Government of Ethiopia
Water Resources Development Authority
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Development of Irrigated Agriculture
Contract No. DP/ETH/82/008-1/AGOE

KESEM IRRIGATION PROJECT FEASIBILITY STUDY

FINAL REPORT

Volume 2: Annex A: Soil and Land Suitability
Annex B: Agriculture
Annex C: Sociology and Livestock
Annex D: Environmental Aspects
Annex E: Health

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

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Arrangement of Report

VOLUME 1

Main Report

VOLUME 2

Annex A	Soil and Land Suitability
Annex B	Agriculture
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ALBUM 2 (630 x 297 mm format)

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ABBREVIATIONS

(Annex A has another list, with specialised abbreviations related to soils)

AADC	Awash Agricultural Development Corporation
AIMC	Agricultural Inputs Marketing Corporation
AMC	Agricultural Marketing Corporation
ARC	Agricultural Research Centre at Melka Warer
AVA	Awash Valley Authority
AVSA	Awash Valley Settlement Agency
C	Cotton
CIF	Carriage Insurance Freight
DFC	Direct Foreign Currency
DM	Dry matter
DPSA	Development Projects Study Agency
EBJV	Ethio-Bulgarian Agricultural Joint Venture of Kesem Kebena
EELPA	Ethiopian Electric Light and Power Authority
EIRR	Economic Internal Rate of Return
el.	Elevation (above sea level)
ELACO	Ethio-Libyan Joint Agricultural Company
EOPEC	Ethiopian Oilseeds and Pulses Export Corporation
ESTC	Ethiopian Science and Technology Commission
ETMC	Ethiopian Tobacco and Matches Corporation
FAO	Food and Agriculture Organization of the United Nations
FOB	Free on Board
G	Gurmile
H	Horticulture
HDC	Horticultural Development Corporation
IAR	Institute of Agricultural Research
IBRD	International Bank for Reconstruction and Development
ID and FP	Irrigation, drainage and flood protection
IFC	Indirect Foreign Currency
ILCA	International Livestock Centre for Africa
KIP	Kesem Irrigation Project
KSFO	Kesem State Farm Office
KSO	Kesem Settlement Office
KWRO	Kesem Water Resources Office
LC	Local Currency
LLU/LSU	Livestock Unit
MAADE	Middle Awash Agricultural Development Enterprise
MADC	Middle Awash Development Corporation
MAP	Mean annual precipitation
MAR	Mean annual runoff
MCH	Maternal and Child Health
MMP	Sir M. MacDonald & Partners Limited (the Consultant)
MOA	Ministry of Agriculture
MOH	Ministry of Health
MSFD	Ministry of State Farm Development
MWRC	Melka Warer Research Centre
N	North
NEADE	Nura-Era Agricultural Development Enterprise
NERDU	North-East Rangelands Development Project
NOMADEP	A French-financed programme of aid to the Afar, now discontinued
NWRC	National Water Resources Commission
O&M	Operation and maintenance
PCC	Project Control Centre
PMF	Probable maximum flood
PMP	Probable maximum precipitation
PV	Present value

ABBREVIATIONS (cont.)

RAM	Readily available moisture
RDP	Rangelands Development Project
RRC	Relief and Rehabilitation Commission
S	South
SCF	Standard conversion factor
SCS	Soil Conservation Service - (USA)
SD	Standard deviation
SDU	Staged Development Unit
SF	State farm
SST	Sea surface temperature
STD	Sexually transmitted diseases
T	Tobacco
TOR	Terms of Reference
UNDP	United Nations Development Programme
USBR	United States Bureau of Reclamation
VADA	Valleys Agricultural Development Authority
WRDA	Water Resources Development Authority
4WD	Four-wheel drive
2WD	Two-wheel drive

UNITS

All units and their abbreviations are SI (Systeme Internationale), which are usually equivalent to metric units, except the following:

qt	quintal (100 kg)
yr	year
d	day
md	man-day
MM	man-months

The specialised abbreviation list at the beginning of Annex A mentions many units, and includes a note on the units for electrical conductivity.

CURRENCY

Unless stated otherwise all financial and economic calculations are made in the Ethiopian currency unit, the Birr, at 1986 prices. The exchange rate used is the official rate, namely Birr 2.07 to US$ 1.

Annex A:
Soil and Land Suitability

ANNEX A

SOIL AND LAND SUITABILITY

CONTENTS

CONTENTS (cont.)

CONTENTS (cont.)

LIST OF APPENDICES
(Bound in Volume 6)

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LIST OF DRAWINGS
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ABBREVIATIONS FOR ANNEX A

API	aerial photographic interpretation
atm	atmosphere
AWC	available water capacity
b	bar
BD	bulk density
BSP	base saturation percentage
C	clay
CEC	cation-exchange capacity
CL	clay loam
cm	centimetre
cS	coarse sand
d	day
EC	electrical conductivity
	(subscripts: e = saturation extract
	i = irrigation water
	p = deep percolation water
ESP	exchangeable sodium percentage
exch	exchangeable
FAO	Food and Agriculture Organisation of the United Nations
FC	field capacity
fS	fine sand
g	gram
GWT	groundwater-table
h	hour
ha	hectare
HC	hydraulic conductivity
ILRI	International Institute for Land Reclamation and Improvement
IR	infiltration rate
K	saturated hydraulic conductivity
kg	kilogram
KIP	Kesem Irrigation Project
km	kilometre
l	litre
L	loam
LcS	loamy coarse sand
LfS	loamy fine sand
LRDC	Land Resources Development Centre
LS	loamy sand
LR	leaching requirement
LUT	land utilisation type
m	metre
me	milliequivalent
mg	milligram
ml	millilitre
mm	millimetre
mS	millisiemens
OM	organic matter
pF	measure of soil water tension
pH	measure of acidity/alkalinity
ppm	parts per million
PWP	permanent wilting point
s	second
S	siemens (amps/volt, 'mho')
SAR	sodium adsorption ratio

ABBREVIATIONS (cont.)

SC	sandy clay
SCL	sandy clay loam
SL	sandy loam
t	tonne
TOR	terms of reference
TSAU	Tropical Soil Analytical Unit (within LRDC)
UK	United Kingdom
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
vfS	very fine sand
v/v	volume for volume
w/w	weight for weight
Z	silt
ZC	silty clay
ZCL	silty clay loam
ZL	silty loam
°C	degree Celsius
	greater than
	less than

Note on Units for Electrical Conductivity:

The traditional unit is "mho/cm", and hence mmho/cm and µmho/cm, and these are well established in the literature and in the memories of practitioners. The proper SI unit is S/m, where 1 S is 1 mho so that 1 mmho/cm (or 1 mS/cm) is 0.1 S/m. Various intermediate usages have been introduced, usually in an effort to keep the numbers the same as in the old units mmho/cm and µmho/cm: for instance the FAO Irrigation and Drainage Paper 29 Revision 1 (1985) uses dS/m. This report uses mS/cm because a rigorous adherence to the correct form S/m would produce different numbers, while dS/m is neither widely known nor familiar.

CHAPTER A1

INTRODUCTION

This is one of fourteen annexes which, together with the Main Report and two albums of drawings, constitute the Report on the Feasibility Study of the Kesem Irrigation Project. The overall study was carried out by Sir M. MacDonald & Partners Ltd. (MMP) for the Water Resources Development Authority (WRDA) of the Government of Ethiopia, under contract to FAO as part of the UNDP-financed project DP/ETH/82/008. The soils investigations covered by this annex were made by MacDonald Agricultural Services Ltd., a subsidiary of MMP, with assistance from the UK Government Land Resources Development Centre.

Within the overall feasibility study the principal objectives of the soil studies were threefold:

- to map and describe at semi-detailed level the distribution of the soils, taking account of characteristics affecting land suitability for sustained irrigated agricultural production; in particular the hazards of waterlogging, salinity and sodicity;

- to identify and map the soil characteristics that determine crop productivity and cost of production with particular reference to the experience of existing irrigated farms in the area and the findings over the past 21 years of the Irrigated Agricultural Research Station at Melka Warer;

- to produce maps of land suitability for irrigated agriculture that would enable the planning of an effective, fully costed irrigation layout and productivity projections made of alternative production possibilities.

The area surveyed in the Middle Valley of the Awash river basin covered about 22 500 ha (gross) of land previously identified as being suitable for irrigated agriculture. (Ref. 1)

This annex describes in detail the soil and land suitability characteristics of the area. It should be read in conjunction with the other annexes, particularly those dealing with the agriculture, irrigation and drainage aspects of the feasibility study (see Annexes B and L).

After description of background environmental information in Chapter A2, and details of the study methods used in Chapter A3, detailed findings of the semi-detailed soil survey are given in Chapter A4 and land suitability is discussed in Chapter A5. Chapter A6 discusses the soil and land management problems likely to be associated with any future development. The main conclusions and recommendations of the soils study are presented in Chapter A7.

The 1 : 20 000 maps accompanying this annex are bound separately in Album 1 of the report; at this scale the soil study area is covered by two sheets. The topics covered by the maps are Soils (Drawings A1 and A2); Land Suitability for Irrigation (Drawings A3 and A4); Irrigability and Drainability (Drawings A5 and A6) and Current Land Use and Vegetation (Drawings A7 and A8). In addition, a set of 1 : 10 000 soil and land suitability maps is presented separately in Volume 6.

There are three appendices to this annex: A1 giving detailed soil pit descriptions for selected typical sites; A2, the soil analytical and field results from every pit site and A3, the laboratory methods used in the chemical and physical analysis of the soils. Because of their bulk they are bound in a separate volume (Volume 6).

References are listed at the end of the main text of the annex, and there is a list of abbreviations at the beginning of each volume of the report.

CHAPTER A2

THE ENVIRONMENT

A2.1 Location

The Kesem Irrigation Project is located on the left bank of the river Awash in the middle Awash section of the northern Rift Valley in an area known as the Afar Triangle. This part of the valley is traversed by three significant perennial tributaries of the Awash; the Kebena, the Kesem and the Filweha rivers. In addition, several smaller ephemeral streams flow off the western escarpment of the Rift Valley, but are dissipated in the valley alluvium and never reach the Awash river.

Only the soils of those lands within command of the potential diversion site at Saboret have been surveyed and mapped. To avoid confusion, this area will be referred to as the soil study area to distinguish it from the much larger project area which, in addition to the soil study area, includes the potential damsite areas.

The soil study area comprises all the land between the offtake on the river Kesem at Saboret and the Awash river, extending north to Dofan Mountain, south-west to the boundary of the Awash National Park, and south-east to the Filweha river. The total area surveyed and mapped, including the central Gurmile volcano, is some 21 850 ha divided into three blocks by the Kesem and Kebena rivers; these blocks are designated from south to north as shown in Table A2.1, and their location is shown on Figure A2.1.

TABLE A2.1

Survey and Development Blocks

Block name	Area (ha)
South Kesem or South	6 700
Gurmile	9 250
North Kebena or North	5 900
TOTAL	21 850

A2.2 Delineation of the Soil Study Area

It became apparent early in the study that the initial reconnaissance undertaken in 1965 (Ref. 1) had both underestimated the extent of the potential irrigable area and had eliminated certain lands near the river Awash likely to prove suitable for irrigation. Since it was also clear that significant areas that had been designated as being irrigable were in fact unsuitable, it was decided to redefine the soil study area so as both to maximise the extent of irrigable land and also to rationalise its overall boundaries.

The eastern boundary was established along the line of the Awash river; land encompassed by tight meanders was excluded on the basis that such land could not be irrigated economically. The position of the highest potential diversion site at about 800 m on the river Kesem near the present offtake at Saboret defined the maximum height of the western boundary. In the south-west of Gurmile block, however, the western boundary approximates to the marked break in slope caused by a north-trending Rift Valley fault just below the 800 m contour, above which the land whilst theoretically within command is seriously gullied, undulating and boulder-strewn and unsuitable for irrigation development.

To the north, Dofan Mountain, and to the south-east, the Filweha river and the immediately adjacent alkaline terrace escarpment form natural boundaries to the soil study area. The Filweha itself rises in a series of springlines associated with a fault in the lava outcrops, which themselves form a natural southern boundary to the area. The south-western limit, near Saboret is formed by the boundary of the Awash National Park, a boundary which has been recognised as inviolate by the International Union for Conservation of Nature and Natural Resources (IUCN).

The soil study boundary as defined here with the approval of both WRDA and FAO, is shown on the accompanying maps (see Drawings A1 to A8).

A2.3 Geology and Landforms

The soil study area is located at the base of the Rift Valley close by the series of ascending scarp faults that constitute the western side of the Rift. Following major faulting in the Tertiary and Eocene, a great thickness of complex silts, sandy silts, gravels and boulder beds have accumulated largely by deposition from successive drainage courses leading off the western escarpment. As a result of this faulting, these deposition products are almost exclusively calcareous material partially weathered from per-alkaline volcanics.

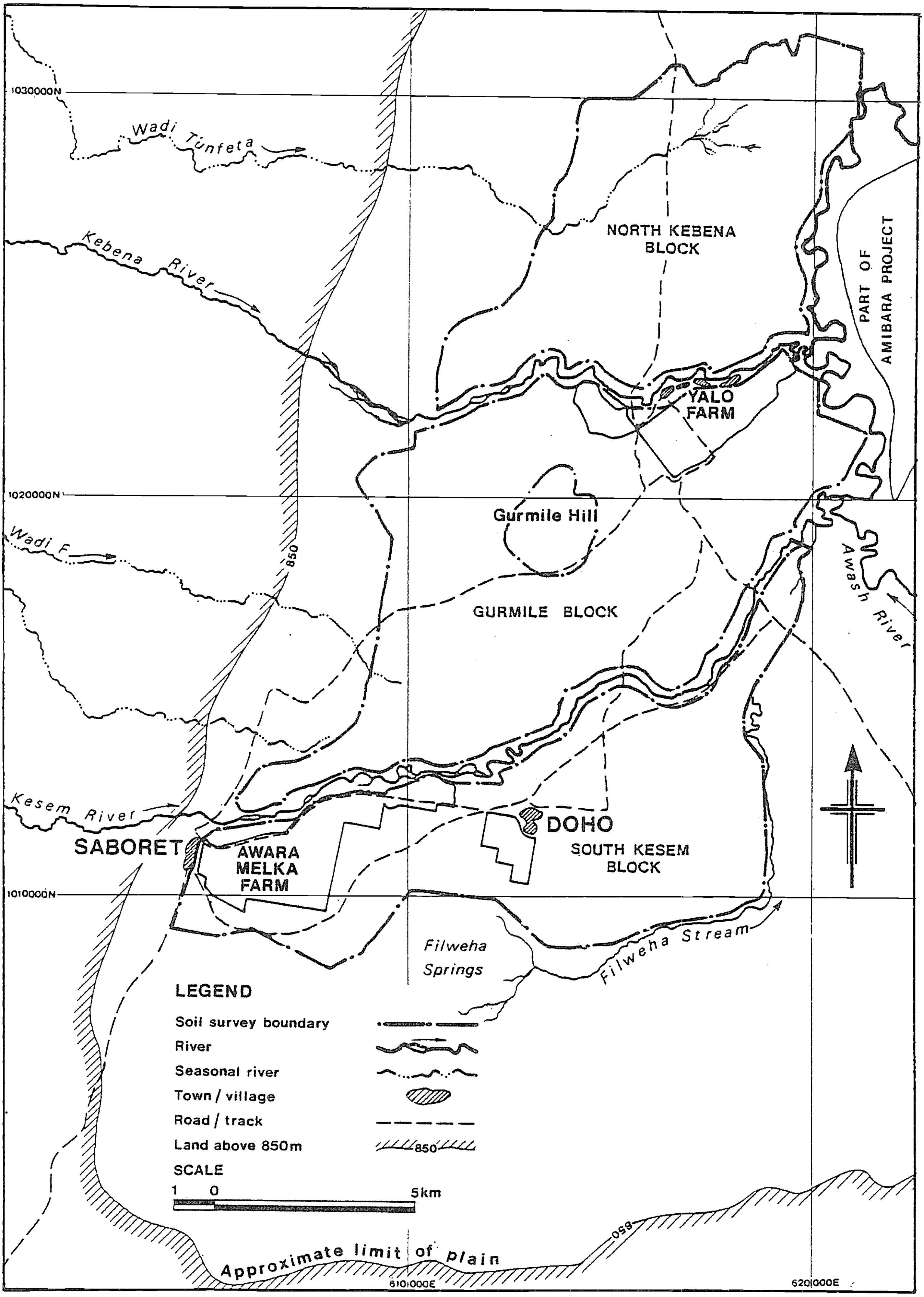
There has been much re-working of these materials over time by river torrents which were, and continue to be, characterised by irregular changes in their courses. It is only close to the present Awash river meander belt that classic floodplain deposition has taken place, with heavy clays and silty clays in extensive backwater depressions and silty or fine sandy materials on river levees and other recent depositional sites. In contrast, towards the first north-trending fault scarp in the west, coarse colluvial outwash materials predominate with gravels, stonelines and boulder beds associated with local gullying. The alluvial-colluvial deposition is characterised throughout by high textural variability, both laterally and vertically, with discontinuous fine silty and clay horizons of low hydraulic conductivity contrasting with highly permeable sand horizons.

Gravel terraces and successive erosion surfaces have been reported within the soil study area (Ref. 2), but these are difficult to detect in the field. Very localised terrace remnants can be identified, and where these occur, they are associated with intensely high levels of both salinity and sodicity presumably derived from weathering materials within the terrace. The best exposure of such a per-alkaline terrace scarp lies south of the Filweha river just outside the soil study area.

A number of basaltic and cinder cone intrusions through the alluvial deposits indicates recent volcanic activity. In the centre of the area, Gurmile Hill (810 m) represents an inlier of basaltic lavas with several vents. Recent basalt flows also surround the Filweha springs which issue along a fault line in the lava; these hot springs (43 °C) have a uniform electrical conductivity of about 2 500 μS/cm.

Figure A 2.1

Location Map



Within North Kebena block the alluvium at some sites is extremely hot, up to 60°C, within the surface 3 m; the silty clay loams and clays developed at such sites have been designated 'hyperthermic'. This phenomenon, thought to be associated with underground hot springs issuing from Dofan Mountain, is found at a few sites immediately south-west of the mountain, but more widespreadly in the lowest-lying part of the soil study area, towards the river Awash, in eastern North Kebena.

The topography of the soil study area reflects the recent geomorphological history of this part of the Rift Valley. While gradients are generally west to east and flat or almost flat (0.1% to 2%), towards the west where there has been significant admixture of colluvium and/or coarse-textured alluvial outwash, slopes may exceed 4% with an undulating or gullied micro-relief. Thickets, especially those dominated by Salvadora persica tend to mask a strikingly irregular micro-relief. The degrading effect of water and wind erosion may be locally serious on unprotected surfaces, especially in central South Kesem.

Meandering gullies with sandy levees, and/or boulder beds, represent the former courses of rivers flowing across the area from the west. Of particular note is the former course of the Kebena river, which at one time flowed south of Gurmile Hill towards the present course of the Kesem, a more recent channel of the Kebena flowing immediately north of Gurmile Hill, and the Kesem itself which used to flow south into the Filweha. The second channel of the Kebena is currently an overflow when the river is in spate, the water being dissipated in the Acacia nilotica forest between Yalo Farm and the Awash river. The floodplain of the Awash converges on these alluvials only in the eastern part of the area close to the Awash river, where it is characterised by level basins of heavy clay prone to seasonal flooding and locally pronounced levee formations. In the north-eastern extremity, runoff from Dofan accumulates to form a small permanent lake on the Awash flood plain, Lake Keles. A seasonal stream connects the lake with the Awash, flowing in alternate directions depending on whether the Awash is in flood or Lake Keles is overflowing. The only other major watercourse in the area is the seasonal Wadi T'unfeta which does not reach the Awash river, but ends in an outwash fan south of Dofan Mountain.

Ground elevations range from 800 m at the diversion site at Saboret to about 735 m on the Awash floodplain in North Kebena. Contouring at 1-m intervals based on the 1984 1 : 20 000 aerial photography is shown on the accompanying maps (see Drawings A1 to A8).

A2.4 Climate

Located at 9°N and at about 750 m above sea level, the area experiences a typically tropical semi-arid climate with rainfall normally in the range 350 to 600 mm (mean = 470 mm). At Saboret, the annual rainfall can be expected to exceed 375 mm in 8 years out of 10. Temperatures vary from mean minima of 15°C and 21°C to mean maxima of 23°C and 38°C in December and June, respectively; frost is unknown. Mean relative humidities are lowest in July (36%) and highest in August (58%). Mean daily sunshine reported on an annual basis is 8.5 h. Wind runs are longest in June and July when they may exceed 200 km/d. Annual potential evapotranspiration, estimated by the Penman method, approximates to 2 400 mm, ranging from a monthly mean of 170 mm in August to 252 mm in June.

Mean monthly data from four Rift Valley stations are presented in Table A2.2. Only one station, Saboret, (Awara Melka) with a relatively long record (1962 to 1981, missing 1966), actually lies within the soil study area and would appear to be representative of it. The other stations, Metahara, Awash Station and

TABLE A2.2

Mean Monthly and Annual Rainfall for Four Locations in the Middle Awash Valley (mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual total
Saboret (Awara Melka) 1962-1981	13	26	46	47	30	16	93	109	41	20	14	13	469
Awash Station 1963-1981	16	48	56	72	47	33	74	149	54	28	24	9	644
Melka Warer 1975-1985	21	34	57	63	31	21	118	123	39	33	19	2	560
Metahara 1962-1985	13	30	34	41	42	28	110	134	45	27	16	5	520

Note: Mean figures have been calculated using actual recorded values only; no attempt has been made to correct for 'missing values', hence mean annual totals are not necessarily the summation of mean monthly values.

Melka Warer, whilst they are all within 30 km of the area, appear to have somewhat higher rainfall. Rainfall tends to be locally highly variable, both temporally and spatially, though a fair correlation has been found between the monthly records of the four stations analysed. The mean annual rainfall recorded at the long-established agricultural research station at Melka Warer (560 mm) is some 20% higher than that recorded from within the area at Saboret (469 mm). Such a difference in rainfall is likely to be agriculturally significant, so much so that many of the research findings established at Melka Warer may not necessarily be applicable to the study area.

The overall pattern of rainfall is weakly bimodal, approximately 60% of the annual total (275 mm in the case of Saboret) falling as the main rains between July and September. The annual variability of rainfall during these 3 months is relatively low and can be expected to exceed 200 mm at Saboret in 4 years out of 5. There is, however, another minor and less reliable period of rainfall peaking sometime during the period March to May; these short rains account for a further 25% of the annual total. The 1-in-5 year maximum 24-hour rainfall has been estimated to be 57 mm (Halcrow 1985, Ref. 9). The driest 3-month period is November to January when only about 35 mm can be expected, but actual amounts are highly variable.

A2.5 Natural Vegetation

The soil study area lies within the Eastern Africa Ecoclimatic Zone V. The dominant shrubs and bushes of this zone have evolved a varied phenology in response to periodically severe soil water deficits developing a delicate balance between the perennial and annual species of the herbaceous communities. The typical deciduous bushland of this zone is best developed on the lava terrace towards Awash Station south of the study area; within the area itself this bushland has been much modified with a number of significant edaphic ecotones consequent on variations in soil moisture, drainage, salinity and sodicity. A number of species anomalies were noted; such as the non-existence within the study area of Acacia mellifera generally one of the dominant species elsewhere in the Middle Awash Valley. Evergreen bushes and trees are also much more widespread within the study area than is general for the zone as a whole. Species commonly found include: Cadaba rotundifolia, Salvadora persica, Suaeda monoica, Tamarix aphyalla, and Tacazzea sp. cf yototacola. Acacias are, nevertheless, fairly well represented with extensive areas of A. nilotica and A. tortilis, and localised areas of A. nubica and A. senegal.

The distribution of the principal plant communities, shown on Drawings A7 and A8, is governed by a complex of interacting factors; the most important of these are salinity, sodicity, propensity to seasonal waterlogging and human pressures. Study of aerial photographs, taken over the last 20 years or so, indicates that there have been some quite dramatic changes in vegetation over this period, seemingly associated with shifting watercourses. Of particular instance is the outwash from the Wadi T'unfeta which has moved gradually south away from Dofan Mountain into the A. nilotica woodlands of North Kebena resulting in a considerable thickening of the woodland and its subsequent development into closed canopy forest. The most notable change, however, has been the extensive development of A. nilotica forest and Tacazzea thicket to the south of Yalo State Farm, presumably associated with effects resulting from the new, more northerly course of the Kesem river, and outwash from the present overflow channel from the Kebena flowing immediately north of Gurmile Hill.

A. nilotica forest, defined as a closed stand of acacia trees rising from 7.5 to 30 m in height, is characteristic of heavy clays subject to seasonal flooding on the Awash floodplain; it is particularly prevalent in North Kebena. Local associate species include Terminalia sp. and Tamarix aphyalla, though the latter is restricted to the immediate levees of the Awash river; there is little or no ground cover under the closed canopy of this forest.

In contrast, the Acacia Open Woodland dominated by A. tortilis on the better drained sites, and A. nilotica on those that are seasonally flooded is characterised by trees of up to 18 m in height and a canopy cover exceeding 20%. It is nevertheless sufficiently open to allow a scattered understorey cover of shrubs and bushes, especially Achyranthes, Cadaba, Solanum spp, and Vernonia sp. This woodland is common throughout the study area, particularly on the sandier soils in the western half of Gurmile sub-block where Acacia tortilis 'parkland' is dominant.

In the south of South Kesem, the doum palm Hyphaene thebaica is a prominent component on sites with shallow sodic groundwater. Also in western Gurmile, where groundwater associated with a fault line approaches the surface, there is a distinctive line of tall evergreen woodland, with a wide range of species more typical of moister zones, including Cordia, Ficus and Tamarindus spp.

The widespread shrubland/bushland comprises an open assemblage of woody plants, mostly of shrubby habit, having a shrub canopy of less than 6 m in height (with occasional emergents) and a canopy cover generally over 10%. Typical components include: Acacia nilotica, Cadaba farinosa, C. rotundifolia, Grewia tenax, Salvadora persica and Tamarix aphylla. Variants include: Tamarix bushland along streams and canal banks and former river channels; A. nilotica shrubland on sodic clay flats; A. nubica bushland and shrubland on re-sorted sandy and gravelly alluvium in the west of North Kebena; low A. senegal shrubland on localised lava outcrops; and ephemeral Calotropis procera along upper river terraces. Where these species form a closed stand, the vegetation is defined as thicket. Thickets mapped include those in South Kesem where seasonally waterlogged saline soils have recently been invaded by tall dense stands of Suaeda monoica (saltbush); clumps of dense thicket in Gurmile and North Kebena where higher-lying sodic silts have been subject to expansion of Salvadora persica circular thickets which are based on single original Salvadora bushes surrounded by narrowing avenues of grassland; and wooded thicket, most common in eastern Gurmile, where the pernicious invader Tacazzea yototacola is also rapidly advancing.

Grass growth is restricted by grazing, but in the shade and protection of the denser acacia bushland species such as Cenchrus, Cynodon, Dactyloctenium and Panicum are common. Grassland, defined as land with an herbaceous cover and widely scattered, or grouped trees and shrubs, the canopy cover of which does not exceed 10%, is itself particularly well developed in eastern South Kesem and in North Kebena. Subject to intensive grazing throughout much of the year, and especially in dry seasons, the Cynodon - Chrysopogon - Eragrostis grass cover is generally short and sparse, commonly including the herb Tribulus terrestris. Other associates include a number of dwarf shrubs, including Abutilon, Barleria, Cassia, Crotalaria and Solanum. Bare areas are common, particularly associated with intensely saline/sodic conditions, localised gullying and Afar settlements. Settlement sites are usually characterised by a surround of bare ground within which every single bush has been removed for the construction of huts and stock kraals. Seasonally wet areas have a cover of Cynodon dactylon (stargrass); parts of Yalo abandoned because of waterlogging have been invaded by the sedge Cyperus rotundus ('nut-grass'); wet sodic swamp is covered by a low rush Juncus sp; in permanent freshwater swamp there is a continuous stand of the bulrush, Typha latifolia. Two grass species were found to be sensitive field indicators of certain soil conditions: Sporobolus sp. cf. pyramidalis, of surface soil salinity; and Sporobolus spicata of high exchangeable sodium.

A2.6 Present Land Use

The forest and woodland of the study area play a significant role in the Afar economy in providing fuel, gums, honey, browse, wood for water containers, bark for clothing and branches for shelter. This and large-scale irrigation encroach on a third land use: wildlife conservation, which is now in rapid retreat. Formerly the Wildlife Conservation Organization had designated the entire project area as part of a wider Awash West Wildlife Reserve. Now only the core Awash National Park remains, and even within the park itself, wildlife encounters stiff seasonal competition from local Afar and Kerayu graziers. In the study area, the large range of bird species was noted, but numbers of large mammals are in severe decline, the most notable remaining being lion and leopard resident in western Gurmile, and the endemic Soemmering gazelle migrant, but occurring in Gurmile and North Kebena.

The most important form of present land use is providing dry season grazing for transhumant Afar clans, who are almost entirely dependent on livestock. This dry season grazing is a vital complement to the effective wet season utilisation outside the Kesem area of up to 2 500 km^2 of semi-arid rangeland whose only economic use is in rearing livestock. Within the study area, the Afar retain semi-permanent settlements where the less mobile members of the community remain when the main body of the clan migrate. These villages tend to be located on relatively higher-lying sites, thus reducing the risk of flooding. Some of these sites have been occupied for generations, and some have associated graveyards which will have to be respected. Settlements and graveyards are delineated on the Current Land Use and Vegetation Maps (see Drawings A7 and A8).

Several attempts, notably by the aid programme NOMADEP have been made to introduce small-scale irrigation to the area and the Afars in particular. For various reasons these attempts have largely failed; currently there remains 2 ha of irrigation near Yalo, and a nominal 80 ha of maize and cotton at the RRC-settlement at Doho. These will be further discussed in Annex C (Sociology and Livestock).

Irrigation within the soil study area is consequently almost exclusively the preserve of the Awara Melka State Farm, employing migrant labour from the Highlands. This farm, run by the Horticultural Development Corporation, is organised into four units: three of these comprise the 1 400 ha enterprise (also known as Awara Melka) lying south and east of the diversion structures on the river Kesem near the village of Saboret. Although originating as a private farm in 1904, the enterprise remained a small citrus plantation of under 100 ha, until the mid-1960s, when there followed a considerable expansion in production area. Since the 1970s, however, increasing areas of land towards the eastern end of the farm, the land most recently brought into production, have been abandoned in the face of increasing salinity associated with perched watertables. The land abandoned at Saboret up to 1984 totals 350 ha, or about 25% of the total farm area. Some 1 050 ha gross remain in the cropping cycle. In 1986, the farm management reported that the following net areas had been planted:

	Area (ha)
Virginia flue-cured tobacco	300
Mixed citrus with some interplanted mangoes	270
Dwarf Cavendish bananas	66
Acala 1517/70 cotton	110
Sweet potato	10
Total	756

The fourth unit developed in the early 1960s comprises Yalo Farm, some 625 ha gross irrigated by a 3 km canal from an offtake on the Kebena river. Of this, about 125 ha (20%) has been abandoned, principally because of waterlogging associated with a perched watertable locally exacerbated by secondary salinisation and sodification. The remainder, about 400 ha net is under cotton production.

From the area currently under production crop yields are low, and crop quality poor. Citrus at Saboret is in a poor state suffering from extensive dieback and other apparently physiological disorders. The remarkably low yield of bananas (mean 6.7 t/ha in 1984-5); and the low yield and quality of tobacco (mean 980 kg/ha over 12 years, falling to 940 kg/ha over the last 4 years) have both been noted. More crucial are the low and declining yields of cotton seed at Yalo, down from 2 000 kg/ha on establishment in the 1960s to presently only 1 300 kg/ha. It is clear that the State Farm enterprise, both at Saboret and Yalo is severely affected by major soil problems; soil structure deterioration, rising watertables and local secondary salinisation and sodification. These problems are further aggravated by sub-optimal standards of farm and water management. These issues of management will be further discussed in Chapter 6 of this annex.

CHAPTER A3

METHODS OF INVESTIGATION

A3.1 Introduction

The soil survey was designed to conform with the following standards:

(a) an overall density of observations of not less than 8 points per km^2 or 1 observation per 12.5 ha;

(b) the procedural guidelines set out in the FAO Guidelines for Land Evaluation for Irrigated Agriculture (Ref. 12) were to be used to assess the land suitability for irrigated agriculture. In particular:

(i) the information collected on the salinity, sodicity and drainage characteristics of the soils was to be sufficiently detailed to permit the required design and costing of possible irrigation and drainage layouts to be drawn up.

(ii) the survey and analytical data relating to soil productivity would be sufficiently detailed to enable economic projections to be made for each major land suitability class and sub-class.

The soils within the study area have been previously studied and described by SOGREAH (Ref. 1). Other reports covering adjacent areas in the Middle Awash Valley were also consulted both prior to and during the survey. Of particular interest were the 1969 ITALCONSULT feasibility study report of the Amibara Irrigation Project (Ref. 5), the various reports produced by Sir William Halcrow & Partners on the Amibara and Angelele-Bolhamo Irrigation Projects (Ref. 6, 9 and 10), and the NEDECO reports on the Amibara and Angelele-Bolhamo Irrigation Projects (Refs. 7 and 8). Various annual reports from the Melka Warer Research Station also provided useful agronomic information on the Middle Awash area.

The mapping bases used in the field were the recent (January 1984) aerial photographs flown at a scale of 1 : 20 000. Prior to the soil survey, a preliminary aerial photograph interpretation (APl) was undertaken. The boundaries drawn were those of broad ecological units based on site and/or vegetation associations and the apparent surface characteristics of the soils as reflected by their tone on the photographs. The assumption was that at least some of these inferred associations would be found by the semi-detailed survey to be indicative of different soil types.

It was acknowledged, however, at an early stage in the survey that there were in some of these apparently uniform 'ecological units' large, agriculturally significant variations in soil properties, particularly in soil texture and salinity. As the aerial photographs were not able to pick out these variations consistently, the only way to identify and accurately locate soil boundaries was to site the auger observation holes on a regularly spaced, predetermined rectangular grid, supplemented where necessary by additional boring located by free survey.

The augering and pit survey are described in the next two sections. Table A3.1 summarises the number of observation sites which total 1 768 for a mapped area of 21 823 ha (8.1 sites/km^2, 12.3 ha per site).

TABLE A3.1

Soil Survey Observations

Block	Area surveyed and mapped (ha)	Auger holes 3 m grid	3 m free	3 m total	4.5 m	Pits	Total inspection sites
North Kebena	5 869	316	73	389	29	14	432
Gurmile	9 250	552	165	717	32	29	778
South Kesem	6 704	424	100	524	25	9	558
Total	21 823	1 292	338	1 630	86	52	1 768

A3.2 The Main Survey

A grid of proposed augerholes was laid out. It was decided that because of the very different characteristics between the three blocks (North Kebena, Gurmile and South Kesem) the direction of the grid should be varied in an attempt to survey across the grain of the land. The standard augerhole spacing on the grid was 300 m on lines spaced at 600 m intervals, though where the soil and/or land was obviously unsuitable for irrigation development the spacing was widened to 600 m by 600 m. On the state farms at Saboret and Yalo the spacing was intensified to 200 m by 400 m to provide further detailed information on the way these soils respond to irrigation under established levels of agricultural management. A total of 1 292 auger observations were made on the grid, each to a depth of 3 m, unless prevented at a shallower depth.

A further 338 auger observations were made, again to a 3 m depth, on free survey primarily to confirm the location of soil boundaries identified as a result of the grid auger survey. The total number of grid and free auger observations made to 3 m over the whole area was 1 630. In addition, 86 free auger observations were made to 4.5 m in an attempt to evaluate the drainage and salinity characteristics of the deeper horizons.

The auger observations were all fully described to FAO standards (Ref. 11). In addition, pH was measured colorimetrically on each significant horizon at every augerhole. Possible sodic soils were identified by particularly high field pH values (pH more than 9.2). So as to confirm and quantify the occurrence and distribution of salinity and sodicity, a system of sampling was established for subsequent testing in the field laboratory. Samples were taken from about one in every 4 augerholes usually at a rate of 3 to 4 samples per sampled augerhole across the area and not necessarily at sites where salinity and/or sodicity was suspected. The following tests were carried out on each of the 1 714 samples: the electrometric measurement of soil pH (to confirm the colorimetric measurement made in the field), and determination of electrical conductivity and exchangeable sodium on saturated soil extracts. Initially a system of salinity and sodicity screening was devised but as so few of the samples were being discarded, it proved more time efficient to abandon the screening process in favour of preparing saturation extracts for every sample.

Many of the soil types identified and classified as a result of the auger survey could not be related directly to the 'ecological units' mapped during the preliminary API. A soil classification scheme was drawn up based primarily on a combination of site and soil textural properties. A second API was subsequently undertaken and the soil boundaries marked initially on the 1 : 20 000 aerial photographs. These boundaries were later transferred to the topographic base maps at a scale of 1 : 10 000.

A3.3 Pits, Soil Analysis and Physical Tests

A total of 52 soil pits were dug to 2 m at representative sites to describe the main soil types identified by the auger survey. Samples were taken from each significant horizon down to 2 m depth and were dried and ground prior to full chemical and physical analysis at the National Soils Laboratory in Addis Ababa. A total of 215 pit samples were analysed there and a further 37 duplicate samples taken to the Tropical Soil Analysis Unit in Reading, UK, for checking; methods are summarised in Appendix A3.

Soil physical tests were undertaken both in situ and on disturbed and undisturbed samples in the laboratory. The field measurements were designed to provide basic data on water movement and retention in the soils, primarily to assist in design of the irrigation and drainage installations. The following table summarises the programme undertaken.

TABLE A3.2

List of Physical Investigations

Measurement	Number of sites sampled	Total number of measurements
Infiltration rate[a]	31	93
Hydraulic conductivity[a] [b] [c]		
- constant head	26	60
- falling head	10	18
Undisturbed cores		217
- bulk density		86
- moisture release	26	86
- permeability		139

Notes:
(a) Normally three replicates at each site.
(b) Some hydraulic conductivity measurements were abandoned because of problems at site - notably the presence of very thin, coarse-textured layers in the profile.
(c) In some cases both falling and constant head measurements were made at the same site.

The infiltration rates were determined in triplicate at each site, using the double ring infiltrometer method described in FAO Soils Bulletin Nr 42 (Ref. 13). The inner rings used had diameters of about 30 cm and were spaced 10 to 15 m apart around the corresponding soil pit. Where possible Kesem river water was used for the tests although on days of low (or zero) flow, water from the Kebena was substituted. At each location a small bund was dug around each measurement site and the area filled with water to a depth of about 10 cm on the afternoon preceding each test. This was designed to avoid the unrealistically high infiltration rates that can result from tests begun on dry soils, as reported by Turner and Sumner (Ref. 15). For each measurement a plot was made of cumulative and instantaneous intake against elapsed time as shown in the example illustrated by Figure A4.1. From this the basic infiltration rate (the constant rate attained after a few hours) was obtained.

The majority of hydraulic conductivity measurements were made by the shallow well pump-in test also described in FAO Soils Bulletin Nr 42 (Ref. 13), using the same water sources as for the infiltration tests and with sites located between the infiltration ring positions. As requested by WRDA, a few of the measurements were made using the falling head method described by the International Institute for Land Reclamation and Improvement (Ref. 14). Depths of the tests were normally between 1 and 2 m, although they were varied to allow sampling of a range of representative soil textures and to restrict the measurements, as far as possible, to reasonably homogeneous parts of the profile. At each site the augered soil samples were checked to ensure that the section of the profile under test would be texturally uniform and, where necessary, a new hole, or holes, were bored. During the borings, care was taken to maintain as uniform a diameter as possible in the holes; measurement during the project indicated that the nominal 7 cm diameter auger produced a hole (after cleaning with a wire brush) with a diameter that varied between 8 cm at the surface to 7.5 cm at about 60 cm depth. The results were plotted as shown in the illustrative samples in Figures A4.2 and A4.3.

The undisturbed soil cores were taken from representative horizons at each sample site using cylindrical steel cores 5 cm in diameter and 5 cm long. Each layer was normally sampled in triplicate. Because of the very high vertical variability encountered in the soils (see Section A4.3) a greater number of cores than required by the terms of reference was taken for water retention and bulk density measurement, with a corresponding reduction in the number of hydraulic conductivity tests on the cores, as described below.

For the soils of the Kesem area, permeability measurements on undisturbed soil cores were found to give extremely high and unrepresentative values (see Section A4.5.6) and, after measurement of 139 samples, its use was discontinued in favour of additional bulk density and moisture release measurements. The same samples were also used by the National Soil Laboratory to determine bulk density and soil moisture at 1/10, 1/3, 1 and 15 bar pressure.

Details of the chemical and physical analytical methods used at the National Soils Laboratory are given in Appendix A3 and the soil analytical results from every pit site in Appendix A2. Detailed soil pit descriptions for selected typical sites are given in Appendix A1.

A3.4 Report Compilation and Other Activities

This report and the accompanying maps have been compiled using information and data collected during the field soil survey and from the results from the associated in situ soil tests and laboratory analyses, combined with an extensive desk study of the aerial photographs and information obtained from previous reports on work conducted both in the project and on adjacent areas in the Middle Awash Valley and as a result of team discussions. Some land surveyed, but subsequently found as a result of these discussions to be out of command of the proposed irrigation works, has not been mapped. This land, located on the western fringes of Gurmile and North Kebena blocks, was, in any case, found to be unsuitable for irrigation, because of excessively coarse soil textures, extensive gullying and rill erosion, and/or the dissected nature of the topography.

Extensive discussions were also held with the managers of both the state farms within the soil study area at Saboret and Yalo, as well as with senior personnel at the neighbouring Amibara Irrigation Project and the Melka Warer Research Station so as to define the critical limits for land suitability classes and to enable potential crop productivity predictions to be made for the main soil types.

CHAPTER A4

THE SOILS

A4.1 Previous Studies

The soils of the project area have been previously studied and described by SOGREAH in an extensive study of the Awash river basin (Ref. 1). This study was designed to identify development possibilities and production potentialities throughout the basin. It was undertaken in three successive phases:

(a) General reconnaissance of the whole river basin, mapped at a scale of 1 : 1 000 000.

(b) Reconnaissance soil survey of the lowlands to identify potential irrigable areas, mapped at a scale of 1 : 250 000.

(c) Semi-detailed soil survey of the potential irrigable areas identified, mapped at a scale of 1 : 100 000.

The reconnaissance soil survey identified fairly large areas of recent alluvium in the Middle Awash potentially suitable for irrigation. To identify and define suitable areas for irrigation development at greater intensity, a semi-detailed soil survey was undertaken in the Metahara, Melka Sadi, Amibara, Kesem-Kebena and Angelele-Bolhamo areas. The survey standards were designed so as to define, map and classify patches of land of 25 to 30 ha and larger. The mapping base was 1 : 40 000 aerial photographs, eventually reduced to 1 : 50 000. The final mapping was published at a scale of 1 : 100 000. The reported survey intensity was about one profile analysed per 200 to 300 ha. The soils were classified into soil groups and their suitability for irrigation assessed using the criteria defined by the US Bureau of Reclamation. None of the land in the survey area was found to be Class I for irrigation; the best land found was defined as Class II, mapped as alluvial soils developed on recent very slightly or non-calcareous deposits. Also identified were Class III deep vertisolic and hydromorphic soils more especially near the confluence of the Awash and Kesem rivers as well as patches of moderately saline soils throughout the area. Nearer the western escarpment were found areas of shallower coarser textured alluvial and colluvial Class IV soils. These soils were considered to be non-irrigable in their present state, but with appropriate treatment under the right conditions, Class IV soils were thought to be of limited suitability for certain special crops or pasture.

The 1965 study concluded that there were 18 700 ha of Class II land in the Kesem-Kebena area of moderate suitability for irrigation development.

Other reports made on the soils of adjacent areas in the Middle Awash Valley include the 1969 Feasibility Study for the Amibara Irrigation Project undertaken bv ITALCONSULT (Ref. 5), the various reports made by Sir William Halcrow & Partners on the Amibara Irrigation Project (Ref. 9 and 10), the 1975 Feasibility Study for the Angelele-Bolhamo Irrigation Project also by Sir William Halcrow & Partners (Ref. 6), the 1973 report by D.T. Currey (Ref. 2) and the 1982 and 1985 NEDECO reports on the Angelele-Bolhamo Irrigation Project (Ref. 7 and 8).

Useful as these reports were in providing valuable background information on conditions in other parts of the Middle Awash Valley, their direct relevance to the present study was somewhat limited. Despite close geographical proximity, the soil and topographic conditions were found to be very different in the Kesem area. Whereas in both the Amibara and Angelele areas most of the soils have been classified as basin clays and levee soils, in the Kesem-Kebena area these soils are relatively unimportant; here soils developed on alluvial fan deposits predominate.

Despite these differences, the soil classification systems and the general methodology used in each of these studies are broadly similar. This present report is, however, the first in the Middle Awash Valley to use the FAO Framework approach to Land Evaluation (Ref. 12). The previous reports all used the US Bureau of Reclamation system of Land Suitability Classification for Irrigation (Ref. 19).

A4.2 Soil Classification

The primary soil classification is based on geomorphological grounds with subdivisions according to textural properties, as shown in Table A4.1. Further division into phases is discussed below (Section A4.8).

A4.3 General Description of the Soils

The SOGREAH study (Ref. 1) identified a soil pattern of predominantly medium-textured alluvium grading into heavier-textured less well drained soils nearer the Awash and Kesem rivers. The medium textured alluvium was reported to be potentially highly fertile, its suitability for development being limited only by its low water holding capacity. Patches of soil affected by varying degrees of salinity were also found, with strongly saline and sodic soils particularly in the vicinity of the Filweha river.

These general findings are confirmed by the present study. As a result of the increased survey intensity, both the properties and location of the individual soil units are now known with greater accuracy. It is clear, however, that the soils are very much more variable (both laterally and within individual profiles) than previously thought, and that much larger areas are affected by problems of salinity and/or sodicity.

Most of the soils in the area are developed on a complex pattern of inter-calating alluvial fans. Along the banks of the major water courses, particularly the Awash and Kesem rivers, a narrow strip of levee soils may be found. Relict levee soils may also be found along old dry water courses throughout the area; in both cases their extent is very limited.

Soil textures vary considerably, reflecting the very complex recent geomorphological and hydrological history of the area. Alluvial fans continue to be developed as meandering watercourses repeatedly alter their courses. Aerial photographs taken over the last 20 years or so indicate, for instance, that in North Kebena the outwash fan from the Wadi T'unfeta has gradually moved south away from the Dofan Mountain. Extreme spatial variation in soil textures would indicate that this phenomenon has been common throughout the area for some time.

Most of the soils are predominantly medium textured - typically silty loams, silty clay loam, very fine sandy loam and very fine sandy clay loams, with potentially moderate to high water holding capacities. Although some of these soils are well or moderately well drained, many are imperfectly to poorly and very poorly drained. In some cases this is due to the presence of underlying heavier textured material, but more often because of the massive nature and inherently poor physical characteristics of the silty material itself.

TABLE A4.1

Soil and Land Types

Soil type/ land type	Soil or Land Description
Colluvial Soils (<3% slopes)	
1	Coarse-textured colluvial boulder fans; undulating with rills and highly calcareous.
Alluvial Plains (<2% slopes)	
(a) Sandy	
2	Permeable loamy sand and sandy loams, often with gravel lenses but few stones/boulders; depth >30 cm.
3	Permeable loamy sands and sandy loams overlying heavier textures in the second metre; depth >1.5 m, without stony or gravelly lenses.
(b) Silty	
4	Well drained; permeable; layered fine sandy silts overlying predominantly sandy textures.
4b	Less well drained; slowly permeable; layered fine sandy silts overlying a significant clay horizon.
5	Seasonally impeded drainage; slowly permeable; compact (massive) silt loams and silty clay loams with poor physical properties.
5a	Better drained, slowly permeable, compact silt loams with potential for improvement.
5b	Less well drained, slowly permeable, compact silt loams and silty clay loams with significant clay layers and little economic potential for improvement.
(c) Clays	
6	Generally well drained and well structured clays and clay loams.
7	Seasonally poorly drained heavier clays and silty clays derived from Kesem or Kebena alluvium, receiving drainage and locally sodic.
7b	Permanently wet, very poorly drained, low-lying swampy silty clays and clays.
8	Impermeable poorly drained clays and silty clays of the Awash floodplain.
8a	Poorly permeable clays and silty clays of the Awash floodplain, overlying sandy material.
Miscellaneous Land Categories	
A	Alkaline hot springs, or areas influenced by a high alkaline watertable.
B	River beds and banks.
G	Gully complex: slopes/microslopes < 3%; local erosion; ridges exceeding 0.5 m in relative height, requiring excessive levelling.
R	Rocky (sufficient to exclude mechanical cultivation); higher ground out of command; lava hills and sheets.
S	Saline and/or sodic surface outcrops, often on receding terrace edges, and strongly saline-sodic soils.
V	Permanent villages and graveyards.

Infiltration rates are low to very low, on these poorly to very poorly drained soils. Soil structure is often weak to very weak in the surface tending to massive in depth, though well-structured clays and clay loams do occur locally in some areas.

Well drained, permeable coarser-textured soils are moderately common especially towards the western edge of the area nearer the foothills of the Rift Escarpment. Typically, these soils are loamy sands and sandy loams of low water holding capacities, with and without stony and gravelly lenses, but with few (if any) stones and boulders.

Very coarse textured soils developed on undulating colluvial boulder fans are found exclusively on the western edge of the area. These soils are typically highly calcareous and of low to very low water holding capacity. Rill erosion is common on these soils.

The heavier textured soils can be subdivided into those developed on material derived from Kesem or Kebena alluvium, and those developed on the Awash floodplain. Typically the latter are mostly clays and silty clays with clay loams but in the case of well structured, moderately well drained heavy soils on the Kesem-Kebena alluvium textures of clay loams, sandy clay loams, as well as clay predominate. The Awash clays and silty clays are usually vertic often demonstrating gilgai microrelief as well as pronounced swelling and cracking. These soils have generally high water holding capacities.

In North Kebena south of Dofan Mountain hyperthermic soils have been found. These have been defined as being soils hot to the touch within 3 m of the surface and are thought to be associated with an underground hot spring or springs originating from Dofan.

In view of the importance of both sodicity and salinity, the soils have been subdivided on the basis of these two criteria, as described below.

A4.4 Sodicity and Salinity

This annex uses the term 'sodic' rather than the older more ambiguous term of 'alkali' to describe soils with high sodium levels. Sodic soils may be saline or non-saline.

Sodium, potassium, calcium and magnesium are the principal readily exchangeable cations in the soil solution. Normally calcium and magnesium dominate the exchange complex, but in sodic soils the most important cation is sodium. The level of sodium in the soil solution of sodic soils will be high enough to effect adversely the growth of most plants. Soils may be either inherently sodic or may suffer from induced sodicity. The latter can occur in soils which are irrigated repeatedly with sodium-rich water.

Whatever the cause of sodicity, as long as there are free salts present to mitigate somewhat the effects of high sodium, the soil pH remains below about 8.5 and the flocculating effects of the salts maintain the structure and permeability of the soil. Apart from the effects of high sodium levels on plant growth the properties of these saline-sodic or 'white alkali' soils are similar to those of saline soils, (see below). Should the free salts be leached from these soils, the pH rises rapidly to more than 8.5, the clay becomes dispersed and the soil structure collapses thus reducing the infiltration and permeability to low or very low rates. Under these conditions of high pH, some of the soil organic matter is dissolved and dispersed throughout the profile and accumulates on the soil surface a thin black deposits, thus giving rise to the common term 'black alkali soil' for non-saline sodic soils.

Sodicity is usually measured by the exchangeable sodium percentage (ESP), defined as:

$$ESP = \frac{\text{Exchangeable Na}}{\text{CEC}} \times 100$$

where CEC = the cation exchange capacity of the soil.

