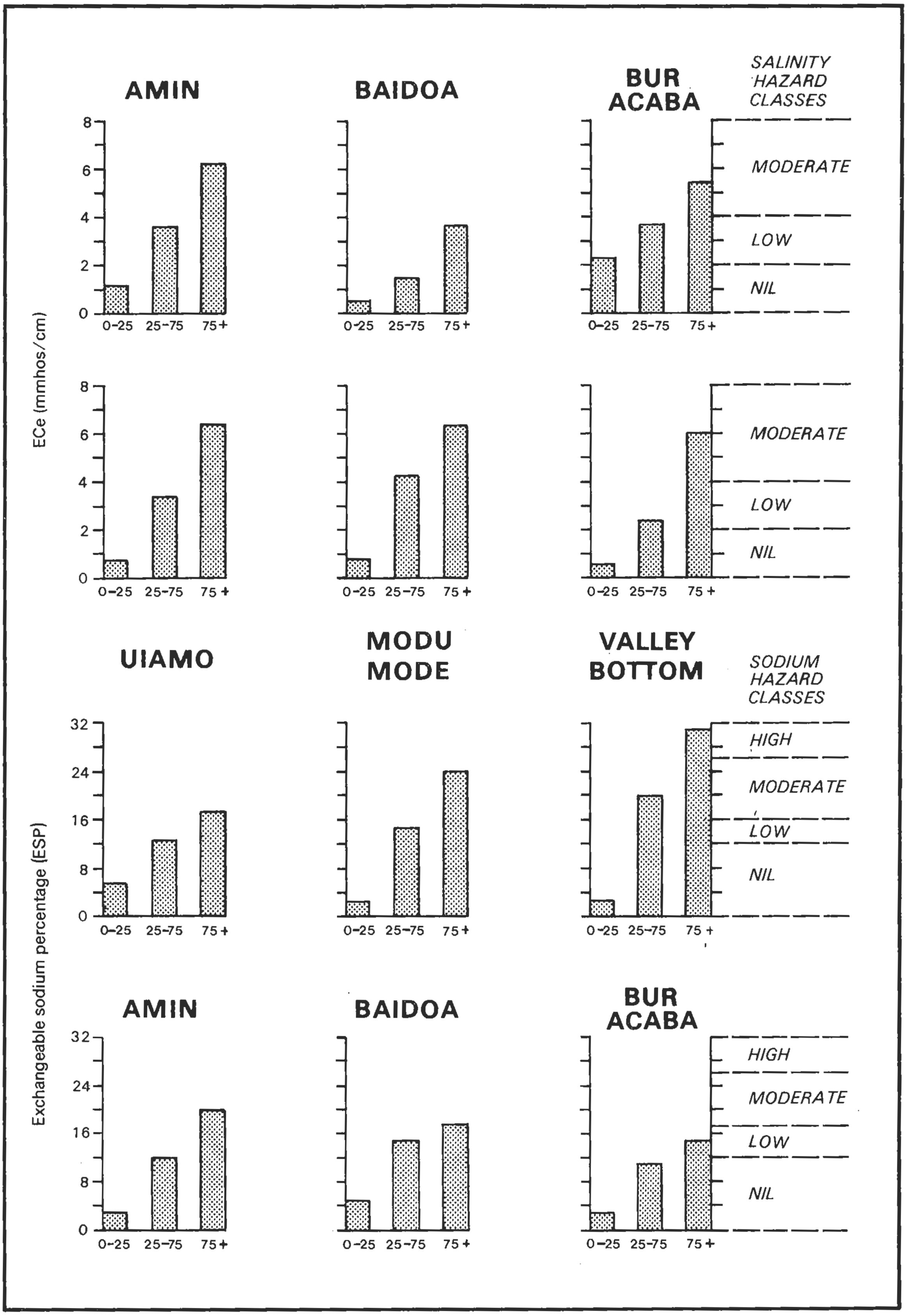
Some high ECe values were observed in samples collected from pits some time after they had been opened. Efflorescence on ped faces is a common phenomenon in the clay soils indicating that under conditions of evaporation soil moisture and salts were moving through the profile to the pit face. This phenomenon has been observed in clay soils throughout Somalia (HTS, 1978; MMP, 1979) where expected ECe values of 4-8 mmhos/cm actually exceeded 13 mmhos/cm.

From the limited number of samples collected in the irrigated land south of Baidoa there appears to be a significant increase in salinity levels in the surface horizons as a result of irrigation practices. At all three sample sites surface horizon values are at least twice those of the subsurface between 25 and 75 cm. Although only at one site T059 are they limiting to crop development.

10.2.5 Alkalinity

The degree of alkalinity in soils is most commonly expressed in terms of exchangeable sodium percentage (ESP). ESP is the percentage of the cation exchange capacity which is occupied by exchangeable sodium. The main effect is in the dispersion of the clay causing the soil to be dense and difficult to work, reducing the permeability and infiltration rates and in general making it a poor medium for plant growth. Finely dispersed clay may be washed down the profile increasing the clay content in the deeper layers. A soil is considered alkali when the ESP exceeds 15. This is also generally accepted as the limit beyond which deterioration in the soil's physical properties will excessively affect crop performance and cultivation. However, evidence from the Sudan and elsewhere (Dudal, 1965) suggests that in soils dominated by the swelling and shrinking properties of expanding

10.1 Salinity and sodium characteristics of main agricultural soils



lattice clays, little effect on yield results until ESP values are as high as 30. This is probably due to the fact that since the structure and permeability qualities depend almost entirely on the cracks which develop in the dry soil, high levels of sodium will not greatly alter this and movement of dispersed clay is likely to be very slow in these soils and again would have little effect in reducing permeabilities so long as the soil cracks. Some deleterious effect on tillage is likely but expanding lattice clay soils are not easily tillable irrespective of the level of exchangeable sodium.

The effect of irrigation on soils in respect of alkalinity depends on various factors. Soils with high ESP, but containing few soluble salts or alkaline earth carbonates will not improve on leaching, unless special ameliorating agents like gypsum, sulphur or carbonates are used. There is then sufficient calcium to progressively replace sodium on the exchange complex as leaching proceeds. However, when the soil itself contains gypsum in significant amounts there is enough calcium present to allow the ESP to be lowered naturally in leaching. The quality of the irrigation water is also important, SAR levels are often used to categorise the quality of water in respect of dangers of increasing the exchangeable sodium in the soil.

In terms of soil chemistry leaching would pose no problems as sodium and chloride ions which account for much of the soil salinity are mobile. The soils themselves contain considerable reserves of gypsum and exchangeable calcium and have low SAR values indicating that leaching of sodium ions should not have any adverse effect on soil permeability.

Table 10.2 summarises the main ESP values obtained from the routine samples. Most of the values fall below 12 per cent and most of the upper horizons have values of less than 5 per cent. Only a few values have been obtained from the deeper subsoil with critical values indicative of alkalinisation.

TABLE 10.2 SUMMARY OF ESP VALUES BY SOIL MAPPING UNITS

ESP groups	ESP hazards	Per cent of total routine samples	Per cent total observation mapping units					
			Am	Ba	Br	Mo	Ua	VB
0-12	None	64	63	49	55	67	59	46
13-17	Low	16	13	24	12	8	20	7
18-26	Mod.	12	13	17	17	8	12	20
>26	High	8	11	10	16	17	9	27

There has been some discussion (Gitec Consult, 1978) on the adverse effects of high magnesium plus sodium ratios to calcium in the exchange complex. An examination of the data for the current study indicates that the ratio of Ca to Na + Mg is mainly more than 1:1. Average values for all the samples show no unfavourable characteristics.

10.2.6 Topography

(a) Macrotopography

The overall landform of the cultivable lands is flat with slopes generally less than 0.5 per cent. Local irregularities exist especially south of the limestone plateau where some stream channels are incised into the clay plains with steep sided banks.

Topography is a major limitation on the escarpment where slopes often exceed 10 per cent; soils in this area are generally downgraded to Class VII (suitable only for rangeland).

(b) Gilgai Formations
Gilgai and sink holes are widespread features of the vertisolic clay soils in the area. Gilgai consists of a complex pattern of convex ridges and intervening depressions, orientated in a polygonal pattern, resulting from the alternate swelling and shrinking of the clays.

However, investigations have shown (HTS, 1978) that the cracking pattern and consequent gilgai formation is unlikely to develop under conditions of almost constant moisture regimes associated with irrigation. Severe gilgai formations are unlikely to reform in these soils unless they are allowed to dry out for significant periods. In most of these soils chemical characteristics detrimental to crop growth are rectifiable hazards and rarely occur above 0.5 m depth in the soils.

10.2.7 Derived Characteristics

(a) Soil Water Reactions
The predominance of the vertisol characteristics of very fine textures and expanding lattice clays have a profound influence on soil-water relations which is particularly significant for both irrigated agriculture and rainfed cropping. Due to the observed tendency for soil aggregates to slake on wetting, little stable macroporosity exists in the saturated soil and transmission of water is confined almost entirely to the very fine pores between the clay particles. The particular problems associated with irrigated land use on vertisols therefore involve water movement, specifically the efficiency of:

(i) entry of sufficient water to meet gross water requirements;

(ii) removal of sufficient water to meet drainage requirements.