The limits adopted for sodicity in this report are given in Table A4.2; they reflect the broad ranges discernible by API in the project area, mainly as a combination of vegetation pattern (see Section A2.5) and topographic position.

TABLE A4.2

Soil Sodicity Classification

Symbol	ESP	Sodicity description
none	<6%	Non-sodic
A	6-15%	Moderately sodic
A+	>15%	Sodic

Areas of saline-sodic soils were found to be associated with saline non-sodic soils particularly in Gurmile Block and in the vicinity of the state farms at Saboret and Yalo. Also identified were more limited areas of non-saline sodic soils.

The limits adopted for salinity in this report, given in Table A4.3, are based on the patterns discernible by API, as described for sodicity above, as well as reflecting the standard limit for non-saline soils (4 mS/cm, see FAO 1979, Ref. 13) and the approximate value at which a 20% decrease in cotton yield can be expected (Ref. 22).

TABLE A4.3

Soil Salinity Classification

Symbol	ECe (mS/cm)	Salinity description
none	<4	non and very slightly saline
s	4-12	slightly to moderately saline
s+	>12	moderately to strongly saline

Soluble salts in soils originate from the in situ breakdown of weatherable minerals and the deposition of translocated salts from both ground and surface water. The main salts present in these soils are sodium chloride, sodium sulphate and calcium carbonate.

Under these semi-arid climatic conditions where evaporation exceeds precipitation, the upward movement of soil water results in a concentration of salts in the surface horizons, often indicated in extreme cases by white salt incrustations on the soil surface.

Saline soils were identified throughout the soil study area, but especially in Gurmile Block and both on and in the vicinity of the state farms at Saboret and Yalo. They appear to be most widely associated with the outcrops of receding terrace edges and seepage along fault lines. Many saline soils are also sodic. Some evidence of secondary salinisation exists on the state farms under conditions of impeded drainage. At Yalo this is thought to be associated with a locally perched watertable above a narrow impermeable horizon of Awash flood-plain clay present in the soil profile at varying depths of less than 3 m. No subsurface drainage facilities have been installed at Yalo, so once the profile above the impermeable horizon has been saturated, water is restricted to limited sideways movement and evaporation. As there is no general opportunity to leach the salts out of the profile the tendency is for the soil profile to become increasingly saline.

A4.5 Physical Properties

A4.5.1 Texture

Textures vary greatly both vertically within the soil profile and spatially across the area as a reflection of the wide range in depositional conditions instrumental in the formation of these alluvial soils. Almost every possible texture can be found somewhere in the area: the only exception being sandy clay. Most of the soils are, however, predominantly medium textured: typically silty loams, silty clay loams, very fine sandy loam and very fine sandy clay loams. Texture has been used as the main criterion in classifying the soils (Section A4.2).

A4.5.2 Effective Depth

Effective depth is unlikely to be a major limitation to development of the area. Except for soils with high groundwater and shallow stony, coarse-textured soils developed on colluvial and alluvial material (Sections A4.8.1, A4.8.2) the effective depth of most of the soils is at least 2.0 m and in many cases considerably more.

A4.5.3 Soil Structure

Soil structure in many of the soils is weak to very weak in the surface horizons, tending to massive at depth. Some of the finer-textured horizons may have moderately to even strongly developed structures. Many of the medium-textured silts are particularly compact even relatively high up the profile giving rise to problems with permeability, water infiltration and root penetration.

A4.5.4 Bulk Density

The bulk densities of the soils vary overall as follows:

	Bulk density (g/cm^3)			
	Mean	Range	Standard deviation	Nr of samples
Topsoils (0 to 20 cm)	1.18	1.06 - 1.36	0.07	21
Subsoils (>20 cm)	1.17	1.03 - 1.44	0.07	75

With the exceptions of the 0 - 50 cm sample of PG 29 (bulk density 1.36 g/cm^3 for a sandy loam) and the 26 - 61 cm sample of PG 17 (1.44 g/cm^3 for a sandy loam) all measured bulk density values were less than 1.30 g/cm^3, and about 70% of the samples had values of less than 1.20 g/cm^3. These generally low results indicate that no major problems of root penetration or of soil aeration and drainage are likely in the study area. Appendix A2 gives the results for individual sites.

A4.5.5 Soil Drainage

The depth to groundwater varies, generally being deeper than 10 m in the west and shallower in the east (see Annex H, and also Drawings A5 and A6 of this Annex). Areas of shallow groundwater (less than 3 m) are found in the North Kebena area associated with the underground hot springs emanating from Dofan Mountain. Perched watertables can be found throughout the soil study area, more generally in areas of saline soils, and particularly in the Yalo area.

Many of the soils are only poorly drained; some as in the case of the heavier-textured clay and silty clay soils of the Awash floodplain, as a result of topographic position and soil textural properties, others including many medium textured silty soils are poorly drained because of their massive, compact structure and related low porosity.

Tne better structured soils of both medium and heavy textures are well to moderately well drained. The coarse textured soils are frequently excessively well drained.

Soil drainage is discussed further in Section A6.3.

A4.5.6 Infiltration Rates

The results of the infiltration tests are shown in Table A4.4, both by soil type and by surface texture, and a sample infiltration curve is presented in Figure A4.1; results for individual pits are given in Appendix A2.

At most sites, reasonably consistent results were obtained from the three replicate measurements, although in a few the intake rate in one ring differed markedly from the other two. In these cases the higher intake values presumably resulted from large cracks or holes in the soil, or the presence of a thin layer or layers of coarser soil, whilst the lower values will have varied due to textural or bulk density differences. Because of such variability, little can be usefully said about the infiltration rates with respect to soil types; even within a single soil phase there can be considerable differences in soil characteristics such as texture, porosity and the sequence of layers in the topsoil, each of which can have profound effects on the infiltration rate. As an extreme example, the 9 replicates on soil type 3 produced results ranging from 17 to 84 mm/h.

Analysis of the results by textural grouping produces a slightly more regular pattern, the coarser-textured soils clearly having higher infiltration rates than the rest. However, the average rate for the fine textures is slightly greater than that for the medium-textured grouping, possibly reflecting greater structural development in the former. In view of the presence of montmorillonitic clays in the area, such structural development will be an extremely important influence in places (most notably in the vertic and vertisolic clays bordering the Awash river), although at most of the test sites on non-vertic

TABLE A4.4

Summary of Infiltration Results

A. By soil type

Soil type and phase[a]	Number of replicates	Surface textures(s)[b]	Basic infiltration rate (mm/h) Mean	Range	Standard deviation
2s+	3	SL/SL-	55	54-57	-
2sA+	3	vfSL	28	24-35	-
3	9	SL+,C	50	17-84	18
4,4b, 4sA	15	fSL, vfSL, CL, C	25	15-43	10
5,5/5a, 5a, 5A, 5b, 5bs/5s, 5s 5s+A	42	LS, fSL+ vfSL+, fSCL+, ZCL, CL C	27	11-66	14
6	15	cS, fSCL, C	24	10-44	11

B. By surface texture of soil (b)

Surface textural grouping	Number of replicates	Soil types and phases[a]	Basic infiltration rate (mm/h) Mean	Range	Standard deviation
Coarse textures					
LS, cS, SL+, SL, SL-	15	2s+, 3, 5A, 6	44	28-84	17
Medium textures					
fSL/vfSL	21	4b, 4sA+, 5, 5a	24	13-35	5
fSL/fSCL	18	2sA+, 5, 5s, 5s/5bs, 5/7	25	10-58	15
fSCL/vfSCL	3	5a, 5s+A, 6	19	12-25	-
All medium textures	42	-	24	10-58	10
Fine textures					
CL, ZCL	18	4, 5, 5s+A, 6	30	14-66	16
C	15	3, 4b, 5b, 6	26	13-65	17
All fine textures	33	-	28	13-66	16

C. All tests

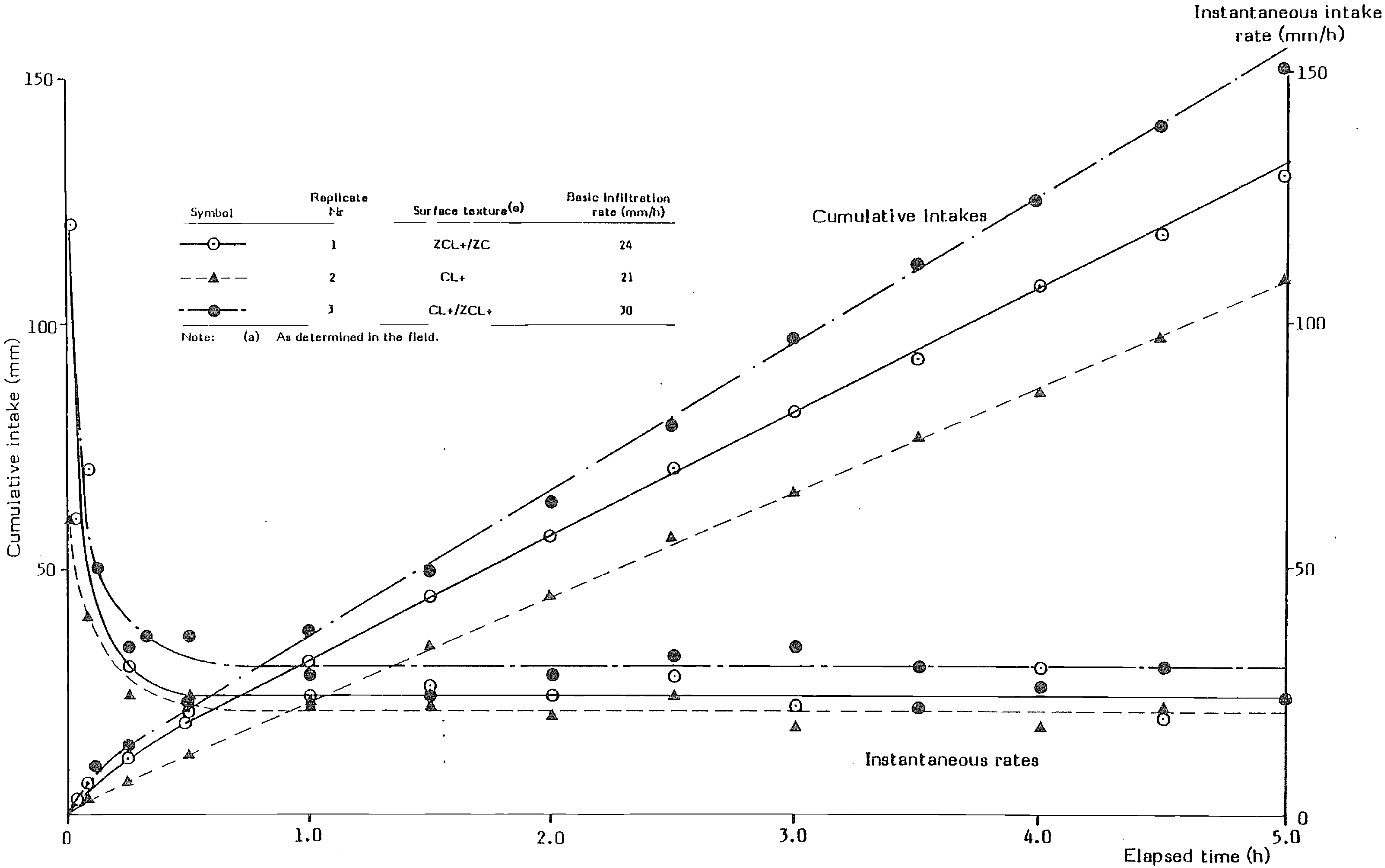
	Number of replicates		Mean	Range	Standard deviation
	90	-	29	10-84	15

Note: (a) See Section A4.8.

(b) As determined in the field at the site of the infiltrometer.

Figure A 4.1

Sample Infiltration Curves (Site PG 10, Soil Type 5)



soils derived from the escarpment, there was little or no evidence of a reduction in rate over periods of up to 5 h or so during the tests (see Figure A4.1). Some reduction in rates over very much longer periods may occur, but no observations could be made within the current survey schedule. A comparison of the rates measured during this project and the representative rates quoted by FAO (Ref. 13) show that for most of the soils the rates are broadly within the expected ranges (see Table A4.5).

The exception is the rates for finer-textured soils, whose measured rates are of the order of ten times higher than the published rates. This is probably due to the vertic nature of many of the clays in the finer-textured soils and the very strong structural development in these as they dry out. In the comparatively short periods of rewetting represented by the infiltration tests the soils would not swell sufficiently to close all the structural cracks and reduce the infiltration rates to the lower values normally associated with wet clays. Superficial observations at Amibara indicate that these vertic soils retain good structure, at least in the surface layers, and that slow or very slow infiltration rates are not a major problem.

However, considerable changes in infiltration rate can occur if soils are allowed to deflocculate during leaching. This is a potentially serious problem over those parts of the Kesem area where soils with high silt or clay contents predominate, and if unchecked, could lead to effective sealing of the surface of such soils. No such sealing effects were observed during the present infiltration measurements.

A4.5.7 Hydraulic Conductivity

Table A4.6 presents the results of the hydraulic conductivity tests by soil textural grouping. Illustrative samples of the plotting techniques for both constant and falling head methods are shown in Figures A4.2 and A4.3, respectively. Results for individual pits are given in Appendix A2. Because of the complex variation in soil profile characteristics - not merely within the same soil phase but also between sites only a few metres apart - no meaningful grouping of hydraulic conductivity measurements on a soil series or a spatial basis can be made.

Interpretation of the hydraulic conductivity results for the Kesem area must be made with great caution, for several reasons, which can be summarised under three main headings:

(a) Soil Variability

The extreme soil variability makes accurate interpretation of the hydraulic conductivity results very difficult. Although the depth of each test was chosen to coincide with uniform textural layers described in the corresponding pit, uniform conditions were not always encountered. Even at sites where the auger samples appeared uniform, the effects of mixing during augering may have obscured the presence of thin layers only a few centimetres thick. Such layers may have had an undue influence on the measured hydraulic conductivity values, especially if water was able to percolate rapidly through one or more such layers formed by coarse-textured soil. Similar effects may be produced by the presence of faunal channels or other voids within the soil. An example of variability in apparently uniform soils is provided by the results at Site PN 13 (see Figure A4.2).

TABLE A4.5

Comparison of Infiltration Results with FAO Representative Values[a]

Soil textural grouping		Basic infiltration rate (mm/h)			
		Mean		Range	
KIP[b]	FAO	KIP	FAO	KIP	FAO
Coarse textures					
	S		50		20-250
LS, cS		39		39-52	
Medium textures					
	SL	51	20	6-84	10-80
f to vf SL f to vf SCL		24		10-58	
	L		10		1.0-20
Fine textures					
CL, ZCL		30		14-66	
	CL		8.0		2.0-15.0
	ZC		2.0		0.3-5.0
C	C	26	0.5	13-65	0.1-8.0

Notes: (a) FAO Soils Bulletin Nr 42 (Ref. 13)
(b) See Table A4.4.

TABLE A4.6

Summary of Field Hydraulic Conductivity Measurements[a]

Soil textural grouping[b]	Number of replicates	Hydraulic conductivity (m/d) Mean	Range
SL	7	0.161	0.109-0.212
fSL/vfSL	6	0.552	0.153-1.493
fSL/fSCL	11	0.194	0.020-0.570
SCL	1	0.102	0.102
vfSCL/fSCL/ZCL	14	0.124	0.046-0.380
CL	2	0.097	0.090-0.104
CL/C	8	0.034	0.018-0.057
C	11	0.046	0.016-0.112

Notes: (a) Constant head results only; falling head measurements are given in Appendix A2.

(b) As determined in the field at each measurement site.

Figure 4.2

Sample Water Intake Curves for Hydraulic Conductivity Constant Head Method (Site PN 13, Soil Type 5s)

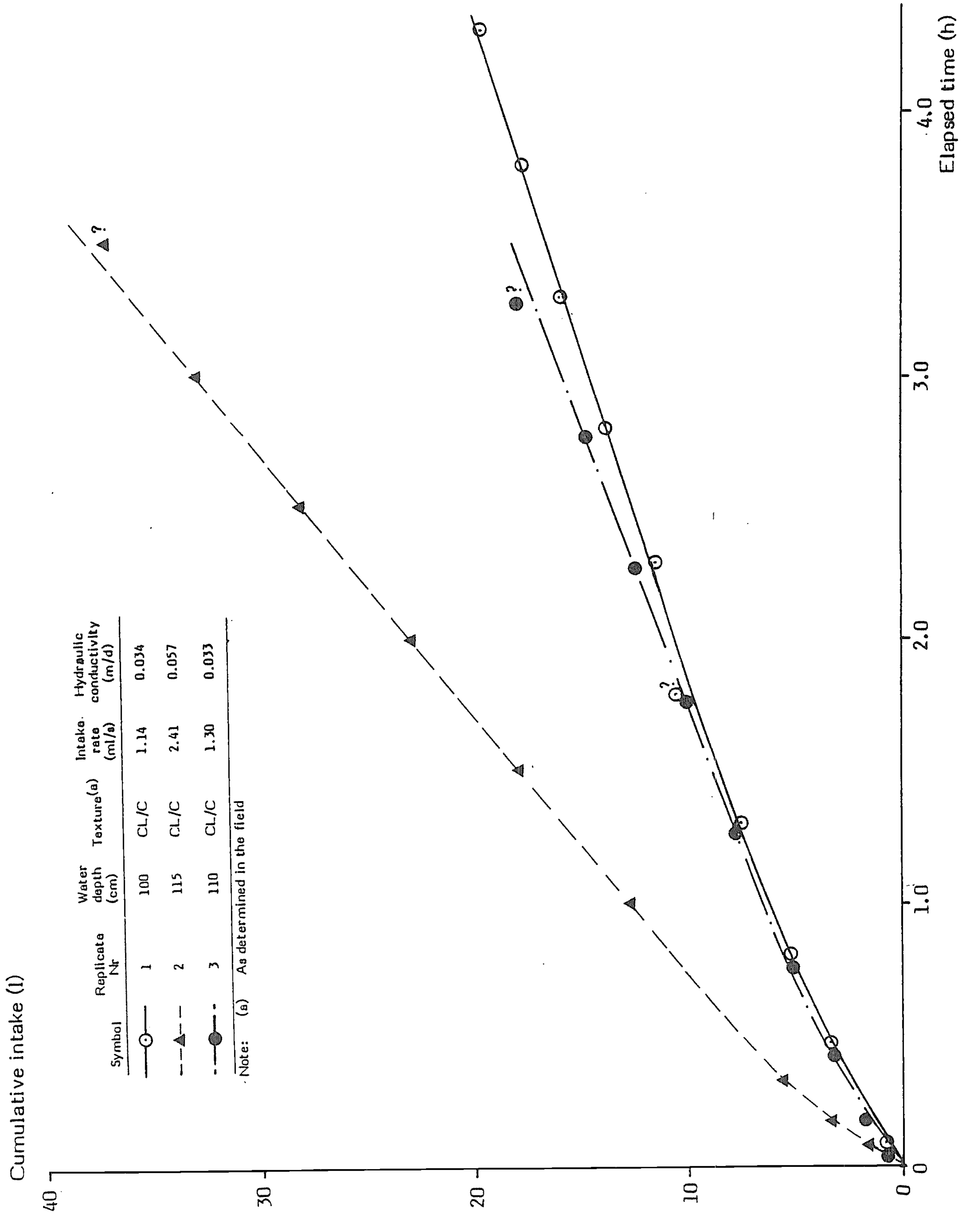


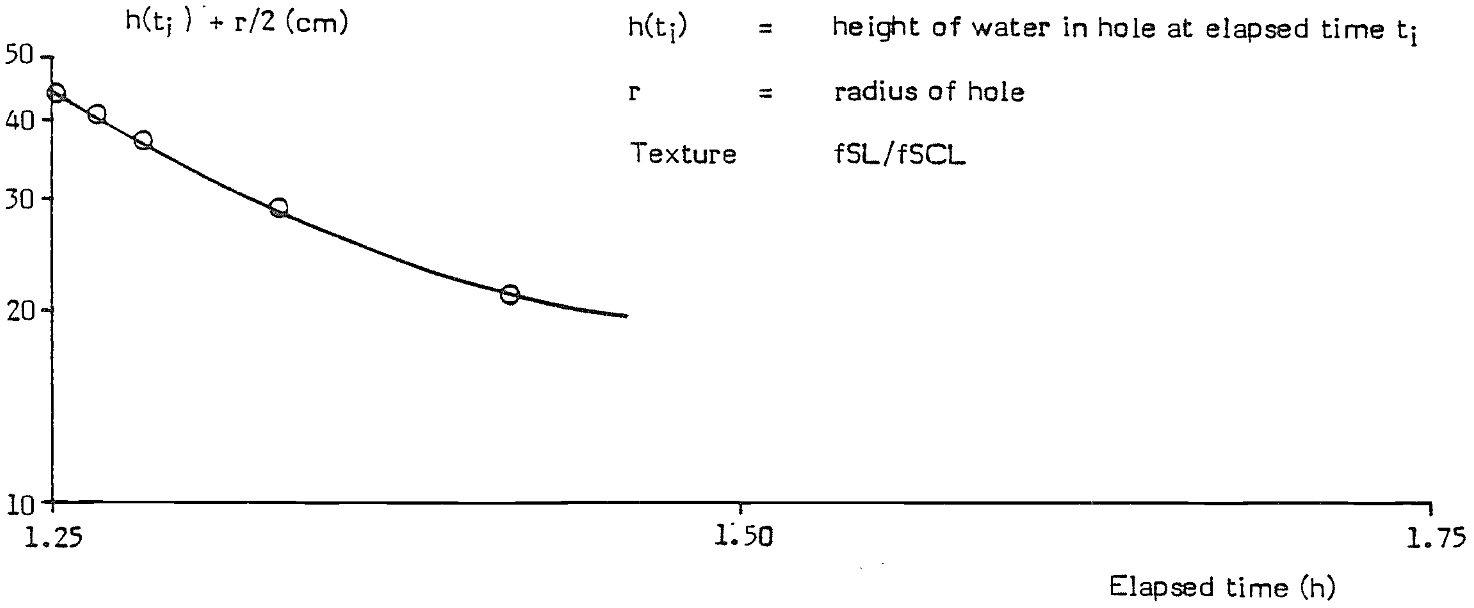
Figure A4.3

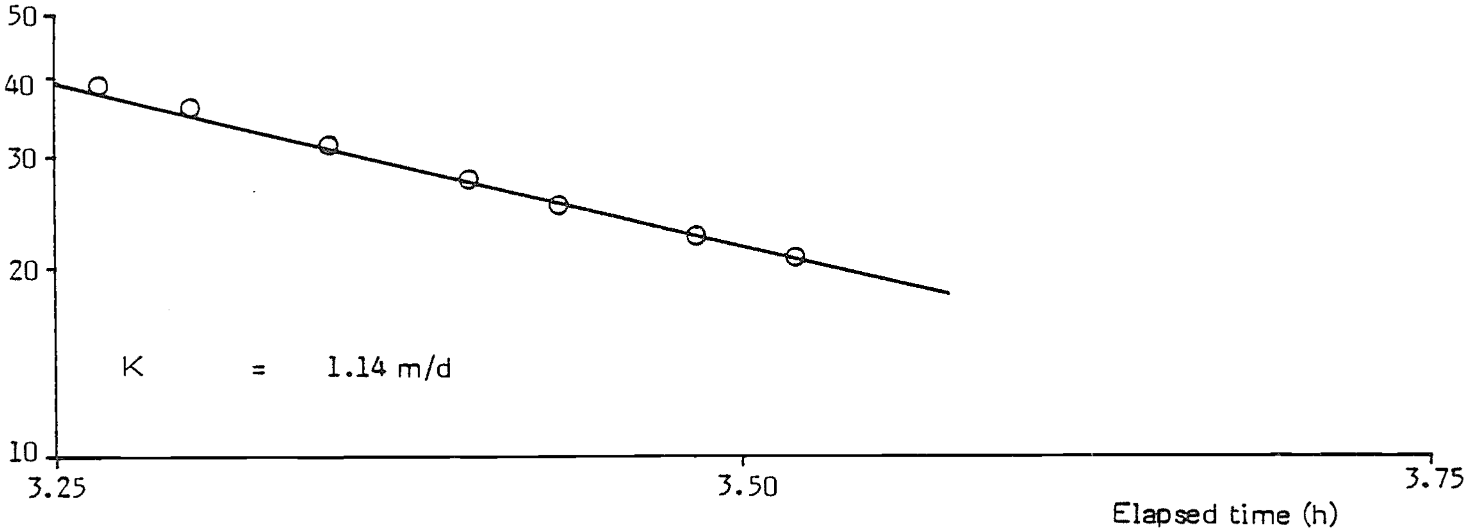
Sample Plots for Hydraulic Conductivity Falling Head Method (Site PG 10, Replicate 3; Soil Type 5)

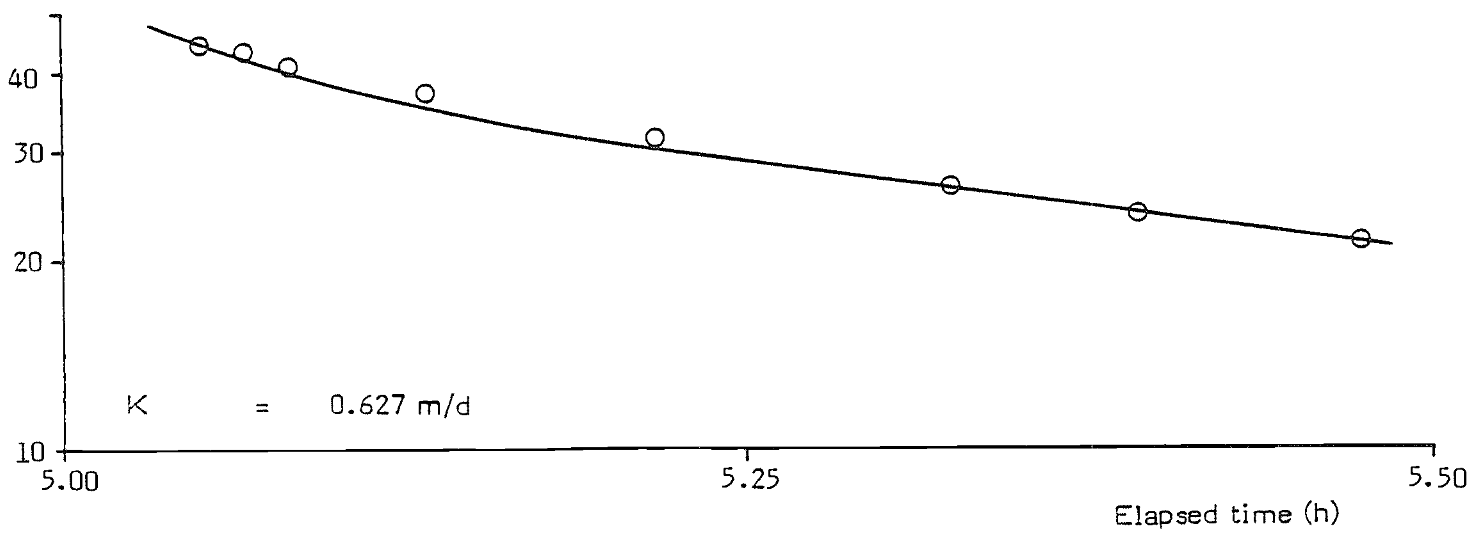
$h(t_i)$ = height of water in hole at elapsed time t_i

r = radius of hole

Texture fSL/fSCL







(b) Test Conditions

The accuracy of the pour-in test used to measure hydraulic conductivity depends on the fulfilment of several conditions during the test, notably those mentioned by Winger (Ref. 16):

- use of silt-free water;
- presence of stable soil material;
- no formation of a seal on the hole periphery;
- use of correct minimum and maximum volumes of water required to develop and maintain a proper wetting cone;
- maintenance of a uniform diameter of the hole, both along its length and throughout the test period;
- correct electrolytic concentration of the water.

These conditions are seldom all met for a particular measurement, and even small variations can produce significant errors in the calculated result. In a study by Kessler (Ref. 17) of the augerhole method, for example, an actual hole diameter of 10 cm, instead of the assumed 8 cm, produced a calculated hydraulic conductivity 30% too low.

(c) Applicability of Test Values

The values obtained may not be directly applicable to the actual conditions encountered during development. In particular, the effects of soil deflocculation in saline or saline-sodic soils may critically affect the values, as discussed for infiltration rates in Section A4.5.5 above, and the presence of lenses and layers of both fine- and coarse-textured material at various depths in the soil will have considerable local influence on water movement within the soil profile.

As a check on the results obtained, Table A4.7 presents a comparison by textural grouping of hydraulic conductivity values measured during the project and representative values published by FAO (Ref. 13). In general, the results show fair correlation, although some of the values measured in coarser soils are slower than expected, possibly due to siltation within their pores. With this exception, the results provide reasonable order-of-magnitude values of hydraulic conductivity for use in project planning, provided that adequate allowance is made for the inherent limitations, both of the measurements and their interpretation, noted above.

A4.5.8 Water-holding Capacities

Because of the large number of layers in many of the pits, it was not possible to sample every layer in every pit for moisture release measurements, although between 3 and 7 samples were taken at each sample site at depths corresponding to the thicker layers. For each of the unsampled thinner layers an average value was taken, calculated using results for the same texture measured in the other pits. The results can be summarised as shown in Table A4.8. Figure A4.4 shows sample moisture characteristic curves.

TABLE A4.7

Comparison of Hydraulic Conductivity Results with FAO Representative Values [a]

Soil textural grouping		Hydraulic conductivity range (m/d)	
KIP[b]	FAO	KIP	FAO
Coarse textures			
SL	SL	0.109-0.212	1.5-3.0
Medium textures			
fSL/vfSL	vfSL	0.153-1.493	0.5-1.5
fSL/fSCL	vfSL, SCL	0.020-0.566	0.05-1.5
SCL	SCL	0.102	0.05-0.5
vfSCL/fSCL/ ZCL	ZCL/SCL	0.046-0.380	0.05-0.5
Fine textures			
CL	CL	0.090-0.107	0.05-0.5
CL/C	CL/C	0.018-0.057	0.05-0.1
C	C	0.016-0.112	0.05-0.1

Notes: (a) FAO Soils Bulletin Nr 42 (Ref. 13, p177)
(b) See Table A4.6.

Sample Moisture Characteristic Curves

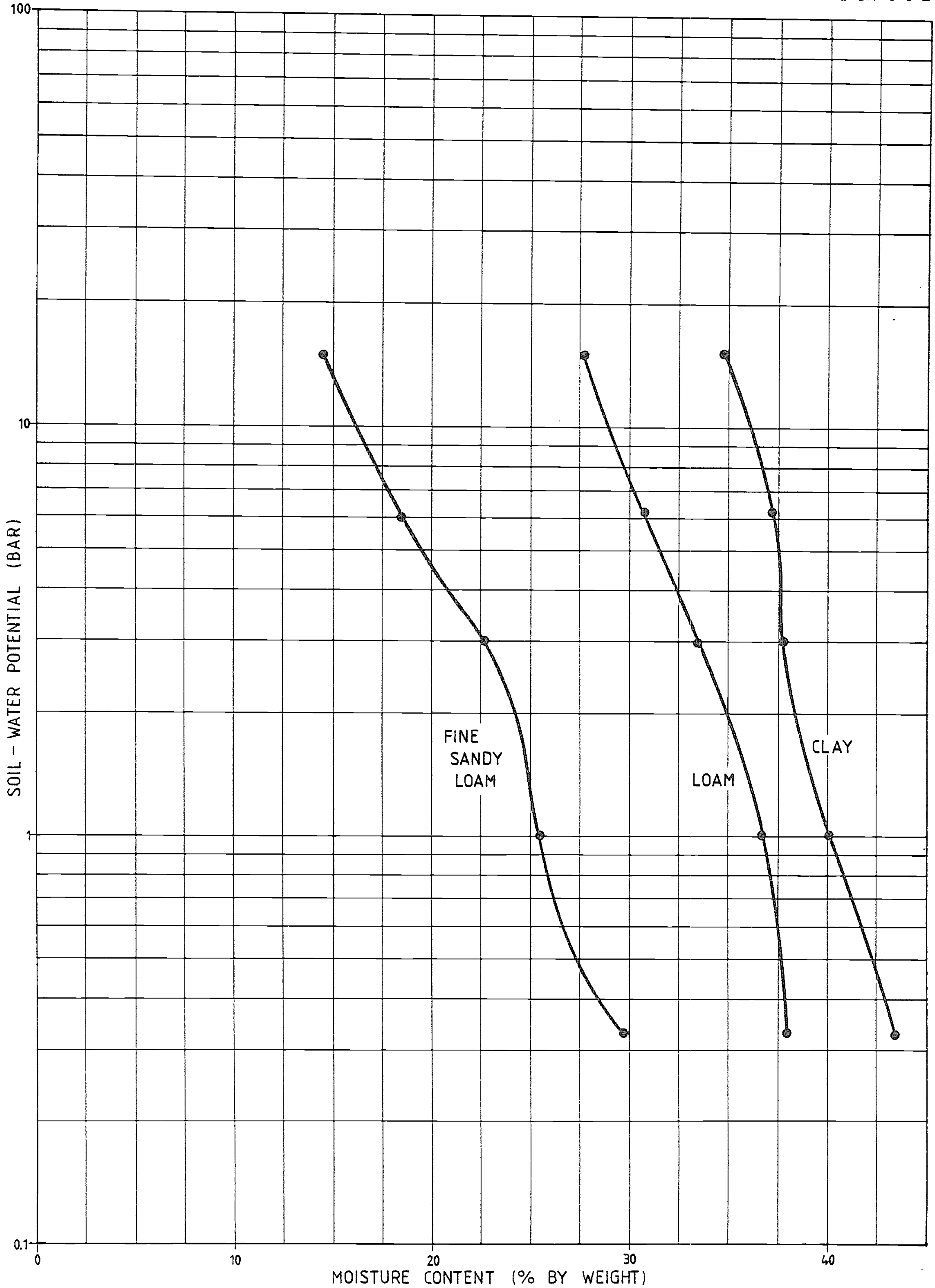


TABLE A4.8

Summary of Soil Water Release Figures

	Value (mm/m) Mean	Range	Nr of samples
Available water capacity			
Profile (0-100 cm)	219	156 - 280	21
Field capacity			
Topsoils (0-20 cm)	405	531 - 297	21
Subsoils (20 cm)	397	86 - 571	75
Permanent wilting point			
Topsoils (0-20 cm)	188	90 - 313	21
Subsoils (20 cm)	181	43 - 380	75

Values of individual soil layers are presented in Appendix A2, whilst a breakdown of AWC values by texture is given in Table A4.9:

TABLE A4.9

Available Water Capacity Related to Soil Textural Groupings

Textural grouping[(a)]	Nr of samples	Mean bulk density (g/cm^3)	AWC (mm/m) Mean	Range	Standard deviation
Coarse textures					
LS, LS/SL	9	1.27	330	194 - 497	108
SL	4	1.19	190	154 - 246	-
Medium textures					
fSL	16	1.20	220	78 - 220	75
fSCL	16	1.14	204	98 - 204	66
Fine textures					
ZCL, CL, CL/C	17	1.12	201	56 - 370	104
C	11	1.09	245	160 - 361	82

Note: (a) As determined in the field.

These values for AWC are moderately high to very high and would indicate that available water capacity is not a problem in the study area. Such results, as well as the low bulk density values (Section A4.5.4), are to be expected in an area where soil materials of volcanic origin have made appreciable contributions to the soils. However, scrutiny of the results shows that there are some extremely high field capacity values and it may be that some of these are due to insufficient time allowances for equilibrium of the cores at low tension in the laboratory. We would therefore recommend very careful measurements on a selection of representative textural samples, preferably with in situ tests for field capacity, to confirm the above AWC values before any project design is finalised.

For the purposes of outline irrigation design and costing in this study (see Annex L) an overall value for soil AWC of 180 mm/m has been taken. This value, intended as a representative figure for the predominantly medium-textured soils found in the area (see Section A4.5.1), lies between the values of 200 mm/m and 140 mm/m quoted in FAO Irrigation and Drainage Paper Nr 24 (Ref. 25) for fine- and medium-textured soils respectively. From this figure the readily available water capacity has been calculated using an indicative factor of 0.5, based on the range given by FAO (Ref. 25) for a variety of crops.

A4.6 Chemical Properties

The soils as a whole are inherently at least moderately fertile. Most have a moderately alkaline reaction, with pH values varying from 8.0 to 8.8, though strongly alkaline reactions were recorded in the field on non-saline sodic soils (pH over 9.0). Most of the soil horizons analysed were found to be at least very slightly saline (ECe = 1.0 to 4.0 mS/cm) though some were identified as being strongly saline (ECe = more than 12 mS/cm). All the soils contain some free calcium carbonate; generally the levels found were about 5 to 8%, though figures in excess of 10% were recorded for some sites. Most of the soils do not contain gypsum; in the few soils where it was found analytically, percentages were almost invariably less than 1%. As would be expected under harsh semi-arid conditions, the soils have low to very low organic matter levels. Even in the topsoil horizons organic matter rarely exceeds 0.8%, staying fairly constant down the soil profile. There is consequently little colour change with depth, most profiles being brown throughout (typically 10YR 3/2, 10 YR3/3, and 10YR 4/3 when moist). Similarly levels of total nitrogen are also very low, ranging from 0.01 to 0.6%. Available phosphate levels are generally low to very low (below 3 ppm P_2O_5). The cation exchange capacity of most of these soils lies in the range 12 to 30 meq/100 g of soil; the principal clay type is probably a 2 : 1 illitic clay lattice type except for the vertic clays of the Awash floodplain where it is montmorillonitic, though in neither case has this been demonstrated analytically by this study. The exchange complex is dominated by moderately to very high levels of sodium and high levels of calcium, and high levels of exchangeable potassium and magnesium. Base saturation is almost invariably 100%. Analytical results suggest that the most common salts found in these soils are sodium chloride, sodium sulphate, and calcium carbonate.

A4.7 Hyperthermic Soils

In North Kebena some of the soils were found to be hot to the touch within 3 m of the surface and temperatures of up to 60°C within the top 3 m were measured; these hot soils were classified as hyperthermic phases. Hyperthermic phases were found in a wide range of different soil types all as a result of underground hot springs and/or volcanic activity originating from Dofan Mountain. Very often, but not exclusively, this phenomenon seemed to be associated with high groundwater as well. Hyperthermic soils tend to support only shallow rooting grasses and epheremals vegetation types. In extreme cases the soil surface is completely devoid of any vegetation. Hyperthermic phases are designated by the suffix (h).

A4.8 Soil Mapping Units

A4.8.1 Introduction

The soil and land types have already been defined in Table A4.1: 13 soil types (1, 2, 3, 4, 4b, 5, 5a, 5b, 6, 7, 7b, 8 and 8a), and 6 land types (G, A, B, R, S and V) have been identified. With 3 levels each of salinity and sodicity and

2 levels of hyperthermic activity, there are a potential number of 234 soil mapping units. In order to reduce this to a reasonable number of mapping units the salinity/sodicity categories have been regrouped as follows:

Salinity/ sodicity category	Soil phase mapped (suffix)	Land type mapped	Description
s	s	-	Moderately saline
s+	s+	-	Strongly saline
A	A	-	Moderately sodic
sA	A	-	Moderately sodic, saline
A+	A+	-	Strongly sodic
sA+	A+	-	Strongly sodic, moderately saline
s+A	-	S	Strongly saline-sodic
s+A+	-	S	Strongly saline-strongly sodic

Note: For non-saline, non-sodic soils, only the soil or land type symbols appear.

The saline non-sodic soils (salinity/sodicity categories s and s+) have not been regrouped and have been mapped as 1s and 1s+, etc. Of the sodic soils a few are non-saline, but most are both saline and sodic. In view of the predominantly silty textures of the soil profile, sodicity is likely to a more critical hazard to crop growth than salinity. Soils that are both moderately sodic and non-saline or slightly to moderately saline have therefore been grouped together into soil phase A, and have been mapped as 2A, 3A, etc. Soils that are strongly sodic and either non-saline or slightly to moderately saline have been grouped together into soil phase A+, and have been mapped as 2A+, 3A+ etc. Soils that are strongly saline and either moderately or strongly sodic have been included in land type S.

Consequently for each soil type there are four phases of salinity and/or sodicity (suffixes: s, s+, A, A+); each of which can be hyperthermic or non-hyperthermic; hyperthermic phases being designated by the suffix h. There are thus 130 potential soil mapping units. However, many of these were not found and several others were too small and insignificant to map at a scale of 1 : 20 000. Nevertheless a total of 13 soil types and 56 soil phases occupy sufficient area to warrant mapping as separate units, making with the 6 land types, a grand total of 74 mapping units in all (see Drawings A1 and A2). The area of each unit mapped is given in Table A4.10. Brief descriptions are given below of each soil type, soil phase and land type. Detailed soil pit descriptions for selected typical sites will be found in Appendix A1 and the corresponding soil analytical data in Appendix A2.

In terms of map accuracy, strongly saline or sodic areas are readily discernible on the aerial photographs by their distinct vegetative pattern and/or topographic position. Less strongly afected areas (soils with ESP values of 6 to 15% and/or EC_e values of 4 to 12 mS/cm) are slightly less readily defined: although the main occurrences are clearly visible, small patches within otherwise good land are not always apparent. The extent of these inclusions is difficult to quantify, but is not expected to exceed about 10%.

TABLE A4.10

Soil Mapping Unit Areas

Soil or land type	Soil phase	Area (ha) North Kebena	Gurmile	South Kesem	Totals Phase	Type	% of mapped area
Soil types							
1		140	32	26	198		
	s	12	6		18		
	s+		18		18	234	1.1
2		818	382	136	1 336		
	s	202	110	36	348		
	s+	100			100		
	A	94	132	12	238		
	A+	24			24		
	h	6			6	2 052	9.4
3		118	174	30	322		
	s	34	10	4	48		
	s+	20	10		30		
	A	38			38		
	A+		12		12		
	hs	6			6	456	2.1
4		378	508	154	1 040		
	s	184	106	52	342		
	s+	20	68	26	114		
	A	20	183		203		
	A+	16	38		54		
	hs	40			40	1 793	8.2
4b		52	262	140	454		
	s	110	104	116	330		
	s+		24		24		
	A	32	40		72		
	h	40			40		
	hs	28			28		
	hs+	10			10	958	4.4
5		340	1 150	1 706	3 196		
	s	132	360	642	1 134		
	s+	4	262	128	394		
	A	18	563	4	585		
	A+		148	12	160		
	h	50			50		
	hs	22		4	26	5 545	25.4
5a		88	246	196	530		
	s	16	128	130	274		
	s+	8	96	30	134		
	A		118	4	122		
	A+			10	10		
	h	18			18		
	hs	50			50	1 138	5.2

TABLE A4.10 (cont.)

Soil or land type	Soil phase	Area (ha)			Totals		% of mapped area
		North Kebena	Gurmile	South Kesem	Phase	Type	
5b		48	252	442	742		
	s		108	212	320		
	s+		88	20	108		
	A	14	120	8	142		
	h	4			4		
	hA+	12			12	1 328	6.1
6		528	647	628	1 803		
	s	264	132	44	440		
	s+	78	12	6	96		
	A	36	24		60		
	A+		6		6		
	h	56			56		
	hs	44			44	2 505	11.5
7			118	184	302		
	s		30	50	80		
	s+	12			12		
	A		88	466	554		
	A+		96	18	114		
	h	10			10		
	hs			4	4	1 076	4.9
7b		8	36	8	52		
	s			2	2	54	0.2
8		498	96		594		
	s	10			10	604	2.8
8a		158	12		170		
	s	4			4	174	0.8
Miscellaneous land categories							
G		294	368	190		852	3.9
A				12		12	0.1
B		227	464	296		987	4.5
R		104	464	36		604	2.8
S		172	733	404		1 309	6.0
V			66	76		142	0.7
Total		5 869	9 250	6 704		21 823	100

A4.8.2 Description of the Soil Mapping Units

A4.8.2.1 Soil Type 1

Limited areas of coarse-textured undulating colluvial boulder fans with slopes of up to 3% were found on the western fringes of the survey area usually immediately adjacent to the base of the escarpment. These are most widespread in the southwestern part of North Kebena block where they are associated with a small line of ridges running south-west to north-east across the survey area. The soils developed on these fans are invariably gravelly and highly calcareous and tend to be both coarse textured and stony. Shallow soils predominate; these soils are at best only about 30 cm deep. The soils are typically dark brown (10YR 3/3) throughout the profile and are usually non-saline.

Two phases of this soil have been mapped in addition to soil type 1: a moderately saline phase (1s) and a strongly saline phase (1s+). No phases of sodic or hyperthermic soils have been recorded. The soils tend to be well to excessively well drained, and can be expected to have low rates of available water capacity and high rates of infiltration and hydraulic conductivity, generally with no major impermeable layers within the top 2 m. Much of this soil type is subject to seasonal rill and gully erosion: 234 ha have been mapped, almost all of it in North Kebena Block, representing 1% of the soil study area.

A4.8.2.2 Soil Type 2

These alluvial soils developed on slopes of less than 2% are permeable, loamy sands and sandy loams with 75% of the top 2 m consisting of textures of loam or coarser. The soils are likely to be at least moderately deep (more than 30 cm) with few stones and boulders occurring either at the surface or within the profile, although gravel lenses are common at any depth. Soil colour is typically dark brown (10YR 3/3) throughout, with varying degrees of brown and grey mottling possible at depth. Soil structure is generally weak to very weak in the upper horizons tending to massive in depth. The soils tend to be well to moderately well drained, generally with no major impermeable layers within the top 2 m. Measured infiltration rates range from moderate to moderately high (24 to 57 mm/h); overall, hydraulic conductivity values below 1 m can be expected to range from very slow to moderate (0.1 to 1.5 m/d).

The soil profile is generally calcareous, though levels for individual horizons vary considerably from non-calcareous to highly calcareous. Although these soils are predominantly non-saline, non-sodic, moderate levels of salinity and sodicity are not uncommon, with high levels of salinity and sodicity being recorded at a few sites. Soil type 2 is the dominant soil type in the central, northern and western parts of North Kebena Block and in the north-western part of Gurmile Block. It is much less common in South Kesem; the only appreciable area identified was found immediately south-east of the settlement at Saboret, though several small patches occur along the banks of the Kesem river and along the line of old relict watercourses. A small area of hyperthermic soil has been identified in this unit just south of the outwash area of Wadi T'unfeta in North Kebena.

Five phases of this soil have also been mapped in addition to soil type 2: a moderately saline phase (2s), and a strongly saline phase (2s+), a sodic phase (2A), a strongly sodic phase (2A+) and a non-saline, non-sodic hyperthermic phase (2h). A total of 2 052 ha has been mapped all but 716 ha of this being non-saline, non-sodic and non-hyperthermic. The whole soil type covers 9.4% of the soil study area. A representative profile description (see Appendix A1) of soil type 2 is presented (see Appendix A2) by profile number PG 8.

A4.8.2.3 Soil Type 3

The alluvial soils of soil type 3 are somewhat similar to those of soil type 2: developed on slopes of less than 2%, they are permeable, loamy sands and sandy loams. The main difference in soil type 3 is that these overlie heavier textures such as clay loam, sandy clay loam or clay found in the second metre of the profile. The soils are invariably deep (more than 1.5 m) and are non-stony, and non-gravelly. Soil colours are typically very dark greyish brown to dark brown (10YR 3/2 to 3/3), with varying degrees of brown and grey mottling possible at any level within the profile. Soil structure is generally moderate to weak in the upper horizons tending to massive in depth, though it may be better in individual horizons, particularly those of finer textures. The soils tend to be moderately well to imperfectly drained, generally with no major impermeable layers within the top 2 m. Measured infiltration rates are highly variable (17 to 84 mm/h), and hydraulic conductivity between 1 and 2 m can be expected to vary from slow to very slow (less than 0.5 to 0.1 m/d).

The soil profile is generally slightly calcareous, though individual horizons may be non-calcareous. The soils are predominantly non-saline, non-sodic. Whilst moderate levels of salinity have been recorded at a few sites, high levels of salinity and all levels of sodicity are much less common. Soil types 2 and 3 tend to be very similar in their geographical distribution; in both cases they are considerably more common in North Kebena and the northern half of Gurmile Block than in the rest of the area. Soil type 3 is, however, not as widespread in its distribution and certainly cannot be described as being the dominant soil type anywhere. Very locally in North Kebena hyperthermic phases of soil type 3 have been identified.

Five phases of this soil have also been mapped in addition to soil type 3: a moderately saline phase (3s), and a strongly saline phase (3s+), a sodic phase (3A), a strongly sodic phase (3A+), and a moderately saline, non-sodic hyperthermic phase (3hs). A total of 456 ha has been mapped, all but 134 ha of this being non-saline, non-sodic and non-hyperthermic. The soil type 3 covers 2.1% of the soil study area. A representative profile description (see Appendix A1) of soil type 3 is presented (see Appendix A2) by profile number PG 20.

A4.8.2.4 Soil Types 4 and 4b

These two different alluvial soils are somewhat similar and are differentiated on the basis of the dominant texture of the second metre in the profile.

Soil Type 4

These are permeable, well drained layered fine sandy silts, developed on slopes of less than 2%, with between 25% and 50% of the top 2 m consisting of textures of fine sandy loam, silty loam or silty clay loams overlying generally predominantly coarse sandier textures. The soils are invariably deep or very deep and are non-stony and non-gravelly. Soil colours are typically very dark greyish brown to brown (10YR 3/2 to 4/3), with varying degrees of brown, reddish brown and greyish mottling and iron staining present at depth. Soil structure is generally moderate to weak in the upper horizons tending to massive in depth.

The soils are usually well drained, generally with no major impermeable layers within the top 2 m. Measured infiltration rates are moderate (15 to 42 mm/h) and hydraulic conductivity in the 1 to 2 m layer will be very slow to slow (less than 0.05 to 0.5 m/d).

The soil profile is generally calcareous, though levels for individual horizons vary considerably from non-calcareous to highly calcareous. Moderate levels of salinity and/or sodicity have been recorded at several sites, though high levels of salinity and sodicity are less common. This soil type tends to be distributed fairly evenly throughout the soil study area; it is, however, most common around the extinct volcano of Gurmile in the middle of the area and relatively less common in South Kesem. Locally in North Kebena these soils may be hyperthermic.

Five phases of this soil have also been mapped in addition to soil type 4: a moderately saline phase (4s), and a strongly saline phase (4s+), a sodic phase (4A), a strongly sodic phase (4A+), and a moderately saline, non-sodic hyperthermic phase (4hs). A total of 1 793 ha has been mapped; of this 1 040 ha have been mapped as being non-saline, non-sodic and non-hyperthermic. Soil type 4 covers 8.2% of the soil study area. A representative profile description and corresponding analytical results (see Appendices A1 and A2) of soil type 4 are represented by profile number PG 4.

Soil Type 4b

These are less well drained, slowly permeable layered fine sandy silts, developed on slopes of less than 2%, with 25% to 50% of the top 2 m consisting of fine sandy loam, silty loam or silty clay loam overlying a significant horizon of clay or silty clay in the second metre at least 30 cm and usually more than 50 cm thick. The soils are invariably deep or very deep and non-stony and non-gravelly. Soil colour is typically very dark greyish brown to brown (10YR 3/2 to 4/3), with varying degrees of brown, greyish, orange and red mottling and iron staining at depth. The soils tend to be imperfectly to poorly drained and may contain impermeable horizons within the top 2 m. Measured infiltration rates are generally moderate (9 to 43 mm/h) and hydraulic conductivity between 1 and 2 m are expected to be very slow to moderate (less than 0.5 to 1.5 m/d).

The soil profile is generally at least slightly calcareous. Moderate levels of salinity have been recorded at several sites, though high levels of salinity and all levels of sodicity are rare. This soil type tends to be distributed fairly evenly throughout the soil study area and does not dominate any particular part, though it is most common in the Yalo area and across the Kebena river on the opposite banks in North Kebena Block, where locally hyperthermic phases may also be found.