HTS (1978) investigations of Shebelle alluvial soils have found that although water can be transmitted several metres laterally through the cracks of an initially dry soil, the cracking pattern which reforms after complete saturation of the soil is different from the original pattern. This tends to indicate that fissures and planes of weakness along which cracks could develop do not persist in the saturated state and that cracking cannot be depended on to significantly aid drainage in these soils. However, Booker McConnel (1976) suggest that cracks persist as minor features even after saturation of the soil and consequently aid drainage.

(b) Water Holding Capacity
The capacity of a soil to retain water available to plants has a direct bearing on the required depth and frequency of irrigation. It is also important in areas where rainfall distribution is unreliable and crops depend on residual soil moisture supplies over longer dry spells. In an irrigated crop regime available water capacity is not a limiting factor for rice which obtains its nutrients under anaerobic conditions. For upland crops easily available water capacity is probably the most important characteristic for irrigation in the land classification.

In general available water is water held in the soil against a pressure of up to approximately 15 bars. The pattern of water availability in the soil throughout the range from near saturation to wilting point is important. Soil water holding capacity and weight percentage at specific tensions have been obtained for a number of samples at 0.1, 0.3, 1.0 and 15 bars. These values have been converted to volume percentages by multiplying by the bulk density of the soil and have been plotted against the corresponding tensions in Figure 10.2 to obtain soil moisture characteristic curves. These samples were obtained from sites within the area selected for the irrigated land development studies.

The data in Figure 10.2 are based on information provided in Chapter 3. One of the problems of assessing available and easily available moisture contents in vertisols is the definition of the concept of field capacity. Farbrother (1972) adopted the view that to calculate available water capacity in these soils the difference between saturation (0 atmosphere) and the 15 bar percentage moisture contents should be used. Easily available water capacity which is used in calculations of irrigation interval requirements is based on the moisture held between 0.1 bar and 1 bar. In these two samples levels of available moisture are high indicating that despite high infiltration rates these soils have good moisture holding characteristics.

10.2.8 Soil Fertility and Toxicity

Average values for chemical characteristics obtained from the detailed analyses of the soil profile pits are shown in Table 10.3. Cation exchange capacity values are highest in the soils derived from the limestones. Lower values occur in the Bur Acaba soils and on the basement complex latosols. Levels of exchangeable calcium are very high particularly on the plateau soils. This is probably as a result of a breakdown of finely divided calcium carbonate in these soils which is apparent from the high levels of total carbonate present. Levels of exchangeable magnesium are also slightly influenced by the high carbonate contents. Levels of exchangeable potassium are fairly high and potassium tends to decrease with depth. K:Mg ratios are adequate and it is unlikely that these soils will show more response to potassium fertilisers.

10.3 CAPABILITY CLASSIFICATION CRITERIA

Eight main rainfed land capability and five rangeland capability classes have been recognised.

The most important criteria which affect these classes and which often introduce subclass limitations are discussed in the following paragraphs.

10.3.1 Soil Factors

Soil texture is the most commonly limiting factor and land is downgraded if the soil is excessively coarse or excessively fine textured. Soils with coarse textures have low water holding capacities and excessive infiltration rates, features which reduce irrigation efficiency and limit their development for rainfed crops. Fine textures adversely affect aeration and root penetration for dry foot crops, but have inherently higher water holding capacities which are important in rainfed cropping. In the classification the coarsest acceptable texture is a sandy loam containing at least 15 per cent clay. Textures coarser than this have limited available water holding capacity and low CEC values. Soils with textures as coarse or coarser than loamy sand are considered to be unsuited for both irrigation development even under sprinkler, and rainfed crops; while because of their erosion hazard especially on the basement complex peneplain they have little potential for range. Soils which are predominantly fine textured or contain significant fine textured horizons in the profile

TABLE 10.3 AVERAGE SOIL CHEMICAL CHARACTERISTICS

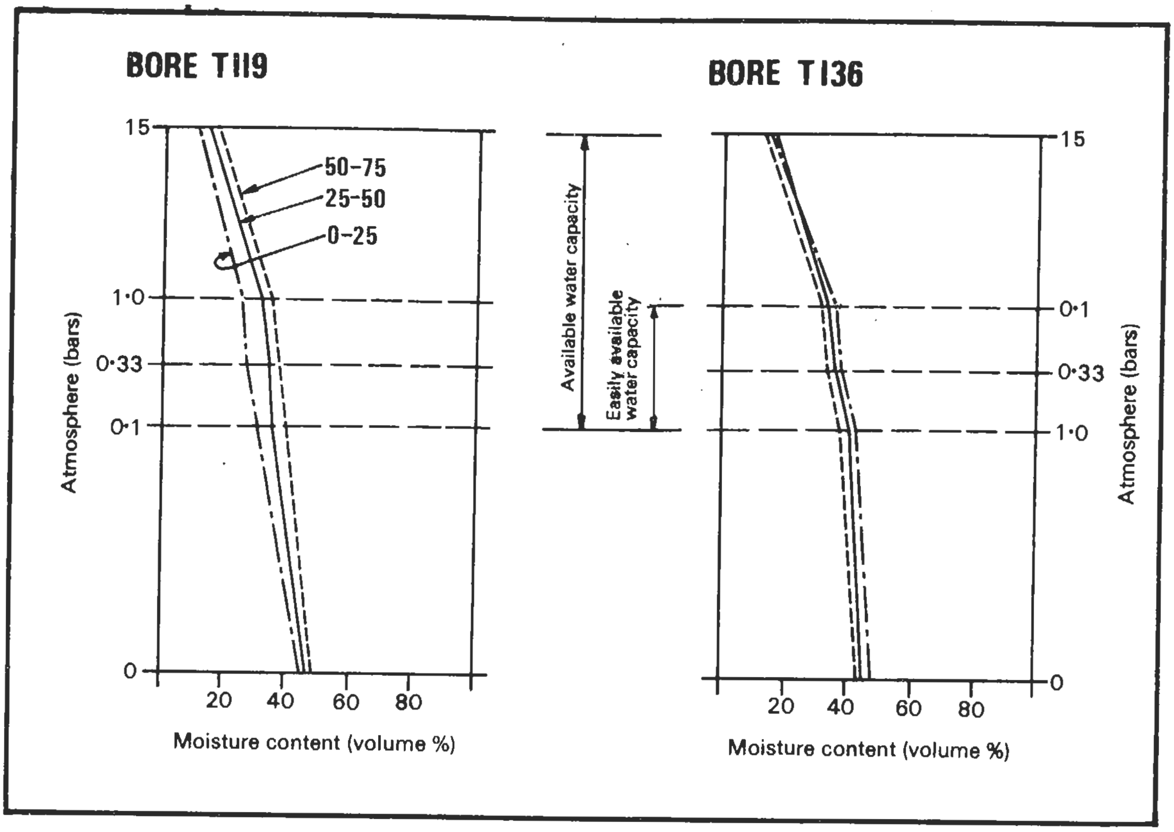
Mapping Unit		No. sites		ECe mmhos/cm	pH	CEC me/100g	ESP	Exchangeable cations meq/100g Ca	Mg	Na	K	Total carbonate %	Total gypsum meq/100g
Ua	Uiamo	6	surface	0.6	7.9	35.3	1	25.1	6.8	0.6	1.0	7.7[1]	1.0
			subsurface	2.5	8.0	37.7	9	23.2	9.8	3.6	0.4	10.0	1.5
Am	Amin	1	surface	0.4	7.9	43.1	2	33.0	8.0	0.9	1.2	8.3	0.9
			subsurface	4.4	7.9	40.7	14	42.7	11.9	5.9	1.0	7.8	1.2
Mo	Modu. mode	1	surface	0.3	8.0	40.5	4	30.4	9.2	1.4	0.4	2.9	1.1
			subsurface	3.5	8.0	44.4	11	28.7	11.3	5.1	0.3	6.6	1.7
Br	Bur Acaba	2	surface	0.6	8.0	32.5	1	21.9	6.8	0.4	0.7	9.7	1.4
			subsurface	4.9	8.0	34.6	24[2]	19.3	13.0	7.7	0.5	12.1	2.2
Ba	Baidoa	1	surface	3.5	7.6	48.3	2	37.7	10.9	0.9	3.2	2.7	0.6
			subsurface	7.7	7.6	47.0	9	42.5	15.7	4.4	1.0	2.4	0.8
As	Asharow	4	surface	0.6	7.9	26.3	1	16.5	4.8	0.2	1.3	38.0	0.3
			subsurface	0.9	7.9	24.3	1	15.0	4.4	0.3	0.7	43.1	0.5
Is	Issur	1	surface	0.7	7.2	22.2	3	11.7	6.1	0.7	1.1	1.2	0.6
			subsurface	0.4	7.4	29.2	5	12.7	6.3	1.4	0.3	0:0	0.6
V.B	Valley bottom	1	surface	0.4	8.0	27.9	4	16.4	7.5	1.0	0.7	2.9	0.8
			subsurface	5.3	8.1	26.3	29	12.5	10.7	7.1	0.5	2.0	2.4
Bd	Berdaale	1	surface	0.4	7.6	19.4	6	10.4	5.4	1.1	1.2	19.2	0.9

Notes:

[1] *Values for samples from 3 PADU sites only: irrigated studies are surface 45.8*
subsurface 51.5

[2] *0-100 cm value 13.2 per cent*

10.2 Soil moisture characteristics



are considered most suitable for rice development while medium textured soils are preferred for upland crops. In view of the predominance of montmorillonitic expanding 2:1 clays in these soils most have been downgraded one class for irrigated cropping of dry foot crops.

Extensive rock outcrops and limestone pavements together with concretionary surface deposits have more effect within the range capability classification. Areas of land with more than 50 per cent surface outcrops of limestone rock are usually unsuitable for rangeland because of the severe limitation that this imposes on the plant cover. Several areas with extensive concretionary surface deposits on the limestone plateau have also been downgraded to Class 4R with little rangeland improvement potential.

10.3.2 Alkalinity

Exchangeable sodium has been recognised as a soil factor liable to limit crop productivity. This limitation derives from a combination of the toxic effects of the sodium ion on plant nutrition and the deleterious effect on the soil physical conditions resulting from a relatively high proportion of sodium in the exchange complex. The exchangeable sodium percentage (ESP) is considered to be a more reliable yardstick for expressing the amount of sodium on the exchange complex relative to calcium and magnesium. An ESP of more than 15 in the root zone is normally considered to be injurious to crops (Russell, 1973) and this initial value has been used in the classification to downgrade lands.

Table 10.4 indicates some important relationships between alkalinity and salinity values and the land classes in this study.

TABLE 10.4 LAND SUITABILITY CLASSIFICATION - SALINITY AND EXCHANGEABLE SODIUM LIMITS

(a) Salinity

	Electrical Conductivity (mmhos/cm)		
Depth	0-25 cm	25-75 cm	> 75 cm
Salinity Class			
I	2 (nil)	2 (nil)	4 (low)
II	4 (low)	8 (moderate)	8 (moderate)
III	8 (moderate)	8 (moderate)	16 (high)
IV		no limit (very high)	

(b) Exchangeable sodium

	Exchangeable Sodium Percentage		
	0-25 cn	25-75 cm	> 75 cm
Sodium Class			
I	12 (nil)	12 (nil)	17 (low)
II	12 (nil)	17 (low)	26 (moderate)
III	17 (low)	26 (moderate)	no limit (high)
IV		no limit (high)	

Rice is more tolerant of alkali conditions and an upper limit of 25 is acceptable for Classes II and III for this crop in the upper horizons.

10.3.3 Salinity

In these areas salinity is considered to be a rectifiable hazard when considering irrigated crops. The quality of the water available for irrigation and the high content of available gypsum in the soil should allow sufficient movement of ions through the profile to prevent a salinity build up and correct any deficiencies. However, where a salinity hazard is combined with low permeability characteristics the possibilities of effectively and economically removing the salts are very limited, and in such cases the land has been downgraded to Class VI. For rice crops it is assumed that salinity build up under conditions of low deep percolation will not be so hazardous as for upland crops. However, rice is sensitive to salinity particularly at germination though this hazard can be overcome by growing in nursery beds and then transplanting. In the short term one would expect reduced yields at ECs of 4-8. In the longer term due to leaching overall EC will reduce and rice yields will not be subject to yield reduction due to salinity.

Table 10.5 indicates the general levels of salinity values accepted for standard depths of soil within each land class, under rainfed cropping development.

10.3.4 Topography

The main limitation to land development for irrigated cropping within this factor arises not from slopes but from uneven microrelief which requires considerable levelling before irrigation can be effectively developed. It is expected that much of the levelling that takes place will be carried out by mechanical graders. In this context areas where only slight levelling is required with less than 0.25 m cut and fill are placed in Class II, areas with an average cut and fill of up to 0.5 m cut have been placed in Class III. However, when classifying lands on topographic limitations, the removal of soil should be considered. In the deep clay soils there are no problems in the removal of surface soil and productivity

TABLE 10.5 SALINITY AND SODIUM CLASSES

Salinity - subclass e

I	O - O - O Issur Madamrodi Asharow Berdaale				
II	O - L - L Uiamo Modu Mode	O - L - M Bur Acaba	O - M - M Amin	L - L - L Dinsor	L - M - M Baidoa Cor Cor
IV	L - H - H Dudumai Burei	M - H - V Bardeera			

Sodium - subclass a

I	O - O - O Madamrodi Issur Cor Cor Asharow Berdaale Dinsor		
II	O - L - M Baidoa Bur Acaba Modu Mode Uiamo Dudumai	O - O - M Amin	
III	O - M - M Burai	O - M - H Valley bottoms	L - M - H Bardeera

Notes: Codes O-L-M, M-M-H, etc. refer to salinity or sodium levels in the 0-25 cm, first digit; 25-75 cm, second digit; and 75-120 cm, third digit according to the following specifications:

Hazard	EC (mmhos/cm)	ESP
O - None	0-1.9	0-12
L - Low	2-3.9	13-17
M - Moderate	4-7.9	18-26
H - High	8-16	>26
V - Very high	>16	

Note: Additional information from HTS (1977).

should be relatively quickly restored. In areas of severe microrelief development, where more levelling and soil removal may need to be carried out an additional hazard is exposure of more variable soil horizons. This produces a resultant decrease in efficiency of irrigated water use. Hence land downgraded to Class III on topographic grounds cannot automatically be graded/levelled and placed in Class I.

Land which has slopes in excess of the acceptable maximum limits for irrigated crop development (four per cent) are generally associated with undulating or rolling topography and moderately shallow to shallow soils. As a result they are generally unsuitable for cultivation, with various limitations for use as rangeland. Land with slopes of only one or two per cent has in some areas been downgraded from Class VI to VII or even VIII. This is particularly important in areas of heavy grazing where the herbaceous cover is reduced to almost nil at the end of the dry season. In these areas run-off is very rapid, even on slopes of only one or two per cent. Moisture penetration into the soil profile is reduced and fewer plants germinate. As a result topography is considered a major constraint to development and the land is downgraded to Class III.

10.3.5 Derived Characteristics

(a) Permeability

This factor is based on a combination of observed soil characteristics and, where possible, measured values for horizontal and vertical hydraulic conductivities. Profile drainage characteristics are largely determined by the soil texture and surface drainage. Deficiencies in soil permeability are considered to be permanent and non-rectifiable. This is particularly important when irrigated cropping is considered.

However, within the soils considered for irrigation in the present studies there are no indications that internal profile drainage will lead to an adverse build up of salts, especially in the Asharow soils.

Land which would have been downgraded on poor internal drainage characteristics for irrigation would probably have already been downgraded because of heavy textures or poor surface drainage. Class I soils are usually moderately well or well drained.

(b) Infiltration

This is primarily of importance for irrigated cropping. A Class I soil would be expected to infiltrate the normal crop irrigation requirements in an eight hour period. This being the length of the normal working day. Optimum infiltration rates for gravity irrigation purposes are in the general range of 7 to 35 mm per hour (USBR, 1953). Only two sites were examined in the current studies and both had rates in excess of this figure. It is likely that the use of small basins practised on existing schemes is indicative of high infiltration rates on the Asharow soils.

10.3.6 Rainfall

Rainfall distribution is discussed more fully in Chapter 2. While the contribution of rainfall to irrigated agriculture can be important its major effect in determining land for cultivation is obviously in the rainfed sector. Average annual rainfall is incorporated into the rainfed land suitability classification of deep soils on level topography as follows:

- Above 500 mm rainfall area.
- Rainfall adequate. Land class (rainfed) determined by pedological characteristics.
- 450-500 mm rainfall area.

- Transitional zone. All soils pedologically suited to Classes I and II downgraded to rainfed Class III.

- Below 450 mm rainfall area.

- Rainfall inadequate. Land downgraded to rainfed Class VI (unsuitable), unless special characteristics qualify it for rainfed Class V.

In some places the 450 mm and 500 mm isohyets will constitute rainfed land class boundaries in the areas of cultivable land.

10.3.7 Plant Factors

These are primarily used in the range capability assessment. Range physionomy, species component and palatability, and penetrability are all important criteria. Areas of vegetation with good penetrability and physionomy have a higher capability for improvement and development than areas of dense thickets, low penetrability and variable physionomy. Species component, especially palatable species, are significant indicators of range capability and areas with larger numbers on non-palatable species and a poor inherent component have a lower capability rating.

10.4 LAND CLASSES AND SUBCLASSES

On the map the factors which either singly or in combination result in land being designated to a particular land class are shown using the following subclass symbols:

s - soil characteristics - texture, profile drainage and structure;
a - sodium hazard;
e - salinity hazard;
t - topographic restraint.

The salinity and alkalinity subclass limitations have been derived from an analysis of these values obtained from the routine sample analyses, as shown on Table 10.6. These characteristics have been combined in Table 10.7 to provide an overall assessment of the lang capability of each soil mapping unit for irrigation, range and rainfed cropping under different rainfall regimes. The relationship between the various subclass limitations for each soil unit are discussed in the following sections.

10.4.1 Amin Soil

This soil has a low to moderate salinity hazard and a low sodium hazard. It is unlikely to occur in any areas with sufficient water for irrigated crop development but has been placed in Class IIae. Most of these soils lie on the 450 to 500 mm p.a. rainfall area and because of their well structured surface horizons and ease of tillage are Class IIae for rainfed cropping. Areas of these soils which lie outside the 450 mm isohyet are placed in Class Vae (rainfed). It is unlikely that any further expansion of cropping could take place on these soils which have up to 72 per cent of their area cleared at present. It is also likely that the present system of minimum mechanised tillage helps to maintain the soil's surface structure and prevents subsurface soil compaction.

10.4.2 Asharow Soil

This soil was only separately differentiated during the semi-detailed irrigation area studies. It has no salinity or sodium hazard. Rainfall in this area is generally favourable for rainfed cropping and the main limitation is the broken topography of the valley areas. It has been placed in Classes I and IIt for irrigation and rainfed crops.