Six phases of this soil have also been mapped in addition to soil type 4b: a moderately saline phase (4bs) and a strongly saline phase (4bs+), a sodic phase (4bA), a non-saline, non-sodic hyperthermic phase (4bh), a moderately saline, non-sodic hyperthermic phase (4bhs), and a strongly saline, non-sodic hyperthermic phase (4bhs+). A total of 958 ha has been mapped; of this 454 ha has been mapped as being non-saline, non-sodic and non-hyperthermic. Soil type 4b covers 4.4 of the soil study area. A representative profile description (see Appendix A1) of soil phase 4bA is presented with analytical results (see Appendix A2) by profile number PG 27.

A4.8.2.5 Soil Types 5, 5a, and 5b

These three alluvial soil types are differentiated on the basis of their underlying textures and corresponding drainage class. All three soil types are only slowly permeable being composed of massive silts at least in the surface horizons.

Soil Type 5

These slowly permeable massive silt loams developed on slopes of less than 2% possess poor physical properties and seasonally impeded drainage. More than 50% of the top 2 m consists of textures of fine sandy loam, silty loam, silt and silty clay loam. The soils are invariably deep or very deep, and non-stony and non-gravelly. Soil colour is typically very dark greyish brown to brown (10 YR 3/2 to 4/3), with amounts of brown, greyish, orange and yellow mottling possible throughout the profile. Soil structure is generally moderate to weak. The soils tend to be moderately well to imperfectly drained, and may contain impermeable horizons within the top 2 m. Measured infiltration rates are variable 13 to 66 mm/h), and hydraulic conductivity values between 1 and 2 m are likely to be very slow to moderate (less than 0.05 to 1.5 m/d).

The soil profile is generally only slightly calcareous. Although moderate levels of salinity and sodicity are quite common, high levels of salinity and sodicity have been recorded at relatively few sites. This is by far the most common soil type found in the soil study area. While it tends to be found throughout the area, it is particularly dominant in parts of Gurmile and South Kesem blocks. In South Kesem it covers a large proportion of the land away from Saboret Farm. Locally in North Kebena hyperthermic phases have been identified.

Six phases of this soil have also been mapped in addition to soil type 5: a moderately saline phase (5s), and a strongly saline phase (5s+), a sodic phase (5A), a strongly sodic phase (5A+), non-saline, non-sodic hyperthermic phase (5h), and a moderately saline, non-sodic hyperthermic phase (5hs). A total of 5 545 ha has been mapped; of this 3 196 ha have been mapped as being non-saline, non-sodic and non-hyperthermic. Soil type 5 covers 25.4% of the soil study area. Representative profile descriptions and analyses are presented in Appendices A1 and A2 as profile numbers PG 10 (soil type 5), and PN 14 (soil phase 5A).

Soil Type 5a

These slowly permeable massive compact silt loams also developed on slopes of less than 2% are somewhat better drained than soil type 5. Again more than 50% of the top 2 m consists of textures of fine sandy loam, silty loam, silt and silty clay loam, but these overlie coarser textured material, with typically more than 30% of the top 2 m being coarse sandy loam, loamy sand and sand. The soils are invariably deep or very deep and non-stony and non-gravelly. Soil colour is typically very dark greyish brown to dark brown, (10YR 3/2 to 3/3), with varying degrees of brown and ochreous brown mottling possible throughout the profile. Soil structure is weak in the upper horizons tending to massive in depth. The soils tend to be moderately well drained, generally with no major impermeable layers occurring within the top 2 m. Measured infiltration rates varied from 13 to 58 mm/h, and hyraulic conductivity values between 1 and 2 m will be highly variable, from very slow to rapid (0.05 to 3.0 m/d).

The soil profile is generally slightly to very slightly calcareous. Moderate levels of salinity and sodicity combined, and high levels of salinity are relatively commonly found; high levels of sodicity are rare. This soil type tends to be distributed fairly evenly throughout the soil study area and does not dominate any particular part, though it is proportionally much less common in North Kebena Block. Locally in North Kebena hyperthermic phases have been identified.

Six phases of this soil have also been mapped in addition to soil type 5a: a moderately saline phase (5as), and a strongly saline phase (5as+), a sodic phase (5aA), a strongly sodic phase (5aA+), non-saline, non-sodic hyperthermic phase (5ah), and a moderately saline, non-sodic hyperthermic phase (5ahs). A total of 1 138 ha has been mapped; of this 530 ha have been mapped as being non-saline, non-sodic, and non-hyperthermic. Soil type 5a covers 5.2% of the soil study area. A representative profile description and analytical data of soil type 5a are represented by profile number PG 29 in Appendices A1 and A2.

Soil Type 5b

These slowly permeable massive compact silt loams also developed on slopes of less than 2% are less well drained, and contain significant layers of fine textured material in the soil profile. Although more than 50% of the top 2 m consists of fine sandy loam, silty loam, silt and silty clay loam, more than 25 cm of the top 1 m or 50 cm of the top 2 m is clay or silty clay in texture. The soils are invariably deep or very deep, and non-stony and non-gravelly. Soil colour is typically very dark greyish brown to dark yellowish brown (10YR 3/2 to 3/4), there may be some tendency at some sites to redder hues (of 7.5 YR). Brown and yellowish brown mottling may be common throughout the profile. Soil structure is variable, from very weak to moderately strong, increasing structure generally being associated with the finer textures in the profile. The soils tend to be imperfectly drained, and may contain impermeable horizons within the top 2 m. Infiltration tests were made at only one site, with results of about 15 mm/h; in general, rates are likely to be moderately slow to moderate (18 to 25 mm/h), and hydraulic conductivity between 1 and 2 m slow to very slow (0.05 to 0.5 m/d).

The soil profile is generally only slightly calcareous. Moderate levels of salinity have been recorded at several sites, and high levels of salinity and moderate sodicity may be locally significant. This soil type tends to be distributed fairly evenly throughout the soil study area, and does not dominate any particular part, though it is proportionally much less common in North Kebena Block. Locally in North Kebena hyperthermic phases have been identified.

Five phases of this soil have also been mapped in addition to soil type 5b: a moderately saline phase (5bs), and a strongly saline phase (5bs+), a sodic phase (5bA), non-saline, non-sodic hyperthermic phase (5bh), and a strongly sodic hyperthermic phase (5bhA+). A total of 1 328 ha has been mapped; of this 742 ha have been mapped as being non-saline, non-sodic and non-hyperthermic. Soil type 5b covers 6.1% of the soil study area. Representative profile descriptions (Appendix A1) of soil type 5b are represented in (Appendix A2) by profile numbers PN 15, and for soil phase 5bhA+ by PN 1.

A4.8.2.6 Soil Type 6

These are generally well structured alluvial clay and clay loams developed on slopes less than 2%. The soils are invariably deep or very deep, and non-stony and non-gravelly. Soil colour is typically very dark greyish brown to dark brown (10YR 3/2 to 3/3), with little brown and reddish brown mottling within the profile. Soil structure is generally moderate to strong in the surface horizons, tending to be weak or massive in depth. The soils tend to be moderately well to imperfectly drained, though impermeable layers may be found within the top 2 m. Measured infiltration rates vary from moderately slow to moderate (10 to 44 mm/h), and hydraulic conductivity values at depths between 1 and 2 m can be expected to be slow to very slow (0.05 to 0.5 m/d).

The soil profile is generally only slightly calcareous. Although moderate levels of salinity have been recorded at several sites, high levels of salinity and even moderate levels of sodicity are relatively rare. This soil type tends to be distributed fairly evenly throughout the soil study area, though it is most common in the eastern part of Gurmile Block. Locally in North Kebena these soils can be hyperthermic.

Six phases of this soil have also been mapped in addition to soil type 6: a moderately saline phase (6s), and a strongly saline phase (6s+), a sodic phase (6A), a strongly sodic phase (6A+), non-saline, non-sodic hyperthermic phase (6h), and a moderately saline, non-sodic hyperthermic phase (6hs). A total of 2 505 ha has been mapped; of this 1 803 ha have been mapped as being non-saline, non-sodic, and non-hyperthermic. Soil type 6 covers 11.5% of the soil study area. A representative profile description (Appendix A1) of soil type 6 is represented with analytical results (Appendix A2) by profile number PG 19.

A4.8.2.7 Soil Types 7 and 7b

These soils are the heavier clays and silty clays derived from Kesem or Kebena alluvium; they have been subdivided according to site position and drainage.

Soil Type 7

These are seasonally poorly drained soils, developed on slopes of less than 2%. At least 75% of the top 2 m consists of textures of clay, silty clay or sandy clay loam. The soils are invariably deep or very deep, and non-stony and non-gravelly. Soil colour is typically dark brown to dark yellowish brown, with brown mottling common throughout the profile. Soil structure is generally moderately strong in the surface horizons, but tends to become weak and massive in depth. The soils are poorly drained, and by virtue of the dominant fine texture essentially impermeable. Infiltration rates were not measured in the field on this soil type, but are likely to be moderately slow to slow, with hyraulic conductivity also thought to be slow to very slow.

The soil profile is likely to be generally moderately calcareous. Although moderate levels of salinity have been recorded at a number of sites, moderate levels of sodicity are particularly common, and high levels of sodicity are by no means rare. The soil type tends to be distributed fairly evenly throughout Gurmile and South Kesem blocks, though it is particularly common on the southern fringes in South Kesem. Locally in North Kebena these soils may be hyperthermic.

Six phases of this soil have also been mapped in addition to soil type 7: a moderately saline phase (7s), and a strongly saline phase (7s+), a sodic phase (7A), a strongly sodic phase (7A+), non-saline, non-sodic hyperthermic phase (7h), and a moderately saline, non-sodic hyperthermic phase (7hs). A total of 1 076 ha has been mapped; of this 302 ha, have been mapped as being non-saline, non-sodic and non-hyperthermic. Soil type 7 covers 4.9% of the soil study area. A representative profile description (Appendix A1) of soil phase 7A+ is represented with analytical results (Appendix A2) by profile number PG 12.

Soil Type 7b

These are permanently wet, very poorly drained, impermeable, low-lying swampy silty clays and clays. The soils are invariably deep or very deep, and non-stony and non-gravelly. Only moderate levels of salinity have been recorded in this soil type; no evidence of sodicity was found, nor has a hyperthermic phase been recorded for this soil type. Only one phase of this soil has been mapped in addition to soil type 7b: a moderately saline phase (7bs). A total of 54 ha has been mapped; of this 52 ha have been mapped as being non-saline and non-sodic. Soil type 7b is very restricted in its occurrence and only covers 0.2% of the soil study area.

A4.8.2.8 Soil Types 8 and 8a

These are the poorly drained clays and silty clays of the Awash floodplain developed on slopes of less than 1%, subdivided into two soil types.

Soil Type 8

These soils are impermeable and poorly drained consisting of 100% medium clay and silty clay, and frequently demonstrating vertic properties of swelling and cracking, commonly with gilgai microrelief. They are invariably deep or very deep, and non-stony and non-gravelly. Soil colour is typically dark brown to very dark greyish brown (7.5 YR 3/2 to 10 YR 3/2), with varying degrees of brown, reddish brown and whitish calcareous mottling throughout the profile. When dry initial infiltration rates in soil type 8 are likely to be high to very high, but as the clay minerals swell, the rate will fall to very slow; hydraulic conductivity is likely to be very slow, though no field measurements were made on this soil type. These soils are generally only very slightly calcareous and occur exclusively along the banks of the Awash river, becoming particularly dominant in the north-east part of North Kebena Block, and in the extreme eastern part of Gurmile Block between the confluences of the Kebena and Kesem rivers with the Awash river. This soil type is predominantly non-saline and non-sodic. Only moderate levels of salinity have been recorded in this soil type; no evidence of sodicity was found, nor has a hyperthermic phase been recorded for this soil type.

Only one phase of this soil has also been mapped in addition to soil type 8; a moderately saline phase (8s). A total of 604 ha has been mapped; of this 594 ha have been mapped as being non-saline and non-sodic. Soil type 8 covers 2.8% of the soil study area.

Soil Type 8a

These are poorly permeable, poorly drained clays and silty clays overlying more than 25 cm of permeable sandy or loamy material in the second metre of the soil profile. The soils are invariably deep or very deep, and non-stony and non-gravelly and occur exclusively along the banks of the Awash river in North Kebena and Gurmile blocks. Despite the presence of coarser textured material within the profile, the soil properties are essentially very similar to those of soil type 8. Soil type 8a is predominantly non-saline, though moderate levels of salinity have been recorded at a few sites. No sodic or hyperthermic phases have been recorded.

Only one phase of this soil has been mapped in addition to soil type 8a: a moderately saline phase (8as). A total of 174 ha has been mapped; of this 170 ha have been mapped as being non-saline and non-sodic. Soil type 8a covers 0.8% of the soil study area.

A4.8.2.9 Miscellaneous Land Categories

Six land types have been identified (Table A4.1). Five of these are geomorphical in character, and one, a non-agricultural land use type referring to village and graveyard sites.

Land Type G

This is a composite mapping unit containing areas where slopes or microslopes exceed 3%, where the relative relief of ridges exceeds 0.5 m in height, and where erosion has been sufficiently severe to result in extensive gully and rill formation. The levelling costs incurred in bringing this land into irrigated production are likely to be excessive. Such areas occur principally in the western part of the soil study area close to the base of the escarpment of the Rift Valley. This land type covers 852 ha or 3.9% of the total mapped area.

Land Type A

Included in this mapping unit are alkaline hot springs and more general areas influenced by a high alkaline watertable. The only significant area of this type occurs in South Kesem in the vicinity of the hot springs at Filweha; most of this land type is outside the designated soil study area, though 12 ha were found just within the mapped area.

Land Type B

Mapping unit B consists of the river beds and banks of the Kebena and Kesem rivers where these pass through the soil study area. Also included is the major relict channel of the Kebena river passing immediately north of the extinct volcanic outcrop of Gurmile. This land type covers 987 ha or 4.5% of the total soil study area.

Land Type R

This is also a largely composite mapping unit comprising the isolated rocky volcanic hills and outcrops out of command of the proposed irrigation works, as well as other lands; which, whilst within command, are too rocky to be suitable for mechanical cultivation. Apart from the extinct volcano of Gurmile in the middle of the area, this land type occurs principally in the western part of the soil study area close to the base of the escarpment of the Rift Valley more especially in North Kebena. This land type covers 604 ha or 2.8% of the total mapped area.

Land Type S

This mapping unit includes both the saline and saline-sodic surface outcrops, associated with receding terrace edges, and strongly saline-sodic soils found more generally throughout the survey area. The mapping unit dominates large parts of central and southern Gurmile and central South Kesem blocks. This land type covers 1 309 ha or 6.0% of the total mapped area. A representative profile description (Appendix A1) of a strongly saline-sodic soil is represented with analytical results (Appendix A2) by profile number PN 9.

Land Type V

Land type V comprises all the permanent settlements and structures within the survey area, irrespective of their nature or character, together with the known Afar graveyard sites. As mapped on the Soils Map (Drawings A1 and A2). Land type V covers 142 ha or 0.7% of the total mapped area, but does not include seasonal or semi-permanent settlements and structures. These are shown separately on the Current Land Use and Vegetation Map (Drawings A5 and A6).

CHAPTER A5

LAND SUITABILITY

A5.1 Introduction

A5.1.1 Water Quality

Before discussing the land suitabilities for irrigated agriculture, the quality of irrigation water needs to be assessed, particularly in respect to its potential effect on soil salinity and sodicity. Salts dissolved in the irrigation water can accumulate in the soil profile, with possible damaging results on both the soil properties and crop yields.

The results of the Kesem river water analyses given in Table A5.1 suggest that the water is of low sodium and medium salinity, according to the USDA classification of irrigation water salinity (Ref. 18). According to the more detailed levels quoted by the FAO (Ref. 22, updated 1985), the highest EC_W value of 520 µS/cm, at low flow in February, represents only a slight to moderate restriction on use, as does the combined effect with the SAR (value 3.6) on soil infiltration rates. As such the water can be used to irrigate plants with moderate salt tolerance in most instances without special practices for salinity control assuming a moderate amount of leaching occurs. Problems may occur on soils where this is not possible, either under conditions of high groundwater or where the soils are only slowly permeable and subsurface drainage ineffective. Leaching and drainage will be further discussed in Section A6.3. The levels of cations and anions as indicated by the analytical results are unlikely to prove detrimental to most plant growth.

Information on groundwater quality is presented in Annex H.

A5.1.2 Land Suitability Classification

The FAO Guidelines for Land Evaluation for Irrigated Agriculture (Ref. 12) were used in assessing the land suitability of the area for irrigated agriculture. The basic principles on which this method is based are complementary to those of the older system of the US Bureau of Reclamation (Ref. 19), but direct comparison between the two systems is not possible.

The FAO system is based on five basic principles:

(i) Land suitability should be assessed with respect to specified types of land use with defined cropping patterns, irrigation and management systems. These may be major kinds of land use, such as arable farming, livestock production, forestry, etc., or they may be land utilisation types, described in some detail.

(ii) Land suitability assessment should be multi-disciplinary in approach; in this case evaluating not just soil suitability, but land suitability for irrigation development by considering all relevant land characteristics, including: soils, climate, topography, water resources, vegetation and also socio-economic factors. Only then can proper land use decisions be made.

TABLE A5.1

Water Quality

(1) Analysis of water samples taken from river Kesem at Awara Melka gauging station.

Determinand	Unit	Date 17/2/86	18/4/86	30/6/86
pH		7.32	7.71	7.86
Electrical conductivity	(μS/cm at 25°C)	520	369	286
Total dissolved solids	(mg/l, 105°C)	nd	nd	185
Calcium	(mg/l)	29.0	35	38.0
Magnesium	(mg/l)	11.2	19	6.0
Sodium	(mg/l)	89	54.5	14.6
Potassium	(mg/l)	10.0	6.2	3.5
Silica (soluble) as SiO_2	(mg/l)	17	23.1	2.3
Iron	(mg/l)	0.07	0.2	0.16
Zinc	(mg/l)	nd	nd	0.006
Manganese	(mg/l)	nd	nd	0.006
Copper	(mg/l)	nd	nd	0.001
Nickel	(mg/l)	nd	nd	0.001
Boron	(mg/l)	0.5	0.1	0.10
Arsenic	(mg/l)	nd	nd	0.001
Mercury	(mg/l)	nd	nd	0.005
Chloride	(mg/l)	nd	nd	5.8
Sulphate	(mg/l)	nd	nd	27
Alkalinity: carbonate as $CaCO_3$	(mg/l)	202	160	98
Nitrate as N	(mg/l)	0.2	0.2	4.0
Phosphate as PO_4	(mg/l)	0.1	0.1	0.1
Fluoride	(mg/l)	1.74	1.0	1.0

(2) Other measurements taken in and in the vicinity of the soil study area.

Location	Date	EC (μS/cm)
Kesem river at Saboret offtake	17.2.86	575
Kesem river at Saboret offtake	7.3.86	520
Kesem river at Saboret offtake	26.4.86	460
Kesem river at Saboret offtake	30.6.86	290
Kesem river at Awara Melka gauging station	18.4.86	370
Kebena river at Yalo state farm	23.2.86	250
Kebena river at Yalo state farm	26.4.86	350
Canal on Yalo state farm	17.2.86	225
Well on Yalo state farm (8 m depth)	17.2.86	1 000
Well at Bolyta village in former bed of the Kebena river (20 m depth)	17.2.86	525
Well south of Gurmile Hill (12 m depth)	17.2.86	2 100 (32°C)
Filweha river, source	17.2.86	2 500 (43°C)
Filweha river, upper	17.2.86	2 500 (41°C)
Fileweha river, at Awash/Yalo road crossing	17.2.86	1 500 (32°C)
Filweha river, at Awash/Yalo road crossing	26.4.86	2 300 (32°C)

(iii) The development of any land use or land utilisation type specified must not bring about severe or progressive environmental degradation. To ensure that any recommended development is sustainable over time, land suitability evaluation should consider future interactions between soils, water, crops and economic and social conditions.

(iv) A comparison of benefits with inputs should be part of any land suitability evaluation. Some factors that affect land suitability are permanent and others are modifiable. Permanent factors include: temperature, soil texture, soil depth to bedrock and macro topography. Modifiable factors, which may be altered either deliberately or inadvertently, typically include: vegetation, salinity, depth to groundwater, micro relief and some social and economic conditions. The assessment should conclude with an economic evaluation and comparison of the different developmental possibilities being considered. To do this both physical and economic factors must be included. The economic and environmental consequences of any development should be predicted as part of the land suitability assessment process and their costs determined. The benefits should also be assessed. For instance, so as to calculate the expected economic return to the farmers, the predicted productivity of the land should be quantified using soil specific crop yields.

(v) Land suitability evaluation should take account of local physical, economic and social conditions.

The structure of the land suitability classification is given in Table A5.2. For each land utilisation type there are two suitability orders, Suitable and Not Suitable, which are divided into a total of six classes. The order Suitable has been subdivided into four classes: highly, moderately, marginally suitable, S1, S2, S3, and conditionally suitable, Sc. There are only two classes in the order Not Suitable: N1, currently not suitable; and N2, permanently not suitable. If a land utilisation type is found to be currently not suitable (N1), this would indicate that whilst physically possible, the development under consideration is not considered viable under present economic conditions. If permanently not suitable (N2), then the proposed development would be physically impracticable. Normally the boundaries between suitability classes will be subject to revision with time in the light of technical developments and economic and social change. The boundary between N1 and N2 is, however, normally physical and permanent.

Each suitability class can be further subdivided into subclasses to reflect the kinds of limitations that restrict the suitability of the land. The number of subclasses has been kept to the minimum necessary to distinguish land with significantly differing management requirements or production potential; S1 land with no significant deficiencies, is not divided into subclasses. Each subclass is designated by one of the following suffixes:

Suffix	Land suitability limitation
A	Sodicity hazard.
C	Poor physical properties ascribed to coarse soil textures with gravel or stones and shallow rooting depth.

TABLE A5.2

Land Suitability for Irrigation: Orders and Classes

Suitable Land

Class S1	**Highly Suitable** Land having no significant limitations for the sustained application of the land use type envisaged. The class may include areas with minor limitations but these should not significantly reduce productivity or net benefits, nor raise costs above an acceptable level.
Class S2	**Moderately Suitable** Land having limitations which in aggregate are moderately serious in effecting a reduction in the productivity and net benefits to be derived from the main land utilisation type envisaged, or a significant increase in costs.
Class S3	**Marginally Suitable** Land having limitations which in aggregate are so severe for the sustained application of the land utilisation type envisaged that productivity or benefits will be so reduced, or costs so increased, that irrigation investment will be only marginally justified.
Class Sc	**Conditionally Suitable Land** Land having special limitations which are imperfectly understood and which require specific long-term research before any irrigation development may be initiated. Only one such subclass will be defined: that of the unique hyperthermic soils, the suitability of which is unknown at the current state of knowledge[a].

Not Suitable Land

Class N1	**Marginally Not Suitable** Land having limitations that may be surmountable in time, but which cannot be corrected with existing knowledge under present social and economic conditions to yield acceptable levels of productivity.
Class N2	**Permanently Not Suitable** Land having such severe physical limitations that it is highly unlikely that it will ever be developed for irrigation; major land reclamation or improvement measures will be necessary, but are unlikely to be economically or socially feasible.

Source: FAO (Ref. 12).

Notes: (a) But note that for the immediate purposes of this study these lands have been classed as N2 (see Section A5.3.1).

(b) Subclasses are summarised in Table A5.7.

d	Poor physical properties ascribed to excessive content of silt; low levels of infiltration and permeability, with a tendency to compaction and surface crusting.
h	Hyperthermic soils - only applied to Class Sc.
m	suboptimal climatic conditions.
n	intractability due to heavy texture.
p	impermeability ascribed to an excessively high clay-plus-silt content.
s	salinity hazard.
t	topographic limitation requiring extensive grading and levelling.

The application of these subclasses designations and the resulting areas are described in Section A5.3.

A5.2 Proposed Land Utilisation Types

A5.2.1 Introduction

Four main kinds of land use are considered the most promising for the study area:

- state farms; irrigated citrus, cotton, tobacco, wheat, maize;
- smallholder settlements: irrigated groundnuts, cowpeas, maize;
- irrigated pasture;
- woodlots.

Using the terminology of the FAO Guidelines (Ref 12), six separate Land Utilisation Types (LUT) have been identified. For each of these, the land qualities that affect their suitability need to be specified individually in order to arrive at an individual land suitability classification for each LUT, as described in Sections A5.2.2 to A5.2.7.

A5.2.2 State Farms (Cotton and Wheat)

The major rotation proposed for the state farms is a main season crop of cotton followed by wheat grown as a cool season crop. The soil and land qualities required for the production of tobacco and citrus are so different that they have to be considered separately (in Sections A5.2.3 and A5.2.4).

In economic and real terms, cotton will probably be the dominant crop and so the limiting factors presented in Table A5.3 refer primarily to the land suitabilities for cotton production. This is inevitably a compromise: cotton is tolerant, whereas wheat is moderately sensitive to salinity. In practice, however, farm management and planning considerations necessitate that these crops be examined as a single land use unit. The dominant requirement for both crops is a deep well to moderately well drained soil with a high available water-holding

TABLE A5.3

Land Suitability Class Limiting Factors for Irrigated State Farm Cultivation of Cotton and Wheat

Land characteristic	Class S1	Class S2	Class S3	Class Sc	Class N1	Class N2
Soil texture	loamy fine sand fine sandy loam silt loam silty clay loam	loamy sand sandy loam loam clay loam silty clay clay	fine sand loamy coarse sand coarse sandy loam sandy clay loam	any texture	coarse sand heavy clay	coarse sand heavy clay
Effective soil depth	at least 2m	at least 2m	at least 2 m	at least 2 m	at least 2 m	< 2 m
Depth to groundwater	>3 m	>3 m	>3 m	could be<3 m	<3 m	<3 m
Drainage	well drained, moderately well drained	imperfectly drained	poorly drained	very poorly drained to excessively well drained	very poorly drained excessively well drained	very poorly drained excessively well drained
Surface infiltration	7 to 35 mm/h	3 to 7 mm/h 35 to 65 mm/h	1 to 3 mm/h 65 to 125 mm/h	1 to 250 mm/h	< 1 mm/h >250 mm/h	<1 mm/h >250 mm/h
Permeability	1.4 to 3 m/d	0.5 to 1.4 m/d	0.2 to 0.5 m/d	0.2 to 3.0 m/d	< 0.2 m/d > 3.0 m/d	< 0.2 m/d > 3.0 m/d
Salinity*	4 mS/cm	4 to 12 mS/cm	4 to 12 mS/cm	0 to 12 mS/cm	4 to 12 mS/cm	>12 mS/cm
Sodicity*	ESP 6%	ESP 6% to 15%	ESP 6% to 15%	ESP 0% to 15%	ESP 6% to 15%	ESP>15%
Reaction	pH 7.0 to 8.5	pH 7.0 to 8.5	pH 7.0 to 8.5	pH 7.0 to 8.5	pH 7.0 to 8.5	pH>8.5
Topography	0% to 2% relative relief <50 cm termitaria few	0% to 2% relative relief < 50 cm termitaria common	0% to 2% relative relief < 50 cm termitaria common/frequent	0% to 2% relative relief < 50 cm termitaria common/frequent	0% to 2% relative relief < 50 cm termitaria common/frequent	>2% relative relief >50 cm termitaria abundant
Other qualities				Hyperthermic soils hot to the touch within 3 m of surface		

Note: * In any horizon within the surface 125 cm where the average textural class is coarse; within 90 cm where it is medium; and within 75 cm where it is fine.

capacity. From farm management considerations the land should be level and the soil moderately uniform spatially over large areas of land. In practice, mechanised state agriculture would not adopt differing management techniques to deal with widely varying soil conditions. In planning the detailed layout, care should be taken to avoid, wherever possible, the inclusion of too many soil mapping units with very different management requirements within the same field or management unit, though the high variability of the soils will make this difficult.

A5.2.3 State Farms (Tobacco)

More limited areas could be planted to tobacco as a cash crop rotated with either wheat and cotton or cotton and maize. Like cotton and wheat the dominant requirement for growing tobacco is a deep, well to moderately well drained soil with a high available water holding capacity, but unlike cotton, tobacco is moderately sensitive to saline and sodic conditions. Moreover for the best quality flue-cured tobacco free draining sandy soils are required. The limits defined in Table A5.4 take account of these factors. From farm management considerations the land should be level and the soil moderately uniform spatially over large areas of land. The same caveats apply to state farm management of tobacco as noted for cotton and wheat, as noted in Section A5.2.2 above.

A5.2.4 State Farms (Citrus)

Climatically, the Middle Awash Valley is not very suitable for citrus production; consequently there is no Class S1 land for irrigated citrus production in the area. Of the four main citrus types, lemon is the most sensitive and lime the most tolerant of the prevailing climatic conditions, with orange and grapefruit somewhere in between the two extremes. In addition, citrus is sensitive to salinity and sodicity. Apart from this, citrus has the same general requirements as those for cotton, wheat, maize and tobacco: a deep, well to moderately well drained soil with a high available water-holding capacity. The limits defined in Table A5.5 take account of these factors. From farm management considerations the land should be level and the soil moderately uniform spatially over large areas of land. The same caveats apply to state farm management of tobacco as noted for cotton and wheat, as noted in Section A5.2.2 above.

A5.2.5 Smallholder Settlement

The principal crops proposed for the settlement farms are likely to be cowpeas, groundnuts, maize, sesame and wheat together with irrigated pasture (which is considered in Section A5.2.6). In addition, it is anticipated that many settlers will also cultivate a number of vegetables (including sweet potato) tolerant, or at least moderately tolerant of saline conditions. The dominant soil requirements for all these crops are similar to those for cotton, wheat, maize and tobacco cultivation on the state farms: deep, well to moderately well drained soils with high available water-holding capacities. It is unlikely, however, that the smallholders will have access to the use of heavy agricultural machinery to cope with land preparations and cultivation, and that they will rely initially on hand tools and later, as development takes place, on ox-drawn machinery for this work. Heavy textured soils are consequently less well suited to this land utilisation type and so land with dominant textures of clay loam, silty clay and clay has been downgraded in Table A5.6.

TABLE A5.4

Land Suitability Class Limiting Factors for Irrigated State Farm Cultivation of Flue-cured Tobacco

Land characteristic	Class S1	Class S2	Class S3	Class Sc	Class N1	Class N2
Soil texture	loamy fine sand fine sandy loam loamy sand sandy loam	loam silt loam silty clay loam	fine sand loamy coarse sand coarse sandy loam sandy clay loam	any texture	coarse sand heavy clay clay loam silty clay clay	coarse sand heavy clay clay loam silty clay clay
Effective soil depth	at least 2m	at least 2m	at least 2 m	at least 2 m	at least 2 m	<2 m
Depth to groundwater	>3 m	>3 m	>3 m	could be <3 m	<3 m	<3 m
Drainage	well drained, moderately well drained	imperfectly drained	poorly drained	very poorly drained to excessively well drained	very poorly drained excessively well drained	very poorly drained excessively well drained
Surface infiltration	7 to 35 mm/h	35 to 65 mm/h	65 to 125 mm/h	1 to 250 mm/h	< 7 mm/h > 250 mm/h	< 7 mm/h >250 mm/h
Permeability	1.4 to 3 m/d	0.5 to 1.4 m/d	0.2 to 0.5 m/d	0.2 to 3.0 m/d	< 0.2 m/d > 3.0 m/d	<0.2 m/d > 3.0 m/d
Salinity*	< 4 mS/cm	<4 mS/cm	<4 mS/cm	< 4 mS/cm	4 to 12 mS/cm	>12 mS/cm
Sodicity*	ESP<6%	ESP<6%	ESP<6%	ESP <6%	ESP 6% to 15%	ESP >15%
Reaction	pH = 7.0 to 8.5	pH = 7.0 to 8.5	pH = 7.0 to 8.5	pH = 7.0 to 8.5	pH 7.0 to 8.5	pH 8.5
Topography	0% to 2% relative relief <50 cm termitaria few	0% to 2% relative relief <50 cm termitaria common	0% to 2% relative relief <50 cm termitaria common/frequent	0% to 2% relative relief < 50 cm termitaria common/frequent	0% to 2% relative relief < 50 cm termitaria common/frequent	2% relative relief > 50 cm termitaria abundant
Other qualities				Hyperthermic soils hot to the touch within 3 m of surface		

Note: * In any horizon within the surface 125 cm where the average textural class is coarse; within 90 cm where it is medium; and within 75 cm where it is fine.

TABLE A5.5

Land Suitability Class Limiting Factors for Irrigated State Farm Cultivation of Citrus

Land characteristic	Class S2	Class S3	Class Sc	Class N1	Class N2
Soil texture	loamy fine sand, loamy sand fine sandy loam, sandy loam, silt loam, loam silty clay loam, clay loam silty clay, clay	fine sand loamy coarse sand coarse sandy loam sandy clay loam	any texture	coarse sand heavy clay	coarse sand heavy clay
Effective soil depth	at least 2m	at least 2 m	at least 2 m	At least 2 m	<2 m
Depth to groundwater	>3 m	>3 m	could be <3 m	<3 m	<3 m
Drainage	well drained, moderately well, to imperfectly drained	poorly drained	very poorly drained to excessively well drained	very poorly drained excessively well drained	very poorly drained excessively well drained
Surface infiltration	3 to 65 mm/h	1 to 3 mm/h 65 to 125 mm/h	1 to 250 mm/h	< 1 mm/h > 250 mm/h	>1 mm/h >250 mm/h
Permeability	0.5 to 3.0 m/d	0.2 to 0.5 m/d	0.2 to 3.0 m/d	0.2 m/d 3.0 m/d	0.2 m/d 3.0 m/d
Salinity*	<4 mS/cm	<4 mS/cm	<4 mS/cm	<4 mS/cm	>4 mS/cm
Sodicity*	ESP<6%	ESP<6%	ESP<6%	ESP<6%	ESP>6%
Reaction	pH 7.0 to 8.5	pH 7.0 to 8.5	pH 7.0 to 8.5	pH 7.0 to 8.5	pH>8.5
Topography	0% to 2% relative relief <50 cm termitaria few	0% to 2% relative relief <50 cm termitaria common/frequent	0% to 2% relative relief <50 cm termitaria common/frequent	0% to 2% relative relief <50 cm termitaria common/frequent	>2% relative relief >50 cm termitaria abundant
Other qualities			Hyperthermic soils hot to the touch within 3 m of surface		

Notes: * In any horizon within the surface 125 cm where the average textural class is coarse; within 90 cm where it is medium; and within 75 cm where it is fine.

TABLE A5.6

Land Suitability Class Limiting Factors for Irrigated Smallholder Settlement Units

Land characteristic	Class S1	Class S2	Class S3	Class Sc	Class N1	Class N2
Soil texture	loamy fine sand fine sandy loam silt loam silty clay loam	loamy sand sandy loam loam	fine sand loamy coarse sand coarse sandy loam sandy clay loam clay loam silty clay, clay	any texture	coarse sand heavy clay	coarse sand heavy clay
Effective soil depth	at least 2m	at least 2m	at least 2 m	at least 2 m	at least 2 m	< 2 m
Depth to groundwater	>3 m	>3 m	>3 m	could be <3 m	<3 m	<3 m
Drainage	well drained, moderately well drained	imperfectly drained	poorly drained	very poorly drained to excessively well drained	very poorly drained excessively well drained	very poorly drained excessively well drained
Surface infiltration	7 to 35 mm/h	35 to 65 mm/h	1 to 7 mm/h 65 to 125 mm/h	1 to 250 mm/h	<1 mm/h >250 mm/h	<1 mm/h >250 mm/h
Permeability	1.4 to 3.0 m/d	0.5 to 1.4 m/d	0.2 to 0.5 m/d	0.2 to 3.0 m/d	< 0.2 m/d >3.0 m/d	<0.2 m/d >3.0 m/d
Salinity*	4 mS/cm	4 to 12 mS/cm	4 to 12 mS/cm	0 to 12 mS/cm	4 to 12 mS/cm	>12 mS/cm
Sodicity*	ESP 6%	ESP 6% to 15%	ESP 6% to 15%	ESP 0% to 15%	ESP 6% to 15%	ESP>15%
Reaction	pH = 7.0 to 8.5	pH = 7.0 to 8.5	pH = 7.0 to 8.5	pH 7.0 to 8.5	pH 7.0 to 8.5	pH 8.5
Topography	0% to 2% relative relief	0% to 2% relative relief <50 cm termitaria common	0% to 2% relative relief <50 cm termitaria common/frequent	0% to 2% relative relief <50 cm termitaria common/frequent	0% to 2% relative relief <50 cm termitaria common/frequent	>2% relative relief >50 cm termitaria abundant
Other qualities				Hyperthermic soils hot to the touch within 3 m of surface		

Notes: * In any horizon within the surface 125 cm where the average textural class is coarse; within 90 cm where it is medium; and within 75 cm where it is fine.

A5.2.6 Irrigated Pasture

The dominant requirement for irrigated pasture is a deep, well to moderately well drained soil with a high available water capacity. It is expected that the species selected in establishing the pastures will be tolerant or at least only moderately sensitive to conditions of salinity and sodicity. The pastures will be established and prepared using heavy agricultural machinery. The land suitability limiting factors defined for the state farm cultivation of cotton and wheat (in Table A5.3) can therefore also be used as the basic limits for economic irrigated pastures.

In practice economic considerations need not be of paramount importance when selecting areas for pasture development. Soils with both coarse and fine textures may be slightly upgraded in their suitability for pasture. It may be considered, for instance, practicable to establish pasture on the very coarse colluvial soils of type 1, and the very heavy vertic clays of soil types 8 and 8a, when both these soil types are clearly unsuitable for state farm cultivation and intensive irrigated pasture development. Such factors have been taken into consideration in assessing the suitability of particular soil types and phases to this land utilisation type.

A5.2.7 Woodlots

The dominant requirement for woodlots is a deep, well to moderately well drained soil with a high water-holding capacity. It is expected that the woodlots species selected will be tolerant or at least only moderately sensitive to conditions of salinity and sodicity. The land suitability limiting factors defined for the state farm cultivation of cotton and wheat (in Table A5.3) can, therefore, also be used as the basic limits for economic irrigated woodlots.

In practice economic considerations need not be of paramount importance when selecting areas for woodlots development. Soils with both coarse and fine textures may be slightly upgraded in their suitability for woodlots. It may be considered, for instance, practicable to establish woodlots on the very coarse colluvial soils of type 1 and the very heavy vertic clays of soil types 8 and 8a, when both these soil types are clearly unsuitable for state farm cultivation and intensive irrigated woodlots development. Such factors have been taken into consideration in assessing the suitability of particular soil types and phases to this land utilisation type.

A5.3 Land Suitability Classes, Subclasses and Mapping Units

A.5.3.1 Overview

A5.3.1.1 Classes and Subclasses

The limiting factors set out in Tables A5.3 to A5.6 have been used as a broad guide in assigning land suitability subclasses to each of the soil types, phases and land types mapped. Each proposed land utilisation type (state farm cultivation of cotton and wheat, tobacco and citrus, smallholder settlement, irrigated pasture and woodlots) has been assessed separately. In this context it needs to be emphasised, however, that the suitability criteria set out in these tables are purely guidelines, the critical importance of each of which has to be weighted in each case. A final decision as to suitability for a particular land use is a matter for careful judgement. Thus, when allocating land suitability classes and subclasses to specific soil types and phases, as set out in Table A5.7, the suitability criteria should not be applied too rigidly.

TABLE A5.7

Land Suitability for Irrigation: Subclasses by Land Utilisation Type and Mapping Units

Soil phase/ mapping unit(a)	Smallholder cultivation	Pasture grasses	Woodlots	State farm crops Cotton wheat	Tobacco	Citrus	Land suitability mapping unit(b)
1	N2c	S3c	S2c	N2ct	N2ct	N2c	4
1s	N2c	S3c	S2c	N2ct	N2st	N2cs	4
1s+	N2cs	N2cs	N1cs	N2ct	N2s	N2s	5
2	S3c	S2c	S2c	S2c	S1	N1c	3A
2s	S3c	S2c	S2c	S2c	N1s	N2cs	3C
2s+	N2cs	S3cs	S3cs	N1cs	N2s	N2cs	4
2A	N1Ac	S3Ac	S3Ac	S3Ac	N1A	N2Ac	3C
2A+	N2Ac	N2Ac	S2Ac	N2Ac	N2A	N2Ac	5
2h	N2h	N2h	N2h	N2h	N2h	N2h	5
3	S2c	S2c	S1	S2c	S1	S3c	2
3s	S2c	S2c	S2s	S2c	N1s	N1cs	3C
3s+	N1cs	S3cs	S3s	N1cs	N2s	N2cs	4
3A	S3Ac	S3Ac	S3A	S3Ac	N2A	N2Ac	3C
3A+	N2Ac	N2Ac	N2A	N2Ac	N2A	N2Ac	5
3hs	N2h	N2h	N2h	N2h	N2h	N2h	5
4	S1	S1	S1	S1	S	S2m	1
4s	S2s	S2s	S2s	S2s	N1s	N1s	3C
4s+	N1s	S3s	S3s	N1s	N2s	N2s	4
4A	S3A	S2A	S2A	S2A	N2A	N1A	3C
4A+	N2A	N2A	N2A	N2A	N2A	N2A	5
4hs	N2h	N2h	N2h	N2h	N2h	N2h	5
4b	S1	S1	S1	S1	S2d	S2m	1
4bs	S2s	S2s	S2s	S2s	N1ds	N1ds	3C
4bs+	N1s	S3s	S3s	N1s	N2ds	N2ds	4
4bA	S3A	S3A	S3A	S3A	N2d	N1d	3C
4bh	N2h	N2h	S2h	N2h	N2h	N2h	5
4bhs	N2h	N2h	N2h	N2h	N2h	N2h	5
4bhs+	N2hs	N2hs	N2hs	N2hs	N2hs	N2hs	5
5	S2d	S1	S2d	S2d	S3d	S3d	2
5s	S3ds	S2ds	S2ds	S3ds	N2s	N2ds	3C
5s+	N2s	S3s	S3s	N2ds	N2s	N2s	4
5A	N1Ad	S3A	S3Ad	N1Ad	N2A	N2Ad	4
5A+	N2Ad	N2Ad	N2Ad	N2Ad	N2A	N2A	5
5h	N2h	N2h	N2h	N2h	N2h	N2h	5
5hs	N2h	N2h	N2h	N2h	N2h	N2h	5
5a	S2d	S1	S1	S1	S2d	S2m	1
5as	S3ds	S2	S2s	S2s	N2s	N1s	3C
5as+	N1s	S3s	S3s	N1s	N2s	N2s	4
5aA	N1A	S2A	S2A	N1A	N2A	N1A	4
5aA+	N2A	N2A	N2A	N2A	N2A	N2A	5
5ah	N2h	N2h	N2h	N2h	N2h	N2h	5
5ahs	N2h	N2h	N2h	N2h	N2h	N2h	5

TABLE A5.7 (cont.)

Soil phase/ mapping unit(a)	Smallholder cultivation	Pasture grasses	Woodlots	State farm crops Cotton wheat	Tobacco	Citrus	Land suita-bility mapping unit(b)
5b	S2d	S2d	S2d	S2d	N1d	S3d	3B
5bs	N1ds	S2d	S2ds	N1ds	N2ds	N2ds	4
5bs+	N2ds	S3ds	S3ds	N2ds	N2s	N2ds	4
5bA	N2Ad	N1Ad	N1Ad	N2Ad	N2Ad	N2Ad	5
5bh	N2h	N2h	N2h	N2h	N2h	N2h	5
5bhA+	N2Ah	N2Ah	N2Ah	N2Ah	N2Ah	N2Ah	5
6	S3n	S1	S2n	S1	N1d	S2m	3B
6s	S3ns	S2s	S2n	S2s	N2ds	N1ns	3C
6s+	N2ns	S3s	S3ns	N2s	N2s	N2s	4
6A	N2An	S3A	N1An	S3A	N2Ad	N1An	3C
6A+	N2An	N2A	N2An	N2A	N2A	N2A	5
6h	N2h	N2h	N2h	N2h	N2h	N2h	5
6hs	N2h	N2h	N2h	N2h	N2h	N2h	5
7	N2p	S2p	S3p	S3p	N2p	N2p	3C
7s	N2ps	S2p	S3p	N1ps	N2ps	N2ps	4
7s+	N2ps	N1ps	S2ps	N2ps	N2ps	N2ps	5
7A	N2Ap	N1Ap	S2Ap	N2Ap	N2Ap	N2Ap	5
7A+	N2Ap	N2Ap	S2Ap	N2Ap	N2Ap	N2Ap	5
7h	N2h	N2h	N2h	N2h	N2h	N2h	5
7hs	N2h	N2h	N2h	N2h	N2h	N2h	5
7b	N2p	N1p	N2p	N2p	N2p	N2p	5
7bs	N2ps	N2p	N2p	N2ps	N2ps	N2ps	5
8	N2p	S3p	S3p	N2p	N2p	N2p	4
8s	N2ps	N1p	N2p	N2ps	N2ps	N2ps	5
8a	S3p	S2p	S2p	S3p	N2p	N2p	3C
8as	N1ps	S3p	S3p	N1ps	N2ps	N2ps	4
G	N2t	S3t	S2t	N2t	N2t	N2t	4
A) B) subclass R) unspeci- B) fied S) V)	N2	N2	N2	N2	N2	N2	5

Notes:
- (a) See Section A4.8.2
- (b) See Table A5.9.
- (1) Subclass symbols are defined in Section A5.1.2.
- (2) The classification for smallholder cultivation, pasture grasses and woodlots is necessarily highly generalised and would in practice vary according to the specific type of crop, grass or tree under consideration.
- (3) All soils with suffixes A+(N2) and h (Sc) are grouped in General Suitability Class 5.
- (4) Miscellaneous land categories A, B, R, S, V are all included in General Suitability Class 5 (N2 for every land utilisation type).

Over the area as a whole there is a wide range of suitabilities for irrigated development, some soil types and phases being suitable for many different possible utilisation types, others being much more limited in their developmental suitabilities; a substantial area of land is not suitable for any irrigated development at all. The areas of land suitability classes for each LUT are presented in Table A5.8.

Before any irrigation development of hyperthermic soils can be recommended, specific long-term research should be undertaken so as to ascertain the exact limitations and characteristics of these soils. It is unlikely even if this were to be initiated immediately, that the results would be available within either the short- or medium-term future. Moreover any development would probably necessitate some form of previous land treatment or reclamation technique, which would almost certainly not be economically feasible at the present stage of development. Consequently for the immediate purposes of this feasibility study, all hyperthermic soils have been downgraded from being conditionally suitable (Sc) to being permanently not suitable (N2).

A5.3.1.2 Mapping Units

For overall planning and design purposes the land suitability classes for all the LUT have been amalgamated into composite mapping units so that the information can be presented on one readily comprehensible map (Drawings A3 and A4); Table A5.9 shows the resulting map legend of seven units. Land designated as Unit 1 is the most suitable for a wide range of different irrigated LUT, whereas Unit 5 land is unsuitable for any irrigated agricultural development. Intermediate units from 2 to 4 are varyingly but decreasingly suitable for irrigated development. These seven mapping units constitute a generalised irrigation land suitability classification which is specific to this project. It is not the standard classification (the FAO system defined in Section A5.1.2 and Table A5.2 fills that role), and it cannot be compared with any other classification such as that of USDA.

The land suitability mapping unit corresponding to each soil unit or miscellaneous land category is given in the last column of Table A5.7 and the area of each suitability mapping unit is presented in Table A5.10.

Study of the land suitability for irrigation maps (see Drawings A3 and A4) indicates there are relatively few large uniform blocks of land highly or moderately suitable for irrigated development in the form previously envisaged by the project. Table A5.8 shows that out of a mapped total of 21 823 ha a maximum of 17 195 ha is suitable at least to some extent for irrigated agriculture (including pasture); of this, only 4 000 to 5 000 ha occurs in relatively large blocks, leaving the remainder scattered throughout the area as small and isolated fragments of land, which - depending on their size, location and suitability - may not warrant consideration for high-cost irrigation development.

A5.3.1.3 Summary of Land Suitability

The amalgamated areas of land presented in the land suitability mapping unit summary (see Table A5.10) mask the marginality of much of the soil study area. Instead the individual crop-related figures presented in Table A5.8 should be used to provide the basis for feasibility assessment of any irrigation scheme.

TABLE A5.8

Land Suitability for Irrigation - Summary of Areas by Classes for Individual Land Utilisation Types

Land suitability class	Area (ha) suitable for: Smallholder cultivation	Pasture grasses	Woodlots	State Farm Crops: Cotton	Tobacco	Citrus
Suitable						
S1	1 494	7 023	2 346	3 827	2 698	0
S2	5 510	6 513	11 876	7 581	984	3 827
S3	5 818	3 659	2 913	2 014	3 196	4 260
Sub-total	12 822	17 195	17 135	13 422	6 878	8 087
	(59%)	(79%)	(79%)	(62%)	(32%)	(37%)
Not Suitable						
N1	1 571	770	220	1 513	4 125	3 227
N2	7 430	3 858	4 468	6 888	10 820	10 509
Sub-total	9 001	4 628	4 688	8 401	14 945	13 736
	(41%)	(21%)	(21%)	(38%)	(68%)	(63%)
Total (100%)	21 823	21 823	21 823	21 823	21 823	21 823

TABLE A5.9

Land Suitability for Irrigation : Mapping Units[a]

Mapping unit	Description
Unit 1	Land that is highly suitable (S1) or moderately suitable (S2) for a range of climatically adapted crops and cropping systems, including state farm cultivation of cotton, wheat, maize, tobacco and citrus; smallholder development; irrigated pasture and woodlots.
Unit 2	Land that is highly suitable (S1) to marginally suitable (S3) for a range of climatically adapted crops and cropping systems, including state farm cultivation of cotton, wheat, maize, tobacco and citrus; smallholder development; irrigated pasture and woodlots.
Unit 3	Land having only moderate or marginal suitability for a restricted range of crops and cropping systems:
Unit 3A	Land suitable (S2/S3) for state cultivation of cotton, wheat, maize and tobacco, but <u>not</u> citrus; suitable also for smallholder development, irrigated pasture and woodlots.
Unit 3B	Land suitable (S2/S3) for state cultivation of cotton, wheat, maize and citrus but <u>not</u> tobacco; suitable also for smallholder development, irrigated pasture and woodlots.
Unit 3C	Land marginally suitable (S3) for state cultivation of cotton, wheat, maize and irrigated pasture but <u>not</u> citrus or tobacco; much of Unit 3C is also suitable for woodlots and smallholder development.
Unit 4	Land only suitable for irrigated pasture and woodlots.
Unit 5	Land unsuitable for any irrigated agricultural development.

Note: (a) This system of units has been designed to allow cartographic representation of the very complex land suitability pattern in the Kesem Project Area. It should not be confused with a standard land suitability classification scheme.