TABLE 10.6 LAND CLASSES AND SUBCLASSES

Soil Unit	Symbol	Salinity Class (e)	Sodium Class (a)	Irrigation	Range	Land suitability Classes annual rainfall >500 mm	>450 mm	<450 mm
Amin	Am	II	II	III	-	II	III	V
Asharow	As	I	I	I	-	I	I	II
Baidoa	Ba	II	II	III	-	II	III	V
Berdaale	Bd	I	I	II	-	II	III	V
Bur Acaba	Br	II	II	II	-	II	II	V
Modu Mode	Mo	II	II	III	-	II	II	V
Uiamo	Ua	II	II	III	-	II	III	V
Valley bottom	VB	II	III	IV	3	III	III	VI
Issur	Is	I	I	VI	3	IV	IV	VI
Dinsor	Di	I	I	VI	5E	IV	IV	VI
Madamrodi	Mr	I	I	IV	3	-	IV	VI
Burei	Bi	IV	III	IV	3	-	IV	VI
Bardeera	B	IV	III	IV	4	-	-	V
Dudumai	Du	IV	III	IV	4	-	IV	VI
Cor Cor	RCr	II	I	VI	4R	VI	VI	VI
Regosols	R	-	-	VI	4R	VII	VII	VII

TABLE 10.7 LAND CAPABILITY UNIT AREAS (hectares)

Rainfed agriculture	Rangeland	Area (hectares)
IIae	-	375 782
IIIae	-	204 485
IIIs	3	19 796
IVs	2	48 799
IVs	3	610 071
IVs	4E	93 916
IVae	1	58 007
IVae	2	52 022
IVs	5E	544 598
IVae	4	40 052
IVae	3	206 248
Vae	4R	200 338
VIs	3	119 697
VIs	2	374 746
VIs	4	91 153
VIs	4E	22 098
VIes	2R	89 785
VIs	4R	3 224
VIae	3	9 375
VIs	5E	109 569
VIIs	3	73 660
VIIs	4R	304 769
VIIst	4E	30 845
VIIst	4R	2 300
VIIes	4R	184 830
VIIIst	4R	197 040
		4 067 205

TABLE 10.8 LAND CLASSIFICATION AREAS LIMESTONE DEPRESSION SURVEY

Land Class (irrigation)	Land Class (rainfed)	Area (ha)
I/IIt	I/IIt	8 220
IIst	IIt	2 180
IIs	I	4 050
IIIae	IIae	13 797
IVae	IIIae	3 180
VIs	VIs	45 310
		76 737

There is some evidence from existing routine analyses that without adequate supplies of water to permit through drainage of water supplies in the profile, salinity levels can build up in the surface horizons of this soil. As a result any irrigation development in these areas should take account of this factor.

10.4.3 Baidoa Soil

This fine textured soil is Class IIae for irrigation, because of a moderate salinity hazard in the subsurface horizons. Surface horizons are well structured and, in most of the areas in which they occur, rainfall is sufficient for adequate development under rainfed crops. Where rainfall exceeds 500 mm p.a. they are Class IIae (rainfed), lower rainfall areas are Class IIIae. As in the case of the Amin soils limited mechanised cultivation will help to maintain these surface horizons' fine structure and tilth. It is possible that over time mechanised cultivation will lead to compaction and smearing of the subsurface horizons which will require expensive amelioration treatment. At present up to 72 per cent of this soil unit is cultivated and it is unlikely that there are many areas for further expansion of cropping.

10.4.4 Berdaale Soil

The deeper phases of this soil in the limestone depression appear to have no salinity or alkalinity hazards, and are placed in Class IIs for irrigation. Most of the shallower phases have little agricultural potential and have been downgraded to Class VIs, and where topography is limiting to VIst.

Areas of these soils which have been identified adjacent to the Baidoa soils on the plateau have been placed in Class IIIae for rainfed cropping where rainfall is adequate (above 500 mm p.a.) and IIIae elsewhere.

These soils are variable in nature and at the reconnaissance level of survey it was not possible to identify and map all this variation. As a result although these soils are not as extensively cultivated as the Baidoa soils it is likely that most of the area with the highest potential are already cropped and there will be little opportunity for further expansion of the cropped areas.

10.4.5 Bur Acaba Soils

Small areas of these soils near to the escarpment were identified during the semi-detailed studies in the limestone depression with very low salinity sodium hazards and these are placed in IIs (irrigation). Elsewhere these fine textured grumosols have a low salinity hazard and a low to moderate sodium hazard and have been placed in Class IIIae for irrigation. Where rainfall exceeds 450 mm they are Class IIae (rainfed), because of their well structured surface horizons and ease of tillage. To the east and north east of Bur Acaba rainfall is below 450 mm p.a. and much of this area has been downgraded to Class Vae (rainfed). It is also possible that more detailed surveys in this area would reveal pockets of shallower soils less suited to rainfed agriculture.

Although the intensity of cultivation within the Bur Acaba soils is lower than for the other grumosols in the study area, variability of rainfall and pockets of shallower soil limit the potential for expansion of crop areas on these lands. Up to 50 per cent of the area is currently cultivated and this may well represent the optimum level.

10.4.6 Modu Mode Soils

This well structured fine textured soil has a low salinity and a low to moderate sodium hazard. It is placed in Class IIIae (irrigation). Most of these soils have been mapped in the more favourable rainfall areas with an excess of 450 mm p.a. and are placed in Class IIae (rainfed).

These soils have one of the highest intensities of cultivation in the Project Area, from field observations it appears unlikely that there is any land available for expansion of cropping.

10.4.7 Uiamo Soils

The levels of salinity and sodium observed in the Uiamo soils identified during the semi-detailed studies in the limestone depression were not limiting for irrigation and most of these soils are placed in Classes IIs and IIst in that area. Elsewhere there is a low salinity and sodium hazard and they are placed in Class IIIae for irrigation.

These fine textured soils have favourable tillage characteristics and are well structured. Where rainfall exceeds 500 mm p.a. they are Class IIae (rainfed), between 450 and 500 mm rainfall Class IIIae (rainfed) and Class Vae where rainfall does not exceed 450 mm.

The Uiamo soils are cultivated over about 45 per cent of their current area. In many places there appears to be a long term fallow rotation practised. To what extent this is due to variable rainfall or differing social conditions is not known. However, it seems likely that these soils have a greater potential for controlled expansion of the cropping area to an intensity nearer to that found on the Baidoa soils to which they are similar in many respects.

10.4.8 Valley Bottoms

Except where areas of the Asharow soils have been positively identified these soils are very variable. Most valley land has been placed in Class VIs. Limited areas identified during the course of studies in the Buulo Fulaay area have a moderate salinity and sodium hazard and these have been downgraded to Class IVae (irrigation) and IIIae (rainfed).

10.4.9 Issur Soils

These medium textured soils are mainly latosolic with no salinity or sodium hazard. They are considered unsuitable for irrigation (Class VIs), although it is unlikely that they occur in any areas with water available for irrigation. In areas with more than 450 mm p.a. rainfall they are placed in Class IVs (rainfed). These soils have a low inherent fertility and a low capacity to retain nutrients against leaching and are generally better suited to rangeland development (Class 3).

10.4.10 Dinsor Soils

These are somewhat coarser textured latosols with no salinity or sodium hazards. They are Class VIs (irrigation) and because of their low inherent fertility and susceptibility to erosion Class IVs (rainfed) and Class 5E (rangeland). In areas with less than 450 mm p.a. rainfall they are Class VIs (rainfed).

10.4.11 Madamrodi Soils

This soil has medium textures and rather variable characteristics, there is no sodium or salinity hazard but it is downgraded because of coarse textures to Class IVs (irrigation). They are regarded as marginal for rainfed (Class IVs) because of low moisture holding characteristics. Areas outside the 450 mm isohyet are downgraded to Class VIs (unsuitable for rainfed). Most areas of these soils support good rangeland and are placed in Class 3 (range).

10.4.12 Burei Soil

This soil is placed in Class IVae (irrigation) because of a high salinity hazard and a moderate sodium hazard. It is unlikely that there will be sufficient water for irrigation available in areas where this soil is mapped. In the 450 to 500 mm rainfall areas it is Class IVae (rainfed), but outside the 450 mm rainfall isohyet it is downgraded to Class VIae (rainfed). The rangeland on the Burei soils has a moderate to good potential and it is placed in Class 3 (range).

10.4.13 Bardeera Soil

These soils are classed as marginal for irrigation (Class IVae) because of salinity and sodium hazards. Despite low rainfall they have some agricultural potential and are Class Vae (rainfed). These Bardeera soils occupy small areas in the west of the Bay Region and it is not thought that they have any potential for larger scale expansion of the cropping area.

10.4.14 Dudumai Soil

This fine textured soil has a high salinity hazard and is Class IVae (irrigation). Most of these soils occur in the lower rainfall areas and are Class IVae (rainfed), where rainfall totals are below 450 mm p.a. it is downgraded to Class VIae (rainfed). It is Class 4 (range).

10.4.15 Regosols

These soils which include the concretionary phases (RCr) cover approximately 1 371 230 ha on the limestone plateau. They have no agricultural potential (Classes VIes and VIs to VIIst) and are Class 4R (range).

11

Agricultural Planning

11.1 INTRODUCTION

In this chapter the areas where land resources are currently underutilised are summarised, and the infrastructure (mainly water supplies) necessary to enable them to be brought into use for either arable farming or grazing of livestock are identified. In addition, the IBRD Appraisal Report plans for the 'Intensification of the Farming System' are reviewed in the light of information available to the present study. Finally some preliminary agricultural planning proposals are made.

11.2 THE POTENTIAL FOR AGRICULTURAL EXPANSION

11.2.1 Arable Farming

Whilst there is potential for intensification of production within the existing area of cultivated land there is also potential for expansion of the cultivated area. Map Sheet 5 indicates areas in which some of this expansion is already taking place naturally both as a result of population growth and from land pressure. It also shows those areas where the total potential cultivated area has not yet been realised. If it is assumed that the percentage of cultivated land in stratum 1 as derived from the aerial census, which stands at approximately 75 per cent, is the optimum, then on this basis there is room for expansion of the cultivated land area up to this percentage for a number of strata as shown in Table 11.1.

TABLE 11.1 UNUTILISED LAND POTENTIAL

Geomorphic unit	Main soil types	Per cent land area still available for cultivation
5	Amin	65
8	Uiamo	30
20	Uiamo	60
10	Bur Acaba/Modu Mode	20
12	Valley bottom/clay plains	65
24	Asharow/valley bottoms	60

These theoretical increases do not, however, take account of the limitations that exist within these geomorphic units, in respect of soil and other conditions, which will affect the degree of utilisation.

On the basis of the revised data resource base provided by the current studies it is unlikely that further large scale expansion of the cropping area is feasible within strata 10, 12 and 24. Most of stratum 10 which includes the Bur Acaba and Modu Mode soils falls outside the 450 mm annual rainfall isohyet. This limitation together with unfavourable chemical characteristics in the subsoil make much of the Bur Acaba soils east and northeast of Bur Acaba only marginal for rainfed crop production (Map Sheet 4). The Modu Mode soils in the northwest of the stratum have a higher rainfall regime and are generally more extensively cultivated. For these reasons further areas for crop expansion are not thought to exist in the Bur Acaba and Modu Mode soils.

The clay plains of stratum 12 include areas of the Burei soils. More detailed observations were carried out within parts of this stratum for the PADU sample surveys at Buulo Fulaay. Subsoil characteristics and soil structures are generally unfavourable for crop production. The soils are very compact and cloddy when dry and because of moderate to high sodium levels disperse and are difficult to work when wet. It is likely that crop expansion presently taking place in this area will become confined to small pockets of more favourable soils. Less favourable sites will become abandoned on a trial and error basis by the farmers themselves, unless more detailed soil surveys are conducted.

Semi-detailed soil investigations were also carried out in the stratum 24 area as part of the studies of irrigation potential. The chemical characteristics of the soils in these areas are generally more favourable for crop production under both rainfed and irrigated conditions. Some expansion of crop production is already taking place in the eastern parts of the area. Stratum 24 lies close to the escarpment and receives considerable run-off during the rainy season. Some areas of erosion of the clay soils were observed and any expansion of cropping onto the less utilised clays would need to take into account careful conservation measures to prevent further degradation of the landscape.

The areas with the greatest potential for the expansion into unutilised areas were tentatively identified in the Interim Report (April, 1982). These included strata 5, 8 and 20. At that time a lack of available water supplies for domestic use was identified as the primary cause of this phenomenon. Map Sheet 3 which shows the major permanent water sources in the Region clearly indicates a lack of water within stratum 5. Much of the land is cultivated in this area on a migratory basis with no permanent villages and only temporary homesteads are established during the rainy seasons. The people return to Kansadere during the dry season. However, a further lmitation is the somewhat lower annual rainfall which may render crop production more marginal. The soils although showing many similarities with those nearer Kansadere are often shallower with a tendency to become more droughty and less able to retain available moisture. For this reason only about 7 000 to 8 000 ha of land are thought to be suitable for crop expansion in stratum 5.

Strata 8 and 20 are covered mostly by Uiamo soils. Parts of stratum 8 fall within Land Suitability Class IIae (Map Sheet 4) with more than 500 mm of annual rainfall. This class also applies to most of the Baidoa soils in stratum 1. On the basis of existing mapping it appears that much of this area is already extensively cropped with some natural expansion into underutilised land. The Consultants do not anticipate much potential for further expansion into this part of stratum 8. Within much of the remainder of strata 8 and 20 the Uiamo soils are placed in Land Suitability Class IIIae. This class is suited to a limited range of cultivated crops. Topography is level and soils are normally deep but they suffer from at least one deficiency which is difficult to correct and which reduces yields.

Although these soils may suffer from mild deficiencies in plant nutrients, they are not inherently infertile. Generally levels of sodium are low to moderate below 50 cm and these are accompanied by massive clays in the subsoil. A long term fallow rotation was observed in the Buulo Guduud area which may possibly be related to crop production difficulties on the Uiamo soils. As a result although up to 95 000 ha of land not at present used could be cropped it is likely that the actual potential area for cropping is smaller. It has been assumed that between 35 000 and 40 000 ha occur in stratum 8 and between 25 000 and 30 000 ha occur in stratum 20.

11.2.2 Irrigation Development

One of the main concepts that was used as a basis for the development of irrigation in the area was the presence of a large body of groundwater in the so-called limestone depression south of the escarpment. The work of the Consultants has so far failed to reveal any significant quantities of groundwater-bearing limestone in this area. It is also unlikely that sufficient water will be available for the size of irrigation areas envisaged in the IBRD Appraisal Document. Our studies have also shown that within the area originally outlined as likely to contain groundwater, a gross area of only about 24 400 ha is likely to have any agricultural potential and this lies mainly in the valleys of stratum 24 in the west of the area.

The Consultants feel that given these constraints to additional irrigation development the BRADP could more successfully devote its resources to improvement of the existing data based on the on-going irrigation schemes in the Shiikh Asharow valley. It is estimated that there is approximately 100 ha of irrigation development in this area. These schemes are well run and produce a variety of tree, fruit and vegetable crops. Assistance could be provided by the BRADP in the form of advice through the extension service on improvement of water use and irrigation efficiencies, irrigation layouts and design and the marketing of crops. It is apparent that the area is water short particularly at the end of the dry season after the 'Der' rains. Most of the crops produced are marketed locally in Baidao and it is unlikely that significant expansion of irrigation in the area would be able to produce crops that could compete with markets outside the immediate environs of Baidoa.

11.2.3 Underutilised Grazing

The field investigations and the aerial census of livestock populations have indicated extensive areas of range which are probably underutilised in the dry season. The majority lies in a broad band to the south of the region (in strata 14, 17, 18, 19, 21, 22, 25 and 29) a total of 703 800 ha and the remainder lies on the northeast (strata 4 and 28), a total of 461 200 ha. Permanent watering points found during the field survey (wars, hand-dug wells and drilled wells) together with wars administered by the National Range Agency, and information from the Water Development Agency on drilled wells are all plotted on Map Sheet 3. A ten kilometre belt around each watering point shows the main extent of dry season grazing. It is apparent that these strata coincide with areas generally water short during the dry season when the census was carried out.

The range in these water short areas was found to be in a noticeable better condition than those areas near existing watering points. On this basis it appears that there is scope for opening up these areas of dry season grazing by the creation of more permanent sources of water supply. Most of these strata occur in areas where there is potential for groundwater development either on the coastal plain or the limestone plateau. It would also appear feasible to construct more wars similar to those provided under the EEC programme in 1974. However, it will be important to establish more data on movements of stock during the wet season into these areas. It is possible that this underutilised dry season grazing represents an important wet season grazing resource and that the lack of watering points confines grazing to the wet season. This enforces a natural period of resting in the dry season and acts as a self-regulating mechanism to prevent overgrazing of the resource.

11.3 REVIEW OF EXISTING AGRICULTURAL PROPOSALS

11.3.1 General

The agricultural proposals in the appraisal report have been conceived on the understanding that the Region is a traditional livestock area in which nomadic pastoralists have relatively recently turned to producing arable crops and that the systems developed are unstable and cannot be sustained in the absence of surplus land resources. They assume that the present systems are characterised by land being cropped continuously until yields reach uneconomic levels and the family moves elsewhere to start the cycle again. They also assume that so far there has been little positive effort to integrate livestock and arable activities.

The investigations completed during the current study do not confirm the above. They suggest instead that arable farming has been practised in the Bay Region for many generations and, contrary to the view that the system is characterised by shifting cultivation, the systems practised in the major areas of cultivation (i.e. the clay plains: strata 1, 8 and 10) are long established, stable and well adapted to their agroecological environment. Besides this there is a considerable degree of integration between livestock and arable activities. Of these areas, which together account for about 320 000 ha of cropped land (86 per cent of the total), expansion of cultivation is only noticeably rapid in land system unit 8. Outside these areas expansion is proceeding rapidly in the more marginal rainfall areas (strata 5, 12, 20 and 24), two of which, units 5 and 24, have markedly longer fallow periods with fallow and recently abandoned land together accounting for about 50 per cent of the land in the cultivation cycle.

Although there is a fundamental disagreement over the background and stability of the existing farming systems, the broad components of the agricultural intensification programme are considered appropriate. These include adaptive research, field trials, extension, veterinary services and the seed farm at Bonka. The detailed proposals are considered in the following sections where suggestions for modification are also made.

11.3.2 Adaptive Research and Field Trials

The adaptive research and field trial programme would have two main components: the strengthening and training of the research team at Bonka, and the establishment of four pilot agricultural development units (PADUs).