TABLE A5.10

Land Suitability for Irrigation - Areas by Mapping Unit

Area (ha) suitable for:

Land suitability mapping unit	Smallholder cultivation	Pasture grasses	Woodlots	State farm crops Cotton	Tobacco	Citrus	Mapping unit total
1	2 024	2 024	2 024	2 024	2 024	2 024	2 204
2	3 518	3 518	3 518	3 518	3 518	3 518	3 518
3A	1 336	1 336	1 336	1 336	1 336		1 336
3B	2 545	2 545	2 545	2 545		2 545	2 545
3C	3 399	3 999	3 939	3 999			3 999
Sub-total units 1 to 3							13 422
4		3 773	3 773				3 773
Sub-total units 1 to 4							17 195
5							4 627
Total (ha)	12 822	17 195	17 135	13 422	6 878	8 087	21 823
(%)	(59)	(79)	(79)	(62)	(32)	(37)	(100)

TABLE A5.11

Comparison of Suitable Land Areas by Land Suitability Class for Individual Land Utilisation Type

Land suitability class		Area (ha) suitable for: Small-holder cultivation	Pasture grasses	Woodlots	State Farm crops: Cotton	Tobacco	Citrus
Highly suitable							
S1	(ha)	1 494	7 023	2 346	3 827	2 698	0
	(%)	12	41	14	28	39	0
Highly and moderately suitable							
S1+S2	(ha)	7 004	13 536	14 222	11 408	3 682	3 872
	(%)	55	79	83	85	54	47
Marginally suitable							
S3	(ha)	5 818	5 659	2 913	2 014	3 196	4 260
	(%)	45	21	17	15	46	53
Total Suitable (100%)							
S1+S2+S3	(ha)	12 822	17 195	17 135	13 422	6 878	8 087

Further analysis of the suitable land is shown in Table A5.11, which again emphasises the inherent deficiencies. For tobacco, citrus and smallholder cultivation about 50% of the land designated as suitable is only marginally so (Class S3), although for cotton 85% of the suitable land is highly or moderately suitable (Classes S1 and S2). The implications for area selection for the different crops are clear: as far as soil variability permits, land for the high-value state farm crops that demand the better soil characteristics (citrus and tobacco) should be carefully selected before the land for other uses. This has been done (Annex L).

For state farm development it is preferable that the land should be in reasonably large, uniform blocks, again as far as soil variability permits. About 1 000 ha of comparatively uniform land is to be found in central North Kebena immediately west of the existing track running north-south across the area. This area, by virtue of its predominantly sandy textures, (largely soil type 2), is particularly well suited to tobacco production. A further 1 000 to 2 000 ha (largely soil type 5) is to be found in several separate blocks in south-east Gurmile, particularly between Gurmile Hill and the riverine forest immediately south of the state farm at Yalo.

Finally an area somewhat in excess of 1 000 ha (largely soil types 5, 5b and 6) has been identified in South Kesem: much of this last block is presently being cultivated or otherwise included in the cadastral boundaries of Awara Melka state farm. To satisfy the needs of the local market a small expansion in the area devoted to citrus production could perhaps be envisaged in this area. The maximum size of the citrus unit would be about 400 ha, incorporating the existing plantations at Saboret.

Expected yields and recommended agronomic practices are given in the Agriculture Annex (Annex B).

A5.3.2 Land Suitability of Individual Soil Mapping Units

A5.3.2.1 Soil Type 1

Soil type 1 is moderately suitable for woodlots development and marginally suitable for irrigated pasture; it is permanently unsuitable for the cultivation of state farm crops of cotton, wheat, tobacco and citrus, and for smallholder development. Its suitability is limited by two main factors: slopes of up to 3%, coarse, gravelly, somewhat stony textures, having low nutrient and water holding capacities and high to very high permeabilities.

Two phases of this soil have also been mapped: a moderately saline phase (1s), and a strongly saline phase (1s+):

> **Soil Phase 1s** is also moderately suitable for woodlots development and marginally suitable for irrigated pasture; it is permanently unsuitable for the cultivation of state farm crops of cotton, wheat, tobacco and citrus and for smallholder development. Its suitability is limited by 3 main factors: slopes of up to 3%, excessive drainage and low water holding capacities due to coarse, gravelly, somewhat stony textures. Salinity is not a particular problem as their coarse gravelly texture will readily permit adequate amount of leaching on this soil.

Soil Phase 1s+ is permanently unsuitable for any irrigated development, except for woodlots, for which it is marginally unsuitable. Its suitability is limited by 3 main factors: high salinity, slopes of up to 3% and low water holding capacities due to coarse, gravelly, somewhat stony textures.

A5.3.2.2 Soil Type 2

Soil type 2 is highly suitable for state farm cultivation of tobacco and is moderately suitable for state farm cultivation of cotton and wheat irrigated pasture and woodlots; it is only marginally suitable for smallholder development; it is marginally unsuitable for citrus cultivation. The main limiting factor of soil type 2 for most crops is low to moderately low water holding capacities due to coarse, somewhat gravelly, textures and in certain cases effective depth limitations. Its suitability for smallholder and citrus development has been downgraded because of these properties especially as low water holding capacities are thought to be more critical for smallholder cultivation than for state farm production of cotton and wheat. Where depth is not a limitation, soil type 2 may be particularly well suited to flue-cured tobacco production; a large block of nearly 1 000 ha, mostly soil type 2, has been identified in central North Kebena immediately west of the existing north-south track.

Five phases of this soil have also been mapped: a moderately saline phase (2s), and a strongly saline phase (2s+), a sodic phase (2A), a strongly sodic phase (2A+) and a non-saline, non-sodic hyperthermic phase (2h):

Soil Phase 2s is moderately suitable for state farm cultivation of cotton and wheat, irrigated pasture and woodlots and marginally suitable for smallholder development; it is marginally unsuitable for tobacco, and is permanently unsuitable for cultivation of citrus. Limitations due to low water holding capacities are aggravated by the presence of moderate levels of salinity, which effectively prevent the cultivation of saline-sensitive crops like tobacco and citrus. Low water capacities are thought to be more critical for smallholder cultivation than for state farm production, consequently the suitability of this soil for smallholder development has been downgraded, relative to that for state farm production of cotton and wheat.

Soil Phase 2s+ is marginally suitable for irrigated pasture and woodlots; it is marginally unsuitable for state farm cultivation of cotton and wheat and permanently unsuitable for cultivation of tobacco and citrus and smallholder development. Limitations due to low water holding capacities are further aggravated by the presence of high levels of salinity, preventing the cultivation of all but saline-tolerant species of grass and trees as pasture and woodlots.

Soil Phase 2A is marginally suitable for state farm cultivation of cotton and wheat, irrigated pasture and woodlots; it is marginally unsuitable for smallholder development, marginally unsuitable for tobacco and permanently unsuitable for cultivation of citrus. Limitations due to low water-holding capacities are aggravated by the presence of moderate levels of sodicity, with or without moderate levels of salinity, which effectively prevent the cultivation of saline-sensitive crops like tobacco and citrus. In addition, problems of sodicity further downgrade the suitability of this land to all the other uses under consideration.

Soil Phases 2A and 2h are both permanently unsuitable for all irrigated development, other than for village sites, due to high levels of sodicity, or the presence of hyperthermic activity.

A5.3.2.3 Soil Type 3

Soil type 3 is highly suitable for woodlots and state farm cultivation of tobacco, moderately suitable for state farm cultivation of cotton and wheat, irrigated pasture and smallholder development; it is marginally suitable for citrus development. The main limitation is moderately low water holding capacity, particularly in the top metre of soil.

Five phases of this soil have also been mapped: a moderately saline phase (3s), and a strongly saline phase (3s+), a sodic phase (3A), a strongly sodic phase (3A+), and a moderately saline, non-sodic hyperthermic phase (3hs).

Soil Phase 3s is moderately suitable for state farm cultivation of cotton and wheat, irrigated pasture, woodlots and smallholder development; it is marginally unsuitable for citrus and tobacco development. Limitations due to moderately low water holding capacities are aggravated by the presence of moderate levels of salinity, which effectively prevent the cultivation of saline-sensitive crops like tobacco and citrus.

Soil Phase 3s+ is marginally suitable for woodlots and irrigated pasture; it is marginally unsuitable for state farm cultivation of cotton and wheat and smallholder development; it is permanently unsuitable for tobacco and citrus development. Limitations due to low water holding capacities are aggravated by the presence of high levels of salinity, preventing the cultivation of all but saline-tolerant species of grass and trees as pasture and woodlots.

Soil Phase 3A is marginally suitable for state farm cultivation of cotton and wheat, irrigated pasture, woodlots and smallholder development; it is permanently unsuitable for tobacco and citrus development. Limitations due to moderately low water holding capacities are aggravated by the presence of moderate levels of sodicity, with or without moderate levels of salinity, which effectively prevent the cultivation of saline-sensitive crops like tobacco and citrus. In addition, problems of sodicity further downgrade the suitability of this land to all the other uses under consideration.

Soil Phase 3hs is permanently unsuitable for all irrigated development, other than for village sites, due to the presence of hyperthermic activity.

A5.3.2.4 Soil Types 4 and 4b

(a) Soil Type 4

Soil type 4 is highly suitable for state farm cultivation of cotton and wheat and tobacco, irrigated pasture, woodlots and smallholder development; it is moderately suitable for citrus development. Its suitability for citrus development has been downgraded primarily on climatic considerations.

Five phases of this soil have also been mapped: a moderately saline phase (4s), and a strongly saline phase (4s+), a sodic phase (4A), a strongly sodic phase (4A+), and a moderately saline, non-sodic hyperthermic phase (4hs).

Soil Phase 4s is moderately suitable for state farm cultivation of cotton and wheat, irrigated pasture, woodlots and smallholder development; it is marginally unsuitable for citrus and tobacco development. The presence of moderate levels of salinity, effectively prevents the cultivation of saline-sensitive crops like tobacco and citrus and also downgrades the suitability of the soil to all the other uses under consideration.

Soil Phase 4s+ is marginally suitable for irrigated pasture and woodlots; it is marginally unsuitable for state farm cultivation of cotton and wheat and smallholder development; it is permanently unsuitable for tobacco and citrus development. The presence of high levels of salinity, effectively prevents the cultivation of all but saline-tolerant species of grass and trees as pasture and woodlots.

Soil Phase 4A is moderately suitable for state farm cultivation of cotton and wheat, irrigated pasture and woodlots, and marginally suitable for smallholder development; it is marginally unsuitable for citrus development and permanently unsuitable for tobacco. The presence of moderate levels of sodicity, with or without moderate levels of salinity, prohibits the cultivation of saline-sensitive crops like tobacco and citrus. In addition, problems of sodicity further downgrade the suitability of this land to all the other uses under consideration.

Soil Phase 4A+ is permanently unsuitable for all irrigated development due to high levels of sodicity, although village sites could be located on this soil.

Soil Phase 4hs is permanently unsuitable for all irrigated development, other than for village sites, due to the presence of hyperthermic activity.

(b) Soil Type 4b

Soil type 4b is highly suitable for state farm cultivation of cotton and wheat, irrigated pasture, woodlots and smallholder development; it is moderately suitable for tobacco and citrus development. Its suitability for citrus development has been downgraded primarily on climatic considerations. Imperfect to poor drainage and heavier textures downgrade its suitability to flue-cured tobacco production.

Six phases of this soil have also been mapped: a moderately saline phase (4bs), and a strongly saline phase (4bs+), a sodic phase (4A), a non-saline, non-sodic hyperthermic phase (4bh), a moderately saline, non-sodic hyperthermic phase (4bhs), and a strongly saline non-sodic hyperthermic phase (4bhs+).

Soil Phase 4bs is moderately suitable for state farm cultivation of cotton and wheat, irrigated pasture, woodlots and smallholder development; it is marginally unsuitable for citrus and tobacco development. The presence of moderate levels of salinity, effectively prevents the cultivation of saline-sensitive crops like tobacco and citrus and also downgrades the suitability of the soil to all the other uses under consideration.

Soil Phase 4bs+ is marginally suitable for irrigated pasture and woodlots; it is marginally unsuitable for state farm cultivation of cotton and wheat and smallholder development; it is permanently unsuitable for tobacco and citrus development. The presence of high levels of salinity, effectively prevents the cultivation of all but saline-tolerant species of grass and trees as pasture and woodlots.

Soil Phase 4bA is marginally suitable for state farm cultivation of cotton and wheat, irrigated pasture, woodlots and smallholder development; it is marginally unsuitable for citrus development and permanently unsuitable for tobacco. The presence of moderate levels of sodicity, with or without moderate levels of salinity, prohibits the cultivation of saline-sensitive crops like tobacco and citrus. In addition, problems of sodicity further downgrade the suitability of this land to all the other uses under consideration.

Soil Phases 4bh, 4bhs and 4bhs+ are all permanently unsuitable for all irrigated development, other than for village sites, due to varying levels of sodicity and the presence of hyperthermic activity.

A5.3.2.5 Soil Types 5, 5a and 5b

(a) Soil Type 5

Soil type 5 is highly suitable for irrigated pasture, moderately suitable for state farm cultivation of cotton and wheat, woodlots, and smallholder development; it is marginally suitable for tobacco, and citrus development. Suitability limitations are due mainly as a result of seasonally impeded drainage and low rates of permeability caused by poor physical properties. These limitations are thought to be more critical in the case of flue-cured tobacco and citrus production than for cotton and wheat. Ripping and regular deep ploughing will be essential merely to sustain production on these soils.

Six phases of this soil have also been mapped; a moderately saline phase (5s), and a strongly saline phase (5s+), a sodic phase (5A), a strongly sodic phase (5A+), non-saline, non-sodic hyperthermic phase (5h), and a moderately saline, non-sodic hyperthermic phase (5hs).

Soil Phase 5s is moderately suitable for irrigated pasture, and woodlots, marginally suitable for state farm cultivation of cotton and wheat, and smallholder development; it is permanently unsuitable for tobacco, and citrus development. Limitations due to moderate levels of salinity are aggravated by seasonally impeded drainage and low rates of permeability, making leaching of excess salt from the soil profile difficult. These problems effectively prevent the cultivation of saline-sensitive crops like tobacco and citrus, and also downgrade the suitability of the soil to all the other uses under consideration.

Soil Phase 5s+ is marginally suitable for irrigated pasture and woodlots; it is permanently unsuitable for state farm cultivation of cotton, wheat, tobacco, and citrus and smallholder development. Limitations due to high levels of salinity are severely aggravated by seasonally impeded drainage and low rates of permeability, making leaching of excess salt from the soil profile difficult, thus preventing the cultivation of all but saline-tolerant species of grass and trees as pasture and woodlots.

Soil Phase 5A is marginally suitable for irrigated pasture and woodlots; it is marginally unsuitable for state farm cultivation of cotton and wheat and smallholder development; it is permanently unsuitable for tobacco, and citrus development. The presence of moderate levels of sodicity, with or without moderate levels of salinity, prohibits the cultivation of saline-sensitive crops like tobacco and citrus. In addition, problems of sodicity further downgrade the suitability of this land to all the other uses under consideration, so much so that only the cultivation of saline-tolerant, sodic-tolerant species of grass and trees as pasture and woodlots is possible on this soil.

Soil Phases 5A+ and 5hs are all permanently unsuitable for all irrigated development, other than for village sites due to high levels of sodicity, or the presence of hyperthermic activity.

(b) Soil Type 5a

Soil type 5a is highly suitable for state farm cultivation of cotton and wheat, irrigated pasture and woodlots; it is moderately suitable for tobacco, citrus, and smallholder development. Suitability limitations are due mainly to low rates of permeability in these soils; they are however somewhat better drained than the soil type 5, because of their somewhat coarser texture. As a result, soil type 5a may have more potential for improvement. Ripping and regular deep ploughing will, nevertheless, be essential to sustain production on these soils. Unfortunately in areal terms soil type 5a is much less important than soil type 5.

Six phases of this soil have also been mapped; a moderately saline phase (5as), and a strongly saline phase (5as+), a sodic phase (5aA), a strongly sodic phase (5aA+), non-saline, non-sodic hyperthermic phase (5ah), and a moderately saline, non-sodic hyperthermic phase (5ahs).

Soil Phase 5as is moderately suitable for state farm cultivation of cotton and wheat, irrigated pasture, and woodlots; it is marginally suitable for smallholder development; it is marginally unsuitable for citrus and tobacco development. Limitations due to moderate levels of salinity are aggravated by low rates of permeability, making leaching of excess salt from the soil profile relatively difficult, effectively preventing the cultivation of saline-sensitive crops like tobacco and citrus and also downgrading the suitability of the soil to all the other uses under consideration.

Soil Phase 5as+ is marginally suitable for irrigated pasture, and woodlots; it is marginally unsuitable for smallholder development and state farm cultivation of cotton and wheat, and permanently unsuitable for tobacco, and citrus development. Limitations due to high levels of salinity are aggravated by low rates of permeability, making leaching of excess salt from the soil profile difficult, thus preventing the cultivation of all but saline-tolerant species of grass and trees as pasture and woodlots.

Soil Phase 5aA is moderately suitable for irrigated pasture, and woodlots; it is marginally unsuitable for state farm cultivation of cotton and wheat, citrus and smallholder development; and permanently unsuitable for tobacco. The presence of moderate levels of sodicity, with or without moderate levels of salinity, prohibits the cultivation of saline-sensitive crops like tobacco and citrus. In addition, problems of sodicity further downgrade the suitability of this land to all the other uses under consideration, so much so that only the cultivation of saline-tolerant and sodic-tolerant species of grass and trees for pasture and woodlots is possible on these soils.

Soil Phases 5aA+, 5ah and 5ahs are all permanently unsuitable for all irrigated development, other than for village sites, due to high levels of sodicity, or the presence of hyperthermic activity.

(c) Soil Type 5b

Soil type 5b is moderately suitable for state farm cultivation of cotton and wheat, irrigated pasture, woodlots, and smallholder development; it is marginally suitable for citrus development, and marginally unsuitable for tobacco. Suitability limitations are due mainly as a result of poor drainage and low rates of permeability caused by very poor physical properties. These soils have heavier textures than both soil types 5 and 5a, so much so that it is doubtful whether they will show as much response to ripping and regular deep ploughing.

Five phases of this soil have also been mapped; a moderately saline phase (5bs), and a strongly saline phase (5bs+), a sodic phase (5bA), non-saline, non-sodic hyperthermic phase (5bh), and a strongly sodic hyperthermic phase (5bhA+).

Soil Phase 5bs is moderately suitable for irrigated pasture, and woodlots; it is marginally unsuitable for state farm cultivation of cotton and wheat, and smallholder development, and permanently unsuitable for tobacco, and citrus development. Limitations due to moderate levels of salinity are aggravated by poor drainage and low rates of permeability, making leaching of excess salt from the soil profile difficult, so much so that only the cultivation of saline-tolerant species of grass and trees as pasture and woodlots is possible on this soil.

Soil Phase 5bs+ is marginally suitable for irrigated pasture, and woodlots; it is permanently unsuitable for state farm cultivation of cotton, wheat, tobacco, and citrus. Limitations due to high levels of salinity are aggravated by poor drainage and low rates of permeability, making leaching of excess salt from the soil profile very difficult, so much so that only the cultivation of saline-tolerant species of grass and trees as pasture and woodlots is possible on this soil.

Soil Phase 5bA is marginally unsuitable for irrigated pasture, and woodlots; it is permanently unsuitable for state farm cultivation of cotton, wheat, tobacco, and citrus. Limitations due to the effect of moderate levels of sodicity further reduce the suitability of these soils so much so that this soil is only suitable for village site development.

Soil Phases 5bh and 5bhA+ are both permanently unsuitable for all irrigated development, other than for village sites, due to high levels of sodicity, or the presence of hyperthermic activity.

A5.3.2.6 Soil Type 6

Soil type 6 is highly suitable for state farm cultivation of cotton and wheat, and irrigated pasture; it is moderately suitable for citrus development, and woodlots, marginally suitable for smallholder development, and marginally unsuitable for tobacco. Its predominately heavy textures downgrade the suitability of this soil to tobacco, and smallholder development.

Six phases of this soil have also been mapped; a moderately saline phase (6s), and a strongly saline phase (6s+); a sodic phase (6A), a strongly sodic phase (6A), non-saline, non-sodic, hyperthermic phase (6h), and a moderately saline, non-sodic hyperthermic phase (6hs).

Soil Phase 6s is moderately suitable for state farm cultivation of cotton and wheat, irrigated pasture, and woodlots; it is marginally suitable for smallholder development; it is marginally unsuitable for citrus development, and permanently unsuitable for tobacco. The presence of moderate levels of salinity, and heavy soil textures may make leaching of excess salt from the soil profile difficult, effectively preventing the cultivation of saline-sensitive crops like citrus, and downgrading the suitability of this land to all the other uses under consideration.

Soil Phase 6s+ is marginally suitable for irrigated pasture, and woodlots; it is permanently unsuitable for state farm cultivation of cotton, wheat, tobacco, and citrus, and smallholder development. Limitations due to high levels of salinity and heavy soil textures will make leaching of excess salt from the soil profile difficult, preventing the cultivation of all but saline-tolerant species of grass and trees as pasture and woodlots on these soils.

Soil Phase 6A is marginally suitable for state farm cultivation of cotton and wheat, and irrigated pasture; it is marginally unsuitable for woodlots, and citrus development, and permanently unsuitable for tobacco, and smallholder development. The presence of moderate levels of sodicity, with or without moderate levels of salinity, prohibits the cultivation of saline-sensitive crops like tobacco and citrus. In addition, problems of sodicity further downgrade the suitability of this land to all the other uses under consideration.

Soil Phases 6A+, 6h and 6hs are all permanently unsuitable for all irrigated development, other than for village sites, due to high levels of sodicity, or the presence of hyperthermic activity.

A5.3.2.7 Soil Types 7 and 7b

(a) Soil Type 7

Soil type 7 is moderately suitable for irrigated pasture, and marginally suitable for state farm cultivation of cotton and wheat, and woodlots; it is permanently unsuitable for tobacco, citrus and smallholder development. Suitability of these soils is limited by poor drainage and heavy textures, effectively preventing the cultivation of all but saline-tolerant species of grass and trees for pasture and woodlots, and state farm cultivation of cotton and wheat.

Six phases of this soil have also been mapped; a moderately saline phase (7s), and a strongly saline phase (7s+); a sodic phase (7A), a strongly sodic phase (7A+), non-saline, non-sodic hyperthermic phase (7h), and a moderately saline, non-sodic hyperthermic phase (7 hs).

Soil Phase 7s is moderately suitable for irrigated pasture, marginally suitable for woodlots; it is marginally unsuitable for state farm cultivation of cotton and wheat, and permanently unsuitable for tobacco, citrus, and smallholder development. Limitations due to moderate levels of salinity are aggravated by poor drainage making leaching of excess salt from the soil profile difficult, so much so that only the cultivation of saline-tolerant species of grass and trees as pasture and woodlots is possible on this soil.

Soil Phases 7s+ and 7A are both marginally unsuitable for irrigated pasture, and permanently unsuitable for state farm cultivation of cotton, wheat, tobacco and citrus, woodlots and smallholder development. Limitations due to high salinity and moderate levels of sodicity, with or without moderate levels of salinity, effectively prevent the cultivation of any of the crops under consideration, and make this soil unsuitable for any form of irrigated development.

Soil Phases 7A+, 7h and 7hs are all permanently unsuitable for all irrigated development, other than for village sites, due to high levels of sodicity, or the presence of hyperthermic activity.

None of these soils are likely to be suitable for village site development due to their heavy texture and poor drainage.

(b) Soil Type 7b

Soil type 7b is marginally unsuitable for irrigated pasture and permanently unsuitable for state farm cultivation of cotton, wheat, tobacco, and citrus, woodlots and smallholder development. Its suitability is severely limited by its permanently poor drainage and very heavy textures, making it unsuitable for any form of irrigated development.

Only one phase of this soil has also been mapped; a moderately saline phase (7bs).

> **Soil Phase 7bs** is permanently unsuitable for any form of irrigated development.

Neither of these soils is likely to be suitable for village site development due to their heavy texture and poor drainage.

A5.3.2.8 Soil Types 8 and 8a

(a) Soil Type 8

Soil type 8 is marginally suitable for irrigated pasture and woodlots; it is permanently unsuitable for state farm cultivation of cotton, wheat, tobacco and citrus, and smallholder development. Its suitability is severely limited by low permeability, poor drainage and heavy textures, effectively preventing the cultivation of all but saline-tolerant species of grass and trees as pasture and woodlots on these soils.

Only one phase of this soil has also been mapped; a moderately saline phase (8s).

> **Soil Phase 8s** is marginally unsuitable for irrigated pasture, and permanently unsuitable for state farm cultivation of cotton, wheat, tobacco and citrus, woodlots, and smallholder development. Limitations due to moderate levels of salinity are aggravated by poor drainage making leaching of excess salt from the soil profile so difficult that this soil is unsuitable for any form of irrigated development.

Neither of these soils is likely to be suitable for village site development due to their heavy texture and poor drainage.

(b) Soil Type 8a

Soil type 8a is moderately suitable for irrigated pasture and woodlots, and marginally suitable for state farm cultivation of cotton and wheat and smallholder development; it is permanently unsuitable for tobacco and citrus development. Its suitability is severely restricted by low permeability, poor drainage and heavy textures, though less than in the case of soil type 8, effectively preventing the cultivation of all but saline-tolerant species of grass and trees for pasture and woodlots, and state farm cultivation of cotton and wheat on these soils.

Only one phase of this soil has also been mapped; a moderately saline phase (8as).

> **Soil Phase 8as** is marginally suitable for irrigated pasture, and woodlots; it is marginally unsuitable for state farm cultivation of cotton, wheat, and smallholder development, and permanently unsuitable for tobacco and citrus development. Limitations due to moderate levels of salinity are aggravated by poor drainage making leaching of excess salt from the soil profile difficult, so much so that only the cultivation of saline-tolerant species of grass and trees for pasture and woodlots is possible on this soil.

Neither of these soils is likely to be suitable for village site development due to their heavy texture and poor drainage.

A5.3.2.9 Other Land Types

Land type G is moderately suitable for woodlots, marginally suitable for irrigated pasture, but permanently unsuitable for state farm cultivation of cotton, wheat, tobacco and citrus, and smallholder development.

Its suitability is limited by three main factors; slopes in excess of 2%, low water holding capacities due to coarse, gravelly, somewhat stony textures, and a relative relief of more than 50 cm, requiring excessive amounts of levelling.

Land types A, B, R, S and V are for various and different reasons all permanently unsuitable for all irrigated development other than, possibly, for village sites.

CHAPTER A6

SOIL AND LAND MANAGEMENT

A6.1 General

Much of the land within the soil study area is at best only of moderate or marginal suitability for irrigated development. Of particular concern is the widespread incidence of salinity and sodicity throughout the area, and the poor physical properties of many of the soils. Potentially the most serious of these are: a tendency to surface crusting (thus reducing rates of surface infiltration), poor soil structure, inherently low permeabilities and associated poor drainage. The existing state farm enterprise within the soil study area, both at Saboret and Yalo, is already severely affected by major soil problems: soil structural deterioration, rising watertables and local secondary salinisation and sodification. These problems are presently further aggravated by sub-optimal standards of farm and water management. The problems of soil and land management are discussed here, whilst those of water management are dealt with in Annex L.

A6.2 Soil Management

A6.2.1 Soil Cultivation

The poor physical properties of many of the soils are liable to be aggravated by poor timing of field operations, especially as most of these, particularly on the state farms, will be undertaken using heavy farm machinery. Taking heavy tractors and ploughing on the land when conditions are too wet will easily result in increasing bulk density and surface crusting, reducing soil aeration, surface infiltration and soil permeability through compaction, smearing and the formation of plough pans. Whilst ripping and subsoiling will improve conditions in the top 80 cm to 1 m, care is essential if these operations are not merely to result in the formation of a further pan deeper down the profile. Any deep pans will be not only extremely difficult to rectify, but will also have a potentially serious and possibly irreversible effect on the soil drainage characteristics. This is discussed further in Section A6.2.3.

Equally important is the proper clearing and incorporation or removal of crop residues to prevent carry-over and spread of crop and soil-borne pest and diseases. These can be particularly important in the case of cotton. Adherence to well planned crop rotations will also be essential. Details of these and other recommended agronomic practices to be adopted are given in Annex B, Agriculture.

State farm management will have to be of the highest standard if development is going to be sustainable on these soils.

A6.2.2 The Management of Saline, Saline-sodic and Sodic Soils

A6.2.2.1 Saline Soils

For any saline, saline-sodic or sodic soils included in irrigated areas, special management techniques will have to be adopted to ensure and sustain adequate levels of production.

Salinity affects crop growth primarily through osmotic effects and secondarily through the toxic effects of certain ions. A high salt concentration inhibits the uptake of water and in extreme cases may result in removal of water from the growing crops. Consequently, saline soils should be kept at a higher moisture content than is necessary with non-saline soils during periods of crop growth. In addition, the presence of chloride ion is toxic to some plants (notably tobacco) and there may be a tendency for the essential micro-nutrient boron to accumulate to toxic levels. Salts will move with water up and down the soil profile; accumulating in periods of drought as whitish crusts on the soil surface, where they can have devastating effects on shallow-rooted seedlings.

Crops show differing degrees of tolerance to the effects of salinity depending not only on the level of soil salinity, but also on the physiological constitution of the plant and the stage of plant growth. For the KIP crops the effects are discussed in Section A6.4.

Crop production on saline non-sodic soils can be achieved by leaching the excess salts out of the root zone by heavy and repeated applications of non-saline, non-sodic water in amounts in excess of the irrigation requirement, the amount lost by evaporation from the soil surface and by transpiration from the crops. Such reclamation is proposed for about 2 000 ha.

Unless an artificial sub-surface drainage system is installed before leaching and a high level of water management adopted, the danger is that excessive applications of water will result in the raising of the groundwater table, thus increasing the rate of salt accumulation and aggravating the problems of these soils. Installing drainage is a problem on many of these soils, more especially on those compact silty soils with high bulk densities, poor soil structures and inherently low permeabilities and on very heavy vertisolic soils. This is further discussed in Section A6.3, and also in Chapter L8 of Annex L.

A6.2.2.2 Saline-sodic Soils

Saline-sodic soils suffer from the additional problem of high levels of sodium. The field appearances of both saline and saline-sodic soils are very similar; their effects on crop growth are also somewhat similar. Generally, cotton and some pasture species are relatively tolerant of moderate sodium levels. Citrus, tobacco and bananas on the other hand are particularly sensitive to sodicity.

The effects of high sodium are modified and masked by the presence of free salts. The clay particles remain flocculated and soil structure and permeability unimpaired. As in the case of saline soils, salts will move with water up and down the soil profile and accumulate on the surface as whitish crusts, in periods of drought.

Despite these apparent similarities, it is most important that the saline-sodic soils are distinguished from saline soils to enable the correct management decisions to be made. Merely leaching saline-sodic soils will degrade them into non-saline-sodic soils, effectively destroying any viability the soil might have had; sodic soils are very much more difficult and costly to manage. The properties of sodic soils are discussed further in Section A6.2.2.3.

The vital difference in managing saline and saline-sodic soils is that a soil amendment must be applied to saline-sodic soils before they are leached. The most commonly used amendment is gypsum ($CaSO_4.2H_2O$). The calcium replaces the adsorbed sodium and reacts with the carbonates in the soil solution, precipitating out calcium carbonate. Leaching can then remove the excess sodium and sulphate ions.

The amount of gypsum required will vary depending on the exchangeable sodium percentage and the cation exchange capacity of the soil, but it is likely to be several t/ha. In addition to the difficulties of effectively admixing the gypsum throughout the soil profile, the reclamation and management of saline-sodic soils will suffer from the same problems of leaching and drainage as have already been discussed for saline soils.

A6.2.2.3 Sodic Soils

Whilst sodic soils in the Kesem-Kebena area tend to be both saline and sodic, some areas of non-saline sodic soils were identified. Whereas in the case of saline-sodic soils, the presence of free salts dominated by calcium tends to mask the effect of sodium; this is not the case for non-saline sodic soils. These soils are very strongly alkaline with pH between 8.5 and 10. The high level of sodium ions results in extensive deflocculation and dispersion of the soil colloids, general eluviation of any clay particles present down the profile, severe soil structural failure and the formation of a compact, impermeable soil. Organic matter tends to dissolve at high pH and accumulates on the soil surface as thin black deposits, giving rise to 'black alkali' as the common name for sodic soils, as opposed to the 'white alkali' of saline-sodic soils.

Of the three types of soil, sodic soils are by far the most difficult and costly to manage. The main problem with sodic soils is their very poor physical condition, making it extremely difficult to apply and distribute a soil amendment, such as gypsum, evenly throughout the profile. The amount required can be calculated in the same way as for saline-sodic soils, though very often it is not enough just to treat the topsoil. Improving the subsoil is much more difficult and costly. There is the difficulty of getting the amendment into contact with the subsoil; ploughing the more compact massive soils is especially difficult. Leaching is unlikely to be a practicable proposition on some areas, where the subsoil is very likely to be dispersed and thus highly impermeable, but other areas can be leached and reclaimed (see Section A6.4).

A6.2.2.4 Management Implications

The physical difficulties and expense involved in reclaiming and maintaining saline, saline-sodic and especially sodic soils in sustained agricultural production is likely to be so great that their use will be uneconomic at the present stage of development in the Awash valley.

It must be recognised, however, that under sub-optimal standards of soil and land management, secondary salinisation and alkalinisation may occur as they have elsewhere in the Middle Awash valley, for instance, as on the Amibara project. Decisions must be made on the management requirements needed to forestall such soil degradation at the detailed design stage of the project, and not delayed until the soil symptoms are apparent in the field. This is discussed further in the next section.

A6.3 Drainage

A6.3.1 Requirement for Soil Drainage

Since the installation of irrigation facilities elsewhere in the Awash valley, at Amibara and Angelele, the groundwater table has risen rapidly at a rate of about 1 m/year until reaching a depth of about 1.5 m below the soil surface, after which the rate decreased to about 0.3 m/year. The average terminal equilibrium position may be in the range of 0.75 m to 1.0 m. Recent work has concluded that the natural drainage characteristics of the underlying aquifers are unable to cope with the recharge resulting from irrigation (Reference 9). The rises in watertable have resulted in the secondary salinisation of large areas of land in addition to surface waterlogging. The rate of secondary salinisation is dependent on a number of factors, including the depth to groundwater and its salinity, the evaporation rate at the soil surface and the soil texture. Results at Amibara indicate that in the case of a tolerant crop like cotton yields will collapse within one year where a saline watertable of 5 to 10 mS/cm occurs within 1 m of the soil surface and within 7 years where the watertable is less saline (less than 2 mS/cm). On crops that are more sensitive to salinity the effects are likely to be more severe. There is little evidence to suggest that the overall situation would be any different in parts of the Kesem-Kebena area that might be subject to such rising watertables.

In addition to problems resulting from rising groundwater, difficulties arising from perched surface water are particularly common throughout the Middle Awash valley; within the soil study area itself, perched watertables have been noted both at Saboret and more particularly at Yalo farm. These are related either to the presence of major impermeable layers within the top 2 to 3 m of soil, and/or to the general compact massive structure and poor physical properties of the soil profile. Throughout the eastern part of the soil study area, for instance, including much of Yalo farm, a thin band (about 20 to 30 cm thick) of hard, impermeable, compact, very dark greyish brown clay is found at some depth in the profile, usually between 100 and 175 cm below the soil surface. When irrigation water is applied, water passes normally through the profile down to the clay band; but unless it can move horizontally through the soil, it tends to accumulate, giving rise both to waterlogging and secondary salinisation (as at Yalo farm). Deep drains can be installed, but unless the water can pass through the profile into the drains, these will be of little or no benefit. Deep ripping can ensure that there are no continuous impermeable layers above about 80 cm, but if there is an impermeable layer and/or the soil is generally highly compact and massive between 80 cm and the drains, conventional sub-surface drainage may be ineffective. A solution to this is suggested in Annex L (Section L8.4.3, Treatment D6).

A6.3.2 Drainability Classification

The factors affecting the details of drainage works, if any, on a particular piece of land include the following:

- general soil texture and structure;
- particular soil layers below the surface;
- present and probable future depth to groundwater;
- likely crops and the degree of drainage expenditure that they can economically justify;
- the need for reclamation of the soil;
- likely drainage method;
- conditions for the removal of drainage water, by gravity or seasonal pumping.

For the reasons mentioned in Annex L (Section L8.4.1), the favoured form of drainage for KIP is horizontal drainage by buried plastic field drains with buried collectors discharging into open drains; this will lead the drainage water into one of the rivers or the T'unfeta floodway. For the higher areas the discharge will be by gravity only, but on some low-lying areas in the east pumping will be required during river floods. For most of the time however the water will drain by gravity from these areas too, bypassing the pumps.

The field drains are likely to be laid by trenching machines and surrounded by a filter. The depth to the field drains will vary depending on soil, topography and drainage system layout, but will typically be 2 m. A rough optimisation of drain spacing for the dominant crop, cotton, has been undertaken as part of this study. It shows that it will generally be worthwhile to drain the soils with effective permeability down to about 0.1 m/d, that the optimum drain spacing is not very sensitive to mis-estimates of the permeability, and that drain spacings considerably wider than the optimum will not generally result in very large drops in net benefit. Effective soil permeabilities at or below 0.5 m/d imply optimum drain spacings around 20 m, but unless the permeability is under 0.2 m/d a spacing of 30 m would be almost as good. Permeabilities of about 1.0 m/d imply drain spacings in the range of 30 to 50 m. Some areas may not need drainage immediately, but the only place where this is significant is the Awara Melka area where underlying gravels will continue to provide adequate natural drainage unless or until a general rise in watertable occurs.

The eastern part of the project area often shows one or more clay layers within the top 3 m, even if the surface texture is coarser. In some cases this has been taken into account in the definition and mapping of soil types (as with soil types 4b and 5b), but the auger records have been separately scanned to search for this phenomenon alone, regardless of soil type, and the areas where most of the auger holes show a layer of clay or other very impermeable soil between 0.8 and 2.0 m depth have been mapped on the drainability map mentioned below.

Taking all these factors into account, a drainability classification scheme has been developed specifically for the KIP area and is set out in Table A6.1. It refers only to land in the general suitability classes 1 to 4, which is here treated as the definition of 'irrigable' land. There are six basic classes labelled J, K, L, M, N and P. Class J is land not needing artificial drainage because it has adequate natural drainage, and Class P is land not worth draining because to do so would be so difficult and expensive as not to be worthwhile. This leaves Classes K to N for land that is potentially worth draining. Class K denotes land that would only need widely-spaced drains, either to prevent a rising groundwater table under coarse soils or to enable pasture or woodlots to be grown. Classes L, M and N include soils likely to be used for annual or high-value tree crops and to need field drainage of decreasing spacing. Sub-classes LR, MR and NR are the same in terms of drainage requirement as L, M and N respectively but require reclamation of saline and/or sodic soils by leaching, as discussed in Section A6.4 below.

Drawings A5 and A6 in the Album are an irrigability and drainability map of the Kesem-Kebena plain at 1 : 20 000 using the above definitions. It must be emphasised that this classification and this map represent an estimate of the potential of each piece of land: the proposed treatment of each piece of land under the project is a further matter, involving not only this potential but also practicalities such as layout and crop, and is dealt with in Annex L.

TABLE A6.1

Drainability Classification

Drainage class	Definition
J	Not needing deep drainage
K	Wide-spaced drains to prevent groundwater rise on permeable soils
L	Worth draining, typical field drain spacing 40 m
(LR)	As L but needs reclamation by leaching
M	Worth draining, typical field drain spacing 20 m, probably needs deep ripping
(MR)	As M but needs reclamation by leaching
N	Worth draining but likely to have some relatively impermeable soil between ripping depth and drain depth: typical field drain spacing 20 m but transverse trenching needed also
(NR)	As N but needs reclamation by leaching
P	Not worth draining

The mapping of the drainability classification has been done on the basis of the soil classification (Drawings A1 and A2) together with groundwater information (Annex H) and the mapping of impermeable layers mentioned above. Table A6.2 sets out the drainability classes in terms of soil mapping units, groundwater depth and impermeable layers. The table also lists the total area of each soil mapping unit that has been found in the mapped area, to indicate the relative importance of each soil and the general land suitability classes.

The way this drainability classification has been used is described in Annex L, particularly Section L8.4.3. Drainage will not achieve total control of groundwater (any attempt to do so would be uneconomic), and the long-term slight reduction in crop yields on some areas is included in the determination of the weighted mean yields given in Annex B and used in Annex N.

A6.4 Reclamation

A6.4.1 Crops for which Reclamation is Required

On the basis of policy objectives, analysis of markets, and ranking of ecologically adapted crops, the following crops have been identified (Annex B) as being the most important for the project:

Citrus
Tobacco
Cotton
Maize
Wheat
Pasture

TABLE A6.2

Drainage Classes Related to Determining Factors

Soil mapping unit	Area mapped (ha) (Table A4.10)	General suitability class (Table A5.7)	Drainability class		
			If groundwater now shallower than 10 m	If with low-permeable layer	Otherwise
G		4			
1	198	4	K	-	J
1s	18	4			
2	1 336	3A			
2s	348	3C	K	-	J
2s+	100	4			
2A	238	3C			
3	322	2	-	M	L
3s	48	3C	-	MR	LR
3s+	30	4	-	MR	LR
3A	38	3C	-	MR	LR
4	1 040	1	-	M	L
4s	342	3C	-	MR	LR
4s+	114	4	-	MR	LR
4A	203	3C	-	MR	LR
5a	530	1	-	M	L
5as	274	3C	-	MR	LR
5as+	134	4	-	MR	LR
5aA	122	4	-	MR	LR
4b	454	1	-	N	M
4bs	330	3C	-	NR	MR
4bs+	24	4	-	NR	MR
4bA	72	3C	-	NR	MR
5	3 196	2	-	N	M
5s	1 134	3C	-	NR	MR
5s+	394	4	-	NR	MR
5A	585	4	-	NR	MR
5b	742	3B	-	N	M
5bs	320	4	-	NR	MR
5bs+	108	4	-	NR	MR
6	1 803	3B	-	N	M
6s	440	3C	-	NR	MR
6s+	96	4	-	NR	MR
6A	60	3C	-	-	P
7	302	3C	-	N	N
7s	80	4	-		P
8	594	4	-		P
8a	170	3C	-	N	N
8as	4	4	-	-	P

Notes: (1) A dash (-) means the groundwater level or low-permeability layer does not affect the class.
(2) This table covers all irrigable soils, i.e. general suitability classes 1 to 4.

These vary in tolerance of salinity and sodicity. These are fundamentally independent soil characteristics, and crop tolerance to them has a different physiological basis. The former is an osmotic effect, the latter a toxicity effect. Sodicity can, moreover, have seriously adverse effects on soil structure and permeability. The effect of salinity, in terms of the EC_e of the soil which causes stated levels of yield reduction, is shown in Table A6.3.

The effect of sodium toxicity, the consequence of sodicity, is less well documented. Broadly, the effect of sodicity parallels that of salinity and the ranking of crops is much the same. In any case, the secondary effect of high ratio of Na to divalent cations upon the permeability of the soil, is much more significant, especially in fine-textured soils. Thus, if exchangeable Na represents as little as 6% of the exchange complex (termed exchangeable sodium percentage, ESP), then difficulty in maintaining soil permeability may be expected. Above an ESP of 25% in a clay soil, permeability may be minimal and crops which survive at all characteristically suffer deficiency of the nutrient cations and lack of aeration. The adverse effects of high ESP are greatly exacerbated in alluvia with high silt contents (as at Kesem) where physical conditions even without alkalinity are sub-optimum.

TABLE A6.3

Salt Tolerance Levels for Crops Under Surface Irrigation

	EC_e values (mS/cm)[a] producing yield reductions of:			
Crop	0%	10%	25%	50%
Citrus (orange)	1.5	2.5	3.0	5.0
Cotton	7.5	9.5	13	17
Maize	1.5	2.5	4.0	6.0
Pasture:				
Bermuda grass	7.0	8.5	11	14
Sudan grass	3.0	5.0	8.5	14
Clover, berseem	1.5	3.0	6.0	10
Alfalfa	2.0	3.5	5.5	9.0
Tobacco[b]	1.0	1.0	1.5	2.5
Wheat	6.0	7.5	9.5	13

Notes: (a) Rounded to the nearest 0.5 mS/cm.
(b) Salinity also reduces quality.

Sources: FAO 1976 and 1979 (References 13 and 22).

A6.4.2 Soil and Land Classification in Relation to Reclamation

The classification of saline and sodic soils for KIP has been described in Chapter A4, particularly in Tables A4.2 and A4.7 and in Section A4.8.1. Among the 'irrigable' soils listed in Table A6.2, some 4 800 ha are classified as needing reclamation if used for annual or sensitive crops. The area actually to be reclaimed is much less because the layout (Annex L) deliberately avoids putting such crops on the more saline and sodic soils, except in small patches: the area nominally needing reclamation is 1 900 ha, but there are of course degrees of reclamation need and this is a rough figure based on arbitrary but reasonable classification.

The layout described in Annex L takes account of both land suitability and drainability classifications and the needs of particular crops as follows:

Citrus: Modest extension of the current plantation to about 400 ha may be done at Awara Melka without inclusion of soils with reclamation problems.

Tobacco: The production of light, high quality Virginia leaf is skilled, and easiest on soils of sandy texture and and poor fertility. Heavy fertile soils tend to produce heavy leaf in Virginia type tobacco and are therefore not suitable. Tobacco is very sensitive to salinity and alkalinity, and because of its high return should take priority for the better soils.

Others: The remaining area will be predominantly in cotton and pasture. Grain crops are proposed in rotation with cotton. Of these, maize is the most sensitive to salinity, but land reclamation must be organised to optimise the return to the rotation.

A6.4.3 Reclamation Requirements

Reclamation of non-sodic saline soils should prove straightforward. Pre-requisites in the light of experience at Amibara will be adequate and regular ripping to break pans and lenses of impermeable material, and smoothing to improve efficiency of application and distribution of water. The leaching requirement (LR) may be estimated by the standard equation (Section L8.4.1), but in practice the leaching percentage is unlikely to exceed the application efficiency factor when irrigating with good quality water by surface methods.

Leaching of sandy, less compact and better structured silty and clay soils, will be a fairly rapid process. On the former, complete leaching is likely to occur with the first heavy irrigation. On heavier textures the process may take up to two years to complete (Ref. 16).

The treatment of sodicity is a slower process requiring the application of gypsum and leaching water, and the production of reclamation crops and crops for green-manuring. For calculating gypsum requirements, the soils have been grouped into reclamation categories A1 to A3 for the two sodicity classes A and A+, as shown in Table A6.4, which also gives indicative gypsum requirements.

TABLE A6.4

Gypsum Requirements Related to Exchangeable Sodium Content

Reclamation category	Na (me/100 g)(1)		Gypsum (t/ha)(2)	
	A	A+	A	A+
A1	1	3	5	16
A2	4	12	19	66
A3	8	15	38	82

Note: (1) Assuming average ESP to be 10 and 30% in A and A+ soils respectively.

(2) Gypsum required to reduce ESP to 2% in top 1 m of soil, calculated on the basis of 5.9 t/ha of gypsum to replace 1 me/100 g of Na on the exchange complex.

Gypsum should be of agricultural grade (particle size distribution is important) and should be deeply ploughed-in. The amounts above will need to applied in two to five parts over successive years. Organic manures, green manures and grass species increase carbon dioxide levels and speed up replacement of Na by Ca.

Strongly sodic, fine-textured soils are fairly well-structured and permeable initially. Clay disperses in the early stage of reclamation and permeability falls, thereby slowing the reclamation process; the strongly sodic A3 and A4 categories are most at risk. The heavy gypsum requirement plus the special leaching needs (which may require the use of saline groundwater and ponding initially, followed by several years of rice cultivation) suggest that all A4 soils and the A+ areas of A3 soils should be excluded from the design proposals for the present. This may be reconsidered later following further study of their characteristics. However, a few areas of such soils will be included in proposed blocks, and correspondingly reduced yields must be expected.

A6.4.4 Cropping After Reclamation

Reclamation begins with leaching alone or leaching in combination with gypsum application and special cropping. This process will delay establishment of the crops in the mature rotation and reduce yields in the early years. For the purposes of evaluation of this project, a gradual build-up of yield over the first ten years is assumed, for normal soils (Annex B). The start of production on reclaimed soils is simulated by combining the delay in starting and the early reduced yields together as an effective delay, after which the normal build-up is assumed. This may underestimate production in the first year or two and overestimate it slightly for a few years thereafter, but the assumptions have been arranged to give the correct average effect. As can be seen from Table A6.5 the second element of delay is only significant for tobacco. The delays in starting are weighted means for lands of varying degrees of reclamation need and have been used in the economic analysis in Annex N.

TABLE A6.5

Delay to Agricultural Production through Reclamation

Crop or crop system	Delay in starting production (years)	Reduced yield in early years, equivalent delay (years)	Total effective delay (years)
Tobacco	2.5	1.5+	4+
Cotton	1	0	1
Wheat	1	0	1
Maize	1	0-0.5	1

A6.4.5 Nutrient Deficiencies

High pH and the application of heavy dressings of gypsum are liable to induce deficiency syndromes, notably of zinc, iron and manganese. Foliar application of these nutrients may be necessary and a contingency of 2 l/ha of proprietary product should be allowed on 25% of the area.

A6.5 Land Levelling

During levelling, care must be taken to ensure that saline and saline-sodic soils are not admixed with non-saline soils. In many parts of the soil study area, dense clumps of Salvadora persica protect the underlying soil from rain-induced sheet erosion. As the surrounding unprotected areas under grass and herbs are successively eroded away, these clumps tend to remain as mounds or hummocks over the general lie of the land. There is extensive evidence to show that many of these dense clumps of Salvadora persica are associated with saline and saline-sodic soils. If these were to be levelled, then it is highly likely that saline and saline-sodic soil material could be exposed at, or close to, the surface.

In any case, as both salinity and sodicity tend to increase with depth, poorly managed levelling may merely remove the least saline and/or sodic part of the soil profile, thus further aggravating the potential problems associated with the irrigation development of the area.

A6.6 Soil Erosion Control

At present, the principal causes of soil loss in the area are due to sheet and rill erosion following heavy rain storms. Much of this will be controlled through the careful planning and implementation of a properly laid-out irrigation scheme. Diversion ditches will be constructed along the perimeter of the area particularly to intercept the runoff water off the escarpment hills in the north and west. Bunds will be constructed along the major watercourses including the Awash, Kesem and Kebena rivers to prevent flooding and subsequent water movement over the surrounding areas. Field levelling and ridge and furrowing will also effectively prevent the widespread movement of the water across the area.

CHAPTER A7

CONCLUSIONS AND RECOMMENDATIONS

The present semi-detailed soil survey and land evaluation exercises have demonstrated that much of the study area is, at best, of only moderate or marginal suitability for irrigation development. The potential indicated by earlier reconnaissance reports has proved to be an overestimate because the soils are much more variable than expected and have a higher incidence of salinity and/or sodicity problems, many of which are too severe to permit economic land reclamation. Results from nearby surveys and actual irrigation schemes cannot always be extrapolated for use in the Kesem area, as they apply mainly to alluvial soils derived from flooding of the Awash river, whereas the soils in this study consist largely of quite different deposits from the Rift Valley escarpment.

The extent of irrigable land in the Kesem project area is limited by natural land features: dissected and/or steeply-sloping land to the north and west, the course of the Awash river in the east, and the Filweha Spring and lava outcrops in the south-east. With the exception of a small area of outwash plain in the south which falls within the boundaries of the Awash National Park, the present study of 21 823 ha (gross) covers all the potentially irrigable land in the vicinity.

The results of the survey indicate that 17 195 ha (79% of the area surveyed and mapped) are at least marginally suitable for some form of irrigated development, though some of this cannot be commanded for gravity irrigation. However, for many of the land utilisation types under consideration the areas of suitable land are significantly smaller, as shown in Table A7.1.

TABLE A7.1

Summary of Areas Suitable for Irrigation by Land Utilisation Type

Land utilisation type	Most suitable land Classes S1 and S2		Total suitable land Classes S1 to S3	
	(ha)	(%)	(ha)	(%)
Irrigated pasture	13 536	62	17 195	79
Woodlots	14 222	65	17 135	79
Cotton (state farm)	11 408	52	13 422	62
Smallholders	7 004	32	12 822	59
Citrus (state farm)	3 872	18	8 087	37
Tobacco (state farm)	3 682	17	6 878	32

Total surveyed and mapped 21 823 ha (100%).

Source: Table A5.8.

The effects on crops sensitive to soil salinity and/or sodicity (notably citrus and tobacco) are particularly marked. For tobacco, which has the highest potential economic return, only 2 698 ha (see Table A5.11) are classed as highly suitable (S1) and even Classes S1 and S2 together produce only 3 682 ha, and this is too fragmented for all of it to be used for tobacco. There is no S1 land for citrus development.