(a) Strengthening of Agricultural Research

The permanent staff at Bonka are to be increased and there is to be a general upgrading of their skills. Research programmes are to be broadened and activities are to be adapted more towards the immediate needs of farmers. In particular varietal screening, moisture conservation practices, improvement of farm tools, use of animal power for land preparation, row seeding and intra-row cultivation, improving seed quality and integration of crop and animal production on farm and rangeland and identification of proper crop/pasture rotations are mentioned. Research programmes would also be carried out in farmers fields at carefully selected locations (one in each of the four districts) to reflect variations in soil and rainfall.

The increase in permanent staff has to some extent already been effected. Sites for field trials have been selected at Daynuunay, and at Kansadere and trials combining varieties and insecticide variables will be carried out in the 1982 'Gu' season.

Whilst the proposals to strengthen the research units and the emphasis on adaptive research is strongly supported it is suggested that experiments with animal draught and crop/pasture rotations are delayed; at least until a much greater understanding of the farming systems has been obtained.

(b) The Pilot Agricultural Development Units (PADUs)
The aim of the PADUs is to determine how best farmers and pastoralists may be organised so that they are motivated to preserve the productive potential of their land. The model is based on 750 farmer families, each with access to 10 ha of cultivable land, five of which are planted with arable crops and five are fallow. A comprehensive and highly sophisticated programme of field trials are to be carried out on 10 farms in each PADU. The programme would examine a long term rotation of four years successive cropping followed by four years ley and include variables such as combination of plant populations, types of grain crop, with and without manure and interplanted crops. Although the primary objective of the ley is to replenish soil organic matter to the extent that a long term acceptable yield can be sustained, it would also provide forage for fattening and draught stock.

Besides their arable land, farmers would have access to 55 000 ha of rangeland which is to be provided with two water sources and divided into eight camps of approximately 6 875 hectares. These camps would be for the sole use of the PADU members, stock numbers would be controlled and rotational grazing practised. Methods of range rehabilitation such as seedling with legumes would be tried and the use of the rangeland monitored intensively. A Rangeland Assistant and 12 guards would be provided to assist with stock number control and efforts would be made to involve and use local village authorities.

The Consultants believe that the proposals for range management within the PADUs will require amendment. First it is impracticable to consider rangeland development for existing communities in terms of predetermined size and resource ratios indicated and, secondly the highly complex relationships that exist between local and migrant livestock and the grazing areas adjacent to cropping land together with crop residue grazing, have to be understood. The fundamental amendment suggested is that instead of concentrating on identifying typical areas the emphasis should be changed to identifying receptive communities who could be persuaded to adopt practices which would lead to the achievement of project objectives.

Taking arable and rangeland together a major difficulty with the PADUs is that it would be almost impossible to find a group of farmers which would confirm to such a rigidly defined model. In the first place grazing rights to a block of 55 000 ha of range may not be exclusive to a group of arable farmers and, secondly, throughout the majority of the cultivated areas the cropped land accounts for over 90 per cent of the land in the cultivation cycle and fallow abandoned land no more than 10 per cent. The other major disagreements with the proposals are as follows:

- two lots of field trials i.e. those to be carried out by the Bonka Research Station and those on the PADUs cannot be justified given the demand for skilled manpower to carry them out;

- the emphasis on building up organic matter through the establishment of grass leys on these soils, which are predominantly clays and inherently fertile cannot be justified. In any case organic matter accumulated over a four year period would be oxidised within the first season of cultivation and would contribute little;

- given the present limited knowledge of the farming systems, the role of animals in providing draft power for land preparation is not at all certain and hence the assumption that the major constraints to more widespread use of animal draught is the scarcity of feed in the dry season, has yet to be confirmed;

- the proposed trials, with their sophisticated experimental design and data collection and analysis systems, are unlikely to be implemented as the project will not have all the scientists necessary to carry them out.

In conclusion it is difficult at this stage to see a constructive role in the agricultural development of Bay Region for a PADU based on the model conceived in the appraisal document.

11.3.3 Extension

Agricultural extension throughout the country is to be reorganised and strengthened under a separate project, the Agricultural Extension and Farm Management Training Project. Bay Region is one of the priority regions and thus will benefit from the Project. Whilst liaison would be maintained between the two projects, the BRADP would engage an extension specialist to ensure that the results of the adaptive research programmes were appropriately packaged for delivery to farmers by the Regional Extension Service. Also, it is suggested that already sufficient is known to formulate a simple extension package focusing on improved land preparation, planting in rows and optimal plant densities, that has the capacity to improve yields without additional cost.

Whilst the proposals to reorganise the National Extension Service and to make trained Field Extension Agents (FEA) available to the Bay Region are considered necessary, the assumption that a simple package involving the practices suggested are likely to be appropriate or even acceptable is disputed. There is considerable evidence that the present system practised by a majority of farmers is already well adjusted to the environment and that the farmers use their existing resources effectively. For instance plant densities vary from area to area probably reflecting reliability or variability of rainfall, and moisture conserving practices such as planting in small basins and minimum tillage are widespread. Minimum tillage also probably contributes to reducing weed populations and hence requirement for weed control.

An important omission in both the research and extension aspects of the project is the absence of proposals for pest control; particularly control of stemborer also (*Chilo partellus*) which probably accounts for losses of up to 20 per cent of the crop.

11.3.4 Veterinary Services

The major project component aimed at improving the livestock sector is the upgrading of the Regional Veterinary Service to enable it to provide adequate cover throughout the Region. This expansion of the service is based upon an increase in the staff establishment and infrastructural support principally through the provision of additional dispensaries, staff housing, livestock handling facilities, vehicles, offices and field equipment and their operating costs. In addition a supply of drugs and medicants are to be made available for resale with supplies renewed through a revolving fund.

The service is intended to become more readily accessible to an increasing number of livestock producers through:

- the siting of field staff and dispensaries at strategic points within each of the four districts, and

- the provision of two mobile vaccination teams, one per two districts to carry out the larger scale preventative and treatment programmes.

The project target of 30 functional dispensaries within the District has to be modified because the finance available for an additional 13 dispensaries, is based upon the assumption that 17 were already in existence, (in fact there are only two at Ufuro and Yak Brawe). The information now available concerning livestock movements and areas of high livestock concentration provides a good basis for the selection of dispensary sites.

Implementation priorities should be directed towards the control and prevention of diseases that put the national flock/herd and human population at risk and those diseases that can only be more effectively controlled, on a national or zonal basis e.g. rinderpest, foot and mouth disease, and anthrax. However, as livestock owners are generally uncooperative over routine vaccination programmes, the inclusion of tick control measures, although of doubtful economic benefit within the field programme may provide the stimulus for the acceptance of an increased disease prevention programme.

11.3.5 The Seed Farm

The Seed Farm at Bonka is to be expanded to about 200 ha and staff are to be trained in seed farm management and threshing, cleaning, handling and storing seed. In addition the farm will provide facilities for manufacture, repair and maintenance of animal-drawn implements. An expatriate Farm Manager/Seed Production Specialist will be assigned to the farm.

It is doubtful, however, whether it is necessary to deploy an expatriate on an almost full-time basis to running this farm, given that support could be provided from time to time by the expatriate sorghum agronomist recently appointed to the research station at Bonka. This is particularly important as the number of technical assistance posts available to the project are limited and there are other areas of specialism where assistance may be more needed.

11.3.6 Conclusions

From this review it is recommended that some of the detailed proposals contained in the current agricultural plans (IBRD Appraisal Report) should be amended. The main points are as follows:

(a) Low priority should be given at this stage to experiments with animal traction in the adaptive research programme.

(b) The field trials proposed for Bonka and the PADUs are too sophisticated and are unlikely to be carried out given the shortage of skilled manpower.

(c) Trials with grass leys aiming at building up organic matter cannot be justified on technical grounds.

(d) There is unlikely to be a constructive role for a PADU as conceived in the Appraisal document and it is recommended that this component be abandoned.

(e) It is unlikely that an extension package of simple low cost techniques that would give a dramatic increase in yields, is currently available. Much more work with farm systems research and adaptive research will have to be done before worthwhile packages can be formulated.

(f) Pest control, particularly stemborer in sorghum is a serious problem which the project should make every attempt to overcome.

(g) It is unlikely that deployment of a full-time expatriate on the seed farm at Bonka can be justified. It is suggested that the agronomists at Bonka Research Station could provide whatever technical assistance is necessary from time to time.

(h) The target for veterinary dispensaries in operation may have to be reduced from 30 to 15 because there are fewer existing dispensaries functioning than originally estimated.

11.4 PRELIMINARY AGRICULTURAL PLANNING

The current study has added to the resource data available to agricultural planners in the Bay Region. Detailed information on land use, particularly the distribution of cultivated land and the breakdown of land within the cultivation cycle in terms of the proportions cropped, ploughed, fallowed, abandoned, burnt, etc. is now available. The data on livestock (numbers and distribution in the dry season) on houses, water supplies and other physical infrastructure have also been improved. Besides this, work in the field has produced information on the soils, land capability, vegetation and range, movements of livestock, herd composition in terms of age and sex distribution and some indication of the current levels of productivity.

The principal gap in knowledge remaining is concerned with an understanding of the farming systems being practised. A thorough understanding of these is essential to the formulation of detailed programmes which address the farmers needs. In particular more information is required on the following:

(a) The major problems and constraints recognised by the farmer.

(b) The efficiency with which farmers use the main factors of production, soil, water and labour. Are there any simple cultural practices such as row planting that will produce significant increases in yield at relatively little cost or will the introduction of new technology such as improved crop varieties have to be relied upon?

(c) The extent to which existing plant populations are adapted towards the environment. There is some evidence that plant populations are lower in the drier areas and that it is reasonable to expect that the populations will represent a compromise between a level which is high enough to take advantage of reasonable rains but low enough to ensure at least a modest crop if the rains fail.

(d) The extent to which livestock and arable activities are already integrated on farms in the region. Stover is used for fodder and farmers are aware of the benefits from animal manure.

(e) The relative importance farmers attach to yields of forage and yields of grain from their sorghum crops. To what extent are they prepared to sacrifice yields of grain for yields of forage?

(f) The use of animal power in land preparation or other cultivations.

(g) The importance of the present practice of minimum cultivation in moisture retention and reducing weed populations.

(h) The extent to which the present pricing policy for grains acts as an incentive or disincentive to increasing production.

(i) Farmers' attitudes towards the introduction of other cash crops such as groundnuts and sunflower.

Although some of the questions raised above may be partly answered at present, much more information is required before detailed planning can be undertaken with confidence. This is only likely to be obtained by the establishment of farm system and adaptive research programmes. Whilst some progress is being made with the latter, there has been little systematic collection of agro-economic or socio-economic data at the farm level so far.

11.4.1 Farm Systems Research

Immediate priority should be given to designing and implementing a field survey programme to systematically collect socio-economic and farm management data on the existing farming systems. Besides providing the understanding upon which realistic planning could be based it would also serve as a baseline survey for the Region and a starting point for introducing a continuous system of monitoring and evaluation.

The survey would be organised so that main centres of cultivation (strata 1, 5, 8, 10, 12 and 20) and the major agro-ecological zones were adequately covered by a formally selected representative sample from each. It would aim at documenting such aspects as family size, areas cropped/fallow, and types of crops, crop husbandry and yields, numbers and types of livestock and grazing areas and livestock and grazing management, and productivity of the various types of stock. It should also aim at establishing the degree of interdependance between livestock and arable farming and identifying farmers constraints and problems.

It is logical that responsibility for collecting the majority of this information should be with the Monitoring and Evaluation Unit. The Unit, however, does not have the resources to undertake this work at present. Given its importance to the preparation of agricultural programmes it is considered that the support of an expatriate technical assistance specialist is warranted. The specialist would probably have an agricultural or farm management economics background with extensive experience and a particular interest in smallholder farming systems.

11.4.2 Agronomic Research

The two reports prepared by Mr. D. Schmid for BRADP following a consultancy assignment at the Bonka Research Station provide an excellent account of the research programme carried out at Bonka during the 1981 'Gu' season (more details are included in the Bonka Research Station Progress Report, 1981) and some perceptive guidelines for future research programmes. The Consultants have little to add to these proposals other than re-emphasise the need for specialists (economists, rural sociologists, agronomists, plant protection and animal specialists) to work together in formulating research programmes. The following priority areas for research are noted from Mr. Schmid's report and considered entirely appropriate by the Consultants:

(a) screening of introduced genetic material (e.g. ICRISAT) and selection from local land races should continue to be a priority at the station;

(b) research into dryland farming techniques and methods of moisture conservation should continue to be important. The need to liaise with other research institutes such as the Kenya Dryland Farming Station at Katumani;

(c) testing of other commercial crops, groundnuts and sunflower in particular;

(d) pest control trials to measure the effectiveness of existing controls and other potential on controls of the region's major pest stemborer (*Chilo partellus*) in sorghum;

(e) research into new crops such as perennial shrubs and trees to provide browse for livestock.

Mr. Schmid's report also sets out a sequence of research activities starting with trials at Bonka followed by trials at sub-stations in the districts, field trials in farmers' fields and finally demonstrations in farmers' fields.

Given the importance of stemborer as a pest and the high proportion of grain losses in storage, it is considered that a technical assistance specialist (probably an entomologist) in plant protection would be justified.

11.4.3 Extension

Provision of extension in the Bay Region will continue to be the responsibility of the National Extension Service which is being strengthened by the implementation of the Extension Training and Farm Management Project. Although there will be close ties and coordination between the two projects, provision of extension will not come directly under BRADP. This could lead to some conflict of interest particularly over deployment of staff and frequency of staff transfers.

Whilst there is no well tried and proven package of practices or innovations to offer farmers at the moment, there is clearly a worthwhile role to be fulfilled until these become available. It is essential that the full complement of trained FEA are in post as rapidly as possible. Already four District Extension Agents and 35 FEAs are in post.

Their immediate role would be to make contact with their farmers, gain their confidence and establish workable relationships. They could initiate discussion groups in which farmers and livestock owners can inform them of their major problems and constraints which would provide a focus for research activities. If they are going to make an impact, however, they will have to have something to offer. Two possibilities are pest control and the introduction of oilseeds.

The high incidence of stemborer in sorghum and the damage it causes is probably the most obvious and important problem recognised by the farmers. It would probably increase the status of the service in the eyes of the farmer if the service were to become involved in plant protection and demonstrated a capability to assist in control of this pest. The plant protection services of the MOA already assigns an officer to the extention service, so it is unliekly that there would be a conflict of interest if extension agents became involved in the distribution of insecticides.

Another possibility is the promotion of oilseed cultivation in the Region. Already farmers are showing a considerable interest in groundnuts and sunflower. This could be encouraged by the service if it were to introduce oilseed into their demonstration plots and where possible assist with distribution of seed.

12

Livestock Development

12.1 INTRODUCTION

The livestock studies carried out during the 1978 long dry (Jillal) season comprised an aerial census backed by ground survey conducted during a three month period from February to April. Together they aimed at estalishing:

- the numbers and distribution of stock during the dry season;

- the general direction of movement of stock;

- the herd composition in terms of age and sex distribution;

- some indications of livestock productivity and health.

Whilst a considerable body of information was assembled, the study cannot be regarded as much more than a starting point. Further census work should be carried out in the main wet (Gu) season and a great deal more information on livestock movement, management and productivity is required before a thorough understanding of the current livestock systems is obtained.

In summary the 1982 Jillal season studies indicated that livestock numbers particularly cattle and goats have probably increased significantly since 1975, about 83 per cent of all livestock are managed under semi-nomadic systems, productivitiy is generally low and apart from veterinary there are few services for livestock in the Region.

Despite the contribution of the current study the development proposals in the following sections contain a major element of data collection through the introduction of more regular and systematic livestock surveys and establishment of trial and demonstration units. They also emphasise the need to broaden the current livestock services giving attention to improving husbandry and raising productivity in addition to improving animal health. The proposals are described under the following headings:

- Extension and Farmer Training
- Investigations
- Grazing Resource Development
- Animal Health
- Marketing

12.2 FARMER TRAINING AND EXTENSION SUPPORT

Improvement in livestock husbandry and management without the establishment of owners is unlikely to be achieved without the establishment of an effective livestock extension service. None of the existing agencies, the Veterinary Department, Animal Production Division of the MLFR or the National Range Agency provide extension advice on livestock husbandry management. The Agricultural Department activities are limited mainly to the operation of a pest control service while the USAID financed extension project has so far been confined to crop production.

It is imperative therefore that livestock extension is introduced and this is regarded as having highest priority in the development proposals outlined. The Consultants believe however, that livestock and crop extension should be provided by a single extension service. The reasons for this are as follows:

- the majority of arable farm families are also livestock owners;

- a single service would enable greater efficiency in use of buildings, vehicles and equipment and significantly reduce administrative costs;

- the primary function of the service will be communication; and since this will probably involve only fairly low level technological advice an extension agent should be able to deal with both livestock and crops. The occassional requirements for higher technology should be met by specialists from the veterinary or research organisations.

The cornerstone of the service would be permanent extension offices strategically located in areas of high concentration of crop, livestock of mixed farmers. These offices would be staffed by Field Extension Agents trained under the Extension Training and Farm Management Project. In addition to this, we suggest that the formation of a number of mobile livestock husbandry teams be considered. These teams would service the seasonal livestock areas grazed by migratory stock where a permanent posting could not be justified. It is quite likely that this latter proposal could be linked to mobile veterinary teams.

The organisation of extension services within the Region will have to conform to the national pattern and to the provisions for extension within the BRADP. Effectively this means that extension will not be a local component of the BRADP but will be organised under the recently introduced national Extension Training and Farm Management Project. The BRADP however, will maintain technical assistance post (Extension Coordinators) in its establishment to provide the link between the National project and the specific needs of Bay Region. This Coordinator's post is expected to cover both crop and livestock activities.

The permanent extension offices should initially be organised on a district basis and centre on the towns of Baidoa, Dinsor, Bur Acaba, and Kansadere which are reasonably well linked by road. The effort of these district offices should initially be directed towards areas with the highest population densities manifesting common problems of over grazing, poor nutrition and low productivity. It is important that innovations proposed are relatively simple, have low cost, low risk attached and be broadly applicable to as large an area as possible.

12.3 INVESTIGATION AND MONITORING SUPPORT

Although the animal census and field surveys carried out under the present study have added considerably to the data available for the Bay Region there remains a scarcity of information which limits the extent of planning that can be carried out at present. It is essential therefore that effort and resources are directed towards improving the details and quality of information available on the resources deployed within the livestock sector and their use. In particular it is recommended that:

- a repeat livestock population census (i.e. utilising the same strata as that used in the current census) be carried out during the "Gu" rains: A good indication of seasonal stocking, and range utilisation throughout the year could then be obtained;

- a more intensive programme of field surveys to provide a better understanding of livestock movements, management systems and productivity. The surveys would also help to identify constraints to improving production and eventually contribute to the formulation of appropriate development proposals.