Furthermore, these overall figures mask the effects of the highly variable soil distribution pattern, which affects two major aspects of project development: selection of land based on the practicalities of field layout, and subsequent operational management. For large-scale, state farm development the ideal requirement is for comparatively large areas of sufficiently similar soils, to allow adoption of uniform cultivation practices over management blocks of several fields and certainly within individual fields. For smallholders, the reduced size of individual plots would allow more soil variability to be taken into account during field operations, although there would still be need to ensure that the soils are of reasonable quality for each smallholder, particularly if they are not experienced arable farmers. Selection is further complicated by the need to ensure that small farmers' lands lie at reasonable distances from the settlement sites, do not interfere with the state farm enterprises and allow adequate room for livestock grazing.

In the study area, unfortunately, the high soil variability means that large blocks of uniform soil are rare, as illustrated in Drawings A1 and A2. Only about 4 000 to 5 000 ha of land moderately or highly suitable for irrigation occupy such blocks. The remaining 13 000 ha of suitable land occur only as minor patches, many of which may be too small and/or scattered to warrant inclusion. In planning any detailed field layout in the study area, it is therefore inevitable that soils with very different land management requirements will occur within the same management unit or even field. As far as soil conditions allow, these inclusions should be kept to a minimum on the state farms, but it has to be accepted that on parts of some fields, at least, yields will be reduced because of adverse soil properties and/or the use of inappropriate management practices. For any smallholder cultivation that develops on the 'settlement' areas, the layout will also inevitably include variable soils, and appropriate management techniques geared to specific soil types or phases will need to be developed.

Adoption of skilled soil and water management practices will be crucial to the success of irrigation development in the area. In addition to the practices necessary to combat and prevent excessive sodicity and salinity, measures will also be needed to overcome the poor physical properties of many of the soils. Potentially the most serious of these include the tendency of the siltier textures to form surface crusts (thereby reducing the rates of infiltration); a general lack of good soil structure, and the inherently low soil permeability of the heavier textures which are widespread as depositional bands or major soil layers. These inherent deficiencies would be aggravated by poor soil management, notably by inopportune timing of field operations, especially those using heavy farm machinery which is liable to cause compaction and surface smearing in the silty soils. The severity of the problems is already clearly evident in the lands which have had to be abandoned at Saboret and Yalo: in the space of only a few years these lands have been severely affected by soil structural deterioration, rising watertables and local secondary salinisation and sodification, all further worsened by sub-optimal standards of land and water management.

Management practices may also have to be modified to allow for rainfall differences between the project area and the nearest agricultural research station, at Melka Warer.

Because of the difficulties - and cost - of reclaiming land affected by the soil problems outlined above, it is imperative that preventive measures are taken early on during any development and not delayed until symptoms become apparent in the field. Apart from the land management practices discussed above, a proper drainage system is an essential pre-requisite for a sustainable irrigation project. No soil type or phase should be considered initially for irrigation development unless effective subsurface drainage can be provided, although if this is not possible then low-cost irrigation technology could be considered as an alternative, with corresponding changes in intensity and production.

There is often a tendency in irrigation development planning to delay installation of drainage works until the installation is absolutely necessary, i.e. until after the irrigation system has been established and operated for some time. For the Kesem project, where severe salinity and sodicity problems are apparent and where rapid soil degradation has already occurred in land without adequate drainage, it is strongly recommended that the drainage system be installed as part of the initial development work before irrigation begins. If the installation is delayed until it becomes unavoidable, there is a danger that some external factor - perhaps political, economic or logistical - may further delay or even prevent it, with potentially disastrous consequences for the soils and the project.

Finally, it should be noted that the success of any development will depend on the co-operation and participation of the Afar. The main issues this raises are discussed in Annex C, but it is emphasised here that great care should be taken in the planning and development processes to identify and respect the numerous Afar graveyards throughout the area. Where known, these graveyards are marked on the current land use and vegetation maps (Drawings A7 and A8).

REFERENCES FOR ANNEX A

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Note: * Now updated in Rev 1, 1985.

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Annex B: Agriculture

ANNEX B

AGRICULTURE

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CHAPTER B1

BACKGROUND

B1.1 Introduction

This is one of fourteen annexes which, together with the Main Report and two albums of drawings, constitute the Report on the Feasibility Study of the Kesem Irrigation Project. The study was carried out by Sir M. MacDonald & Partners Ltd. for the Water Resources Development Authority (WRDA) of the Government of Ethiopia, under contract to FAO as part of the UNDP-financed project DP/ETH/82/008.

This Annex covers the Agricultural aspects of the study and includes financial crop budgets, machinery and staffing estimates. Further agro-economic calculations are presented in Annex N. The reader is referred to the Main Report for discussion of overall project planning, to Annex A for soils and reclamation and to Annex C for livestock.

References are listed at the end of the main text of the Annex and there is a list of abbreviations at the beginning of each volume of the report.

B1.2 Previous Studies and Reports

Previous studies and reports on agricultural development and activities in the Awash Valley have provided a basis of valuable information. Earlier feasibility studies, such as the 1975 Angelele Bolhamo study by Sir William Halcrow & Partners (Ref. 2), did not have the advantages of being able to draw on the experiences and development histories of previous projects in the area.

Recent years have provided an increased availability of relevant information on agricultural development activities, in particular from Melka Warer Research Centre (MWRC) and the Amibara Irrigation Project, on the right bank of the river Awash and some 30 km from the Kesem area. Information from progress reports produced by these sources, together with up-dated findings and views gained from discussions with research staff and managerial personnel has provided much of the basic data for this study.

Those reports which have provided relevant data on agricultural development in the Awash Valley are listed in the References at the end of this Annex (Ref. 1 to 17).

B1.3 Existing Development in the Area

B1.3.1 Introduction

There is an existing state farm in the project area, namely the Awara Melka State Farm, which has one of its units separated from the others and located at Yalo. The Kesem-Kebena plain also contains some very small spontaneous agricultural undertakings by the Afar. To the north-east and across the Awash river lies the Amibara system, with three large state farms, a research station, and a settlement component. These are described below.

B1.3.2 Awara Melka State Farm and Yalo Farm Unit

Awara Melka State Farm and Yalo farm unit, being situated within the Kesem Irrigation Project (KIP) area are of significant interest insofar as they provide information on a wide range of crop performances over several years. The crops include cotton, tobacco, banana and citrus; some of the citrus plantations being 27 years old. Available records of yields for citrus and banana extend back for only five years, whilst tobacco and cotton records cover more than ten years. This information, coupled with research development, improvements in cultural techniques at other projects and soil survey results in the project area, has provided the basis on which crop yields have been projected. Relevant details of observations made at these two sites are referred to under the various subjects discussed and analysed later within this Annex.

Nura Era Agricultural Development Enterprise is responsible for the operation of Awara Melka State Farm. Whilst other state farms run by this Enterprise are not in the same ecological zones as those state farms found within Middle and Upper Awash, much useful information relating to citrus and tobacco has been provided by the Enterprise in conjunction with that obtained from Awara Melka.

B1.3.3 Afar Settlements

Doho Settlement Farm is the only settlement farm within the project area and has been in operation for ten years with 180 members in the Farmers' Association. The area of 80 ha is allocated to maize and cotton production.

There is also a small number of Afar farmers within the numerous communities in the project area who carry out simple forms of irrigated cultivation. Outside the project area and adjacent to MWRC there are two groups of Afar farmers at Galisita and Kadigadori who have been growing a number of crops on a group basis under the direction of the research centre. Observations of labour inputs and crop performances have been recorded by the MWRC for the past two years and extracts of these data have been used for the settlement farm development proposals. Likewise, conclusions from the observations made of those farmers conducting various types of sedentary farming within the project area have also been taken into account.

The agricultural activities of the Afar are discussed in Annex C.

B1.3.4 The Amibara System

The Middle Awash Agricultural Development Enterprise (MAADE) is responsible for the running of four irrigated state farms within the vicinity of KIP: the Melka Sadi, Melka Warer, Amibara-Angelele and Dofan-Bolhamo farms. The first three of these are irrigated by gravity from the Awash river by the Amibara Project, and it is proposed to connect the fourth to the Amibara system also. Experiences gained by these farms in recent years, under very similar conditions to those found in the project area, are of immense importance to the development plans of future projects. Constraints faced by these farms during their implementation and running have been taken into consideration. For example, their experiences are reflected in the cropping calendars, planting times, yield estimates and machinery selection made in this study.

B1.3.5 Melka Warer Research Centre and Institute of Agricultural Research

This unit is also part of the Amibara System. Research activities at MWRC are primarily concerned with lowland irrigated crops. Much useful and up-dated information has been made available by MWRC for the study. Reference is made in subsequent chapters to their work on cotton, wheat, oilseed crops and field observation trials with Afar farmers. Results and data on other crops and socio-economic studies have been collected from other Institute of Agricultural Research (IAR) sources, at Nazret and its head offices in the capital.

B1.3.6 Present Agriculture

With the exception of Awara Melka (and Yalo) State Farm, the Afar settlement and sedentary farmers referred to the above there is no agriculture practised within the project area. The semi-nomadic Afar have been and still remain solely engaged in the grazing of cattle and livestock (see Annex C).

Agricultural systems at the state farms within and adjacent to the project area comprise either plantation crops or the continuous mono-cropping of either cotton or tobacco. The recent exception to this has been at Melka Sadi where wheat has been introduced as a secondary (cool season) crop, following cotton. Melka Sadi has also introduced the production of broom sorghum to utilise saline areas, but at the time of the study there were no plans to rotate this with other crops.

State farm crop production is dependent upon mechanisation (for cultivation and crop protection), and intensive labour for harvest and post-harvest operations. All crops are produced under surface irrigation.

CHAPTER B2

PROPOSED DEVELOPMENT

B2.1 Development Approach

The national objectives relevant to this project can be summarised as follows (Ref. 18):

- to use all resources to maximise the potential for agricultural production;

- to produce cash and industrial crops for export and/or import substitutions;

- to produce food crops at least sufficient for the local population.

The development of the agricultural plan has been based on these objectives of achieving maximum production of cash and industrial crops for export or import substitution. At the same time provision has been made for the production of food for the local inhabitants and immigrant casual labour that will work in the area. The overall development plan has not only aimed at maximisation of production from available land and water resources, but maintains a balance in the environmental and agro-ecological conditions prevailing in the area. This is to be achieved by the selection of areas most suitable for the production of arable and tree crops, whilst other areas best suited to pasture production and settlement farming systems have been demarcated. Further, the ecological balance within the area will be maintained by the establishment of woodlots on areas of land unsuitable for agricultural production (see Appendix B2), and by a range of management programmes for the surrounding area.

The maximising approach leads to a proposal to irrigate some 14 090 ha net on the Kesem-Kebena plain. In the context of alternative scenarios (discussed in the Main Report and in Annexes L and N), this is referred to as the 'large project'. It involves four cropping systems centred on tobacco, cotton, citrus and pasture respectively, though the annual systems (the first two) include break crops to an intensity of 150%. Table B2.1 sets out the net cropped areas, which total 12 690 ha of annuals on 8 460 ha of land, and 5 630 ha of perennials on the remaining 5 630 ha of land.

Of the total gross irrigated area of 15 660 ha, 4 400 ha have been demarcated for the local Afar and Soudanis. These areas will be predominantly put down to pasture and be grazed by the Afar cattle, with localised areas of better soils being used for the gradual introduction of sedentary farming and food crop production.

Of the remaining 11 260 ha gross, or 9 910 ha net, 3 120 ha net are considered suitable for the production of tobacco. This will provide 1 560 ha net of tobacco to be grown each year. In conjunction with this, cotton, wheat and maize will be grown as break crops and will provide annually 1 560 ha of cotton, 780 ha of wheat and 780 ha of maize.

The principal crop to be grown in the project will be cotton, which will be grown every year, as main crop, on a net area of 5 340 ha. Half of this area will produce a secondary cool season crop of wheat. The total area cropped to cotton each year will thus be 5 340 + 1 560 = 6 900 ha.

TABLE B2.1

Farming Systems and Net Cropped Areas - Large Project

	Total net area (2)	Annual area cropped						
		Tobacco	Cotton	Wheat	Maize	Citrus	Woodlots	Pasture
State Farm System								
Tobacco/ break crops	3 120	1 560	1 560	780	780	-	-	-
Associated woodlots	690	-	-	-	-	-	690	-
Cotton/wheat	5 340	-	5 340	2 670	-	-	-	-
Associated woodlots	330	-	-	-	-	-	330	-
Citrus	430(1)	-	-	-	-	430	-	-
Sub-total, SF	9 910	1 560	6 900	3 450	780	430	1 020	-
Settlement System								
Pastures with gradual introduction of arable farming	4 180	-	-	-	-	-	-	4 180
Total	14 090	1 560	6 900	3 450	780	430	1 020	4 180

Notes: (1) Includes 268 ha of existing plantations.
(2) Gross areas are 11 260 ha for state farms and 4 400 ha for settlement, totalling 15 660 ha.

A further enterprise for the production of citrus is also planned, with a gross area of 430 ha, reached by extending the existing citrus area of 268 ha.

An area of 1 020 ha net, consisting of areas within the proposed state farms which are not suitable for annual crops, is to be developed as woodlots. Two-thirds of the woodlot area lies within the tobacco farms.

The choice of areas for each cropping system depends on soils and topography and is discussed in Annexes A and L. The choice of crops is the subject of the rest of this chapter, while the cropping systems are discussed in Chapter B3.

B2.2 Crop Selection Criteria

Within the framework of the Ethiopian Government's policies and priorities, agricultural development in the Awash Valley has the following objectives:

- to produce cash and industrial crops for export and for import substitution;
- to fully utilise land and water resources;
- to maximise potential of agricultural production from financial investment made in development projects, but maintaining environmental and ecological balance;
- to attain self-sufficiency in food production for both the local Afar communities and immigrant labour;
- to introduce alternative farming systems to the transhumant Afar communities displaced by the development of irrigation projects.

The selection of crops that might be grown on state or settlement farms is in the first instance governed by the following factors:

- the prevailing ecological conditions;
- the suitability of the crop to be grown under irrigated conditions, and for its cultural requirements to be carried out by either mechanised means or labour intensive techniques;
- the availability of suitable crop varieties or cultivars with an adequate supply of planting materials;
- the availability of appropriate inputs such as fertilisers, chemicals, labour and water;
- xisting knowledge and experience of the crop under consideration growing under similar conditions elsewhere;
- handling and storage characteristics of the produce related to availability of facilities and proximity to markets;
- farmer choice of food crops and potential attitude to the introduction of new food crops and cash crops;

- level of management required for the successful growing of the crop, taking into account the basic management and technical skills available.

In addition to the agronomic and social criteria determining the selection of crops, economic considerations have been taken into account. From the final list of selected crops, cropping patterns and crop rotations have been devised to suit rotational needs to minimise pest and disease problems. Various farming systems have been developed.

The duration of existing crop varieties is one of the principal factors controlling the cropping sequences. Optimum sowing dates (as determined by trials) have to be treated with some degree of flexibility in order to permit double cropping (i.e. two harvests per year on the same land). It is considered that a slight reduction in yield, from a small percentage of the planted area of one crop, can be more than compensated by the returns to be gained from growing a second crop rather than omitting the second crop from the sequence.

The proposed cropping calendars and rotations are illustrated in Chapter B3.

B2.3 Proposed Crops

B2.3.1 Rejected Crops

Given the presence of suitable soils and sufficient irrigation water of adequate quality, many crops are suited to the climatic conditions in the Kesem area. A preliminary assessment of the suitability of a range of crops and their potential profitability was therefore made in order to produce a shortlist of the most promising crops.

The principal crops which were selected and were included in appropriate cropping patterns for different farming systems are:

cotton, wheat, maize, groundnut, sesame,
cowpea, tobacco, citrus.

These crops are discussed in Sections 2.3.2 and 2.3.3 below, for state farms and settlement areas respectively.

Crops which were considered and then excluded from the future cropping proposals included banana, sugar, rice, kenaf safflower, mangoes, teff, haricot beans and tomatoes. The reasons for the exclusion of these crops from future plans are outlined below.

Banana

Among the crops presently grown at Awara Melka is banana (Musa spp.). A small plantation of 66 ha of the cultivar Dwarf Cavendish produces bananas which are sold on the domestic market. The quality of the produce is not of a standard suitable for the export market. Yields in recent years have been variable and have averaged 11.2 t/ha over the four year period from 1981 to 1985. When compared with yields of the major producing countries, which can achieve over 30 t/ha, the yields at Awara Melka are on the low side. However, even with yields of 11 t/ha, present farm gate prices permit a gross margin in excess of Birr 2 000 per hectare. Poor yields at Awara Melka are attributed to a number of factors, the primary one being poor drainage. Bananas require soils which are well aerated, with good structure and porosity, and a clay content of less than 40%. The groundwater table should also be below 1 m. Further, bananas have a low tolerance to salinity. Considerable areas of banana plantations are being lost at Melka Sadi, primarily due to poor drainage and salinity problems.

The Ministry of State Farm Development had, by 1986, decided to centralise all irrigated banana production at Mile in the Lower Awash, and the crop was therefore excluded from the proposals for this project. It subsequently transpired that the area designated at Mile is in the Tendaho reservoir area, so a relocation will be necessary. The Ethio-Bulgarian Joint Venture (explained in Section F1.5 of Annex F) now plans to continue growing bananas at Awara Melka for the local market. With drainage, significant areas of KIP could be used for bananas, and it may prove worth while to include the crop in future planning for the project. The market is not unlimited, however, and the effect on project economics would be small.

Sugar

Although growing conditions in the Middle Awash are generally well suited to the production of cane sugar (on the best soils average annual yields of between 12 and 14 t/ha of raw sugar at Wonji and Metahara), cane must be grown within easy haulage distance of a factory. The existing factory at Metahara is at least 35 km from the KIP at its nearest point; this is not considered an economic distance at current world prices. The alternative of developing a new nucleus estate within the KIP area is not recommended for the following reasons:

(a) the high proportion of low suitability soils, coarse textured with poor moisture-holding characteristics and low nutrient status;

(b) low suitability soils restrict yield potential, so profitable large scale estate operation would be difficult to achieve;

(c) the high capital cost of a new factory at a time when world prices for raw sugar are so depressed;

(d) the projected development of a fourth sugar estate in the Finchaa area.

Rice

This is potentially a highly attractive crop, especially for the extensive areas of the slowly permeable soil types 7 and 8 (see Annex A) within the Awash floodplain, which are otherwise only suitable for pasture grasses and specialised woodlots. Although extensive areas of potential paddy rice land exist within the Middle Awash, the MWRC has to date undertaken no investigations into this promising cereal. Rice is not a significant part of the diet of any large group of people in the country, and as the world market prices are low and likely to fall further, so there is not an attractive market. For these reasons, and because of the absence of any local experience in growing this crop, rice was excluded from further consideration. Other potential disadvantages of rice include:

(a) the high labour requirement in planting, weeding and harvesting;

(b) the high water requirement;

(c) bird damage (though not confined to rice);

(d) the need to invest in a local rice mill.

Notwithstanding the above, the inclusion of rice into the crop pattern should be considered if rice is introduced into the research programme at Melka Warer and shows promising results, and if a market opens up.

Citrus

Citrus is proposed for the state farm system only. It has not been included in the settlement farm system primarily because the Afar sedentary farmer is more interested in growing crops for food than for cash. Therefore, he is more likely to adapt to food production for himself and his family rather than to the growing of tree crops for cash, which will in any case require more than five years for establishment before any return can be expected. Lemons are not included in the recommendations since they are not suited to the climate, are very sensitive to soil salinity and have little or no market.

Kenaf

Despite impressive yields under irrigation in excess of 5 t/ha of dry fibre, there are well known problems in obtaining adequate quality (acidic) water for retting. MWRC advocates mechanisation of kenaf retting but, in view of the lack of operational experience both in large-scale production and in processing, it is thought prudent not to recommend this crop at this time. Nevertheless, in view of the considerable national imports of jute (for which kenaf is a substitute), it is hoped that experimentation will be continued into this promising crop.

Safflower

This oilseed has yielded 1 to 1.6 t/ha at MWRC. This yield level is considered insufficient to compensate for the major costs associated with harvesting the crop, in particular the high labour requirement.

Mangoes

These undoubtedly have long-term potential and the proposal by FAO to establish a mango nursery at the MWRC is to be welcomed. However, until some research results are available and markets reliably identified for the future, large scale planting of mango cannot be recommended for the Kesem area.

Teff

This versatile cereal, a staple food for the highland immigrant population, has had to be discarded owing to the lack of high-yielding cultivars under irrigation. Despite low current yields at the MWRC, if selection of teff varieties adapted to irrigation and appropriate for the altitude of the Middle Awash proves possible, then this crop should be considered.

Haricot Beans

This traditional Ethiopian export is currently commanding exceptionally buoyant prices and should be considered for production in the cooler dry season in the Middle Awash Valley. An 85 to 90 day crop produced between November and February could be rotated with wet season crops of maize or tobacco. This crop is not included in the recommendations here because of the lack of experimental information on its performance under Middle Awash conditions. A test programme would be advisable, and might lead to its introduction later.

Tomatoes for Processing

The Middle Awash Valley is ideally suited for intensive tomato production under furrow irrigation. Although it is considered that yields of 40 t/ha should be attainable under state farm conditions, it is recommended that the first step should be the trial of appropriate varieties under research conditions leading on to a full-scale feasibility study for industrial tomato paste production. There is not sufficient data available at present to justify the inclusion of tomatoes in the recomendations. There is already a tomato processing operation in the area (near Metahara), and the market may turn out to be a significant limitation.

B2.3.2 Selected Crops - State Farms

Cotton - Gossypium spp.

At the present time the variety Acala 1517/70 is the only variety grown in the Kesem area. However, there is a general consensus that the genetic quality of the seed being supplied has declined in recent years. The introduction of new cultivars, expected within the next five years, will have a considerable impact on yields. It is not possible to predict the effect of new cultivars on production, thus Acala 1517/70 has been used as the basis upon which yields for KIP have been forecast.

The suitability of the ecological conditions for cotton production in the Awash Valley is well proven by 20 years of research carried out at MWRC, and by several years of farm production at the state farms of MAADE, together with the state farms existing within the KIP area. Cotton production uses large quantities of labour for harvesting, whilst mechanisation of land preparation and cultivation require minimal labour. Nearly all the labourers are immigrants or seasonal migrants from the highlands. In recent years the state farms in the Middle Awash and similar areas have experienced increasing difficulty in attracting sufficient labour, partly because of relatively low pay and poor housing.

The introduction of mechanical cotton harvesting has been carried out under trial conditions at Melka Sadi State Farm. It has been concluded that the variety Acala 1517/70 is not suited to mechanical harvesting, owing to the fact that machine picking has to be carried out when 70% to 90% of the bolls are open; this results in the earlier opening lower bolls being lost and damaged by rain showers which occur in September. Further, machine harvesting necessitates the use of defoliants, a technique which has not yet been used in Ethiopia. Consideration must also be given to the increased ginning costs involved due to the unclean seed cotton which results from machine picking. Until such time as new varieties of cotton are developed which are suitable for machine picking, and changes in cropping techniques are adapted to local conditions and introduced, mechanical harvesting cannot be recommended. Even when these conditions are met, the market's preference for the high quality attained by hand picking must also be considered.

Whilst the yields obtained over the last 10 years at Awara Melka and Yalo have been modest when compared with those being achieved at Amibara project during recent years, gross margins for KIP still indicate a favourable return.

Although cotton can be grown on a wide range of soils and is notably tolerant to salinity, surface waterlogging is especially detrimental, causing precocious flowering, boll splitting and serious diminution of yield. It is therefore recommended that the less well drained clays and sodic silt loams be avoided. Yields will still be limited by the poor structure of the silty soils.

Trials at MWRC have clearly indicated that the optimum planting date for cotton is in the first half of May with mid-June being the latest date at which the existing cultivar should be planted. Field experience on the MAADE state farms using pre-irrigation techniques has shown an increase in yields and a decrease in the amount of weed control required. Early opening of the land and exposure of the soil suggest an improvement in pest control, especially with the earliest sown cotton. The operational plan is to plant some of the cotton in the second half of April, and to make the deadline for planting early June. The consequences for the cotton-wheat system are discussed in Section B3.2 below.

The objectives are to reduce the sowing period with the maximum amount of cotton being planted during the optimum planting dates, and to provide an opportunity for double-cropping. To achieve double-cropping, by following cotton with wheat, and to achieve optimum yields with minimum risks of boll damage by rain during July and August, it is proposed that 15% of the cotton be planted in late April, with 70% during May and the balance in early June. With 50% of the cropping area planted by mid-May, it will be possible to plant the same area to wheat in November. The harvesting of cotton planted after mid-May will not be completed until the end of December and therefore too late to follow with wheat. Thus 50% of the total cotton area may be double-cropped. The timing of the cotton-wheat system is discussed further in Section B3.2 below.

Wheat - Triticum spp

Wheat is proposed as a cool season crop which can be grown on the state farms following the main season cotton crop. Some of the soils found within the project area and the temperature ranges during the cool season are generally suitable for wheat growing.

The primary use of the crop will be to provide food for the immigrant labour communities and eventually to provide food for the local Afar population when their dietary habits have become accustomed to the crop. Secondary uses for the crop are that surplus grain requirements could be sold into the domestic market and that the crop residue, wheat straw, would be available as roughage for the Afar livestock.

Present yields achieved under research conditions and on-farm verification trials indicate that wheat should prove to be financially attractive to the producer.

Research commenced into the possibilities of growing wheat in the Awash Valley under irrigation in 1976 with screening trials. By 1980, 109 varieties had been selected from a total of 691 possibilities. Since that time MWRC has conducted trials with the objectives of establishing optimum sowing dates, planting densities, weed control measures and nutritional requirements. Farm verification trials have also been carried out and commercial growing of the crop was carried out on a small scale at Melka Sadi State Farm in 1985/1986.

There are two recommended varieties available, Chenab 70 and Blue Jays. These are of 105/110 day and 90 day durations respectively. Indications are that optimum sowing dates for both these varieties are late October/early November. It is proposed that a combination of the above varieties be sown in the state farms in order to spread harvesting over a six-week period. Such a spread will reduce the number of machinery units required during this period by increasing the available work days. It also reduces the risk of loss by rain during harvesting.

The harvesting of wheat will mostly take place during February and early March. Whilst rain does not occur every February (5 out of the previous 21 have had none) there is a 41% probability that rainfall will exceed 50 mm and a 14% probability that rain will exceed 100 mm in February. Therefore, harvesting delays of seven days or more can be expected once in every seven years, when serious crop losses may occur.

Wheat straw will be cleared by mid-March and the land then prepared for cotton planting. Land used for the growing of wheat will be planted to cotton between mid-May and early June, thus retaining the two month 'closed' season from mid-March to mid-May.

Citrus - Citrus spp.

A range of citrus and other fruit has been grown at Awara Melka for more than 50 years. The citrus under consideration for growing within a state farm system are:

C. sinensis	Sweet orange
C. paradisi	Grapefruit

Fruit is primarily intended for processing at Merti Processing Plant. A small percentage of the production will go to the domestic market.

The history of production at Awara Melka indicates that yields can compare favourably with those in major producing countries. There is a wide variation of yields from country to country and average yields range from 20 to 70 t/ha. Melka Warer has shown yields of between 20 and 30 t/ha in some years.

Citrus is well suited for irrigation. It grows at temperatures between 15^{o}C and 35^{o}C, the optimum requirement being 25^{o}C to 30^{o}C. However, citrus trees are sensitive to salinity, lemons being the most sensitive.

Although conditions for citrus are far from optimal, there is no question that, given good management, some types of citrus (especially grapefruit) are capable of producing economic yields on the better drained and non-saline soils. The capacity of the market and of the local fruit processing factory is limited, but they could take additional quantities of citrus equivalent to production from a further 200 ha of orchards. These orchards should be located on well drained soils within a single management block at the western end of the existing Awara Melka State Farm immediately east of Saboret.

The most promising types are orange and grapefruit:

Orange - C. sinensis

Some 33 ha of 28-year old orange remain at Awara Melka. Losses of trees by 'die back' disease are now occurring at the rate of over 200 per year. It is expected that the loss rate will rapidly increase within the next four or five years as the age of plantations increases.

The cultivars 'Valencia' and 'Washington Navel' are grown.

Grapefruit - C. paradisi

Only half-a-dozen or so old trees remain at Awara Melka. Grapefruit is perhaps the best suited of the citrus species to be grown in the Kesem area, being the least sensitive to salinity and requiring less pruning than other citrus. New plantations are being established by the Horticulture Development Corporation on 100 ha at Awara Melka. The cultivars Red Blush and Starry Robby are used.

It is possible that the grapefruit grown in KIP will be "shy bearing" unless fertilisers are applied. Owing to the lack of experience of growing grapefruit in this area, field observation trials and on-going evaluation will be necessary.

Another type now grown, but not suitable for large scale development, is Lime (C. aurantifolia). Only 2 ha of old trees remain at Awara Melka although a further 76 ha have been established in the past four years. The cultivars Mexican and Pierce are being used. The trees are susceptible to foot rot, anthracnose, and Tristeza, but resistant to scab. The trees are early bearing and generally heavy fruiting but yields are not expected to be as high as those for orange.

Tobacco - Nicotiana tobaccum

Tobacco is the most widely grown commercial non-food crop in the world, and in many countries it is of significant economic importance. The rainfed areas of the country are already growing other types of tobacco, but cannot produce Virginia of which the Ethiopian market needs a certain proportion, so this project can substitute irrigated Virginia for imports.

Flue-cured Virginia tobacco, varieties K1 and K110 originating from Zimbabwe, is being grown at Awara Melka. Yield and production records are available for the past 12 years. Wood-fired conventional convection barns are used.

The crop is planted over ten months of the year under a furrow irrigation system. Tobacco has been grown on the same land on a continuous system without any break crops for the past three years, and no nematocides have been used prior to transplanting. Agronomic practices are generally of a low standard. In many respects the present system of growing and production is inefficient and permits the possibility of a serious build-up of pest and disease infestation.

Leaf curing, conditioning barns and grading sheds, are of a poor standard. Leaf quality presently grades out at around 55% for grades one and two, 40% for grades three to six, and 5% scrap. Fuelwood is transported considerable distances to Awara Melka by road.

Tobacco production is proposed as a main cash crop for state farms on predominantly sandy soils (soil types 2, 3 and 4 - see Annex A). It is proposed that the crop should not be grown on a continuous basis but that it be rotated with either wheat and cotton or cotton and maize, depending on the seasons which will dictate the crop sequence. The three crops of either sequence would be grown over a two-year period. It is further proposed that planting be carried out throughout the year (as is presently being introduced at Nura Era) in order to utilise barn capacity, machinery and available labour well. Many of the labourers will have to be semi-skilled and should be retained to improve and maintain curing and grading standards.

The soil requirements for flue-cured tobacco are principally free drainage, low nitrogen and chloride levels, and reasonable moisture holding capacity. Sandy loams provide the optimum conditions, but a considerable range in texture and other soil characteristics is often suitable.

As the quality of leaf produced is more important than the quantity, improved curing, conditioning and grading facilities are recommended. Energy requirements for processing will require close investigation. Fuelwood can be obtained from the project's land clearing operations during the development period, and new irrigated woodlots will be able to provide fuelwood after about five years (see also Appendix B2). Electricity made available from the Kesem hydro-electric plant may also prove an appropriate energy source.

As tobacco growing and production require a high level of management and experience, it is recommended that the state farm tobacco production unit(s) be separate from the state farm cotton growing units. The break crops grown in the tobacco crop sequence will be under the management of the tobacco production unit farm, in order to ensure the timely implementation of the crop programme and thus prevent a disruption to the tobacco planting programme.

B2.3.3 Selected Crops - Settlement Farms

From surveys conducted among those Afar who carry out some form of sedentary farming and where a variety of crops is known to them, it was observed that in all instances a preference was expressed for the cultivation of cowpea. This is due to the low labour input required by the crop, the relatively short period of time between sowing and harvesting, and the fact that it may be harvested as and when required over a period of several weeks. Some interest was shown in the growing of maize. However, maize did not compete as a food crop with cowpea by preference of choice amongst the Afar. This is attributed to the low yields being experienced and to customary habits.

A dietary preference was also expressed for groundnuts and sweet potatoes but respondents emphasised the fact that both these crops demanded too much work in both their cultivation and harvesting, and that they took a long time to mature. These comments by the Afar are borne out by the well established fact that these crops, especially groundnuts, are extremely labour intensive.

Despite the Afar's very limited experience and knowledge in crop cultivation, a natural selection of crops due to circumstances and preferences is already being made. Apart from their inherent lack of knowledge in the growing of crops the major constraint facing the new farmers will be the limited availability of labour. This will be restricted to available family labour. Priority work will remain, for a considerable period of time, the herding and tending of livestock. For this reason it must be anticipated that only those crops with low labour requirements and short duration will be acceptable in the initial years, and that preferences will be for food crops.

The introduction of animal-powered cultivation will be of paramount importance to crop production by the settlers and only when this has been learnt and adopted by the Afar will the more labour intensive crops be cultivated on any notable scale. Afar in other places are now showing interest in tractors, but with their lack of mechanical skills any mechanisation would lead to undesirable dependence on others. It is a possibility for the remote future, but is not included in the analysis at this stage.

In view of the Afar priority requirement for food, it is most probable that the principal crops grown by them in the initial years of development will be pulses, grain and oil crops, and possibly sweet potatoes by those communities already familiar with the crop. Wheat is likely to prove attractive due to its short duration, low labour requirements for its cultivation, and the value of its straw as forage. Groundnuts and sesame are likely to find a place in the settlers' cropping pattern, and cowpea may prove to be the most popular of all. The quantities grown will be relatively small, and simplified assumptions about production are made, for analysis purposes, in Annex N (Section N4.4).

Cowpea - Vigna unguiculata

Ideally suited to smallholder cultivation, it may be grown both as a main season and a cool season crop with optimum planting in early November. Primarily intended as a food crop, it can also be used as a fodder crop for cattle. Three cultivars are available, White Wonder Trailing (90 day), Black Eyebean EXDZ and TUV 19770DI (70 day). Cowpea can provide food at all stages of growth from the young shoots and leaves eaten as a spinach, fresh seeds and pods and mature dried pulse which can be ground into meal. If the plant is cut back regularly it will continue growing new leaves and for this reason it is very useful as a fodder crop.

Apart from its versatility as a food and fodder crop, cowpea does not mature in a definite period and can be utilised as food or fodder within a very short time after sowing. These characteristics, together with the relatively low labour requirements, will make the crop attractive to the Afar settlers on well-drained soils.

Instruction in the management of the crop under irrigated conditions will be important as the crop is very sensitive to waterlogging. Disease and pests, including cowpea wilt (Fusarium oxysporum), mosaic root-knot nematode (Meloidogyne spp.) and string nematode (Belonaimus gracilis), can seriously affect yields but can be controlled by the use of rotations. The use of extension services for crop management and plant protection monitoring will be necessary to obtain and maintain reasonable yield levels (see Section B2.4.3).

Groundnuts - Arachis hypogea

Groundnuts can only be grown as a summer season crop owing to the low temperatures experienced in December. The variety Shulamit is of 150 days duration and is of the cultivar Virginia; it therefore has runners and a spreading bunch form suitable for manual harvesting by settler farmers, but not suitable for mechanical harvesting. Other varieties NC4X and NC343 (both 150 days) are about to be released and are reported to be better yielding than Shulamit. Shorter 90-day varieties will not be available for some years. High labour inputs required, especially for weeding and lifting, will limit the acceptance of this crop among the Afar, especially until ox-cultivation is introduced and the shorter duration varieties are available. For this reason only small areas of groundnuts are planned in the cropping patterns, and these must be confined to the more suitable sandier soils (soil types 2, 3, 4 and 5a -see Annex A).

However, groundnuts are an important food crop having 25% to 30% protein content and a caloric value of 546 cal/100 g. The haulm (crop residue) can also be used as forage for livestock. In peasant farming the crop is well suited for intercropping. In spite of the long duration of the crop and high labour requirements there are indications that the crop will be accepted by some Afar settlers.

Groundnuts are susceptible to a number of diseases and pests, leaf spot caused by Cercospora arachidicola being the most common. Rosette virus, transmitted by the vector Aphis laburri which causes severe stunting of the plant, is also a frequent problem. As with other crops to be grown on settlement farms, extension services to assist the farmers in crop husbandry and plant protection surveillance will be necessary.

Sesame - Sesamum indicum

Sesame is grown by peasant farmers for its edible seed which has a protein content of 20%, slightly less than that of groundnut, and a caloric value of 547 cal/100 g. The stalks of the plant are a useful fuel. The crop can be grown in both the main season and the cool season. Available varieties are of 85 to 110 days duration. Border irrigation can be used thus reducing the labour requirements. Well aerated and well drained soils are essential (as for groundnuts).

In manual harvesting the crop stems are cut with a sickle when the lowest pods are ripe, and the sheaves are stacked for drying and maturation of all the pods.

No major disease problem affects sesame, though minor incidences of leaf spot (Pseudomonas sesami) and fusarium wilt (Fusarium oxysporum) do occur. The principal pests are stem borers and aphids.

Extension services for instruction in crop management techniques and pest control monitoring are proposed in order to achieve successful yield levels.

Maize - Zea Mays

Although agronomic conditions favour sorghum over maize, maize is the preferred food crop and suffers less from bird damage. Unfortunately, research has not as yet succeeded in identifying a suitable variety for irrigation in the Middle Awash. Under open market pricing it is third in ranking of profitability after groundnuts and sesame.

Maize may well be of considerable importance among settlement farmers as a cool season, or second crop. The variety Regular White 170 takes 140 days from planting to harvest. A gradual shift from maize to wheat is however expected.

Wheat - Triticum spp.

As described in Section B2.3.2 above, wheat is proposed as a cool season crop to follow cotton in the state farms. Likewise it is suitable for growing as a cool season crop under settlement conditions. Should the dietary habits of the Afar change sufficiently, wheat could play a major role in the settlement farm cropping pattern. If, however, the Afar settlers do not take to eating wheat, the crop would provide a cash income and a gross margin (at the government's present fixed market price), equal to that of maize sold on the open market. The main attractions of the crop to the settlement farmers are likely to be its short duration and low labour demand especially when ox-cultivation is used. For this reason the crop will show the greatest return per man-day when compared with other field crops under condsideration. The farmers are expected to shift gradually from maize to wheat, as experience is gained and tastes change.

The varieties Blue Jays and Chenab are 90 and 110 day duration respectively, and labour requirements are moderate. The use of the crop in rotations with cowpea and sesame is well suited. The crop would be grown primarily for food having a starch content of between 63% and 71%, a caloric value of 344 cal/100 g and protein of 8% to 10%. Wheat straw from the crop residue can be chopped and fed to cattle as roughage.

B2.3.4 Woodlots and Afforestation

The scrub areas of the Awash Valley in and around the project site have been subjected to extensive cutting and clearing in past years for charcoal production and in more recent times, especially around Awara Melka, for use as fuelwood for tobacco curing. With the implementation of the KIP, large numbers of immigrant labourers and their families will be moving into the area; consequently, demand for fuelwood for local domestic use will increase. In addition to this, the areas of land to be developed by the KIP will drastically reduce the availability of fuelwood to the local Afar inhabitants. This will put even greater pressure on the remaining scrub vegetation around the project area leading to a vast area of land denuded of trees.

It is essential that fuelwood plantations are established within and around the project area as early as possible in the implementation programme.

Areas of land within the project which are unsuitable for crop production should be used for the establishment of plantations. Such areas could include small blocks of land ranging from only a few hectares to areas of substantial size. After establishment under irrigation, these woodlots may be either irrigated or not. The areas designated (see Annex L) total 1 020 ha and comprise patches of class 4 land within state farm areas.

Production of fuelwood from irrigated plantations may be expected within four to five years from transplanting. Those species which may be coppiced can then be recut every four years. Plantations which are not irrigated will be slower growing and produce 40% to 50% less volume of biomass. It will be advantageous to irrigate the woodlots in years with plenty of water, and leave them unirrigated for a few months in dry years to conserve water.

Some species for growing under irrigated conditions have been identified by the State Forestry Department of MOA. These include:

Eucalyptus sergenti
Eucalyptus oxidentalis
Casuarina equisetifolia
Azadirahta indica

and for plantations where irrigation is not available,

Acacia senegal
Acacia albida
Acacia nilotica (already widespread in the area)
Eucalyptus brocwayi
Tamarix aphylla.

All these should be tried, and also those proposed for Angele-Bolhamo project by NEDECO 1986 (Ref. 4, see Annex D), particularly Eucalyptus camaldulensis. A process of trial and progressive learning should be followed, to find the best mix of species for the long term.

Watershed protection in the Kesem catchment area by the use of reforestation must also be considered. Several species of trees for planting at altitudes between 1 000 m and 1 800 m have been proposed, and include:

Acacia albida
Leucaena leucocephala
Pinus elliotti
Eucalyptus camaldulensis

The cost of establishing fuelwood plantations within the project area has been estimated by SFD at Birr 900 per hectare. For watershed protection the costs are higher and depend on accessibility to the areas, slope gradients, etc. Birr 1 000 to Birr 2 000 per hectare should be allowed for.

Biomass production for the fuelwood plantations is estimated at being 80 m^3 per annum per hectare under irrigation and up to 50 m^3 per annum per hectare under rainfed conditions.

The establishment of trees along roadsides, canal banks, between field boundaries and around buildings and housing areas should be introduced into both state and settlement farms. These will provide windbreaks, fuelwood, building poles and shade for people and livestock.

Introduction should be made of Leucaena leucocephala. This has been demonstrated to grow well at MWRC. Leucaena is a leguminous shrub which can grow to 10 m in height within three to four years. If left uncut its woody growth can be used for fuel. The growth characteristics of Leucaena makes this plant an excellent shade tree and windbreak. A deep penetrating taproot gives it good drought tolerance. It will not act in competition with grass or crops growing adjacent to it.

The leaf of Leucaena can be used for animal feed. The plant produces a vigorous growth and the palatable leaf has protein levels of between 20% and 25%. Regular cutting back stimulates leaf regrowth. The feeding or grazing of Leucaena with grasses minimises the possibility of hair loss which is caused by the presence of an alkaloid substance called mimosine. Trials on cutting intervals and plant height for animal feed are being conducted at MWRC. The versatility of this plant makes it ideally suited for growing on settlement farms.

B2.4 Crop Yields

B2.4.1 General

This section presents the Consultant's estimates of likely crop yields under the specific conditions of the KIP. They are influenced by many factors, the more notable ones being:

- yields at Awara Melka and Yalo farms, considered in the light of present conditions there;
- yields on the Amibara system in the recent past;
- yields elsewhere, so far as they are relevant;
- KIP soil conditions and their ranges of variation;
- the proposed cropping calendars.

The soils are discussed in detail in Annex A and the study area is divided into crop-specific suitability classes following the FAO system (S1, S2, S3, etc.). The tables in Sections B2.4.2 and B2.4.3 give estimated yields at the start of development and at the steady level, which for annual crops is assumed to be reached by year 10. This is done for each relevant suitability class. Most of the tables also show the weighted mean yield, which is derived from the relative distribution of suitability classes in the lands designated for each crop, and modified to account for the slightly reduced yields on some of the land due to groundwater effects. This is because, as is explained in Annex L, the field drains are designed for the approximate economic optimum spacing rather than for maximum yield. The effects of reclamation are included in the analysis by estimating an equivalent delay in starting production, as is explained in Annex A, Section A6.4.4.

The soils on the Kesem-Kebena plain as a whole differ significantly from those of the Awara Melka and Yalo farms within the plain and from those of the Amibara system across the Awash to the north-east. Experience of yields at these places has to be used with caution.

B2.4.2 Yield Projections - State Farms

Cotton

Yields previously obtained in the project vicinity have been taken into consideration when estimating future production levels. In the Amibara system, on land where irrigated cotton is grown as the only crop, yields declined to around 2.5 t/ha but have now climbed again and are generally in the range 3.0 to 3.5 t/ha, varying notably with the standard of management. At Melka Sadi State Farm where between 3.1 and 3.6 t/ha have been obtained. For 1985/86 MAADE reported an average yield for all their state farms as being 3.3 t/ha.

Yields obtained in recent years at Awara Melka and Yalo have not reached those achieved at the Amibara project. Indeed, yields in KIP have declined progressively since these state farms were initiated. At Yalo, 1.2 t/ha were recorded in the second year of production, reaching 2.0 t/ha in the eighth year. By 1985 average yields at Yalo had declined to 1.3 t/ha. At Awara Melka the area under cotton in 1981 was 900 ha; by 1985 this was 110 ha. Yields commenced at 2.1 t/ha, reducing by 25% in the second year and have not yet regained the 2.0 t level. Insufficient irrigation water, poor drainage and increasing salinity are the major factors causing the poor yield performances on these farms.

For KIP, yields will always be affected by soil quality, especially soil structure. At Amibara the soils often have high clay content, but they are relatively well structured. On the Kesem-Kebena plain, however, the high silt contents result in poor structure and the likelihood that structure will also deteriorate under mechanised farming. Two consequences will reduce cotton yields: firstly, surface capping will interfere with timely emergence, and, secondly, poor structure around roots will cause localised micro-scale anaerobic conditions (due to soil structure and unrelated to sodicity or to the adequacy of field drainage). It is anticipated that, during the first two to three years of production, yields will be relatively low, but as management and cultural techniques improve with experience, yields will increase. Projected yields are set out in Table B2.2.

Cotton will be grown in the two proposed systems for state farms; i.e., as a principal crop in the cotton and wheat system, and as a rotational (break) crop in the tobacco production system. As tobacco will take priority in all farming operations in order to maintain scheduled production programmes, any slippage in planting or harvesting dates of tobacco would have to be made up in the operational programmes of the break crops. It is therefore realistic to envisage that management will not be able to maintain optimal planting and harvesting dates for the cotton grown in this system. Consequently, slightly lower yields are projected when cotton is grown in the tobacco-dominated system.

It should be an important aim of management to raise cotton yields. The scope of this will however be limited, since the main constraints are soil type and soil structure, and it will be difficult enough to avoid deterioration of the latter under mechanised cultivation. Mulching with crop residues is generally impracticable because of disease and insect problems. Some slight improvement may result, in the long term, from the development of new varieties.

TABLE B2.2

Projected Cotton Yields - State Farms (t/ha)

Land suitability class[a]	In cotton/wheat system		In tobacco system	
	Year 1	Year 10	Year 1	Year 10
S1	1.9	2.8	1.7	2.5
S2	1.7	2.6	1.5	2.4
S3	1.5	2.1	1.4	1.9
Weighted mean[b]	1.58	2.40	1.46	2.32

Notes: (a) See Annex A, Chapter A5.
(b) The weighted mean yields take into account not only the distribution of land suitability classes but also the slight depression of yields in some fields by partially restricted drainage: see Annex L, Chapter L8.

Wheat

Wheat trials at MWRC presently concentrate on the establishment of optimum sowing dates, plant population, weed control, nutritional requirements and farm verification trials. Yields of wheat in 1984/85 were recorded as being up to 5 t/ha (for Chenab) under research conditions. With increased management experience, together with the results of the present research programme, it is anticipated that research yields will increase substantially from the present level to about 7 t/ha in five to six years time.

The first farm production of wheat was undertaken in the Awash Valley at Melka Sadi State Farm. It was estimated that the 1985/86 yields would be around 3 t/ha, but in the event there were serious losses due to lodging.

Due to the general lack of experience in the production of low altitude wheats under irrigation in Ethiopia, it is more than usually difficult to make projections as to the likely yields. In addition, the lack of experience with this crop by farm management necessitates considerable caution in the yield projections, especially in the early years. Thus, while a good yield of irrigated wheat is generally reckoned to be between 4 and 6 t/ha, yield estimates for KIP are around the lower end of the range, as set out in Table B2.3. A slight increase in the more distant future is possible, with improving management and possibly with more suitable varieties. It should further be noted that where smallholders harvest wheat without the benefit of machinery a 25% yield reduction should be applied to these figures.

TABLE B2.3

Projected Yields of Wheat on State Farms

Land suitability class[a]	Yield, t/ha of grain Year 1	Year 10
S1	2.0	4.5
S2	1.5	3.9
S3	1.0	3.1
Weighted mean[b]	1.46	3.75

Notes: (a) See Annex A, Chapter A5.
(b) The weighted mean yields take into account not only the distribution of land suitability classes but also the slight depression of yields in some fields by partially restricted drainage: see Annex L, Chapter L8.

Tobacco

Yields at Awara Melka over the past 12 years have neared a 1.0 t/ha average of dried leaf. In the past four years, at an average of 0.94 t/ha, yields appear to have been declining slightly. Leaf quality is generally poor owing to agronomic malpractices, e.g. over-irrigation and failure to top. Although the salinity of Kesem river water is such that it is generally suitable for irrigation throughout the year, it does appear that, at the height of the dry season, the water quality degenerates sufficiently to approach the accepted limit for Virginia tobacco of about 25 ppm chloride. Consequently, it is suggested that monthly measurement of chloride content be carried out on the Kesem near Saboret throughout a dry season to provide early warning of the decline in water quality. In any event, tobacco is highly sensitive to salinity - especially in respect to the burning quality of the leaves - and periodic field monitoring will also be required in those irrigation blocks producing tobacco. Where tobacco is to be grown on land which is now saline, thorough reclamation by leaching will be needed, with other crops grown in the first few years. For the purposes of project evaluation, a delay of four years is assumed in the building of tobacco yields.

Improved quality of leaf takes preference over the increase in weight of dried leaf. With in-service training of key personnel, a marked improvement of leaf quality should be achievable within a year or two. Further quality improvement would also be obtained by the introduction of suitable cultural practices and, most importantly, the use of suitable fertilisers which do not have a detrimental effect on the leaf quality. For example, excessive nitrogen or sulphur may severely reduce the leaf quality. Examples of the effects of excess nitrogen can be seen at Awara Melka.

A further constraining factor at present is the capacity of the existing curing barns. It is estimated that the limited barn capacity is resulting in a loss of production of between 20% and 25%. Modern barns would increase leaf throughput and leaf quality and reduce production costs. Any increase of production would have to be kept in line with the maintenance of a predominantly high quality of dried leaf.

Tobacco curing for the production of good quality leaf is dependent upon intensive supervision and experienced management. To achieve improved leaf quality within the shortest time possible it is strongly recommended that instruction and training be given to the managers and supervisors from the outset of the project. As tobacco curing and growing is learnt from good instruction and long experience and as there will be several separate tobacco farm units within the project, each requiring its own manager and team of supervisors, it is recommended that consideration be given to the engagement of a resident tobacco expert for a three-year period in the early stages of project implementation.

Average yields of up to 1.8 t/ha of predominantly high quality leaf should be anticipated within ten years. Further increased yields are only likely to be achieved with the introduction of new cultivars and the appropriate use of nutrients and nematocides. Yield projections are set out in Table B2.4, assuming improved curing barns. They refer to flue-cured Virginia tobacco.

Predominantly high quality leaf in this instance is taken as being:

Grade 1	35%
Grade 2	30%
Grade 3-6	30%
Scrap	5%

TABLE B2.4

Projected Yields of Tobacco on State Farms

Land suitability class[a]	Yield (t/ha dried leaf) Year 1	Year 10
S1	1.2	1.8
S2	1.1	1.5
S3	0.9	1.3
Weighted mean[b]		
- better soils	1.12	1.58
- poorer soils	0.90	1.27

Notes: (a) See Annex A, Chapter A5.

(b) The weighted mean yields take into account not only the distribution of land suitability classes but also the slight depression of yields in some fields by partially restricted drainage: see Annex L, Chapter L8.

Maize

Other crops which will be grown in sequence with tobacco are cotton, wheat and maize. Projected yields for cotton and wheat have been given earlier in Tables B2.2 and B2.3. Projected yields for maize are in Table B2.5.

TABLE B2.5

Projected Yields of Maize on State Farms

Land suitability class[a]	Yield (t/ha dried leaf) Year 1	Year 10
S1	3.9	4.2
S2	3.2	3.5
S3	2.5	2.7
Weighted mean	3.0	3.3

Notes: (a) See Annex A, Chapter A5.