Whilst the costs involved in carrying out an aerial census of livestock in the Region are known the resources required to carry out the field surveys will be determined by the frequency and intensity of the surveys and the level of detail aimed at. Clearly the resources of staff and transport available for these surveys are limited and a balance will have to be sought between the cost and quality of information obtained. The Consultants suggest that livestock surveys should become part of the survey programme of the Monitoring and Evaluation Unit established within the BRADP. Continuous or routine surveys would be carried out by the Unit but if necessary specific surveys dealing with a highly Specialised Technical aspect could be carried out by veterinary or research staff.

The other major area of investigation proposed, is applied research with the aim of identifying management practices and innovations which are appropriate to the area and will lead to improvement in animal production. Since there are currently no facilities in the area to carry out this research, it is proposed to set up a number of Field Centres, which could be used for demonstrations, applied and farmer and staff training. These centres are considered necessary because the activities envisaged are long term and require a level of control over stock and land which is unlikely to be achieved within a communal grazing area.

The centres are expected to require about 15 000 ha or enough land to accommodate the following:

- trials of alternative range utilisation systems involving controlled grazing that might be adopted by farmers using communal grazing areas. These could involve different stocking rates, mixed species grazing, continuous grazing and deferred grazing with seasonal reserves.

- areas for testing range improvement techniques such as partial clearing and reseeding.

- demonstration (and evaluation) of livestock management systems that could be adopted by livestock owners.

- a reserve area for unspecified future needs such as evaluation of livestock breeds or field trials of husbandry techniques using stock supplied by neighbouring livestock owners.

It is proposed that at least five centres be established by the Research Department of th Ministry of Agriculture as follows:

- two in Bur Acaba District; one on the grazing areas associated with the clays and the other on the coastal plain;

- one in Dinsor District on the Basement Peneplain;

- one in Kansadere District on the limestone plateau;

- and one in Baidoa District on the limestone plateau.

12.4 DEVELOPMENT OF GRAZING RESOURCES

Conservation and improvement of a grazing resource which is communally used is extremely difficult to achieve but is fundamental to increasing or to halting a decline in livestock productivity. The key to achieving this lies in the control of stock numbers and adjusting stocking rates to match the carrying capacity of the range. The straight forward imposition of stock numbers control through legislation is unlikely to be successfull.

The major hope must be with some form of voluntary regulations when the benefits of optional stocking rates have been demonstrated. This of course is dependant upon graziers having occupancy rights and direct responsibility for the resource which they use.

The proposals contained in the IBRD Appraisal report for the establishment PADU's have been reviewed briefly in Chapter 11, Section 11.2 where it is pointed out that the grazing proposals are too rigid and entail the imposition of control over large areas (55 000 ha) for which the grazing rights are not known and are almost certainly not exclusive to the group of farmers around whom the PADU's are centred. Another criticism is that they imply, because of a shortage of information, a major element of trial and error. Whilst it is accepted that trial and error is inevitable when proposals are being adopted and modified to fit the situation found by the implementing body, the risk attached to PADU proposals is too great.

However, the proposals do recognise the need to introduce control over stocking rates and it is this aspect which should be pursued. The Consultants suggest that rather than attempt to impose grazing controls on an area, an attempt should be made to interest groups of owners in exercising voluntary control over livestock numbers in the grazing areas to which they have undisputed rights.

The major advantage of this approach is that it is voluntary, much smaller in scale and consequently involves less risk to participants. Other aspects are as follows:

- initially effort would be aimed at sedentary livestock owners and the areas of grazing involved would be close to villages and unlikely to be affected by migratory or traders herds;

- any improvement would be more easily visible and might lead eventually to increased participation or establishment of more schemes;

- incentives such as veterinary care, and improved water supplies and livestock handling facilities could be used to encourage acceptance of the idea and increased participation;

- participants might eventually adopt more formal organisation becoming Grazing Cooperatives with an agreed constitution covering management, discipline, allocation of grazing units for participant, finance, labour and election of officials.

In the longer term the concept could be extended to groups of migratory pastoralists but this is unlikely to be possible until it had been tried, and demonstrated to be successful with the sedentary livestock herds.

The IBRD Appraisal Document suggested that areas of rangeland should be partially cleared. However, it is considered that this does not take into account the stabilising effect on the landscape provided by the larger perennial species. These help to prevent erosion and also provide a seed bank for regeneration. It is suggested that a more practical alternative would be to examine small plots within the proposed investigation and monitoring centres in the following way:

Enclosed	**Open**
Harrow and leave	Harrow and leave
Harrow and replant with locally collected or propogated grass seed	Harrow and leave

The Consultants recommend that such treatment areas be sited in areas of open bushland. There would be less disturbance of the habitat in these areas.

Although the Appraisal Document suggested that pasture legumes should be introduced into the range system it is felt that under the present circumstances it is unlikely to prove successful. The introduction of legumes will require very expensive innoculation measures.

A further requirement for the study of the rangeland areas is the establishment of a reliable year by year monitoring and evaluation of the range production. In semi arid areas, it is often difficult to distinguish year to year variation in available primary production from those brought about by overgrazing or grazing pressure.

Any system of ecological monitoring should meet the following requirements:

(a) provide relevant information on range trends in the context of overall livestock development;

(b) be compatible with work carried out in other parts of Africa;

(c) be cost effective in terms of data collection.

The methods adopted by ILCA (1978) are designed to meet these requirements and combine the recording of data on range assessment cards with measurements made along fixed transects, from photo-interpretation, or satellite images. The data collected is simple and precise and can be compared with information obtained from other sources.

At every monitoring site two permanent lines (fixed transects) are established, going out from one point at right angles for a distance of 50 metres. The three end points are marked by metal rods planted firmly in the ground. Measurements of the grass layer are made along these lines every year. If the plant cover is over 20 per cent, the ring method is used, making measurements within a 2.5 cm ring which is placed every 50 cm along the lines. If the cover is below 20 per cent, all plants are recorded as they intercept the lines. In addition, the tree and shrub cover is measured every five years on two 1 - metre wide belts along the same lines. Twenty-four or more secondary points are selected over an area of 100 to 1 000 km^2 around the fixed transects. These can be placed at random or in locations of particular interest. The cover is estimated and the three dominant plant species listed for the grass and woody layers at each of these points using range assessment cards. These results are compared with the measurements taken at the transects.

The siting of the transects and sampling points must be carried out by a competent ecologist. They should represent the most common vegetation community of the site and ideally should be in a place that has not been significantly disturbed by human activity, (balanced tree population, rich flora, anthropic species absence or represented by a few plants only). The establsihment of such a network of monitoring sites would provide quantative data on the dynamics of the range

12.5 ANIMAL HEALTH IMPROVEMENTS

Although the veterinary Department has functioned within the Region for a considerable number of years, it has been restricted in its effectiveness due to organisational and supply problems. The BRADP has a component to expand the present service and give greater cover throughout the region, by increasing the number of dispensaries from six to nineteen, and by the provision of two mobile teams. The administration of the regional service is now directly under the BRADP Management which provides field services through four District Headquarters.

The Veterinary Service is concerned solely with disease prevention and control and is not involved in animal production on extension work. It has however, a major indirect extension influence in that treatments are readily accepted by livestock owners and efficient coverage in this area may encourage acceptance of other services which are currently viewed with suspicion.

Preventative vaccination programmes, to which there is widespread resistance, require urgent updating, rinderpest in particular, which had previsouly been eradicated by the JP 15 project, could now reach epidemic proportions because of loss of immunity in a new generation of stock.

Little is known of the disease situation within the Region and efforts to rectify this should recieve priority. The collection of diagnostic samples, which would require a staff training programme should become a routine practice in the normal course of visits and during livestock treatments.

In the past the principal service performed by the Veterinary Authorities has been the sale of drugs and medicants to the general public. The distribution of toxic materials and in particular the danger of developing organisms with a resistance to antibiotics and drugs requires review. It is suggested that the sale of such items should be phased out and dealt with only by trained personel and that more emphasis is placed upon the supply of stockmans remedies that would give a general cover for the majority of minor ailments and first aid needs.

12.6 MARKETING

As far as the producer is concerned the ability to sell stock as and when required presents no real difficulty. The location of several marketing centres in each District, which are open every day, together with traders who visit the main livestock centres at frequent intervals, provide an adequate service for the current needs. The methods of marketing have developed through normal commercial principles without the need for marketing organisations and appears to function well.

Traders on the other hand claim that problems do exist in delivering animals, on the hoof, to Mogadishu and Kismayo for the export market. This is probably a communications problem due to the uncertain and irregular departure of livestock carrying vessels from the ports. This falls outside the direct control of the Region but some attempt to coordinate activities should be investigated. The formation of an association of traders within the Region could be the focal point of this coordination but would also serve as a means of controlling sale herd movements and supply statistical information on regional exports.

Being within a few days treking distance of Mogadishu and Kismayo, the region has become the livestock traders holding ground, not only for regional stock but also for those from the north and north west outside of the Bay Region. Traders assemble their sale herds and retain them within the Region whilst awaiting shipment. This causes localised overstocking problems and it is therefore proposed that consideration is given to opening up an area, with appropriate controls, in the lesser utilised areas of the south east to provide a temporary holding facility.