(b) The weighted mean yields take into account not only the distribution of land suitability classes but also the slight depression of yields in some fields by partially restricted drainage: see Annex L, Chapter L3.

Citrus

The ecological conditions prevailing in the KIP area are best suited to the growing of orange, grapefruit and lime. The productive life of the present plantations is not expected to exceed 25 years.

Existing plantations of orange and mandarin are 27 years old and presently extend to 58 ha, but this is decreasing rapidly due to die-back. Production from these existing areas is expected to fall below economic levels within the next six to seven years. Awara Melka is presently the third largest producer of oranges in Ethiopia. The fruit is not of export quality and consequently is used mostly for processing or sold as fresh fruit on the domestic market. Average yields of up to 28 t/ha have been recorded in the past, but have declined in recent years to 20 t/ha.

Yields of grapefruit and lime have not been recorded at Awara Melka but, in line with experience elsewhere, it can be anticipated that grapefruit will be the highest yielding type of citrus. Market projections indicate scope for up to 200 ha of additional citrus plantations, and a mix of orange and grapefruit is proposed. Yield estimates are in Table B2.6.

TABLE B2.6

Projected Yields of Citrus on State Farms

Fruit	Land suitability class[a]	Yield, t/ha Year 1-4	5	10	15	20
Grapefruit	S2	0	1	20	40	30
	S3	0	0.5	15	35	25
Weighted mean		0	0.7	17	37	27
Orange	S2	0	0.5	15	35	25
	S3	0	0.5	10	25	15
Weighted mean		0	0.5	12	30	20

Note: (a) See Annex A, Chapter A5.

B2.4.3 Yield Projections - Settlement Farms

General

During the early years of crop production by Afar settlers, yields will show extreme variations between neighbouring farmers. This will be due to varying degrees of ability to grasp the concepts of simple cultural techniques such as thinning, gap filling, weeding, levelling and ridging, together with the timeliness of these operations. The absence of a 'conception of time' shown by the Afar when related to crop cultivation, has been one of the major observations by MWRC at Galisita and Kadigadora.

A further principal constraint during the early years of development, which will prevent existing crop varieties from reaching their full potential when grown by settlers, will be the limitations of available family labour. Labour requirements for crops grown under irrigated conditions and without the assistance of tractor or animal power are extremely high. With ox-cultivation labour input requirements would be reduced by between 50% and 75% depending on the type of crop.

To ensure even modest benefits to the settler farmer, intensive supervision and instruction will be required from the project extension service. From the outset of the project, ox-training programmes will be essential. All these facilities have been included in the project costings.

The rest of this section gives yield projections for land suitability classes S1, S2 and S3. Since food production can be concentrated on the best 10% to 20% of the land, leaving the rest for pasture, average yields are estimated to be midway between S1 and S2 levels.

Groundnuts

This is the most labour demanding of the field crops under consideration for settlement cultivation. However, groundnuts will provide the greatest gross margin per hectare when grown without the assistance of animal or tractor power.

Yields under research conditions have been reported in excess of 8 t/ha. From field observations at Galisita and Kadigadora, pure stands of groundnuts have yielded between approximately 1.8 and 4.7 t/ha and, when intercropped with either sesame or cowpea, between 2 and 4 t/ha (mechanised cultivation was used in these instances).

As stated, yields are expected to vary between individual plots. Nevertheless, marked yield increases can be expected over time, especially where ox cultivation is introduced, when a further yield increase of some 10% can be ascribed to improved cultivation and weeding. Initially, however, there may be some poor results on the cloddier and siltier land class S3 soils, while the highest yields will be confined to the sandier soil types 4 and 4b. Manual harvesting will not prove easy, especially on soil types 6 and 8a, but with oxen it should be possible to assist picking by ploughing out the pods. The yields projected in Table B2.7 below are based on irrigated smallholder production with pure stands planted in May/June.

TABLE B2.7

Groundnuts - Projected Yields of Shelled Groundnuts on Settlement Farm (t/ha)

FAO irrigation class[(a)]	Year 1	Year 10
Labour only		
S1	2.0	3.0
S2	1.5	2.4
S3	1.0	1.8
Labour and ox cultivation		
S1		3.5
S2	(b)	2.8
S3		2.2

Note: (a) See Annex A, Chapter A5.
(b) None grown by ox cultivation until Year 5+.

Maize

Since research has not yet succeeded in identifying a suitable variety for irrigation in the Middle Awash, the projected yields for the early years are so low that, if grown using labour only and sold at the fixed market price, the crop would show a negative gross margin. With ox-cultivation, however, a small positive margin may be expected even when calculated at the fixed government price.

Yields of 5.5 t/ha have been achieved under research conditions and a three-year average of just over 3 t/ha was achieved at Melka Warer. Observations at Galisita and Kadigadora showed highly variable yields ranging from 1.1 to 3.7 t/ha. Forecasts for KIP are given in Table B2.8.

On the basis that maize would be grown solely as a smallholder crop in small plots on the better drained soils, initial yields can be expected to be relatively low though with marked improvements as experience is gained and improved varieties are identified. The introduction of ox power should gain a further 10% increase in yields ascribed to improved land preparation, ridging and weeding, as well as an estimated reduction in labour requirement of over 60%.

TABLE B2.8

Maize - Projected Yields of Grain on Settlement Farms (t/ha)

FAO irrigation class[a]	Year 1	Year 10
Labour only		
S1	2.0	3.0
S2	1.8	2.5
S3	1.5	2.0
Labour and ox cultivation		
S1		3.3
S2	(b)	2.8
S3		2.2

Note: (a) See Annex A, Chapter A5.
(b) None grown by ox cultivation until Year 5+.

Wheat

No data exist for yields of wheat by smallholder production under lowland irrigated conditions. Estimates derived from other situations are presented in Table B2.9.

TABLE B2.9

Wheat - Projected Yields on Settlement Farms (t/ha)

FAO irrigation class[a]	Year 1	Year 10
Labour only		
S1	1.5	2.5
S2	1.1	2.2
S3	0.7	1.9
Labour and ox cultivation		
S1		2.8
S2	(b)	2.4
S3		2.1

Notes: (a) See Annex A, Chapter A5.
(b) No production by ox cultivation until Year 5+.

Cowpea

It is probable that cowpea will prove to be one of the most popular food crops to be grown by Afar settlers. There are two 70-day varieties and one 90-day variety available and suitable for growing under irrigated conditions. The crop is well suited for intercropping especially with maize and sorghum, but will perform better as a single crop. The principal constraint to high yields under irrigation will be waterlogging. Good water management will provide substantial yield increases.

Yields of 6 t/ha have been recorded under research conditions.

With smallholder irrigation, initial average yields of 2 t/ha are expected. At Galisita recorded yields ranged from 0.8 to 3.8 t/ha. With settlers gaining experience in water management and cultural practices and with the use of ox-cultivation, yields from existing varieties may be expected to reach 2.7 t/ha within ten years.

Sesame

An important lowland crop which grows well under irrigation and is well suited to smallholder settlement farms, sesame can be grown both as a rainy season and a cool season crop. Labour requirements are relatively low as border irrigation may be used. The crop is tolerant of saline soils and will perform well in poorer sandy conditions and the growing period from planting to harvest is less than 100 days. These factors are likely to make the crop attractive to the settler.

Yields at MWRC have demonstrated a potential of 1.5 t/ha for a cool season crop and 2.0 t/ha in the rainy season.

Under farm conditions, however, where labour and animal cultivation are used, considerably lower yields are anticipated. Observations conducted by MWRC on Afar farmers where sesame has been intercropped with other crops indicated yields from 0.3 t/ha to 0.7 qt/ha, low performances being attributed to poor land levelling and absence of timely thinning and gap filling.

With cultural and water management experience, yields of 0.7 to 0.8 t/ha appear possible for crops grown in the cool season, and 1.0 t/ha for the rainy season. Increased yields in future years will be dependent on improved crop management, especially thinning, gap filling, weeding and timely harvesting to prevent crop losses by shattering.

B2.5 Crop Budgets

Crop budgets for all proposed crops are set out in Appendix B1. These provide the calculated gross margins per hectare for those crops to be grown on state farm systems and the gross margin per hectare and per man-day for crops to be grown on settlements.

As settlements will be predominantly irrigated pasture for livestock, the areas of land put down to arable cropping during the early years of development will be a very small percentage. For this reason, use of mechanisation for land preparation (apart from the initial land clearing, levelling and first opening) is not recommended; instead the introduction of draught animals for land preparation and cultivation is proposed, with a gradual changeover from a labour-only system to an ox-cultivation system. Therefore, budgets have been prepared for both systems and jointly illustrated for each crop for comparative purposes.

For those crops where increased yields are projected in future years, such as cotton and wheat, comparative budgets have been shown at selected years. In the case of citrus an average gross margin has been made over a 24-year establishment and production period.

Gross Outputs

Projected yields are given in Section B2.4 above. Farm gate prices are based on 1986 prices. Open market prices (when known to the Agricultural Marketing Corporation) have been used in conjunction with fixed prices for comparative purposes.

Variable Costs

Seeds and fertilisers are taken at 1986 prices. Fertiliser prices reflect a fall from those of 1985.

Chemicals include insecticides, herbicides, fungicides, soil fumigants, seed dressing, etc. As the range of chemicals used on some crops, particularly cotton and citrus, varies from year to year and at different locations, figures are in some instances based on average costs estimated for 1985/86 by MAADE and the Nura Era Agricultural Development Enterprise. Where such estimates are not available, chemical input requirements have been allowed for and costs calculated at present day prices.

Machinery Costs

Machinery costs, illustrated in the budget as tractor hours, include all operational, maintenance and repair costs. Operational costs recorded at the five state farms of MAADE and at Awara Melka have been taken into account when calculating the cost per hour. Machinery of appropriate size has been selected for use by 140 hp and 90 hp four-wheel drive tractors and by 70 hp two-wheel drive tractors. Using these sizes, the operational input hours have been calculated. Machinery units required by operation and by crop area within the cropping pattern of a farming system have been established after allowances for non-operational downtime.

Estimated costs for special equipment or packaging materials for particular crops have been included where necessary.

Labour

Inputs of labour by operation are illustrated in man-days. For some operations average work rates are used, based upon experience gained at existing state farms or from recorded observations from the Socio Economic group of the IAR.

Where no data have been available the Consultant has used his own experiences of labour input requirements for crop operations under similar conditions in other countries. The financial unit cost of Birr 2.00 per man-day has been used throughout.

Animal Power

This is illustrated as ox-pair work hours. Inputs per operation in hours are based upon figures collected by IAR's Socio-Economic group at Nazret and have in some instances, been adjusted to allow for operations under irrigated conditions. Where data have not been available, the Consultant's experience for such operations under similar conditions in other countries has been used.

Crop Budget Summary

Tables B2.10 and B2.11 list the crop budgets, giving the gross margins per hectare for state farms, and per hectare and per man-day for settlement farms. The tobacco budgets use fuelwood as energy scoure for curing: electricity would only be used if its cost was similar or less. The settlement area budgets assume ox-drawn cultivation: manual cultivation may be more common in the early years.

The budgets themselves are in Appendix B1 to this annex.

TABLE B2.10

Summary of Gross Margins for State Farms (money values in Ethiopian Birr at 1986 financial prices)

Crop	Situation	Gross margin per hectare	
		Initial	Final
Tobacco	better soils	2 870	4 630
	poorer soils	2 000	3 350
Cotton	cotton/wheat system	1 200	2 220
	tobacco system	1 160	2 230
Wheat	both systems	260	710
Maize	tobacco system	140	580
Oranges	horticulture	-1 170	9 720 to 15 640
Grapefruit	horticulture	-910	8 620 to 12 580

TABLE B2.11

Summary of Gross Margins for Settlement Areas
(money values in Ethiopian Birr at 1986 financial prices)

Crop	Gross margin per hectare		Gross margin per labour day	
	Initial	Final	Initial	Final
Wheat	-38	660	-0.2	16.5
Maize	-170	340	-0.8	5.3
Groundnuts	560	1 680	2.6	22.4
Cowpeas	660	920	10.9	14.0
Sesame	190	810	1.6	14.0

CHAPTER B3

PROPOSED FARMING SYSTEMS

B3.1 Introduction

As described in Section B2.1 above, four farming systems are proposed. Three of the four farming systems will be adopted on state farms and one on the settlement areas.

Each state farm will be sub-divided into farm units of between 400 and 600 ha, depending upon the farming system involved and the physical design features dictating the layout of fields, canals boundaries, etc. (see Annex L). For management control, each state farm unit will be divided into a number of sections, each with its own section manager or supervisor answerable to the state farm unit manager.

The settlement farm area will extend to about 4 000 ha and will be divided into settlement units of about 300 to 800 ha, depending upon the physical characteristics of the project design.

The settlement farm units will be developed in the peripheral areas of the KIP between the state farms and the undeveloped grazing areas so as to have direct access for livestock between the wet-season grazing areas and the settlement units. The settlement units will comprise both irrigated pasture and arable cropping areas, the latter developing gradually as the Afar choose to move into irrigated agriculture.

In this section each of the systems and their cropping patterns and crop calendars are described. Staffing, labour and machinery requirements are analysed and costed. Although farm units vary in sizes in the planned layout, for analytical purposes these have been based on unit modules for each of the proposed systems. The sizes of these units are as follows, the areas given being the net production area within the unit.

- State farm unit - cotton and wheat	500 ha
- State farm unit - citrus plantation	200 ha
- State farm unit - tobacco production	600 ha
- Settlement farm unit - pasture and arable	500 ha

A summary of the farm unit development is given in Table B3.1. The costs and outputs have been used in the economic analysis (Annex N) by proportion, except that the staff numbers have been adjusted for actual unit sizes.

B3.2 State Farm Unit - Cotton and Wheat

B3.2.1 Explanation of the System

The main enterprise of this unit is the production of cotton. Wheat will be grown as a second crop in the cool season, primarily as a food crop. Cotton will be grown on 100% of the irrigable area followed by wheat on 50% of the area giving an annual cropping intensity of 150%.

TABLE B3.1

Farm Unit Development Summary

		State farm units Wheat/cotton	Citrus	Tobacco	Settlement farm unit
Cropped area	ha	500	200	600	500
Cropping intensity	%	150	Perennial	150	Pasture Perennial
Average monthly labour requirement	Labourers	402	300	545	-(1)
Peak monthly labour requirement	Labourers	618	331	754	-(1)
Annual staff costs	Birr(3)	161 000	166 000	235 000	133 000
Machinery and equipment capital costs	Birr(3)	1 355 000	342 000	2 193 000	369 000(2)

Notes: (1) Family labour only.
(2) Ox cultivation equipment not included.
(3) Rounded to '000.

The cropping calendar for cotton and wheat (Figure B.1) illustrates the main field operations, namely, land preparation, sowing, crop maintenance, harvesting and crop residue removal. In order to illustrate the factors governing the cropping intensity potential of this system, the calendar of operations for cotton has been divided into four separate planting times, namely, late April, early May, late May and early June. For wheat, all sowing is in the first half of November with two varieties of different duration (90 days and 105 days) thereby increasing the spread of harvesting from two to four weeks.

The calendar illustrates that early land preparation for cotton commences in February on land which was previously occupied by the last sown and picked cotton (CC and DD in Figure B.1)) of the previous season. These areas are then used for the first planting, 15% of the total land area being planted in late April and 35% in the first half of May. The third and final picking of the first planted cotton will be completed in mid-October and land preparation for wheat will commence (AA). The cotton planted in the first half of May will have been cleared in late October and early November, allowing time for land preparation of this area (BB) for wheat. The wheat crop will be sown during the first two weeks of November, occupying 50% of the farm unit land area. Cotton planted from mid-May to the deadline date of mid-June will not be cleared until December/ January (CC and FF) and therefore cannot be planted to wheat.

Wheat will be harvested and the straw removed during February and the first half of March (EE and FF). Land preparation of these areas will then commence in March for cotton to be sown between mid-May and early-June. A 2.5 month 'closed' season, when all wheat crop residue is removed, will then be possible on the double cropped areas.

B3.2.2 Development

(a) Labour Requirements

Table B3.2 shows the labour inputs required, in man-days, for each of the operations for cotton and wheat for each operation. Table B3.3 illustrates the number of labourers required during each month of the year.

As cotton will be hand picked (three picks being allowed for) and a proportion of the crop will he hand weeded, plus the requirements of irrigation, over 600 labourers are required during the peak month of September. Labour requirements for wheat are not high, despite hand weeding, and will not compete with labour required by the cotton crop.

(b) Staffing

Table B3.4 shows the total permanent staff requirement of the unit and the anticipated annual costs. The unit farm will have its own maintenance workshop for plant and equipment servicing and minor repairs. A central workshop for major repair work and overhauls is proposed for the state farm; accordingly one-sixth of the staff costs for the central workshop has been attributed to the state farm unit staff costs. Total annual staffing costs amount to Birr 161 000.

TABLE B3.2

State Farm - Cotton/Wheat 500 ha Unit - Man days

Ref.	Operation	Months	Days(1)	Man-days ha(2)	Man-days Unit	Labour required
Cotton 500 ha						
1	Maintenance	Jan - May	125	14	7 000	56
2	Thin and gap fill	May - Jul	55	5	2 500	46
3	Weed	Apr - Sep	112	53	26 500	237
4	Irrigate(3)	Apr - Nov	200	40	20 000	100
5	Picking	Aug - Jan	120	75	37 500	313
6	Handling	Sep - Jan	125	5	2 500	20
7	Cut and burn	Sep - Feb	150	12	6 000	40
8	Other	May - Jan	225	11	5 500	25
Wheat 250 ha						
9	Sow	Nov ½	15	2	500	34
10	Irrigate(3)	Nov - Feb	80	13	3 250	41
11	Weed	Dec - Jan	50	26	6 500	130
12	Handling	Feb - Mar	37	4	1 000	27

Note: (1) 25 working days/month
(2) Crop budgets Annex I
(3) Includes pre-irrigation

TABLE B3.3

State Farm Cotton/Wheat 500 ha Unit - Monthly Labour

Operation Ref. Nr(1)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cotton												
1	56	56	56	56								
2					46	46	46					
3				120	237	237	237	237	120			
4				100	100	100	100	100	100	100	100	
5	157							80	313	313	313	157
6	20								20	20	20	20
7	40	40							40	40	40	40
8	25				25	25	25	25	25	25	25	25
Wheat												
9											34	
10	41	41									41	41
11	130	65										130
12		27	27									
Labour per month	469	229	83	276	408	408	408	442	618	498	573	413

Note: (1) Operations as Table B3.2

FIGURE B 1

Crop Calendar - State Farm - Cotton and Wheat

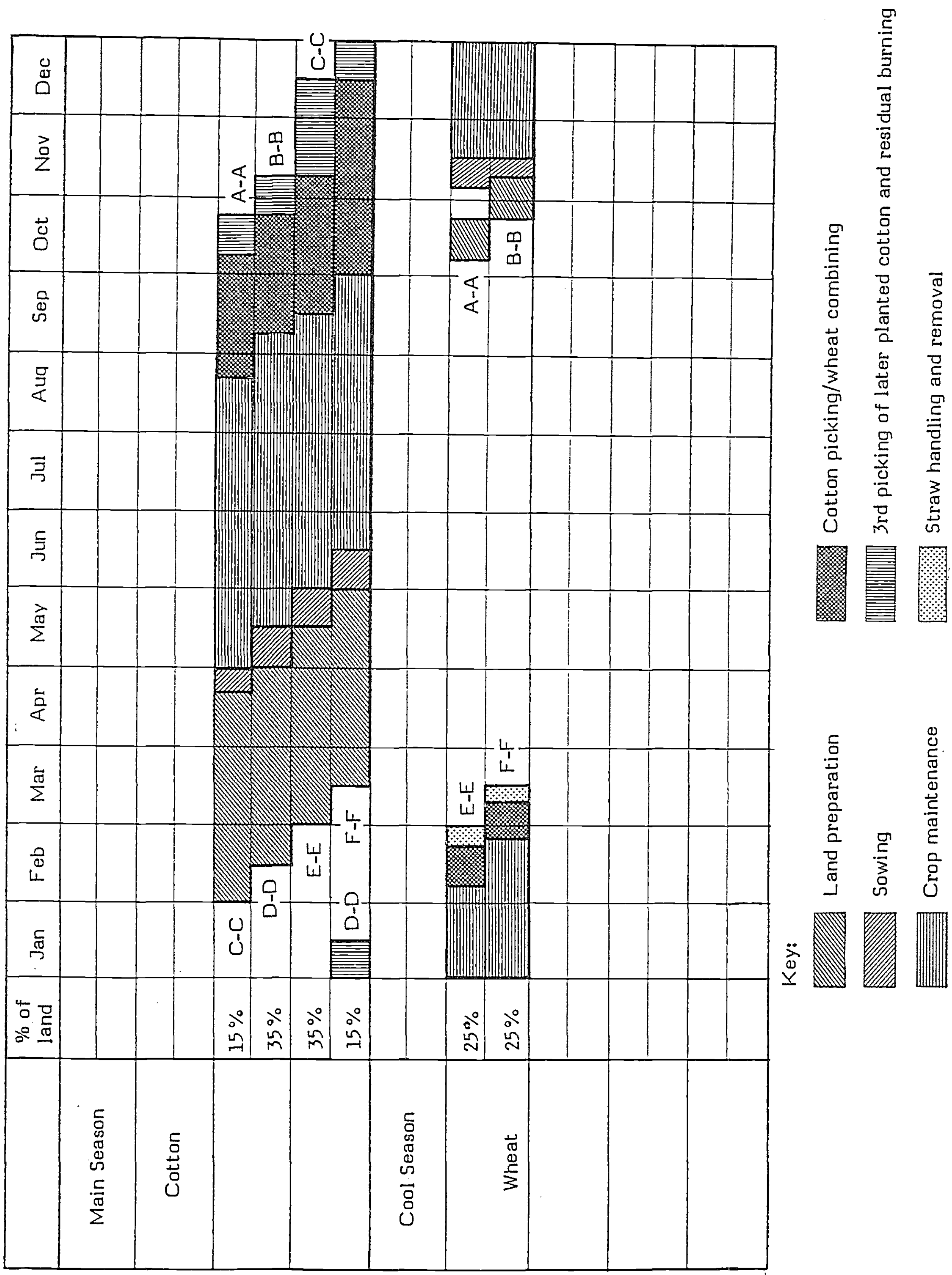

TABLE B3.4

State Farm Cotton/Wheat 500 ha Unit - Staffing

	Number	Unit cost PM (Birr)	Total cost PA (Birr)
Management			
Farm Manager	1	750	9 000
Irrigation Controller	1	325	3 900
Pest Control Officer	1	500	6 000
Field Operations			
Manager	1	600	7 200
Section Foremen	2	270	6 480
Field Foremen	4	110	5 280
Tractor Drivers	11	130	17 160
Technical			
Workshop Manager	1	600	7 200
Mechanics	2	315	7 560
Assistant Mechanics	2	100	2 400
Building Maintenance Artisans	3	175	6 300
Administration			
Manager	1	600	7 200
Accounts (Jnr)	1	400	4 800
Wages Clerk	1	240	2 880
Management Records Clerk	1	300	3 600
Labour Records Clerk	1	240	2 880
Stores Clerks	3	200	7 200
Drivers	2	150	3 600
Health Assistant - Clinic	1	280	3 360
Typist	1	230	2 760
Messengers	2	100	2 400
Guards - Compound Buildings	10	70	8 400
Field/Irrigation Workers	20	70	16 800
			144 360
Central workshops attributed costs			16 280
Total annual staff costs		Birr	160 640

(c) Machinery and Equipment

Machinery units required by the system are shown in Table B3.5, indicating all operations for both crops. Machine units refer to both tractors and the machine or tool units fitted to the tractor to carry out the given field operation. To calculate the number of tractor units and equipment required the following system has been used.

The period of time available in which to carry out a certain field operation is converted into the number of available work days. The work rate in hours per hectare is based upon the working width of the tool and the forward speed of the unit. Forward speeds depend upon soil conditions, tractor power and/or operational speed of the machine unit. Work rates are therefore estimates based on average workability of the soils. The number of hours required to complete the operation on a farm (in this instance 500 ha) can be calculated. The total hours required to complete the operation are divided by the period of work days available, giving the total working hours required per day. This in turn is divided by the number of available working hours of the tractor and tool unit per day. This will provide the number of machine units (tractor and tool unit) required to carry out the operation. The available daily working hours per machine unit depends upon the number and duration of working shifts, less an assumed downtime for repairs, servicing, refuelling and other delays. For operations requiring peak inputs, as for example during land preparation for either cotton or wheat, a double work shift of 8 hours per shift has been allowed for. During the harvesting period of wheat a single 12-hour workshift is planned. Allowances for operational downtime have been put at 45% for tractors and equipment and at 55% for combine harvesters.

Table B3.6 shows the machine units required each month. By applying the number of machine units required by each operation (Table B3.6) to the months in which the various operations are carried out, the total number of units can be established on a month-by-month basis. The peak monthly requirements then indicate the total number of tractors which will be required in the following system. In this case ten units are required in May and June, during the peak land preparation and planting time for cotton, and ten in February when wheat is being harvested and land preparation for cotton commences. Extra equipment for the growing of wheat is limited to one combine harvester one seed drill, two balers and two grain trailers.

Machine picking of cotton is not being proposed at the present time. Assessments of machine picking have been carried out at MAADE during the 1984/85 and 1985/86 seasons. The present cotton variety does not have suitable growth characteristics for machine picking. Loss of the earlier-opening, lower bolls by shedding and rain damage can occur during the time interval required for the higher and later maturing bolls to open. The technique of using defoliants has yet to be perfected and increased growing costs are reported due to the extra cleaning of the seed cotton necessary when machine harvesters are used.

Machinery, equipment and vehicle requirements for the state farm unit are given in Table B3.7. The depreciation periods of five years for powered machinery (tractors etc.) and eight years for non-powered are in line with the standards adopted by MSFD.

Tractor sizes and types have been taken as 140 hp four-wheel drive and 90 hp four-wheel drive to carry out all primary and secondary cultivations, plus operations such as sub-soiling and heavy transport of grain. Four-wheel drive is considered advisable to permit access to the land at all times and provide

TABLE B3.5

State Farm Cotton/Wheat 500 ha Unit - Machinery Units by Operation

Operation	Operational months	Period[1] work days	Work rate h/ha[2]	Machine hour inputs	Hours required per day	Machine hours per day[3]	Machinery units required
Cotton 500 ha							
1. Land preparation	4.25	106	6	3 000	28.3	8.8	3.22
2. Pre-plant cultivate/ridge/sow	2.5	62	3.25	1 625	26.2	8.8	2.97
3. Cultivate/weed	4	100	3.75	1 875	18.8	5.5	3.40
4. Transport	4.75	119	2	1 000	8.4	5.5	1.53
5. Crop residue	3.75	94	2	1 000	10.6	5.5	1.93
Wheat 250 ha							
6. Land preparation/ridge	1.25	31	4	1 000	32.3	8.8	3.67
7. Fertilise/spray	1.5	37	2	500	13.5	5.5	2.45
8. Bale, straw handling	1	25	2	500	20	5.5	3.66
9. Transport	1.5	37	1	250	6.8	5.3	1.24
10. Combine harvest	1	24[4]	0.5	125	5.2	5.4	0.96

Notes:
(1) 25 working days per month.
(2) See crop budgets Appendix B1.
(3) Operations 1, 2 and 6. 2 x 8 hour shifts less 45% downtime; Operation 10, 12 hours per day less 55% downtime; other operations at 10 hours per day and 45% downtime.
(4) 30 days less 6 total, rain days.

TABLE B3.6

State Farm Cotton/Wheat 500 ha Unit - Monthly Machinery Units

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cotton												
Land preparation		3.22	3.22	3.22	3.22	3.22						
Ridge/pre-cultivate/sow				2.97	2.97	2.97						
Cultivate/weed					3.4	3.4	3.4	3.4	3.4			
Transport	1.53								1.53	1.53	1.53	1.53
Residue removal	1.93	1.93							1.93	1.93	1.93	1.93
Wheat												
Land preparation										3.67	3.67	
Fertilise/spray	2.45											2.45
Bale/straw handling		3.66	3.66									
Transport		1.24	1.24								1.24	
Monthly machine units	5.9	10	8.1	6.2	9.6	9.6	3.4	3.4	6.9	7.1	8.4	5.9
Combine harvester units		0.96	0.96									

TABLE B3.7

State Farm Cotton/Wheat 500 ha Unit

Equipment

Item	Depreciation years	Units	Unit Cost (Birr x 000)	Total Cost
Tractors				
140 hp 4WD	5	3	92.5	277.5
90 hp 4WD	5	3	52	156
70 hp 2WD	5	4	36	144
Combine				
110 hp 4.5 m table	5	1	160	160
Machinery				
Sub-soiler	8	1	8	8
Plough 6 disc	8	2	6	12
Plough 4/5 disc	8	2	5	10
Disc harrow offset	8	1	18	18
Disc harrow 22 disc	8	1	10	10
Land leveller	8	1	21	21
Planter, combined fertiliser/ridger	8	1	20	20
Wheat seed drill	8	1	11	11
Ridger 6 row	8	2	7.5	15
Spike tooth harrow	8	1	4.5	4.5
Cultivator rolling	8	4	8.5	34
Sprayer 400 litre	8	1	6.6	6.6
Fertiliser spreader	8	2	22.5	45
Slasher	8	2	8.2	16.4
Ditcher	8	1	3	3
Baler	8	2	34	68
Trailers				
7t grain tipping	8	2	18	36
4 t fixed bed, cotton	8	4	11.6	46.4
Workshops				
Workshop equipment	8	set	-	75
Central workshop equipment attributed	8	-	-	30
Vehicles				
Pick-up 4WD	5	2	37	74
Motorcycles	5	4	5	20
Miscellaneous equipment				
Hand tools	8	600	-	15
Office & Clinic Equipment	8	-	-	30
Total Equipment Cost			Birr	1 366

higher work rates during peak periods. Two power types of four-wheel drive tractors are selected to enable better efficiency in the selection of their use and avoidance of over-powering operations such as drilling, fertiliser spreading and light harrowing.

Two-wheel drive 70 hp tractors are selected for light operations, particularly transportation of labourers, cotton, chemicals, materials, etc.

Machinery, tools and equipment have been selected by size and capacity to suit the above power units.

B3.3 State Farm Unit - Citrus

B3.3.1 Explanation of the System

The size of the unit has been taken as 200 ha and will grow grapefruit and orange. The existing plantations at Awara Melka would be incorporated into a state farm unit, and as productivity of the existing trees declined they would be replaced with new plantings.

Peak production would be reached after approximately 12 years. The productive life of the plantations is anticipated as being 25 years. For crop budgets an average annual yield figure based on 20 years production, together with attributed planting and establishment costs, has been taken.

The state farm citrus unit(s) would not incorporate the production of any field crops, thus allowing the manager, who would be an experienced and qualified horticulturist, to concentrate on fruit production. Some intercropping could be practised while the fruit trees are young, but this is not expected to be significant for the project.

B3.3.2 Development

(a) Labour Requirements

The production of citrus will be labour intensive, labour being required for control of the basin irrigation system, fertiliser application, spraying, weeding, pruning, harvesting, canal and drainage maintenance. Tables B3.8 and B3.9 illustrate the labour input requirements by operation and by month. The peak period is from June to December, when 330 labourers will be required. Should labour availability to the project as a whole be limited, some competition for labour by the cotton state farm units is foreseen from September to December. It will therefore be necessary to establish comparative piece-work rates for both fruit and cotton picking, in order to prevent one enterprise being more financially attractive to the labourers than the other.

(b) Staffing

Permanent staff requirements of the citrus unit are shown in Table B3.10.

As the citrus unit will be part of the state farm, central workshop staff costs have been attributed to the unit's staff costs. The total annual staff costs amount to Birr 166 000.

TABLE B3.8

State Farm Citrus 200 ha Units - Man-days

Ref.	Operation	Months	Work days	Man-days ha[1]	Man-days Unit	Labourers required
Citrus						
1	Irrigation	Jan - Dec	300	84	16 800	56
2	Basin and bund maintenance	Jan - Apr	100	30	6 000	60
3	Fertilise and spray	Jan - Dec	300	26	5 200	18
4	Weed control	Jan - Dec	300	117	23 400	78
5	Prune and desucker	Jan - Mar	75	30	6 000	80
6	Harvest and handling	Jun - Dec	175	82	16 400	94
7	Guarding	Jun - Dec	175	40	8 000	46

Note: (1) From crop budgets averaged for all citrus crops.

TABLE B3.9

State Farm Citrus 200 ha Unit - Monthly Labour

Operation Reference Number	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	56	56	56	56	56	56	56	56	56	56	56	56
2	60	60	60	60								
3	18	18	18	18	18	18	18	18	18	18	18	18
4	78	78	78	78	78	78	78	78	78	78	78	78
5	80	80	80									
6						94	94	94	94	94	94	94
7						46	46	46	46	46	46	46
PM	292	292	292	210	191	331	331	331	331	331	331	331

TABLE B3.10

State Farm Citrus 200 ha Unit - Staffing

	Number	Unit cost Birr (per month)	Cost Birr (per year)
Management			
Plantation Manager	1	900	10 800
Irrigation Controller	1	325	3 900
Horticulturist	1	700	8 400
Field Operators			
Section Foremen	2	210	5 040
Field Foremen	6	110	7 920
Pruning Supervisor	2	130	3 120
Tractor Operators	2	130	3 120
Packaging			
Packing & Despatch Supervisor	1	270	3 240
Despatch Clerk	1	240	2 880
Data Collection/Recorder	1	350	4 200
Administration			
Manager	1	600	7 200
Accountant - Senior	1	500	6 000
Records Clerk	1	300	3 600
Wages Clerk	1	240	2 880
Personnel Supervisor	1	300	3 600
Labour Records Clerk	1	240	2 880
Stores Clerk	3	200	7 200
Typist	1	230	2 760
Health Assistant	1	280	3 360
Drivers	2	150	3 600
Messengers	2	100	2 400
Guards	10	85	10 200
Field/Irrigation Workers	30	70	25 200
Technical			
Workshops Foreman	1	500	6 000
Mechanic	1	315	3 780
Mechanics' Assistants	2	100	2 400
Building Maintenance Artisans	2	175	4 200
Central Workshop Attributed Costs			16 280
Annual Staff Cost			Birr 166 160

(c) Machinery and Equipment

Machinery requirements are limited to those required for land preparation for newly planted areas and the maintenance of those areas under establishment and production. These have been illustrated in Tables B3.11 and B3.12 as for an established plantation where a proportionate area (1/25th) of the plantation is being replanted every year. With a requirement of only two tractor units the average annual operational hours for each will be less than 700 hours; therefore depreciation has been put at ten years. Machinery and equipment required by the unit is given in Table B3.13.

B3.4 State Farm Unit - Tobacco Production

B3.4.1 Explanation of the System

The tobacco production units will be separately managed units within the state farm in the same manner as the citrus and cotton/wheat units. The size of the units will vary from around 400 ha to 900 ha; for analysis purposes the unit size has been taken as being 600 ha. Of the total unit area, 50% would be used for the growing of tobacco in any one year.

In order to sustain consistent production levels over a long period of years and to minimise the risks of pests and disease incidence within the tobacco it is recommended that a rotation of different crops be practised. Further, in order to utilise the capital investment in curing barns, it is proposed that tobacco be grown on a continuous basis throughout the year. This will also assist management by ensuring a system whereby a constant area can be planted and harvested every week or month, and by ensuring a steady level of staff and labour requirements throughout the year.

A major problem facing the continuous growing of tobacco is the build-up of root-knot nematode (Meloidogyne spp.) infestation. Some control is possible with furrow irrigation as the anaerobic conditions caused from time to time by irrigation will not permit the nematodes to survive. However, complete control cannot be expected as the irrigation water is not flooding the soils for a prolonged period and the ridges between the furrows are not flooded. These areas of soil can provide a harbour for surviving nematodes. On-going control to prevent nematode infestation can be achieved by a combination of some or all of the following procedures: the use of soil fumigant, introduction of break crops between the tobacco, use of resistant varieties and field hygiene. For the state farm units where substantial areas of tobacco are to be grown over a period of many years and on the same lands within the vicinity of the curing barns and grading sheds, precautions must be taken to prevent the interruption or decline of production. For this reason, soil fumigants have been included in the crop budgets and a double break crop designed for the crop calendar, Figure B.2.

To produce 300 ha of tobacco per annum on a continuous basis, 25 ha would be planted (and harvested) each month. For tobacco planted between January and June a different cropping sequence would be required from that used with tobacco planted between July and December, owing to the variable seasonal conditions prevailing when the break crops are to be grown.

TABLE B3.11

State Farm - Citrus 200 ha Unit - Machinery Units

Operation	Operational months	Work days	Work rate h/ha	Machine hour inputs	Hours required per day	Machine hours per day	Machinery units required
Planting out 8 ha							
Land preparation	2	50	8	64	1.3	4.4	0.30
Level bunding	1	25	2	16	0.6	4.4	0.14
Slashing	2	50	2	16	0.3	4.4	0.07
Transport	1	25	5	40	1.6	4.4	0.36
Establishment 24 ha							
Spraying	12	300	2	48	0.16	4.4	0.04
Slashing	12	300	2	48	0.16	4.4	0.04
Transport	12	300	2	48	0.16	4.4	0.04
Production 168 ha							
Spraying	12	300	2	336	1.12	4.4	0.25
Slashing	12	300	2	336	1.12	4.4	0.25
Transport	7	175	2	336	1.92	4.4	0.44

TABLE B3.12

State Farm Citrus 200 ha Unit - Monthly Machinery Units

Operation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Planting Out 8 ha												
Land preparation					0.30	0.30						
Level and bunding						0.14						
Slashing				0.07						0.07		
Transport						0.36						
Establishment 24 ha												
Spraying	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Slashing	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Transport	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Production 168 ha												
Spraying	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Slashing	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Transport						0.44	0.44	0.44	0.44	0.44	0.44	0.44
Monthly machine units	0.62	0.62	0.62	0.69	0.92	1.86	1.06	1.06	1.06	1.06	1.06	1.06

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TABLE B3.13

State Farm Citrus 200 ha Unit

Equipment Costs

Item	Depreciation years	Units	Unit Cost (Birr)	Total Cost (Birr)
Tractor 2 WD 70 hp	5	2	30 000	60 000
Ditcher	8	1	3 000	3 000
Disc plough 3/4 disc	8	1	4 000	4 000
Disc harrow tandem	8	1	10 000	10 000
Sub-soiler	8	1	8 000	8 000
Land leveller	8	1	21 000	21 000
Slasher	8	1	8 000	8 000
Sprayer	8	1	6 600	6 600
Trailer 7 t sprung	8	2	15 800	31 600
Trailer 4 t	8	2	6 300	12 600
Motor Knapsack Sprayers	5	4	800	3 200
Hand Tools	8	1 000		25 000
Workshop Equipment	8			30 000
Office and Health Clinic	8			30 000
Pick-up trucks 4 WD	5	2	37 000	74 000
Motorcycles	5	3	5 000	15 000
TOTAL EQUIPMENT COST				Birr 342 000

Therefore, two crop sequences are required to run concurrently (Figure B2):

System A - Crop Sequence: Tobacco - Wheat - Cotton

Tobacco planted between January and June would extend to 150 ha. All tobacco planted during this period would be picked, and crop residue cleared, by mid-October. The tobacco would then be followed by wheat planted in November and harvested the following February. Wheat would then be followed by cotton planted between late-April and the end of May. The earliest planted 25 ha of cotton will have been picked and cleared ready for land preparation and planting to tobacco in January. This would complete a three-crop sequence in a two-year cycle.

System B - Crop Sequence: Tobacco - Cotton - Maize

Tobacco planted between July and December would also extend to 150 ha. This would be picked between November and April, the earlier picked tobacco being followed by early planted cotton in late April and early May. The last planted and picked tobacco would be followed by cotton at the end of May. The cotton would be harvested and cleared between October and December, the first cleared cotton being planted to maize in December and the December-cleared cotton planted to maize in January. The maize crop would be harvested and cleared by the end of May followed by land preparation for the next tobacco planting sequence which would commence in July, thus completing the cycle.

To avoid breaks in tobacco production, both systems are split into equal areas, providing an alternate cropping pattern each year (see also Annex L).

A total cropping area of 900 ha from a 600 ha land area provides a cropping intensity of 150%.

The state farm tobacco unit will comprise two main enterprises, tobacco production and the growing of other crops as break crops. Tobacco production consists of a number of separate activities such as nursery management, field culture, curing and conditioning, and grading and packing.

The entire state farm unit would be managed by a single farm manager, the two main operations, tobacco and other crops, being separately run and supervised by senior foremen or section managers. Tobacco production would take priority within the state farm unit operations, whilst the growing of other crops would be regarded as taking a supportive role only. Avoidance of delays and interruptions to the monthly programme of tobacco activities would, if necessary, take preference over the activities of other crops.

B3.4.2 Development

(a) Labour Requirements

Man-day inputs by each crop and operation are given in Table B3.14. The labour required each month for each crop and for the unit is shown in Table B3.15. Labour for tobacco growing and production remains constant at 260 labourers per month. Peak labour months for the entire unit are from August to December, when approximately 600 to 750 labourers are required, this being primarily caused by cotton picking.

TABLE B3.14

State Farm Tobacco Production - 600 ha Unit - Man-days

Ref.	Crop/operation	Months		Days[1]	Man-days ha[2]	Man-days unit	Labour required
Tobacco 25 ha x 12 m							
1.	Nursery	continuous		300	20	6 000	320
2.	Land preparation	continuous		300	30	9 000	30
3.	Transplant gap fill	continuous		300			
4.	Irrigation	continuous		300	60	18 000	60
5.	Fertilise/spray	continuous		300	8	2 400	8
6.	Weed	continuous		300	16	4 800	16
7.	Top and desucker	continuous		300	4	1 200	4
8.	Leaf picking	continuous		300	40	12 000	40
9.	Cure, grade, pack	continuous		300	62	18 600	62
10.	Guard and other	continuous		300	20	6 000	20
Cotton 300 ha							
11.	Maintenance	Apr -	Jan	225	25	7 500	34
12.	Thin, gap fill	May -	Jul	55	5	1 500	28
13.	Weed	Jun -	Sep	100	53	15 900	159
14.	Irrigate[3]	Apr -	Nov	200	40	12 000	60
15	Picking	Aug -	Dec	110	75	22 500	205
16.	Handling	Sep -	Jan	125	5	1 500	12
17.	Cut and burn	Sep -	Feb	150	12	3 600	24
Wheat 150 ha							
18.	Sow	Nov		15	2	300	20
19.	Irrigate[3]	Nov -	Feb	80	13	1 950	25
20.	Weed	Dec -	Jan	50	26	3 900	78
21.	Handling	Feb -	Mar	38	4	600	16
Maize 150 ha							
22.	Land preparation/sow	Dec -	Jan	50	9	1 350	27
23.	Weed/irrigate	Dec -	May	150	20	3 000	20
24.	Harvest/shell	Apr -	May	50	36	5 400	108

Notes: (1) 25 work days per month.
(2) From crop budgets Annex I.
(3) Includes Pre-Irrigation.

FIGURE B2

State Farm Tobacco Unit
Continuous Tobacco Production and Two Break Crops
Crop Sequences over 2 Year Rotations

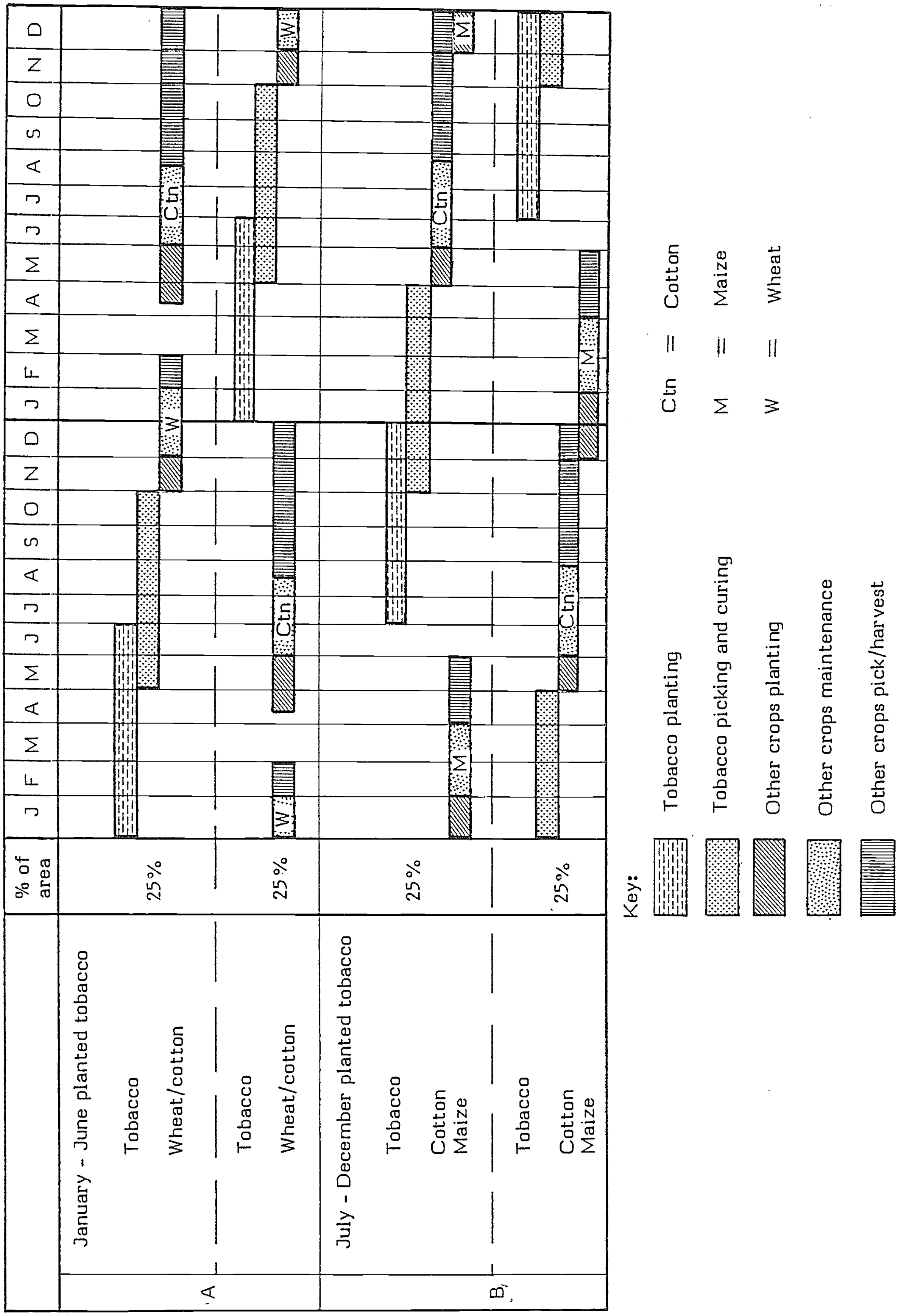

TABLE B3.15

State Farm Tobacco Production 600 ha Unit

Monthly Labour

Crop and Operation Ref Nr (1)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tobacco												
1	20											
2)												
3)	30											
4	60											
5	8				constant all months							
6	16											
7	4											
8	40											
9	62											
10	20											
	260	260	260	260	260	260	260	260	260	260	260	260
Cotton												
11	34			34	34	34	34	34	34	34	34	34
12					28	28	28					
13						159	159	159	159			
14				60	60	60	60	60	60	60	60	
15								205	205	205	205	205
16	12								12	12	12	12
17	24	24							24	24	24	24
	70	24	-	94	122	281	281	458	494	335	335	275
Wheat												
18											20	
19	25	25									25	25
20	78											78
21		16	16									
	103	41	16	-	-	-	-	-	-	-	45	103
Maize												
22	27											27
23	20	20	20	20	20							20
24				108	108							
	47	20	20	128	128							47
Total Labourers	480	345	296	482	510	541	541	718	754	595	595	685

Note: (1) from Table B3.14

(b) Staffing

Table B3.16 illustrates permanent staffing requirements by positions and numbers. The annual staff costs amount to Birr 235 000 and are the highest of the three state farm systems proposed.

(c) Machinery and Equipment

Table B3.17 indicates the number of machine units required by crop and operation. As with the machinery unit requirements for the cotton/wheat unit, land preparation operations for cotton have been based on two 8-hour work shifts with an allowance of 45% downtime for repairs and maintenance, and for combining of wheat a single 12-hour work shift has been taken with a 55% downtime allowance.

The machine units required each month are given in Table B3.18. The number of units required for the 300 ha of tobacco production is four, and a further eight units are required for the mechanised operations for the other crops.

Plant and equipment requirements and costs are shown in Table B3.19. Tractors required for the tobacco operations will each average 1 350 hours annually whilst other crops will demand an average of 965 hours annually.

At Year 10, or when dried leaf production averages 1.4 t/ha, 26 curing barns with a 2 t green leaf capacity on a six day throughput cycle, will be required. Operation will be continuous throughout the year. A 15% non-operative time has been allowed for repairs and maintenance. An average annual output of 16.5 t of dried leaf per barn is expected, providing a total production capacity of 429 t.

B3.5 Settlement Farms

B3.5.1 Explanation of the System

A single settlement farm is proposed for the KIP which would be divided into settlement farm units of about 500 ha each. The principal activity of settlement farm units would be the provision of grazing for Afar livestock displaced by the project. This would be achieved by the establishment of irrigated pastures which would substitute the grazing that will be lost by development of the project area. Further feed would be available by the provision of forage from crop residues, such as wheat straw from the state farms within the project.

It would be an objective of the project to introduce sedentary farming systems to the settlers. This would be done within the settlement farm units, areas of the irrigated pasture being converted for food and cash crop production. Such areas are to be increased at a rate to meet the demands of the settlers as and when farming is adopted by them. As there is no tradition of arable farming amongst the transhumant population of the Awash Valley, it is not possible to forecast the rate of acceptance any innovation. However, there are indications that a proportion of the Afars have, and are prepared to take up, simple forms of culture for the production of food crops.

TABLE B3.16

State Farm Tobacco Production 600 ha Unit - Staffing

	Nr	Unit cost (Birr per month)	Cost (Birr per year)
Management			
Farm Manager	1	750	9 000
Pest Control	1	325	3 900
Tobacco Production Unit Manager	1	600	7 200
Field Operations Manager (other crops)	1	600	7 200
Irrigation Controller - Tobacco	1	325	3 900
Irrigation Controller - other crops	1	325	3 900
Foreman - Tobacco	1	270	3 240
Foreman - other crops	1	270	3 240
Section Foremen	8	110	10 560
Tractor Operators	12	130	18 720
Technical			
Workshops Manager	1	600	7 200
Mechanics	2	315	7 560
Assistant Mechanics	2	100	2 400
Building Maintenance Artisans	4	175	8 400
Administration			
Manager	1	600	7 200
Personnel	1	300	3 600
Accountant (Senior)	1	500	6 000
Accountant (Junior)	2	400	9 400
Clerks - Labour	2	240	5 760
Clerks - Wages	2	240	5 760
Clerks - Stores	3	200	7 200
Clerk - Management Records	1	240	2 880
Clerks - Production Records	2	200	4 800
Clerk - Fuel	1	200	2 400
Health Assistant	1	280	3 360
Drivers	3	150	5 400
Typists	2	230	5 520
Messengers	2	100	2 400
Field, Irrigation Workers (Tobacco)	20	70	16 800
Field, Irrigation Works (other crops)	20	70	16 800
Guards - Stores, etc.	20	70	16 800
Sub-total			218 500
Central Workshops Attributed Costs			16 280
Total			234 780

TABLE B3.17

State Farm Tobacco Production 600 ha Unit - Machinery Units

Crop operation	Operational months	Period[(1)] days	Work rate h/ha[(2)]	Machine hour inputs	Hours required per day	Machine hours per day[(3)]	Machine units required
Tobacco 300 ha							
Land preparation	12	300	10	3 000	10	5.5	1.82
Cultivate/weed	12	300	1	300	1	5.5	0.18
Canal maintenance	12	300	1	300	1	5.5	0.18
Transport	12	300	6	1 800	6	5.5	1.09
Cotton 300 ha							
Land preparation	2	50	6	1 800	36	8.8	4.09
Pre-plant cultivate/ridge/sow	1.5	38	3.25	975	25.7	8.8	2.92
Cultivate/weed	4	100	3.75	1 125	11.3	5.5	2.05
Transport	4	100	2	600	6	5.5	1.09
Crop residue	2.5	62	2	600	9.7	5.5	1.76
Wheat 150 ha							
Land preparation/ridge	2.5	63	4	600	19.5	5.5	1.73
Fertilise/spray	1.5	38	2	300	7.9	5.5	1.44
Bale/straw handling	1.5	38	2	300	7.9	5.5	1.44
Transport	1.5	38	1	150	3.9	5.5	0.71
Combine harvest	0.5	15	0.5	75	5	5.4[(4)]	0.93
Maize 150 ha							
Land preparation	2	50	3	450	9	5.5	1.64
Ridge/plant	2	50	1	150	3	5.5	0.55
Cultivate/weed	2	50	1	150	3	5.5	0.55
Spray	2	50	0.5	75	1.5	5.5	0.27
Harvest/transport	1.5	38	2.5	375	9.87	5.5	1.79

Notes:
(1) 25 work days per month.
(2) From crop budgets Appendix B1.
(3) For cotton land preparation 2 x 8 hour shifts. All shifts less 45% downtime.
(4) Combine 12 hours per day less 55% downtime.

TABLE B3.18

State Farm Tobacco Production 600 ha Unit - Monthly Machinery Units

Crop operation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tobacco 300 ha												
Land preparation	1.82											
Cultivate/weed	0.18	Constant										
Canal maintenance	0.18											
Transport	1.09											
All months	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27
Cotton 300 ha												
Land preparation			4.09	4.09								
Pre-plant cultivate/ridge				2.92	2.92							
Cultivate/weed						2.05	2.05	2.05	2.05			
Transport									1.09	1.09	1.09	1.09
Crop residue										1.76	1.76	1.76
Wheat 150 ha												
Land preparation									1.73	1.73	1.73	
Fertilise/spray												1.44
Bale/straw handling		1.44	1.44									
Transport		0.71	0.71									
Combine harvest		0.93										
Maize 150 ha												
Land preparation											1.64	1.64
Ridge/plant	0.55											0.55
Cultivate/weed		0.55	0.55									
Spray		0.27	0.27									
Harvest/transport				1.79	1.79							
Monthly machine units	3.8	6.2	10.3	12.1	7.9	5.3	5.3	5.3	8.1	7.9	9.5	9.8
Combine harvester		0.93										

TABLE B3.19

State Farm Equipment - Tobacco Production 600 ha Unit

Item	Depreciate years	Units	Unit cost (Birr X000)	Total cost (Birr X000)
Tractors				
140 HP 4WD	5	2	92.5	185
90 HP 4WD	5	2	53	106
70 HP 2WD	5	8	36	288
Equipment				
Sub-soiler	8	1	8	8
Disc plough 6 disc	8	2	6	12
Disc plough 4/5 disc	8	2	5	10
Disc harrow offset		1	18	18
Disc harrow 22/24 disc	8	2	10	20
Land leveller	8	1	21	21
Ditcher	8	2	3	6
Ridger 6 row	8	2	7.5	15
Disc ridger 2 row	8	1	6	6
Planter 4 row	8	1	8	8
Planter 6 row combined ridger and fertiliser application	8	1	20	20
Spring tine harrow	8	1	12	10
Spike tooth harrow	8	1	4.5	4.5
Cultivator rolling tine	8	4	8.5	34
Sprayer 400 litre	8	1	6.6	6.6
Fertiliser spreader	8	1	22.5	22.5
Slasher	8	2	8.2	16.4
Combine harvester 4.5 m table	5	1	160	160
Baler	8	1	34	34
Trailer 7 t tipping	8	2	18	36
Trailer 3.5 t fix bed	8	5	11.6	58
Maize sheller	8	1	7.2	7.2
Miscellaneous equipment				
Soil injector guns	8	20	0.25	5
Hand tools	8	1 000	-	25
Vehicles				
Pick-up trucks 4WD	5	3	37	111
Motorcycles	5	5	5	25
Workshop and office				
Office and clinic equipment	8	-	-	30
Workshop equipment	8	set	-	75
Central workshop attributed cost	8	-	-	30
Tobacco barns	25	26	30	780
Total cost				2 193.2

It is the view of the Consultant that a gradual approach to the introduction of arable farming to the Afar would be preferable to an intensive approach aided by intensive capital investment in machinery and equipment. For this reason mechanised farming techniques are seen as being inappropriate for use within the settlement farms. All field operations would be carried out by hand in the initial years. The introduction of animal power would be attempted on the settlement farms, in order to assist the settlers in the demanding tasks of land preparation and cultivation. As a consequence of this, a larger area would be brought under cultivation and production.

The development of the arable areas would be in blocks or fields varying in size from 5 to 15 ha, individual settler families farming their own allocated plots of 0.5 to 0.75 ha within these blocks. Communal work in tasks such as land preparation and harvesting is already demonstrated by those Afar who grow crops. It is envisaged that these practices would continue within the settlement farm units.

The grouping of arable farmers and their land is also essential for irrigation water control and for the effectiveness of extension services.

The development of the settlement farm would be in three main phases:

(i) Establishment of irrigated pastures.

(ii) Introduction of small scale arable farming using labour only.

(iii) Introduction of draught animals and an increase in the arable farming areas.

B3.5.2 Development

The growing of food crops for consumption will be the primary interest of the Afar settlers. Production surplus to their requirements is likely to be bartered for other commodities or sold for cash locally. The growing of cash crops such as cotton or tobacco is unlikely to be of interest to the Afar within the foreseeable future.

(a) Cropping Calendars

The crop calendars for both labour only and draft animal systems are very similar. Figure B.3 illustrates the growing of three different crops during the rainy season, groundnuts, cowpea and sesame, and three crops during the cool season, wheat, cowpea and sesame.

Under the direction of the settlement farm units extension service the settlers would be instructed on crop husbandry techniques using small plots of land from 1 000 and 2 000 m^2 for individual crops, or on simple intercropping systems as has been demonstrated by the Afar farmers and MWRC at Galisita.

(b) Labour Inputs

For settler farmers using labour only the area of land brought under cultivation will be limited by the amount of family labour available. It is anticipated that at least half of the family labour will be used in the herding and tending of livestock. It is anticipated that only one labour unit would be available for cropping activities at any given time. It has been demonstrated by the Afar that more family labour does participate at periods of peak demand during land preparation and harvesting. Tables B3.20 and B3.21 give the estimated monthly man-days required for all of the four crops. On the assumption that only 24 man-days of family labour are available per month on a regular basis, the proposed system shows that there are only two months when this is exceeded. One labour unit is required for ten months and two labour units for two months of the year on a cultivated area of 0.5 ha. With double cropping being possible (200% cropping intensity) a total area of one hectare of crops could be grown by an average Afar family.

Labour requirements on settlement areas using ox-cultivation are substantially lower, as is shown in Table B3.22. The cropping areas can therefore be increased by 50% and family labour requirements maintained at one per month for eight months of the year with two required for parts of the months of May, June, October and November. In the proposed system 0.75 ha per settler family could be double cropped when using animal power. (See Table B3.23.)

(c) Ox and Equipment Requirements

Ox-unit input requirements for 0.75 ha by crop and operation are given in Table B3.24, and the number of ox-units required by month in Table B3.25, one pair of oxen being required for each 0.75 ha when double cropped under irrigated conditions. It should be noted that if 25% of the land preparation operations were brought forward and carried out in April instead of May, two pairs of oxen would be sufficient for three settler farmers, or 2.25 ha.

(d) Staff and Labour

Hiring of labour by the settlers is not feasible as credit required for their payment would not be recoverable when only food crops are being grown. Therefore, systems involving family labour only are proposed.

The settlement farm units will require a permanent staff in order to maintain the irrigation system, manage the pastures and operate an extension service and ox-training school. Table B3.26 illustrates the staff requirements. The total annual staff costs for a 500 ha unit are estimated at Birr 135 000 including central settlement farm office overheads.

(e) Equipment

Land clearing, levelling and initial land opening will be carried out as part of the project development programme. The preparation of land and the establishment of irrigated pastures and their maintenance, together with the maintenance of canals and drains will be done by the management of the settlement farm units. For these operations machinery and equipment are required and are listed in Table B3.27. The total cost of equipment for the 500 ha unit will amount to Birr 369 000. No allowance has been made for equipment used in cultivation of crops as this will be done by labourers and draught animals.

FIGURE B3

Crop Calendar - Settlement Farm

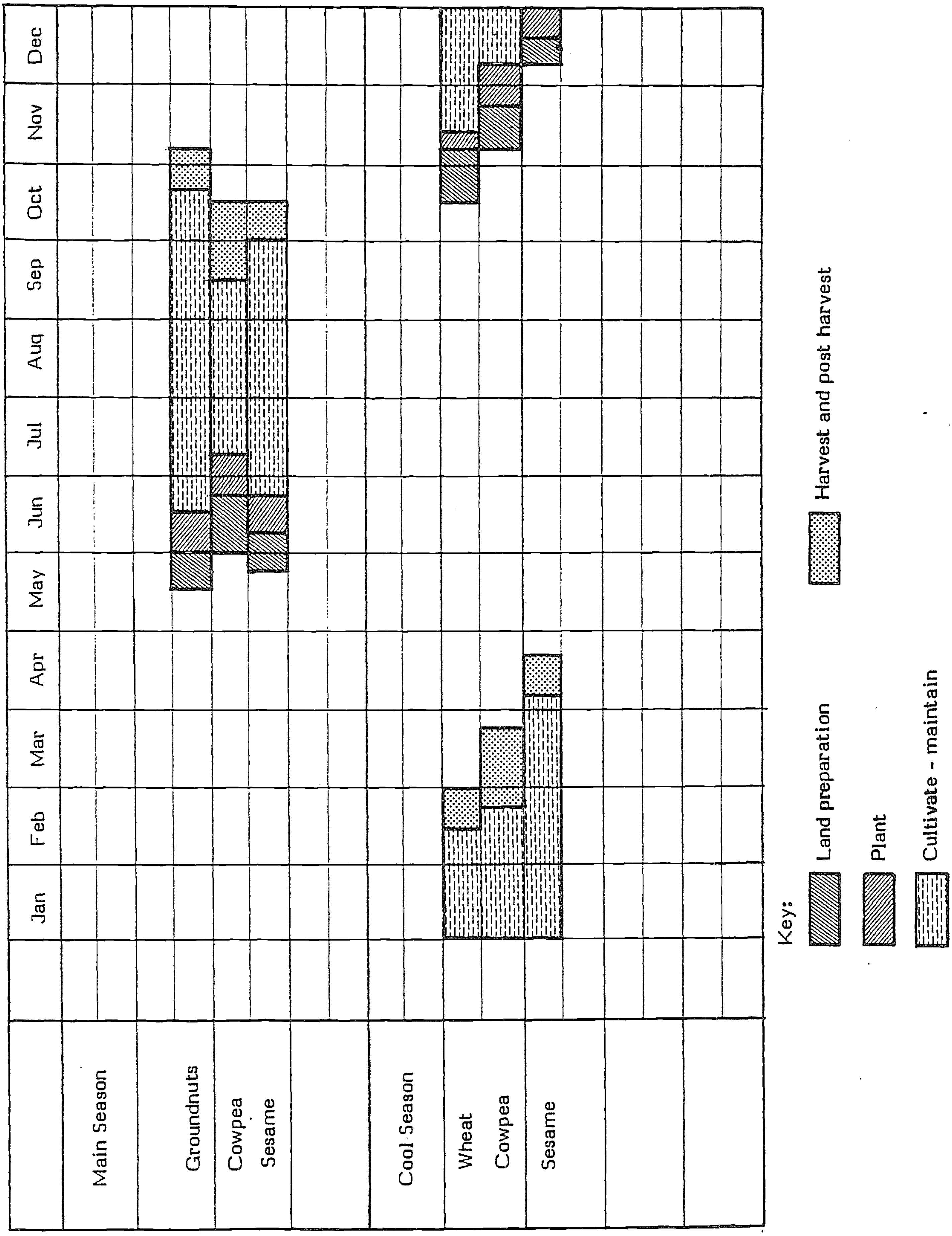

TABLE B3.20

Settlement Farm Labour Only - Crop/Operation Man-days for 1 ha

Crop	Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Groundnuts	Main												
Canal maintenance					4								
Land preparation/sow						24	24						
Ridge/irrigate						35	35	17	17	17	4		
Weed/spray								11	11	11			
Lift/shell											25	30	
					4	59	59	28	28	28	29	30	
Cowpea	Main and cool												
Land preparation/sow							38	6				24	20
Ridge/irrigate		10	10				80	20	15	5		50	50
Weed		8						8	8				8
Harvest			13	14						13	14		
		18	23	14	-	-	118	34	23	18	14	74	78
Sesame	Main and cool												
Land preparation/sow						22	22						44
Bunding							12						12
Thin/gap/weed		16	10	10				16	10	10			
Irrigate		4	4	4			2	4	4	4			2
Harvest					20						20		
		20	14	14	20	22	36	20	14	14	20		58
Wheat	Cool												
Land preparation/sow		-	-								50		
Ridge/irrigate		4	4									79	4
Weed		5											9
Harvest/thresh			20	15									
		9	24	15							50	79	13

TABLE B3.21

Settlement Farm Labour Only - Monthly Man-Days for 0.5 ha

Crop	Season	Per cent of area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Groundnuts	Main	20				0.4	5.9	5.9	2.8	2.8	2.8	2.9	3.0	-
Cowpea	Main	40						23.6	6.8	4.6	3.6	2.8	-	-
	Cool	40	3.6	4.6	2.8								14.8	15.6
Sesame	Main	40					4.4	7.2	4.0	2.8	2.8	4.0	-	-
	Cool	20	2.0	1.4	1.4	2.0							-	5.8
Wheat	Cool	40	1.8	4.8	3.0							10.0	15.8	2.6
Total man-days - rounded up			8	11	8	3	11	37	14	11	9	20	34	24

TABLE B3.22

Settlement Farm Ox Cultivation - Crop/Operation Man-days for 1 ha

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Groundnuts (Main Season)													
Bund maintenance				4									4
Land preparation/sow					9	10							19
Ridge/irrigate					3	4	4	4	4	3			22
Weed/spray							10	5	5	2			22
Lift and shell										30	33		63
Total				4	12	14	14	9	9	35	33		130
Cowpea (Main and 2nd)													
Land preparation/sow						15					15		30
Ridge/irrigate	4	3				5	3	3	2		2	4	26
Weed	1						1	1				1	4
Harvest			22						11	11			44
Total	5	3	22			20	4	4	13	11	17	5	104
Sesame (Main and 2nd)													
Land preparation/sow					7	7						14	28
Bund preparation						5						5	10
Thin/gap weed	10	5					10	5					30
Irrigate	4	4	4			2	4	4	4			2	28
Harvest				10						10			20
Total	14	9	4	10	7	14	14	9	4	10		21	116
Wheat (Cool season)													
Land preparation/sow										10	6		16
Irrigate/weed	5	2									2	5	14
Harvest		10											10
Thresh			10										10
Total	5	12	10							10	8	5	50

TABLE B3.23

Settlement Farm Ox Cultivation Labour Double Cropping 0.75 ha - Monthly Labour

Crop[1]	Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Man-days											
Manual Operations													
Groundnuts	Main	-	-	-	1.0	3.0	3.5	3.5	2.25	2.25	8.75	8.25	-
Cowpea	Main and cool	1.25	0.75	5.5	-	-	5.0	1.0	1.0	3.25	2.75	4.25	1.25
Sesame	Main and cool	3.5	2.25	1.0	2.5	1.75	3.5	3.5	2.25	1.0	2.5	-	5.25
Wheat	Cool	1.25	3.0	2.5	-	-	-	-	-	-	2.5	2.0	1.25
Total		6	6	9	4	5	12	8	6	7	17	15	8
Ox Operations[2]													
All crops		4	6	2	4	21	16	4	4	3	14	16	16
Total monthly man-days		10	12	11	8	26	28	12	10	10	31	31	24
Family labour required per month		1	1	1	1	2	2	1	1	1	2	2	1

Note: (1) Cropping area, 0.25 ha per crop per season.

(2) Ox operation excludes animal care, such as feeding, watering, guarding, etc. This is undertaken with livestock herding activities.

TABLE B3.24

Settlement Farm Ox Cultivation Double Cropping 0.75 ha - Ox Units

	Season	Cultivated area ha per ha per annum	Annual months	Operational work days[1]	Ox hours per unit of area[2]	Ox hour inputs per day Required	Ox hour inputs per day Available[3]	Ox units
Groundnuts	Main	0.25						
Land preparation			0.5	12	18.75	1.6	5	0.32
Level and ridge			0.5	12	7.5	0.63	5	0.13
Cultivate			3.0	75	7.5	0.1	6	0.02
Transport			0.8	20	5.0	0.25	7	0.04
Cowpea	Main and cool	0.5						
Land preparation			1.0	25	37.5	1.5	5	0.30
Level and ridge			1.0	25	15.0	0.6	5	0.12
Cultivate			4.0	100	3.0	0.75	6	0.13
Harvest transport			2.0	50	25.0	0.5	7	0.07
Sesame	Main and cool	0.5						
Land preparation			0.75	19	37.5	1.98	5	0.40
Level			0.75	19	7.5	0.4	5	0.08
Weed			5.0	125	10.0	0.08	6	0.01
Harvest transport			1.0	25	25.0	1.0	7	0.14
Wheat	Cool	0.25						
Land preparation			0.5	12	18.75	1.56	5	0.31
Level and ridge			0.5	12	7.5	0.63	5	0.17
Cultivate			2.0	50	5.0	0.1	6	0.02
Thresh and transport			0.5	12	12.5	1.04	7	0.15

Notes:
(1) Taken as 25 work days per month.
(2) From crop budgets Appendix B1.
(3) Work capacity. For land preparation, level and ridging, 6 hours per day; weeding 7 hours per day less 15% turn round and rest time - figures rounded.

TABLE B3.25

Settlement Farm - Ox Cultivation Double Cropping 0.75 ha - Monthly Ox Units

Crop	Season	Hectares per annum	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Groundnuts	Main	0.25												
Land preparation							0.32							
Level ridge								0.13						
Cultivate									0.02	0.02	0.02			
Transport												0.04	0.04	
Cowpea	Main/cool	0.5												
Land preparation								0.30					0.30	
Level ridge								0.12					0.12	
Cultivate			0.13						0.13	0.13				0.13
Transport and threshing				0.07	0.07						0.07	0.07		
Sesame	Main/cool	0.5												
Land preparation							0.40							0.40
Level								0.08						0.08
Weed			0.01	0.01					0.01	0.01				
Harvest transport						0.14						0.14		
Wheat	Cool	0.25												
Land preparation												0.31		
Level ridge													0.17	
Cultivate			0.02											0.02
Transport and threshing				0.15										
Total			0.16	0.23	0.07	0.14	0.72	0.63	0.16	0.16	0.09	0.56	0.63	0.63

Note: 1 pair oxen will cover peak periods.

TABLE B3.26

Settlement Farm 500 ha Unit - Staffing

	Number	Unit cost per month (Birr)	Total cost per annum (Birr)
Management			
Farm Manager	1	750	9 000
Afar Liaison Officer	1	300	3 600
Irrigation Supervisor	1	325	3 900
Extension and Training			
Extension Supervisor - Arable	1	325	3 900
Livestock Specialist	1	500	6 000
Extension Field Assistants	4	150	7 200
Livestock Field Assistants	2	150	3 600
Ox Cultivation - Instructor	1	325	3 900
Ox Training Assistants	2	150	3 600
Administration			
Administrator	1	600	7 200
Management Records Clerk	1	300	3 600
Wages Clerk	1	240	2 880
Stores Clerk	1	200	2 400
Drivers	2	150	3 600
Typist	1	230	5 520
Messenger	1	110	1 320
Afar Translators	4	70	3 360
Permanent Labourers	20	70	16 800
Guards	6	85	6 120
Tractor Drivers	2	130	3 120
Mechanic	1	235	2 820
Health Assistant	1	280	3 360
Sub-total			106 800
Overheads for central settlement farm office		25%	26 700
Total Staffing Costs		Birr	133 500

TABLE B3.27

Settlement Farm - 500 ha Unit

Equipment

	Nr	Unit cost (Birr)	Total cost (Birr)
Vehicles			
Pick-up trucks 4WD	2	37 000	74 000
Motorcycles	9	5 000	45 000
Farm Equipment			
Tractor 80 hp	2	48 000	96 000
Sub-soiler	1	8 000	8 000
Disc plough (3/4 disc)	2	4 000	8 000
Disc harrow (tandem)	2	10 000	20 000
Ridger	1	3 700	3 700
Ditcher	1	3 000	3 000
Spike tooth harrow	1	4 500	4 500
Fertiliser spreader	1	20 500	20 500
Mower spring disc	1	8 000	8 000
Trailer 4 t	2	11 600	23 200
Office & Health Clinic Equipment			30 000
Workshop Equipment			25 000
Total Equipment Cost			Birr 368 900

CHAPTER B4

EXTENSION, TRAINING AND RESEARCH

B4.1 Extension Within the Settlement Farms

It will not be possible to introduce arable farming to the Afar to any significant extent without the use of an extension service. Similarly, the Afar will require guidance in the effective use of the irrigated pasture in order to prevent over-grazing and excessive loss of forage by trampling. A degree of pasture management by simple grazing control will prolong the life and therefore reduce the cost of the pastures.

An extension section will be required within the management unit of the state farm with each settlement farm unit having its own permanent extension field officers. The day-to-day management and work programmes of the extension section will be the direct responsibility of the farm management. However, the technical direction, instruction and in-service training of the settlement farm extension section will be the responsibility of the Research and Extension Zonal organisations being developed by the IAR and MOA.

At field level within the settlement farm unit, extension work would be divided between livestock and arable, the livestock activities being associated with animal health and feeding. The arable farming programme would initially concentrate on the introduction of different food crops, simple irrigation and cultural methods. Settler farmers would be encouraged to form farming groups cultivating their own areas of land within a single block and jointly assisting each other in the various operations, such as land preparation, weeding and harvesting, etc., these groups being supervised and instructed as a whole by the settlement extension workers. Farmer groups would be able to select their own group leaders within a relatively short period of two to three years. As the groups grew in number and membership, the field extension workers would work directly with the group leaders, providing them with a fortnightly programme of instruction and demonstration. The group leaders would themselves then direct the activities of their own group members.

B4.2 Training

Mechanisation within the settlement farms is not proposed, with the exception of land levelling, initial land preparation and pasture establishment/maintenance. As mechanisation will be inappropriate for the very small scale of arable farming envisaged in the early years of development, it will be necessary to introduce animal power as quickly as possible in order to assist farmers in land preparation and cultivation. Each of the settlement farm units will run an ox-training school. This will train oxen and teach settlers how to plough and cultivate with oxen. Due to the Afar's traditions of cattle ownership, it is envisaged that draught animals will be the property of the individual family. The provision of ox-drawn equipment will be the responsibility of the settlement farm management unit and could be provided as a grant, or on credit, either to the farmer groups or individual farmers.

Training will not be restricted to farmers. Training, especially in-service training, will be necessary for all supervisory and management staff of both settlement and state farms. It will be of importance for the overall success of the project that a training component be incorporated into the project implementation programme. For this purpose it is proposed that a Training Needs Assessment Study is carried out during the first year of the project. This study would assess the requirements and types of training and instruction required at all staff levels. It would propose training programmes to be carried out during the following years of the project. The objectives of in-service training would be to keep all technical and management staff up to date with the developments of innovations and techniques in order to obtain increased levels of efficiency and improved productivity.

B4.3 Research

Research work, such as farm verification trials and adaptive field trials, will be required on both state and settlement farms. This work should be carried out under the direction of the IAR, and control of Melka Warer Research Centre, in close co-operation with the farm management. The Farming Systems Research Unit of the IAR will play an important role in the settlement farms in the identification of problems being faced by the farmers. A permanent research/extension/ management liaison supervisor would be required on the settlement farm to monitor the farming activities of the farmers, identify the constraints and bottlenecks which arise and propose means of overcoming such problems by the application of extension, management and research.

An autonomous or semi-autonomous organisation carrying out research activities on the project farms will not be advantageous and must be avoided. Research - extension - end user must maintain a two-way line of communication. This will assist in the formulation of national and regional research programmes to meet the end users' needs. It would also provide an open exchange of data and information between all farmers and farming institutions.

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APPENDIX B1 to ANNEX B

CROP BUDGETS

(All money values are in Ethiopian Birr at 1986 financial prices)

Table Nr	Crop	Cropping system
B1/1	Tobacco	SF, better soils
B1/2	Tobacco	SF, poorer soils
B1/3	Cotton	SF, cotton/wheat system
B1/4	Cotton	SF, tobacco system
B1/5	Wheat	SF, both systems
B1/6	Maize	SF, tobacco system
B1/7	Oranges	SF, horticulture
B1/8	Grapefruit	SF, horticulture
B1/9	Wheat	Settlement
B1/10	Maize	Settlement
B1/11	Groundnuts	Settlement
B1/12	Cowpeas	Settlement
B1/13	Sesame	Settlement
B1/14	Pasture establishment	Settlement
B1/15	Pasture maintenance	Settlement

Note: SF = State Farm

Table B1/1

Financial Gross Margin

Tobacco, on better soils

	Unit	Unit Value	<-----Year 1----> Quantity	Value	<----Year 10----> Quantity	Value
Yield	t	3960.00	1.12	4435	1.58	6257
Seed	kg	450.00	0.5	225	0.5	225
Urea	kg	0.64	600	384	600	384
DAP	kg	0.81	0	0	0	0
Fumigants	kg/lt	25.00	10	250	10	250
Insecticide	kg/lt	12.00	7	84	7	84
Labour	manday	2.00	260	520	291	582
Materials	sum	100.00	1	100	1	100
Fuelwood	m^3	10.00	7.5	75	11	110
Transport	hour	30.00	2	60	3	90
Fuel Labour	day	2.00	20	40	29	58
Total Costs				1563		1625
Gross Margin				2872		4632

Table B1/2

Financial Gross Margin

Tobacco, on poorer soils

	Unit	Unit Value	<-----Year 1----> Quantity	Value	<----Year 10----> Quantity	Value
Yield	t	3960.00	0.9	3564	1.27	5029
Seed	kg	450.00	0.5	225	0.5	225
Urea	kg	0.64	600	384	600	384
DAP	kg	0.81	0	0	0	0
Fumigants	kg/lt	25.00	10	250	10	250
Insecticide	kg/lt	12.00	7	84	7	84
Labour	manday	2.00	260	520	291	582
Materials	sum	100.00	1	100	1.5	150
Fuelwood	m^3	10.00	8	75	11	110
Transport	hour	30.00	2	60	3	90
Fuel Labour	day	2.00	20	40	29	58
Total Costs				1563		1675
Gross Margin				2001		3354

Table B1/3

Financial Gross Margin

Cotton, in cotton & wheat system

	Unit	Unit Value	<-----Year 1----> Quantity	Value	<----Year 10----> Quantity	Value
Yield	t	1357.50	1.58	2145	2.4	3258
Seed	kg	1.30	25	33	25	33
Urea	kg	0.64	175	112	200	128
DAP	kg	0.81	150	122	180	146
Chemicals	sum	200.00	1	200	1	200
Air Spray	each	7.00	6	42	6	42
Labour	manday	2.00	202	404	227	454
Materials	sum	1.00	30	30	40	40
Total Costs				942		1042
Gross Margin				1203		2216

Table B1/4

Financial Gross Margin

Cotton, a (with Tobacco)

	Unit	Unit Value	<-----Year 1----> Quantity	Value	<----Year 10----> Quantity	Value
Yield	t	1357.50	1.46	1982	2.32	3149
Seed	kg	1.30	25	33	25	33
Urea	kg	0.64	150	96	200	128
DAP	kg	0.81	100	81	100	81
Chemicals	sum	200.00	1	200	1	200
Air Spray	each	7.00	6	42	6	42
Labour	manday	2.00	170	340	199	398
Materials	sum	1.00	30	30	35	35
Total Costs				822		917
Gross Margin				1160		2233

Table B1/5

Financial Gross Margin

Wheat, on state farms

	Unit	Unit Value	<-----Year 1----> Quantity	Value	<----Year 10----> Quantity	Value
Grain	t	340.00	1.46	496	3.75	1275
Straw	t	15.00	1.3	20	3.4	51
Seed	kg	0.70	125	88	125	88
Urea	kg	0.64	100	64	230	147
DAP	kg	0.81	0	0	120	97
Chemicals	sum	60.00	0	0	1	60
Air Spray	each	0.00	0	0	0	0
Labour	manday	2.00	43	86	88	176
Materials	sum	1.00	0	0	0	0
Total Costs				238		568
Gross Margin				259		707

Table B1/6

Financial Gross Margin

Maize, in tobacco system on State Farms

	Unit	Unit Value	<-----Year 1----> Quantity	Value	<----Year 10----> Quantity	Value
Grain	t	200.00	3	600	5.6	1120
Seed	kg	0.60	30	18	30	18
Urea	kg	0.64	275	176	325	208
DAP	kg	0.81	130	105	160	130
Chemicals	sum	26.00	1	26	1	26
Labour	manday	2.00	66	132	76	152
Materials	sum	1.00	3	3	6	6
Total Costs				460		539
Gross Margin				140		581

Table B1/7

Financial Gross Margin

Oranges

	Unit	Unit Value	[Transplanting] <-----Year 1----> Quantity	Value	[Establishment] <--Year 2 to 4--> Quantity	Value	[Production <-----Year 5----> Quantity	Value	<----Year 10----> Quantity	Value	<----Year 15----> Quantity	Value	<----Year 20----> Quantity	Value]
Yield	t	600.00	0	0	0	0	0.5	300	12	7200	30	18000	20	12000
Seedlings	each	7.00	250	1750	25	175	0	0	0	0	0	0	0	0
Fertiliser	kg	0.64	50	32	50	32	250	160	500	320	500	320	500	320
Foliar Spray	lt	10.00	0	0	0	0	10	100	30	300	30	300	30	300
Insectide	lt	17.00	13	221	13	221	20	340	25	425	25	425	25	425
Labour	manday	2.00	457	914	457	914	362	724	398	796	458	916	418	836
Materials	sum	100.00	1	100	1	100	1.5	150	4	400	4	400	4	400
Total Costs				3017		1442		1474		2241		2361		2281
Gross Margin				-3017		-1442		-1174		4959		15639		9719

Table B1/8

Financial Gross Margin

Grapefruit

	Unit	Unit Value	[Transplanting] <-----Year 1----> Quantity	Value	[Establishment] <--Year 2 to 4--> Quantity	Value	[Production <-----Year 5----> Quantity	Value	<----Year 10----> Quantity	Value	<----Year 15----> Quantity	Value	<----Year 20----> Quantity	Value]
Yield	t	400.00	0	0	0	0	0.7	280	17	6800	37	14800	27	10800
Seedlings	each	7.00	120	840	15	105	0	0	0	0	0	0	0	0
Fertiliser	kg	0.64	50	32	200	128	250	160	500	320	500	320	500	320
Foliar Spray	lt	10.00	0	0	0	0	10	100	30	300	30	300	30	300
Insectide	lt	17.00	10	170	12	204	20	340	20	340	20	340	20	340
Labour	manday	2.00	401	802	222	444	219	438	335	670	380	760	360	720
Materials	sum	100.00	1	100	1	100	1.5	150	5	500	5	500	5	500
Total Costs				1944		981		1188		2130		2220		2180
Gross Margin				-1944		-981		-908		4670		12580		8620

Table B1/9

Financial Gross Margin

Wheat, in settlement area

	Unit	Unit Value	<-----Year 1----> Quantity	Value	<----Year 10----> Quantity	Value
Grain	t	340.00	1.4	476	2.6	884
Seed	kg	0.70	125	88	125	88
Urea	kg	0.64	50	32	50	32
DAP	kg	0.81	0	0	0	0
Chemicals	sum	1.00	0	0	0	0
Labour	manday	2.00	190	380	40	80
Materials	sum	1.00	14	14	26	26
Ox pairs	hours	0.75	0	0	175	131
Total Costs				514		226
Gross Margin				-38		659

Table B1/10

Financial Gross Margin

Maize, in settlement area

	Unit	Unit Value	<-----Year 1----> Quantity	Value	<----Year 10----> Quantity	Value
Grain	t	200.00	1.9	380	3.05	610
Seed	kg	0.60	35	21	35	21
Urea	kg	0.64	100	64	100	64
DAP	kg	0.81	0	0	0	0
Chemicals	sum	9.00	3	27	3	27
Labour	manday	2.00	208	415	64	128
Materials	sum	1.00	19	19	30.5	31
Ox pairs	hours	0.75	0	0	155	116
Total Costs				546		270
Gross Margin				-166		340

Table B1/11

Financial Gross Margin

Groundnuts, in settlement area

	Unit	Unit Value	<-----Year 1----> Quantity	Value	<----Year 10----> Quantity	Value
Nuts	t	700.00	1.75	1225	3.15	2205
Seed	kg	1.20	100	120	100	120
Urea	kg	0.64	0	0	0	0
DAP	kg	0.81	100	81	100	81
Chemicals	sum	10.00	2	20	2	20
Labour	manday	2.00	214	429	75	150
Materials	sum	1.00	17.5	18	31.5	32
Ox pairs	hours	0.75	0	0	160	120
Total Costs				667		522
Gross Margin				558		1683

Table B1/12

Financial Gross Margin

Cowpeas, in settlement area

	Unit	Unit Value	<-----Year 1----> Quantity	Value	<----Year 10----> Quantity	Value
Dry beans	t	400.00	2	800	2.7	1080
Seed	kg	0.70	35	25	35	25
Urea	kg	0.64	0	0	0	0
DAP	kg	0.81	0	0	0	0
Chemicals	sum	1.00	0	0	0	0
Labour	manday	2.00	60	120	66	132
Materials	sum	1.00	0	0	0	0
Ox pairs	hours	0.75	0	0	161	121
Total Costs				145		157
Gross Margin				656		924

Table B1/13

Financial Gross Margin

Sesame, in settlement area

	Unit	Unit Value	<-----Year 1----> Quantity	Value	<----Year 10----> Quantity	Value
Grain	t	1000.00	0.5	500	1	1000
Seed	kg	1.50	10	15	10	15
Urea	kg	0.64	30	19	30	19
DAP	kg	0.81	50	41	50	41
Chemicals	sum	1.00	0	0	0	0
Labour	manday	2.00	118	236	58	116
Materials	sum	1.00	0	0	0	0
Ox pairs	hours	0.75	0	0	160	120
Total Costs				311		191
Gross Margin				189		809

Table B1/14

Financial Gross Margin

Pasture establishment in settlement area

	Unit	Unit Value	<-----Year 1----> Quantity	Value
Seed	kg	15.00	10	150
Chemicals	sum	20.00	5	100
Labour	manday	2.00	26	52
Materials	sum	1.00	50	50
Total Costs				352

Table B1/15

Financial Gross Margin

Pasture maintenance in settlement area

	Unit	Unit Value	<---Year 2 on---> Quantity	Value
Urea	kg	0.64	200	128
DAP	kg	0.81	100	81
Chemicals	sum	20.00	10	200
Labour	manday	2.00	48	96
Total Costs				505

Annex C:
Sociology and Livestock

ANNEX C

SOCIOLOGY AND LIVESTOCK

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CHAPTER C1

BACKGROUND

C1.1 Introduction

This is one of fourteen annexes which, together with the Main Report and two albums of drawings, constitute the Report on the Feasibility Study of the Kesem Irrigation Project. The study was carried out by Sir M. MacDonald & Partners Ltd. for the Water Resources Development Authority (WRDA) of the Government of Ethiopia, under contract to FAO as part of the UNDP-financed project DP/ETH/82/008.

This annex is based on the findings of two visits to the project area, the first in January/February 1986 during the dry season and the second in July during the rains. In this way the main seasonal changes in the natural vegetation, and the Afar's responses to them could be observed.

The Afar of the Kesem/Kebena have already lost some land to irrigation schemes. The first incursions into the area, which they regard as their territory by ancient right, occurred over 80 years ago. The subsequent expansion of irrigated agriculture at the expense of their dry season grazing has made them mistrustful of any interference, or even well-meaning assistance, from outside. They fear that they may be treated in the same way as other Afar at Amibara, Gewane and Assaita, who have been displaced by large scale irrigation schemes, and are profoundly suspicious of the proposed KIP.

In addition to land, the Afar have lost great numbers of animals in a succession of droughts. The livestock economy, which until recently had been their sole livelihood, is now barely able to support them. Many households lost all their animals, or had to sell the few that remained to feed themselves. They now depend precariously on the generosity of others, or turn to pursuits other than pastoralism. One of these is small scale irrigation, which a few groups of Afar have spontaneously adopted. In one case they have recruited some non-Afar neighbours, who practise indigenous irrigation, as partners and unofficial extension agents.

Fragile though these efforts are, they are significant for the future of the Afar, and also for the Kesem Irrigation Project (KIP). Carefully fostered they could provide a convergence of interest, and hence the basis of a working relationship between the Afar and the KIP. Such indigenous movements have their own natural pace of development. If artificially forced, through over-enthusiastic external assistance, they grow weak and dependent, and are finally destroyed. It will be many years before a substantial proportion of the Afar is ready to take up the opportunities which the KIP could offer them, and to use them for their own and the KIP's benefit.

These observations have influenced this annex to recommend that the Afar be encouraged and assisted to diversify their economy, along the lines being pioneered by the small scale irrigation groups. This would be achieved through an advance programme, foundations of which have already been laid. Economic diversification does not involve abandoning pastoralism but combining it with irrigated agriculture in a mutually beneficial relationship.

The theme of our recommendations is the development of the skills the Afar already have and of those they are beginning to cultivate; and the increasingly effective use of the natural resources of the area and of the new resources to be offered by the Project.

This chapter describes the present situation in the KIP area. Chapter 2 then reviews the experience of interaction between Afars and irrigation schemes elsewhere. Finally, Chapter 3 presents recommendations for KIP's development. References are listed at the end of the main text of the Annex and there is a list of abbreviations at the beginning of each volume of the report.

C1.2 The People of the Project Area

C1.2.1 General

Three distinct groups of people live and work in the project area. The indigenous people with the longest claims to the area are the Afar pastoralists; they were joined, probably about 50 years ago, by a small group of Shek-Hogele (Shogole) people, who originated in the Sudan and have remained ethnically distinct; and the establishment of state farms at Awara Melka and Yalo in the 1950s brought considerable numbers of staff and labourers from Ethiopia's highlands to the area.

This annex is concerned mainly with the first two groups, who have land rights based on traditional usage in the area; the highlanders have generally confined themselves to the state farms and have not taken up land or permanent residence beyond the bounds of these farms.

C1.2.2 The Afar

The Afar of the Kesem/Kebena area are the southernmost tribe of this large and widely distributed Muslim people. Afar territory extends to the north as far as Massawa on the Red Sea and to the east to Djibouti.

Until the early 1980s the project area was inhabited by two Afar tribes, the Waima and the Dabine. The Dabine are said to have been here for at least 200 years; the Waima are thought to have entered the area some 50 years ago from the east, with a strong influx during the drought of 1972 to 1974. Within the last few years, however, there has been serious conflict between the Waima and the Dabine, and the former have moved away towards Awash town, leaving the Dabine in virtually undisputed possession of the Kesem/Kebena area.

Negotiations between the two tribes, which could lead to a peace settlement, are now taking place. One result of a successful outcome could be that the Waima may move back into the project area, considerably swelling the population there. Inter-tribal negotiations are, however, slow and uncertain, for there is no traditional authority among the Afar above the tribe. Even the tribes themselves have no formal leadership, but are represented by clan heads, among whom one or more may be recognised as having greater influence and authority than the rest. This does not confer any real power since the tribes themselves are little more than loose confederations of clans, which seldom act together except in conflict with other tribes. In the project area one man, named Rasi Edeltu, is acknowledged as spokesman for the Dabine Afar.

Among the Afar the clan is the strongest and most cohesive institution. It is headed by a Makaban (more generally known as Balabat in Ethiopia), who is normally a senior lineage head. The main function of the Makaban is to mediate between his clan and other clans, Government officials, consultants, etc. He deliberates and shares his authority with the clan elders, who are the heads of the lineages constituting the clan. The names of the clans of the Dabine tribe in the project area are given in Table C1.1. There is considerable disagreement among the three sources quoted as to the number of clans, but this sort of confusion is often found in pastoral societies, and is explained by the fact that new clans are formed from time to time by old clans splitting, while some virtually die out, and their remaining members are assimilated by stronger clans. Also some smaller clans may be known by more than one name.

Table C1.1 shows general agreement on the existence of eight clans, with one or more of the sources quoted giving a total of eighteen clans. Detailed study is required at the design stage of the project, to determine the number and name of authentic clans in the Kesem/Kebena area.

TABLE C1.1

Clans of the Dabine Tribe and their Villages

	Clans			Villages
1.	Ma'andita	Ma'andita	Ma'andita	Marintu, Sagento, Yalo, Booneba
2.	Adarisso	Adarisso	Adarisso	Dankara
3.	Abeda*	Abile Abaadi*	-	Hengeda
4.	Iligle	Iligle	Iligle	Boloita, Melka Dura, Adi Abur, Yalo
5.	Ki'ite	Ki'ite	Ki'ite	Ilala, Iddedas, Dankara
6.	Sekabura	Sekabura	Sekabura	Garrato, Durufli, Bildima, Duboona
7.	Gahelo	Gahelo	Gahelo	Carre, Gurumuli, Dankara
8.	Airoroso	Airoroso*	Ayrolaso*	Bontigonna, Namalefan, Doho, Sabure
9.	Heleleto	Heleleto	Heleleto	Kaluale
10.	Gamoosa	-	Gamoosa	Doho, Waseru, Hadasa
11.	Mofaya	-	-	Sabure
12.	-	Bonta	-	Yalo
13.	-	Arkamela	-	Iddedas
14.	-	Daharuma	-	Yalo
15.	-	Fediha	-	Iddedas
16.	-	-	Dali Bura	Alibeti, Didiga
17.	-	-	Adagurto	Doho
18.	-	-	Esetapa	Illala, Iddedas, Boloita, Farris Gubi

Sources: (1) Voelkner, H.E., 1974 (Ref. 17)
(2) NOMADEP, 1983 (Ref. 15)
(3) Ato Mahamud Mohamed, Afar Specialist, 1986

Note: * Although spelt differently, these clans may be the same.

The members of a lineage are related through a common male ancestor who lived up to about five generations back. The lineage may be a residential unit, occupying a section of a village or a rainy season camp. Its members cooperate in such practical matters as herding or guarding the settlement. Cooperation also extends far beyond the lineage and the clan. Especially under difficult conditions of drought or conflict with neighbouring people, men from clans and villages throughout the Kesem/Kebena area may herd and protect their animals together at the rainy season pastures.

Each clan has its own residential and dry season grazing territory, and recognised, though weaker, rights to wet season pastures and water points. Clan territories are based on patterns of land use and residence which have become established over many years. The rights of a clan to its territory are in the nature of general acceptance by the tribe that this particular clan has a long association with a given area, and is established as the dominant group within it. These rights are not exclusive. Most villages consist of a core of local clan members, with people of other clans living amongst them and grazing in the same places. This is illustrated in Table C1.1. People wanting to graze in an area other than their own will usually ask permission of the local clan leaders, and will seldom be refused.

Each clan has a committee consisting of a chairman and members of the clan from each village where it is represented. This committee relates to the Party and the administration and serves as the main channel for official communications between clan and Government. To some extent it circumvents the role of the makaban, who traditionally deals with all external affairs.

The basic institutions of Afar society provide a loose framework, within which individuals exercise a large measure of freedom and autonomy. Only rarely does the clan or the lineage act to restrain this freedom, and this is usually when quarrels and feuds break out and threaten the lives and property of others. Then the lineage or clan elders meet to resolve the issue, but even then they have little power to impose any settlements unless there is virtually unanimous agreement among all those involved.

On rare occasions a lineage or clan will take joint action to restrain or help one of its members. For example, a young man was disposing of his inherited herd irresponsibly, and was publicly warned by the clan elders not to continue wasting these assets on which others also depended; there have been occasions when lineages and clans have come to the aid of one of their members who has lost all or many of his livestock through no fault of his own. The members of the group placed a levy on themselves and helped their kinsman to restock his herd.

Lineages, clans and other Afar institutions have the principal functions of regulating social relationships and resolving conflicts; they have little experience of controlling the use of natural resources, and it would be unwise to assume that they could be used as ready-made associations or cooperatives for purposes of range management, control of livestock numbers, etc.

Negotiations over the transfer of land are conducted, in the first instance, with the clan elders of the territory concerned. In the case of a large tract, such as the KIP, many clans may be involved, and a meeting of all their elders and makabans would be necessary to conduct these arrangements. Even then the process of securing agreement is likely to be long and complex, for the Afar are being asked to give up their rights to land which is the basis of their life and the loss of which has in the past brought disaster to neighbouring Afar clans.

Afar social organisation is based on two principles: territory and spatial relations between individuals and groups, and on kinship. These two principles do not coincide, in that a single territory, however defined, is not occupied solely by kinsmen; nor do kinsmen occupy the same territories. For example, although there are tribal territories, said to be known by everyone, Helland reports 'there seem to be few problems of moving all or parts of households and herds across these boundaries... the cattle of one informant were divided in three different tribal territories - in his own, with a wife in another and with a sister's husband in a third' (Helland 1980:29, Ref. 7).

The boundaries of Dabine territory are redefined from time to time. Much depends on the state of relationships with neighbouring people, especially the Kerayu who graze on and to the south of Fantale mountain. Blood feuds between these two groups are common, and difficult to resolve. They result in ambushes, killings and other violent confrontations. At these times both sides may retreat from their mutual frontier, leaving large areas of grazing unused; or one side, feeling threatened, may retreat from the frontier while the other advances. Kerayu and Afar were in this state of active hostility, with several recent killings on both sides, during July 1986 and large areas in the vicinity of Fantale were considered by Afar as unsafe. Some grazed elsewhere on poorer pastures, while others formed large wet season camps close to Kerayu territory, with armed guards constantly alert. In spite of these tensions some Kerayu had set up their wet season camps well within Afar territory, living and herding peacefully with their Afar partners. These informal herding arrangements are sometimes cemented by marriage between Kerayu and Afar.

During the rains there has also been fighting over water and grazing rights between the Afar and the Arguba, a highland people whose land extends down towards the Kesem/Kebena area. The intensity of these encounters is said to increase when the effects of drought fall more heavily on one area than the other, prompting moves by the less fortunate group into the territory of the other.

In these remote areas the capacity of the Government to intervene in clashes and territorial disputes between neighbouring groups is slight, and the traditional means for resolving such issues are often ineffectual. For this reason boundaries are vague and in constant flux in response to the balance of power between the contending groups.

In preparing for the KIP and in accommodating the claims and wishes of the Afar, it is essential to understand their social organisation and to work through their institutions. At the same time it should be recognised that no Afar leaders have the authority or the power to make decisions without the full involvement and consent of the people they represent. All Afar men, and some women, are regarded as having a full right to make their own decisions on matters directly affecting them. To achieve a genuine consensus, founded on an adequate understanding by the Afar of the implications for them of the KIP, will be hard to achieve. But without consensus active opposition and the erosion of traditional authority are the likely results.

Fuller descriptions of Afar social organisation are given in Voelkner, 1974 (Ref. 17) and Alexander Gibb, 1975 (Ref. 4).

The Afar possess very little apart from their livestock; they live in small portable shelters made of wooden hoops and mats; their economy centres almost exclusively on their herds and flocks; in culture and habit they seem to be nomads, but in fact their seasonal migrations rarely take them more than a day's walk from their permanent villages. They are therefore more justly described as semi-nomads, or transhumants, than as nomads.

In the dry season grazing area shown in Figure C1.1 are the villages of the Afar, which are partially but seldom completely evacuated during the rains. Many of the villages have been in the same place for generations. There are old livestock enclosures with manure $1\frac{1}{2}$ m thick. Yet the great majority of dwellings are of the traditional portable type designed for quick erection and dismantling and easy transport. Most remain throughout the year in the village and the people tending the animals during the rains build simple shelters of sticks and grass at each new camp.

The villages consist of clusters of compounds. Each compound is a bush and stick enclosure, containing from one to ten huts and corrals for small stock and calves. Cattle and camels may be kept in separate enclosures a few metres away. A typical compound is inhabited by a man, his wife or wives, and his children, but often there are others sharing the same compound and even the same huts. A married son, for example, may live with his family in his fathers' compound; brothers may share a compound; even unrelated friends may live in the same compound and sometimes in the same hut. Each wife of a polygamous household has her own hut.

Up to eleven people are reported to live in a single portable hut. This would be physically impossible were all eleven to be in the hut at the same time. Fortunately, Afar spend very little time in their dwellings, and some sleep outside, with their animals or next to the huts.

Members of a lineage tend to build their compounds close to one another, forming lineage clusters within the village. This provides the proximity conducive to cooperation within the lineage in many practical and social matters.

Afar villages have few, if any public amenities. There are no schools or clinics outside the state farm settlements. A few young Afar have some education but the great majority are illiterate. NOMADEP gave a rudimentary training to some 50 men and women in human and animal health (Ref. 14). NOMADEP also sunk some 13 wells, and equipped several with hand pumps. A few are still functional but water is now drawn with buckets. Afar have no well-digging skills, and are little interested in mechanical devices such as pumps, so maintenance has been neglected since NOMADEP's departure.

Some Afar now live permanently in the state farm villages at Saboret and Yalo, or maintain two addresses, moving between their traditional villages and the new settlements. This applies especially to those who are employed on the state farms, and to men who are not at the time engaged in herding, and who enjoy the livelier social life of the new settlements.

Afar make no special provision for sanitation in their own villages, though some have become accustomed to using the pit latrines on the state farms.

C1.2.3 The Soudanis

The ethnically distinct group known locally as Soudanis, or Shek-Hogele, came fairly recently to the project area and now occuply a single village, Tadecha Melka, near the Kesem river upstream of the dam site.

They came from the Sudan, some say as slaves or prisoners of war taken by the emperor of Ethiopia, in the nineteenth century. They are Muslims. For some years they served as soldiers or bodyguards at the imperial court and in the 1930s were given land on the fringe of Afar territory at their present location.

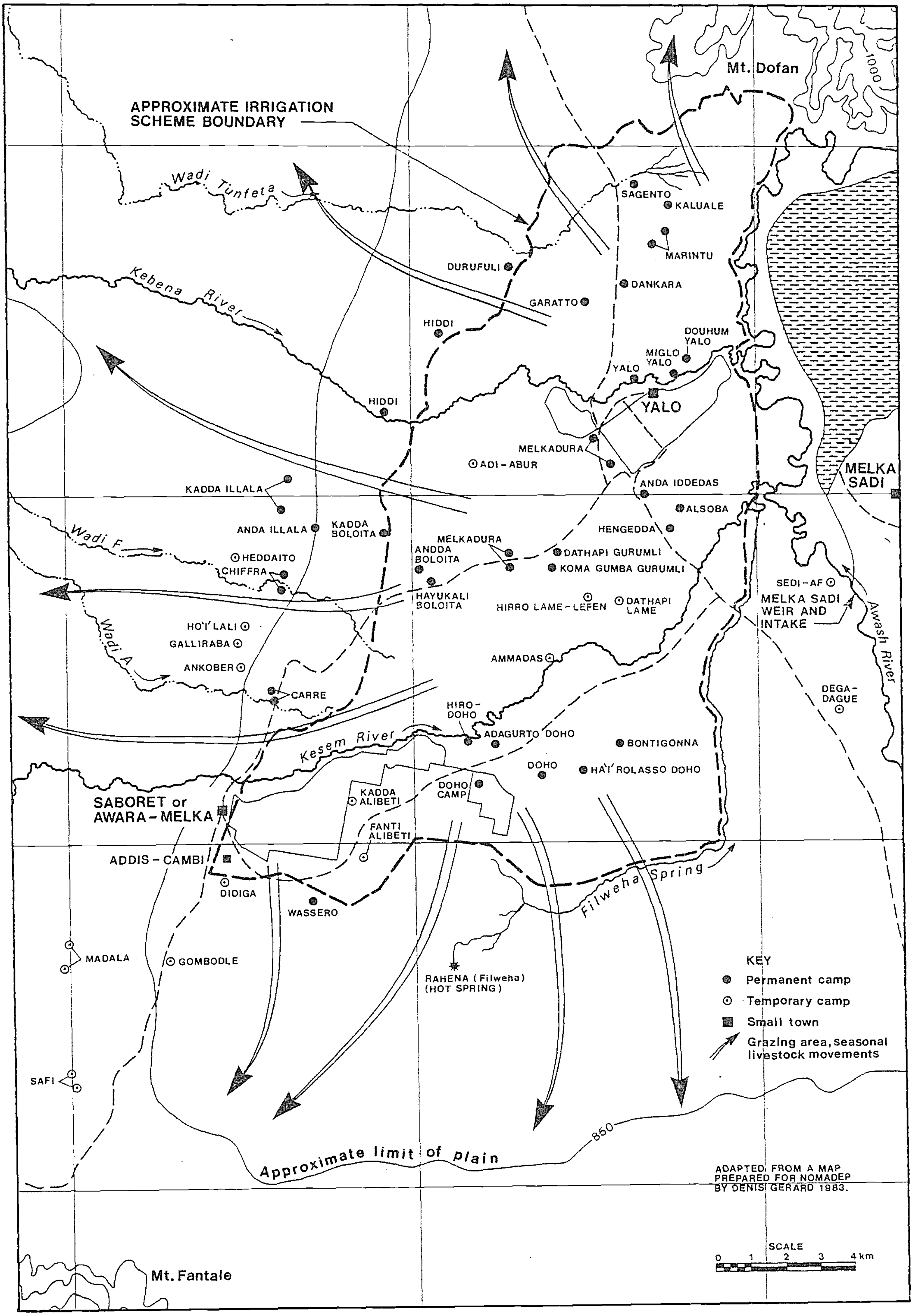
They are skilled farmers and small-scale irrigators and also raise livestock. The grow rain-fed crops on land where no water is available for irrigation and maize and vegetables on the banks of the Kesem river, from which they extract irrigation water.

Many of the men combine employment and farming. They work as guards and rangers at the neighbouring Awash National Park and in various jobs on the state farms at Awara Melka and Yalo. Several have made an agreement to farm in partnership with Afar on the north bank of the Kebena river at Hiddi.

A short history, written by a young educated Soudani, is given as Appendix C1.

Figure C1.1

Afar Settlement and Seasonal Transhumance



C1.2.4 The State Farm Staff and Workers

The state farms at Awara Melka and Yalo are staffed mainly by highlanders, since the Afar are generally reluctant to do heavy agricultural work, apart from guarding and tractor driving and the Soudanis are few.

Permanent staff are housed in government accommodation on the schemes, and are provided with schools and clinics. Temporary work, including cotton picking, attracts labourers from the highlands for several months in the year, as well as a few Afar.

C1.2.5 Total Numbers

There is no single reliable source of population data for the project area. The national census of 1984 was unable to complete its work in Kesem/Kebena on account of disturbances there. The cartographic census of 1981, which preceded the 1984 census, listed only the 'settled' population of the area and omitted most of the Afar. The last comprehensive population count in the area was made by Voelkner in 1974 (Ref. 17), since which time major upheavals, following on drought and starvation, may have influenced the size of the population. The NOMADEP project, which worked in the area from 1974 to 1984 made its own population estimates, based apparently on an independent hut count, but did not carry out a census. The Relief and Rehabilitation Commission (RRC) made various population estimates, with the help of clan leaders, for the purposes of food distribution, but these reflect only a proportion of the local Afar population and that proportion is unknown.

The present study did not undertaken its own census among the Afar. There is, however, good quality aerial photography of the area, dating from January 1984, from which a dry-season hut count could be made. The dry-season is the period of maximum concentration of the Afar and their portable dwellings in the project area. In addition, a field survey was carried out to determine the average number of people living in or associated with each hut. The hut count and the survey of people per hut enabled an estimate of the population to be made. This is a widely used method of estimating nomadic populations, but it has the disadvantage that small variations in the number of people per hut results in large variations in the total population calculated. In this case the survey revealed variations in the number of people per hut between one and eleven, with an average of 5.0.

The Soudani population of Tadecha Melka, including people temporarily absent, was counted in July 1986, giving a total of 204 in 67 households.

Since confidence cannot be placed in any of the available methods of calculating the Afar population, three separate sources and methods have been used in parallel, to enable comparison of the results as given in Table C1.2.

Voelkner counted 9 210 people, including Soudanis, in the Kesem/Kebena area in 1974. The national rate of population increase between 1974 and 1984 has been calculated by the Bureau of Statistics in Addis Ababa to be 2.9% per year. Nomadic populations, however, are normally subject to lower fertility and higher mortality rates than sedentary people. Their rate of increase is assumed for present purposes to be 2% per year, in line with demographic trends in comparable populations. This gives a 1986 population in the project area of approximately 11 700.

TABLE C1.2

Comparative Data on Human Population in the Project Area

Source	Date	Households	Huts	People per hut	Total population	Remarks
Voelkner	1974	1 220	1 645	5.6	9 201	100% census and hut count of Afar.
updated to	1986:	1 557	-	-	11 680	At 2% per year.
NOMADEP	1978	1 168	1 675	5.6	9 380	Hut count x Voelkner's 5.6.
updated to	1986:	1 490	-	-	11 190	At 2% per year plus 200 Soudanis.
MMP	1984	-	2 269	5.0	11 545	Hut count from 1984 air photos, and ground survey, plus 200 Soudanis.
updated to	1986	-	-	-	12 010	At 2% per year.

NOMADEP counted huts but not people, and using Voelkner's figure of 5.6 persons per hut, arrived at a total population, excluding Soudanis, of some 9 400. Extrapolated at 2% this becomes approximately 11 000 in 1986. To enable comparison with Voelkner's count and our own, a round 200 Soudanis have been added to the NOMADEP figure, bringing it to 11 200.

The hut count made from the 1984 aerial photos and the survey conducted in July 1986 of people per hut in the project area, gives a total population of 12 000 in 1986, again adding 200 Soudanis.

The three sources differ by only 7% and for the purposes of this report the higher figure of 12 000, is taken as the provisional total Afar and Soudani population of the project area.

The Awara Melka and Yalo state farm population was found to be 2 576 when the cartographic census was taken in 1981. Extrapolated at 2.9% per year, the national average, the total would be 3 058 in 1986.

The return of the exiled Waima, if it comes about, could make a substantial difference. At present there is no information on the size of this community.

C1.3 The Afar Grazing Lands

C1.3.1 Natural Resources

The soil survey area of some 21 800 ha gross coincides with the dry season grazing of the Afar pastoralists. The three major perennial rivers, Kesem (locally known as Bulgar), Kebena and Awash provide water for people and animals during the long dry season, from October to June, when there are few other surface water supplies in the area. Subsidiary streams such as the Filweha (or Koloba) river, fed by the hot springs at Rahena, are also used for domestic and livestock watering, despite a high mineral content.

The water and grazing resources of the project area and its vicinity are shown in Figure C1.2.

The dry season pastures are on the broad alluvial plain to the west of the Awash river and within about 8 km of perennial water. During the rains these low-lying areas become wet and muddy and are occasionally flooded as the rivers overflow their banks. The extent and frequency of the flooding has been reduced by the Koka Dam which regulates the flow of the Awash river and also by the flood protection works of the state farms at Awara Melka and Yalo. The Afar say the floods used to maintain the grazing in excellent condition and ascribe the present degraded condition of the pasture largely to the flood control measures.

The vegetation in the dry season pasture varies from dense forest along sections of the river banks, through acacia woodland with a mixture of annual and perennial grasses and some edible shrubs, to areas almost completely denuded of vegetation.

NOMADEP carried out a vegetation survey in about 1982 in preparation for a range and livestock programme. The project terminated in 1984 before the results of the survey had been processed or analysed. There are two reports and a vegetation map at 1 : 100 000, reproduced here as Figure C1.2 The data are available in Addis Ababa and Montpellier from sources given in Appendix C2.

The project area of the KIP is subject to heavy grazing pressure, mainly in the dry season. During the rains most of the livestock are taken to higher ground so that some opportunity for regeneration and reseeding is afforded. Some of the best grazing is found close to the rivers, but the moist conditions and the dense tree cover also encourage malarial mosquitoes and other biting insects. Some of the same areas have been invaded by the noxious plant known to the Afar as 'helemarro'. They say it was brought down from the highlands in a flood about 20 years ago. It grows as a creeper, smothering trees and also as a bush, and in both forms it is poisonous to livestock. The Afar tend to avoid these areas unless there is no other grazing available.

The project area is well stocked with valuable browse plants. Acacia nilotica and Acacia tortilis both produce abundant pods with a high protein content. A variety of other trees and shrubs are browsed heavily by camels, cattle and goats. In this area browse probably contributes at least as much as grass to the nutrition of the livestock.

The area around Filweha, the hot springs south of Saboret, is salty. The Afar bring their animals here to graze and lick the earth, which they say provides minerals essential to health.

The low-lying dry season pastures are a small though vital part of an extensive grazing system. The wet season pastures extend to the west towards Fantale and the Awash National Park. There is a loose agreement between the Afar and the park authorities that grazing is permitted during the rains within the park boundaries as long as peaceful behaviour is observed and the wildlife is not molested. The Afar are not keen hunters, but the peace is fairly frequently broken by armed encounters with the Kerayu. So far this has not resulted in their banishment from the park.

To the north and north-west of the KIP the wet season grazing extends towards the headwaters of the Kesem and the Kebena rivers. These areas lie beyond Tadecha Melka towards Wassili mountain and the highlands and are characterised by low acacia trees and bush, with mixed annual and perennial grass, suitable for both cattle and camels. The main limitation on the use of these pastures is the scarcity of surface water. Even during the rains the main rivers are the only reliable source of water. The rain ponds and ephemeral streams dry up from time to time, forcing the herds back on the perennial rivers. Thus large areas are often left very lightly or not at all grazed.

The area to the north of the Kebena river towards Dofan and Rassa suffer from the same restrictions on grazing.

No survey of the wet season pastures has been made, either by the present consultants or others. NOMADEP has some information on the areas used and their vegetations, but it concentrated mainly on the dry season area and its data for the wet season grazing is insufficient for range development planning.

The entire grazing system of the Kesem/Kebena Afar is thought to cover about 2 500 km^2. Some 10% of this consists of dry season grazing, most of which will be occupied by the KIP. The loss of this area, though only a small proportion of the whole, would effectively undermine the entire system, unless the forage it now provides is replaced by other means.

Without a very detailed survey of the project area's productivity and nutritive value it is not possible to provide a precise calculation of the amount of natural forage lost on account of the KIP. For the purpose of this study an estimate was made from various information sources.

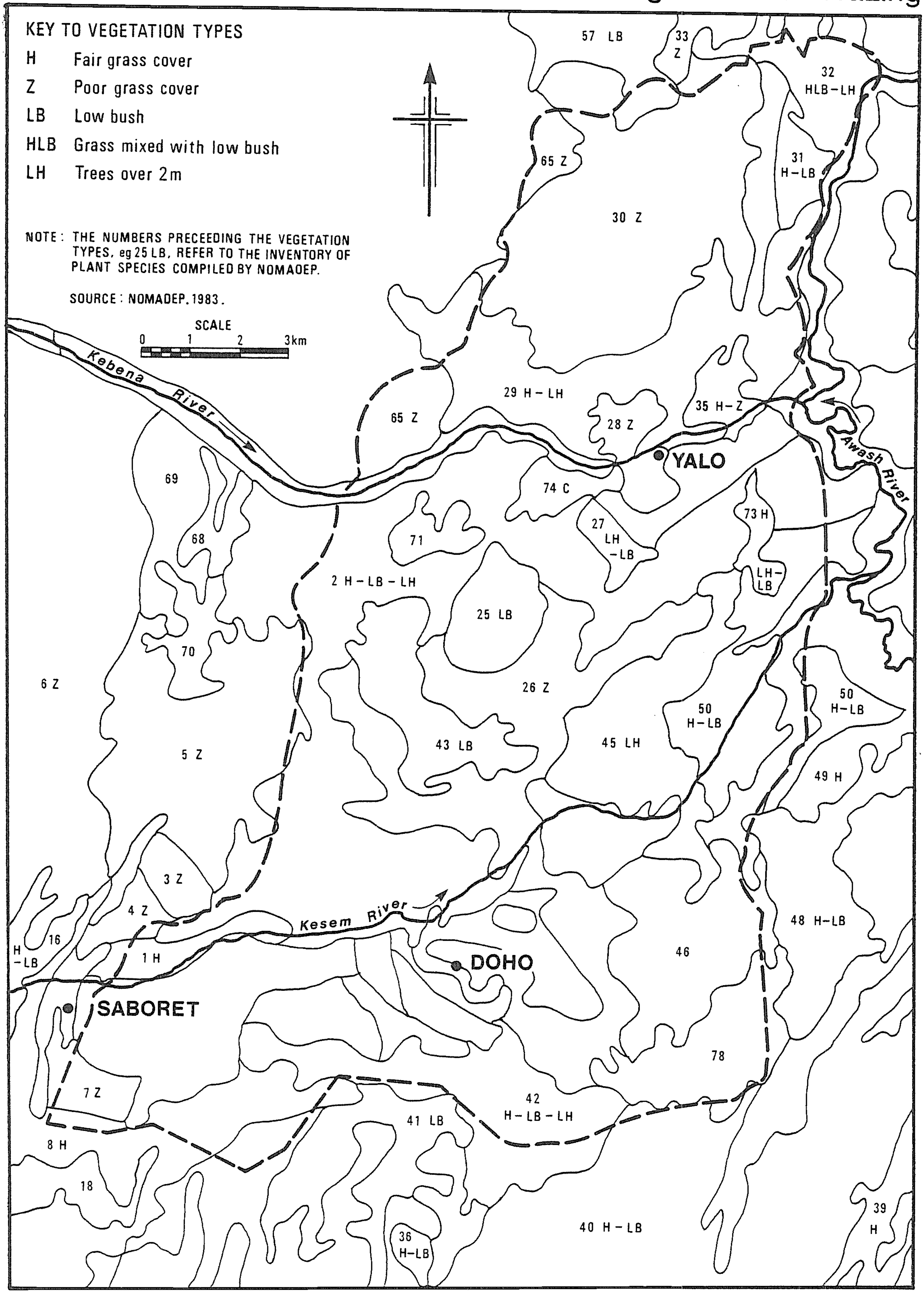
The range ecologist who worked on the 1982 NOMADEP vegetation survey is now with the International Livestock Centre for Africa (ILCA) in Addis Ababa. With his assistance estimates of the consumable dry matter yield (DM) of each vegetation zone in the project area were made. The zones are shown in Figure C1.2. The zones were then planimetered and the results expressed in terms of the total dry matter production from each vegetation zone to be occupied by the project. The consultant made his own independent estimates of the dry matter yield of each zone while traversing the project area, taking into account the grazing and browsing habits of each species of livestock. The results of these two assessments were then compared and found to be in broad agreement.

The gross irrigable area of the KIP ('Large Project' case) is about 15 700 ha. To this should be added 2 900 ha for areas of grazing not actually occupied by the scheme, but rendered inaccessible to grazing (though some of this is thick forest along the Awash river). Of this total of 18 600 ha about 1 500 ha is already occupied by the existing state farm, so the area of dry season grazing lost to the KIP on the Kesem-Kebena plain would be about 17 000 ha. The reservoir will occupy an estimated 3 000 ha of wet-season grazing, plus some arable land. The total area lost to grazing will therefore be of the order of 20 000 ha.

The best pasture land tends to have the best soils, though dry-season pasture productivity also depends on the spatial distribution of flood water. The irrigation scheme will therefore occupy much of the most productive grazing in the Kesem/Kebena area. The dry matter yields in the vegetation zones in the irrigated area ranged from 0.4 to 2.4 t per year, as estimated by the methods described. The estimated average dry matter yield over the area to be occupied by the scheme is 1.3 t/ha per year. Thus, a total of 22 000 t of dry forage would be lost each year from the 17 000 ha of dry-seaon grazing lost in the Kesem/ Kebena plain. To this must be added the forage lost to inundation. In the reservoir area the dry matter yield is estimated at 0.8 t/ha, so the total loss here would be 2 400 t/year. The total dry matter loss to the scheme is therefore estimated at 24 000 t/year.

Figure C1.2

Vegetation for Grazing



C1.3.2 Land Use

The overall pattern of seasonal transhumance is relatively simple, and is shown diagrammatically in Figure C1.1. The dry season is spent in the Kesem/Kebena plain. The wet season is spent on higher ground not more than about 30 km away.

The dry season lasts for 8 or 9 months, from the end of the rains in September to the beginning of the new rains in July. Rainfall distribution is shown in Figure C1.3 (data from Ref. 4). Brief excursions into the wet season pastures may be made during the short rains in February/March but standing water is scarce and unreliable at this time. The greater part of the year is thus spent in the restricted area of the dry season pasture. This is mainly due to the shortage of water in the higher grazing grounds, but also the threat to the security of men and animals from neighbouring tribes in the remoter areas.

With the onset of the rains the Afar send scouts to the areas where they intend to graze, investigating the state of the pasture, the availability of water and the presence of potential enemies. Their migration routes and destinations are indicated in Figure C1.1, but these are simplifications of a pattern which, in reality, and perhaps especially recently, has become extremely complex. In times of peace with neighbouring tribes small groups, often no more than lineages, move off individually to their wet season camps; at times of trouble much larger groupings are formed. For example, we stayed in a place called Dulduble, east of Fantale, at which six clans from six villages were present. The villages were situated in the north, centre and south of the project area. There were about 50 Afar men, women and children, 300 camels and over 500 cattle in this camp. Dulduble is in the Awash National Park and close to the frontier with the Kerayu. The men patrolled day and night, sleeping little, and then among their animals. They were constantly alert to the danger of attack and found the strength to maintain this constant vigilance in their numbers. But such large assemblies of people and animals are cumbersome, requiring large water resources, and they soon exhaust the grazing and browse in the area, necessitating frequent moves to new camp sites.

Wet season grazing territories become established through usage, but they have vague and changeable boundaries. The groups associated with these territories also change in their composition. Some members of the camp at Dulduble had been coming here in the rains for the past 5 years, while for others it was the first time. The area grazed from this camp varies with the security situation at its margins, with the state of the grazing, the location of other Afar camps in the vicinity, the availability of water, and so on.

Essesntial to pastoral life in areas of low and uncertain rainfall is the room to manoeuvre and the flexibility to respond rapidly to changing circumstances. The space available to the Afar has been reduced in recent decades. The state farms at Awara Melka and Yalo have occupied over 1 000 ha of pasture, the national park has restricted access to grazing and water, agriculture has advanced from the highlands down into areas formerly grazed by the Afar, and the Kerayu remain a constant threat. All these have reduced access by the Afar to basic resources, and have greatly complicated the relatively simple pattern of seasonal transhumance which is said to have been followed in earlier times. Whereas previously clan grazing territories were fairly well defined (and in fact were mapped by Voelkner in 1974, Ref. 17), they are now less distinct, as individuals and lineages make their decisions independently of the clan, migrating to new pastures with any other clans with similar intentions.

The Afar of the project area confine themselves mainly to the wet season and dry season grazing grounds shown in Figure C1.1. Some camel owners, however, cross the Awash river and join other Dabine tribesmen for the wet season, grazing towards the Alledeghi Plains to the east. As conditions in the dry season grazing area have deteriorated some Afar have moved their dry season settlements on to the higher ground west of the project area, previously used only during the rains.

A further complication to the pattern of seasonal transhumance is the requirement by each species of livestock for particular types of forage, which may not be found in the same place. Camels, for example, may have to be herded separately from other stock, not only because of their preference for browse over grazing, but because they can remain for many days away from water, which enables them to make use of pastures which are inaccessible to other species. Many of the sheep and goats remain in the project area throughout the year, grazing and browsing small plants which could not sustain other species. Cattle have fairly exacting requirements for grass and certain types of browse, and need watering at least every two or three days. In some areas, at certain times of year, the needs of all species can be satisfied; at other times the species may have to be separated. The directions taken and the pastures grazed under these circumstances are also influenced by the distribution of rain and the availability of labour.

The simple pattern of movement shown in Figure C1.1, according to which the livestock move in the rains to high ground, returning for the dry season to the project area, provides an overall framework, within which many variations are possible, and also some deviations.

C1.4 Livestock

C1.4.1 Herd Performance and Compositon

The Afar keep cattle, camels, sheep, goats and donkeys. Poultry are seldom kept and pigs never, being forbidden to Muslims. With the exception of the donkeys, which are used as pack animals, all species are milked, slaughtered for meat, and sold for cash or bartered for other goods.

No direct measurement of livestock performance in the Kesem/Kebena area has been made. Some information from studies of neighbouring or comparable situations is provided below.

The Third Livestock Project, in a report on an irrigated pasture scheme for the Afar at Amibara (July 1986, Ref. 19) gives the birth, mortality and offtake figures reproduced in Table C1.3. The source of data is unknown, but the report's authors have considerable experience of pastoral conditions in the Awash Valley and of the Afar.

TABLE C1.3

Birth, Mortality and Offtake in Afar Herds and Flocks (%)

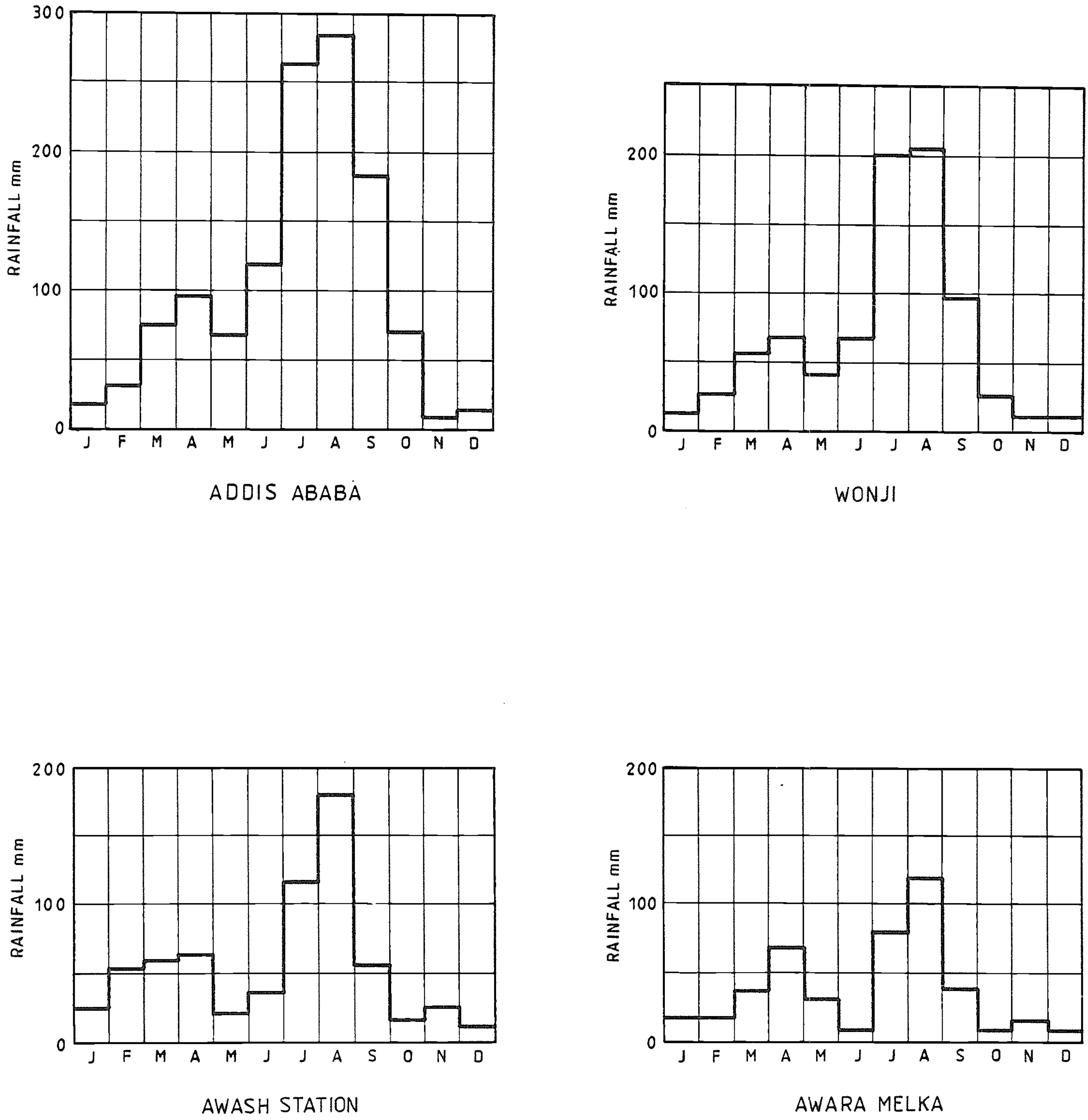
	0-1 year	Over 1 year	Birth rate	Offtake rate
Camels	28	6-12	40	5.5
Cattle	30	8	45	5.6
Sheep	33	10-12	80	17.1
Goats	33	15	95	18.4

Source: Third Livestock Project, July 1986, (Ref. 19)

Figure C1.3

Seasonal Distribution of Rainfall at Selected Stations in the Awash Basin

(Source: Gibb, 1975)



These figures presumably refer to a 'normal' year; the Livestock Marketing Board estimated in 1974, following severe drought, that cattle suffered 90% mortality, sheep 50%, and goats and camels 25% to 30%. The Afar themselves are thought to have lost 25 to 30% of their people to starvation and associated illness during that drought.

Cossins, writing of the Afar in the north-east rangelands, gives calf mortality rates among cattle ranging from 35% to 60% per year, declining to 10% to 12% after the first year of life (Ref. 2).

Some of the mortality recorded may be due to the practice of slaughtering the male calves soon after birth if they or their dams shown signs of weakness, though Cossins believes many of these calves would have died in any case.

According to Table C1.3 camels have mortality rates similar to those of cattle. Under drought conditions, however, camels tend to be far more resilient than other classes of stock. An FAO census taken in Niger in 1979, following the worst drought for over 50 years, showed 100% loss of cattle, 50% of sheep and goats, and only 20% of camels.

Information of milk yields, which are of vital importance to the Afar, is lacking. The Third Livestock Project writes, 'There are no available records of milk production from cattle, however the camel is said to produce up to 1 800 litres a year with a lactation of up to 18 months and the cow gives a maximum of 2 to 4 litres a day within a lactation of 4 to 8 months' (Ref. 19). The FAO, quoting Knoess, who worked in the Awash Valley, reports camels yielding up to 13 kg per day under good rainfed conditions, falling to about half that amount in the dry season (Knoess 1982:10).

One of the few detailed and protracted studies of milk yields in traditional herds was carried out by ILCA on Borana cattle in 1981 and 1982. The Borana stock have distinct genetic characteristics, not necessarily shared by the Afar type of cattle, but the similarities in conformation, management practices and environment are sufficiently close for the Borana data to be relevant here. The median yield per lactation was 843 kg and median lactation length was 250 days. The means of both yield and lactation were considerably higher, at 922 kg and 320 days, due to a number of cows recording very high values. On average, therefore, these cows were giving a total (i.e. human offtake plus calf's share) of 3.4 litres of milk per day over a period of 8 to 9 months. Some lactations lasted as long as 15 months and none was less than 7 months.

Milk yield varied with the bimodal rainfall, reaching its main peak at the end of the long rains, with a lesser peak in the short rains. Milk offtake for human use varied from 25% to 38% of the lactation yield, so the calves usually got more than half of their dams' milk. Despite this a comparison between the calves raised under traditional conditions and other Borana calves raised under controlled ranching conditions showed that the 210 day weights of the former would have been more than doubled had they received all their dams' milk. Human survival is therefore bought at heavy cost in terms of calf growth, and possibly of calf survival - a price of which the Boran, as well as the Afar, are fully aware.

There are no reliable offtake figures for the Afar herds. The Third Livestock Project's estimates are shown in Table C1.3. It is likely that the present economic stress has pushed offtake to its highest possible limit, without encroaching on the breeding herd. The Afar say that this is so, and are supported by an examination of their herd structures, which is discussed below.

The Afar sell their small stock locally and in nearby towns; cattle are sold at Metahara market, and as far away as Nazret, where prices are better. Male calves are sold after weaning, at 7 to 12 months, and many are bought by highland farmers for training as draft animals. Heifers are sold as seldom as possible. Old cows are sold or slaughtered when their milk yield declines irreversibly, or when they have missed one or more calvings.

It is often said that nomads keep and accumulate livestock primarily for reasons of prestige, or to acquire social influence, and that they are singularly disinterested in production for the market. This does not hold for the Afar, who sell as many animals as possible without depleting the breeding capacity of the herd, at the best possible prices, for which they must often travel long distances. Butter and cheese are also sold, by the women, in local markets. One test of the theory that pastoralists accumulate cattle for purposes of prestige is to inspect their herds for animals which are surplus to the need for breeders and replacements for breeders. Since Afar are highly averse to any obvious counting of their animals only three herds, at grazing in the project area, were enumerated, though many more were inspected discreetly to verify the results of the herd counts, which were:

Herd A : 141 head; 3 bulls, 2 steers (about 3 years old), 137 females (including heifers and cows);

Herd B : 29 head; 1 steer (about 2 years old) 28 females;

Herd C : 108 head; 4 bulls, 2 steers, 102 females.

Unweaned calves are herded separately and so are not included in these counts. A striking feature of these herds is the very small number of males, apart from a few bulls. Among the females there were very few old cows. There appears to be a very high rate of offtake among males and of culling among infertile females. Herd owners with whom we discussed these observations confirmed them, saying that hunger had driven them to sell all but their breeding cows, heifers and a few bulls.

Voelkner also remarked on the absence among the Afar of 'any reluctance to sell livestock' for the purposes of buying food or other goods. His tables (Ref. 17, Appendix A, Tables 4 to 6) show a considerable volume of trade in livestock. The main items of expenditure are grain, and to a lesser extent other food, material for their clothing, and weapons.

It is said by the Afar and others who have spent a long time in the Kesem/Kebena area that, over the past decade or more, cattle are decreasing in number and camels and small stock increasing. It is not clear whether this is due to a conscious policy being pursued by the Afar, or to the natural effects of drought on the animals, or to changes in the composition of the vegetation, or a combination of these. NEDECO, reporting in January 1986, also remarked, for the Angelele Bolhamo area, that comparing their own survey with that of Halcrow 10 years previously, 'the number of cattle decreased by approximately 40% but camels and smallstock increased by over 100% and 40% respectively'. (Ref. 12, Volume V, Annex 12, p78).

From the meagre information available at present it seems that the Afar herds and flocks are characterised by very high mortality and offtake rates. High mortality in calves could be due to disease, but veterinary reports do not support this theory. It is more likely to be due to a low intake of milk, possibly because the forage is insufficient to enable the cows to produce more, and also because the Afar depend on milk which must be drawn from a greatly reduced number of cows. It could be expected that if both the Afar and their cattle were to have an improved diet the calves would have a greatly improved chance of survival.

Whatever the actual rate of offtake from the herds and flocks it seems there is little scope for increasing it under present circumstances. Afar do not need to have their attitudes towards commercial offtake altered by extension programmes or other means to persuade them to sell more. They appear to be selling all they can of their animals and animal products at present, and are thus contributing as strongly as their circumstances permit to the national economy.

C1.4.2 Animal Production

The Afar claim to have lived, until recent times, almost entirely on animal products. During the drought of the early 1970s they lost most of their animals. Since that time recurrent droughts and other environmental restrictions (see Section C1.3.3) have curtailed the recovery of the herds and flocks and many families have been unable to survive on animal products. The basic constituent of the famine relief upon which destitute Afar came to depend is grain, and this is now a major item of diet of most Afar. It is obtained from the famine relief programme and from the sale or barter of animals, butter and cheese.

A study of Afar household economy conducted in 1980 for the North-east Rangelands Development Project (NERDU), near Dessie, found that:

> "as little as 10% of an Afar family's energy requirements may be provided by milk, and that grain purchases through selling smallstock are crucial to the Afar existence... the energy intake of the Afar is marginal compared with estimates of the required intake." (Ref. 13).

The average household in that study area bought 530 kg of grain a year, thus alleviating, though not eliminating, the energy deficit in their diet.

The details of that study, made several hundred kilometres north of Kesem/Kebena, are not necessarily directly applicable to both areas, but the main findings probably reflect a similar dependence on grain, financed mainly through the sale of livestock (not only smallstock), and a chronic deficit of energy, which severely inhibits the capacity for hard physical work.

Milk is drunk fresh, curdled and in the form of yoghurt; it is also made into butter and cheese, much of which is sold in the local markets. Milk flows abundantly during the rains, and many people who have no specific herding duties go to the wet season camps to drink milk. Some lactating cows and small stock remain in the permanent villages to provide milk for the people, especially the children, who stay there during the rains.

Afar say they need all four species of milk-producing animals in order to smooth out the milk flow over the year and to cover periods of drought when cattle are especially prone to reduced lactations and to mortality. At such times it is a great advantage to own camels; they give 5 to 13 kg of milk per day over a lactation period of 12 to 18 months (Ref. 18), and their yield is less severely affected by drought than that of cattle, as they can travel much further from water to pasture, and browse on drought resistant trees and shrubs. Camel milk is thought to be especially suitable for men and old people, and is believed by some to have aphrodisiac properties. In hard times it is also given to children.

Sheep and goats often reproduce twice a year and therefore have two lactations. Goats are more commonly milked than sheep, but both types of milk are considered fit mainly for children.

Cattle are the main producers of milk, which is consumed, in its various forms, by men, women and children. The butter is also widely used as a cosmetic. It is highly effective in keeping the skin smooth and supple.

Meat is eaten mainly on ceremonial occasions and animals are seldom slaughtered soley to provide meat. Fortunately, ceremonies are fairly frequent and are attended by large numbers of people, so that the meat is widely, if thinly distributed. The meat of dead or dying animals is not eaten, being considered ritually unclean, as well as potentially hazardous to health.

Animal skins are processed by the Afar for their own use as sleeping mats, sandals, thongs, butter making bags, etc., and are also sold. The skins of dead or sick animals are not used or sold and those taken from slaughtered beasts are often of low commercial value because of the scarifications made in early life for identification.

Only the Soudanis use their oxen for ploughing. A few Afar farmers employ the Soudanis to cultivate their land. The Afar cooperative at Yalo, established by NOMADEP, still plough with the camel trained under that project. Other Afar are becoming interested in camel and ox ploughing, but so far none have actually adopted animal traction. There are precedents among the Afar in using animal traction: Cossins (1972, Ref. 2) reports on the Afar farmers near Mille who had then been ploughing with oxen for at least 5 years. There appears to be no cultural constraint on the use of animals in agriculture, only a lack of experience and equipment, and in many cases of suitable animals.

Livestock still form the basis of the Afar economy and the centre of their interest. But in the past 15 years severe and protracted droughts have decimated their herds and caused many Afar to ask some fundamental questions about their future as a purely pastoral people. Many cling to what remains of the old way of life, hoping that good rains and a cessation of the incursions of others into their territory will revive their traditional economy. Others are now convinced that for themselves at least the old ways have passed and new forms of livelihood are essential if physical survival is to be ensured, even if it is at the cost of Afar cultural identity.

C 1.4.3 Livestock Population Estimates

As far as can be determined there are no data on livestock numbers which could be used with any confidence for planning purposes. Even estimates are rare and probably have no reliable base.

The Afar themselves are averse to revealing the size of their herds and flocks and questions on this subject are evaded or answered falsely. In 1972 Cossins wrote (Ref. 2, p72):

> "They do not like to count or have counted any of their possessions, even children. This widely held superstition is based on the belief that such acts displease God (or the gods) and next time you count them one will be missing. Many Afar thus actually do not know or refuse to know such things as total livestock owned or family numbers."

NOMADEP, in 10 years in the project area, did not attempt to count livestock, but in 1983 produced the following estimates, which probably remain the best informed source.

Cattle	30 000
Sheep and goats	10 000
Camels	10 000

Since 1983 drought and mortality, sales, migrations, births and possible purchases have doubtless altered these figures substantially. The Afar claim to have suffered disastrous losses in recent years. They express this in terms of diminished average herd sizes: 15 years ago a rich man would have owned 60 to 100 head of cattle, now a herd of 20 or 30 is exceptionally large; many who owned average herds of 20 or 30 before are reduced to 2 or 3 and there are great numbers of people who have lost all their stock and depend on relatives or on famine relief.

The veterinary services in the Kesem/Kebena area are directed from Nazret, where statistics on vaccination campaigns are kept. But vaccinations are not regular, do not cover all the cattle, and omit all the other species entirely. The veterinary records show that in 1984/5 35 000 calves were vaccinated against rinderpest in the project area and its immediate vicinity. If this figure is accurate there could be 100 000 head of cattle in the project area. This is highly improbable.

There is at present no basis for estimating stock numbers in this area. Extrapolations from NOMADEP's data, or informed guesses, are likely to be highly inaccurate and therefore misleading. Moreover, livestock numbers are highly unstable, so that even if accurate data were available in 1986, they would be obsolete by the time the project is implemented. It is far better to admit ignorance and to set about obtaining the necessary information at the time when it is needed. It is recommended that an aerial stock census be carried out during the dry season, when the animals are concentrated in the project area, by the team carrying out the final design of the project. The work can be undertaken by ILCA, who has considerable experience in this field. The aerial survey should be accompanied by ground checks to determine factors such as herd composition, ownership and other indices affecting herd performance and production, as far as the reluctant Afar will permit.

C1.5 Existing Small Scale Irrigation

C1.5.1 Background

Several attempts were made by groups of Afar in the Kesem/Kebena area during the 1970s to start small scale irrigation schemes. NOMADEP helped them to establish a garden in Saboret using water supplied by the state farm. The Afar were receptive to this innovation, having suffered acutely during the drought in the previous years, and some at least saw that continued dependence on livestock alone would leave them exposed to the constant threat of hunger. Other irrigated gardens followed. NOMADEP's own analysis of this movement is worth quoting.

> "Thirty Afars became involved in the Saboret garden, which soon covered five hectares. But most were discouraged by the hard work, by the critics of the innovation and by the share levied by the elders. Moreover some cadres felt that gardening favoured individualism against collective work. NOMADEP offered loans but these were hardly ever repaid. The cultivated area decreased rapidly when fewer workers showed up. Now (1983) only one garden remains.

"In 1976 gardening was also attempted at Doho (RRC settlement) separately by men and women. The women kept it up for two years and the men (young Afars) who were first enthusiastic also abandoned their project for the abovementioned reasons. Now only one Afar uses the plot to cultivate chat.

"In 1977 NOMADEP had its greatest gardening success at Yalo near the state farm. After only one year four hectares were under cultivation. NOMADEP provided the seeds and introduced harnessed cultivation with camels trained by NOMADEP for that purpose. This in itself was a real innovation for the Afars. The first crop was good enough to establish a service cooperative. But quarrelling soon appeared amongst the Afars.

"In 1980 the gardens were flooded and the gardeners abandoned their work. The camels bought by NOMADEP were slaughtered or stolen. Now, after two years of rest the president of the cooperative has convinced five Afars to resume gardening with one hectare under maize, green pepper, tomatoes and cabbage. The Afars bought their own tools.

"Another attempt at gardening was made at Wassero without the intervention of NOMADEP but after two years it petered out.

"This outline was necessary for the following conclusions:

- NOMADEP did its utmost to encourage about 100 Afar to undertake gardening and introduce harnessed cultivation.

- Every garden was started with enthusiasm that soon cooled down, the Afars returning to their traditional herding.

- The most successful attempt was made at Yalo where the crop constituted the first capital investment for a cooperative.

- In spite of the new interest shown in gardening few Afar proved sufficiently tenacious. It shows nevertheless that this occupation is not irremediably condemned. We can foresee in this field greater and more spontaneous development." (NOMADEP, 1983, Ref 15, p7).

This short history of NOMADEP's efforts to help the Afar with small scale irrigation illustrates the obstacles they encountered as well as their achievements. It is easy to underestimate the sheer physical effort required to construct, maintain and operate one of these schemes, small though they are. Those which extract water directly from the Kesem and Kebena rivers require intakes and canals up to a kilometre in length. The irrigated areas are generally close to the rivers themselves and are prone to flooding. Some have been washed out and had to be reconstructed elsewhere. Even small floods remove the intakes and silt up the canals. If the level in the river sinks too low the schemes are starved of water, for there is no storage capacity and no lifting mechanism. Except at Yalo the land is cultivated, ridged, levelled and bunded entirely by hand. Hand tools are scarce and many are worn down to stubs. Wart-hogs, baboons, monkeys, gazelles, other peoples' livestock, birds and insects all ravage the crops. Brush fences are inadequate to keep these marauders out.

Under such conditions it is surprising that small scale irrigation should have any attraction for the Afar, and yet at the time of the present study in 1986 at least six groups in the project area were cultivating with considerable determination, in spite of the temptations to abandon this work in favour of the more pleasant occupations of herding and drinking milk. In mid-1986 this represented a real alternative as good rains had fallen and milk was flowing freely. But one group told us "When NOMADEP showed us these things we did not want to see them. Now we remember and are doing them ourselves." Others explained that they had taken up gardening previously following a disastrous drought as their livestock could no longer sustain them. When the rains returned in the mid-1970s and their animals began to multiply they thought they could simply revert to their traditional pastoral life. When drought came again in the 1980s many people realised that they could no longer depend solely on their herds and they would have to diversify. A few pioneers then determined to take up small scale irrigation again and to persevere with it. This spontaneous response seems to have created a more durable set of relationships among the Afar irrigators than did NOMADEP's attempts to stimulate and organise them. The Afar nevertheless freely acknowledge their debt to NOMADEP for introducing them to this innovation. The location of the Afar and Soudani schemes is shown in Figure C1.4.

Prior to NOMADEP's arrival, in 1974, the Kesem/Kebena Afar practised no agriculture and distained it as an occupation unfit for men (i.e. Afar). The Afar in the Awash delta, however, have an agricultural tradition of long standing, so that any prejudice against cultivation is a local and not a universal cultural characteristic of the Afar people.

Kesem/Kebena is not unique in its recent adoption of small scale irrigation. At Airole near Gewane, 150 km downstream on the Awash river, 68 Afar farmers have 55 ha under cultivation. This is their second year of cropping. The farmers came from the nearby Gewane relief settlement and largely on their own initiative opened up fields next to the river. They have been assisted by the RRC, NOMADEP, and the Research Centre in Amibara, and now have pumps, the the occasional use of earthmoving equipment, and 'coordinators' provided by the local council. Some of the ploughing is done with camels, but most work is still performed manually. An adjacent area has been levelled and provided with canals for irrigated pasture, but other Afar have recently moved onto it and are growing vegetables and maize there, without encouragement or authorisation. This is presumably an indication of their determination.

Amibara irrigation scheme made certain formal provisions for settling the Afar it displaced and providing them with opportunities for irrigated agriculture. These are acknowledged to have been largely unsuccessful, and they are generally unpopular with the Afar. It is therefore significant that over the past one to two years several groups of Afar settlers have taken over small patches of waste land on the scheme and have begun to irrigate them, at first without the permission and sometimes with the active opposition of the farm management.

The experience of the last decade or two, in which the Afar have lost large tracts of their most valuable land, and many of their animals, has convinced a small minority, that they must now look to agriculture to augment their income from livestock. There have been many attempts in the past by government and non-government agencies to introduce the Afar to irrigated agriculture, but these have almost without exception been rejected. The existing small scale irrigation schemes have nearly all been started on Afar initiative and are managed and controlled by them. Some are externally assisted, but the Afar remain in charge. None of the small schemes reviewed here has a long history so that no formula for success can yet be discerned. In many of them technical problems and errors are prominent and management may appear lax on occasion. The basis of their survival seems to be their strong sense that these are their schemes, run by themselves according to their own principles and judgement. When others, however well-meaning, take over control in order to manage more efficiently or operate with greater technical efficiency, the Afar lose interest.

C1.5.2 Spontaneous Schemes

Carré

Carré is a permanent Afar settlement some 3 km north of Saboret. The principal clan is Gahelu. Having lost a large proportion of their livestock during the recent drought, the elders of the community organised the construction of a small irrigation scheme on the north bank of the Kesem river. The intake structure was just below the weir which supplies the state farm, whose manager agreed that the Afar could use this water.

Forty-nine households joined the scheme, motivated, they said, by hunger. Using a few old hand tools left over from NOMADEP's time, a few tools borrowed unofficially from the state farm, and oryx horns and sharp sticks, they built an intake structure, dug a canal about half a kilometre long and cleared 2 to 3 ha of bush. They planted maize for their own consumption and vegetables to sell. That season most of their scheme was washed out by a flood. They rebuilt it, but some people were discouraged and left the scheme. The following season started well but before the crop had matured there was a dry spell, and the state farm diverted the entire river flow to its own land, the crop of the Carré farmers withered, and more Afar abandoned the scheme.

By January 1986 only 11 of the original 46 farmers remained. They had maize, teff, sweet potatoes, and a variety of vegetables growing, but with the reduced number of workers they were finding it difficult to maintain the structures, and explained that their main problem was lack of food, without which they had insufficient energy to maintain and operate the scheme.

They had hired the Soudanis to plough for them. Two ploughmen, with a plough and pair of oxen each cost 5 Birr a day and completed the work in about four days. The Afar say they have no oxen of their own, as all have been sold or have died, which is supported by the composition of their herds (see Section C1.4.1). But they watch the Soudanis closely and are convinced they could train and use oxen in the same way if they had the resources.

In July 1986 Carré farmers' scheme was effectively destroyed by a flood control embankment constructed by the state farm to divert the Kesem river away from its present course where it sometimes floods state farm land. The Afars' intake and part of the canal were removed by these earthworks, and the flood waters of the Kesem were diverted over the Carré fields. When this was pointed out to the state farm manager he undertook to reinstate the Carré intake at a new location, to provide a new canal and to make a flood protection bund around the resited Carré fields.

Confronted with the loss of their scheme the Carré farmers decided to plant on the rains and hope that the promised reinstatement of their irrigation system would be implemented soon enough to take the crop through to harvest.

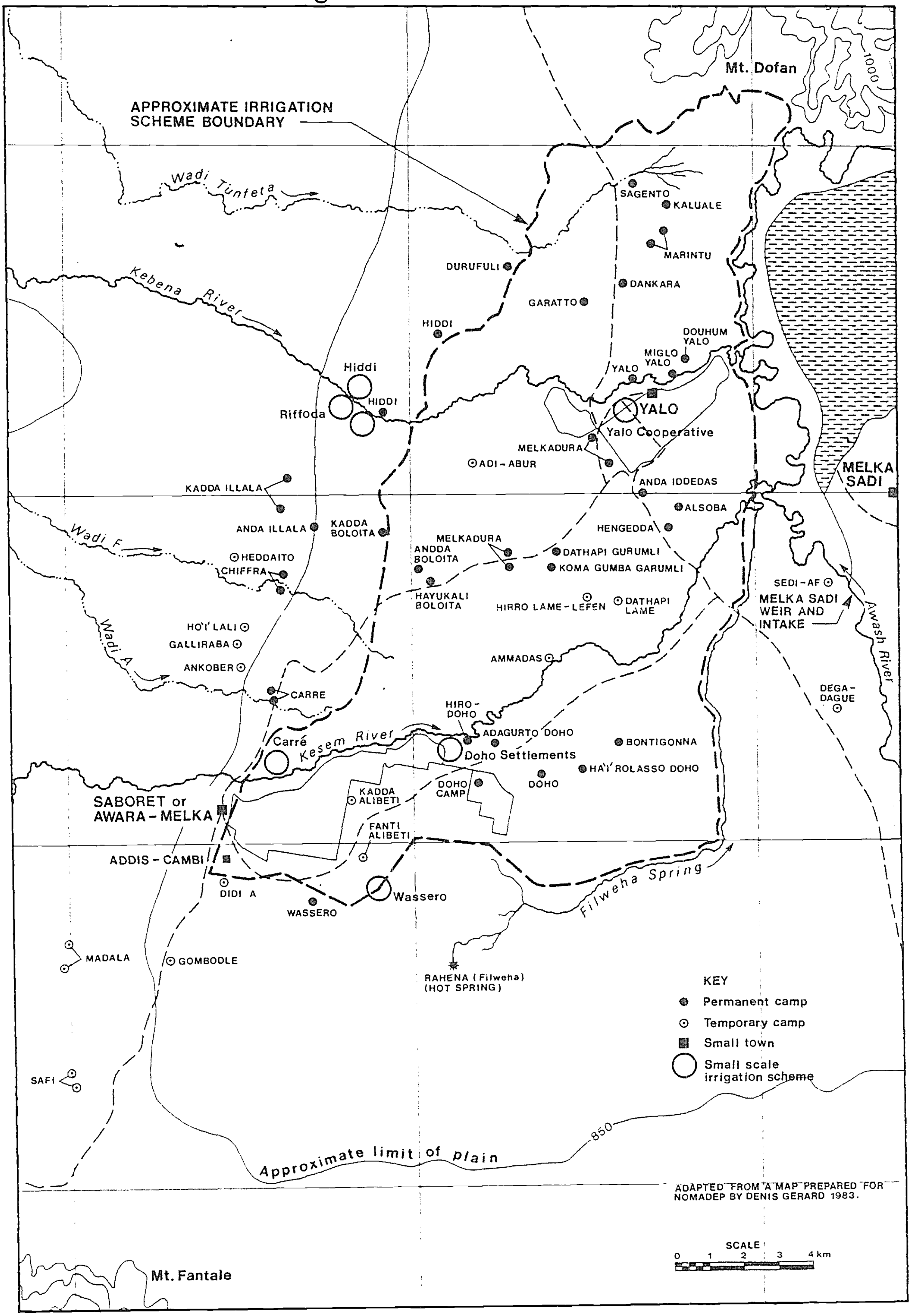
The spokesman for the Carré farmers is Bada Otuban, makaban of the Gahelu clan.

Riffodda

This is the name of a stony ridge running roughly parallel to the Kebena river on its south bank, and of three small irrigation schemes. In 1984 a clan elder from Illala proposed a run-of-the river irrigation scheme at nearby Riffodda. About ten others agreed to join him, and they moved to the bank of the river.

Figure C1.4

Small Scale Irrigation from the Kesem and Kebena Rivers



They made an intake of stones and dug a canal of about 100 m to irrigate a hectare of gardens. Shortly after this another group of about 15 Afar from Illala asked if they might extend the canal to irrigate an area of about 3 ha a kilometre downstream. This was agreed and both communities share the work of canal maintenance and reconstruction of the intake when it is damaged. The downstream site was washed out by a flood but was soon resited.

For some of the Riffodda farmers this is their second attempt at irrigation. The first was under the guidance of NOMADEP about ten years ago. At that time other Afar scorned them for taking up agriculture and would sometimes deliberately turn their animals into the gardens to destroy the crops. Now there is considerable interest among Afar who have not yet taken the step, because the gardens are producing food and cash crops and the life of pure pastoralists has been bitter in the past few years. Agriculture has lost its stigma, say the farmers of Riffodda.

The major problems are with wild animals and insects destroying the crops. No pesticides are in use. The farmers have difficulty in getting seed and that which they have been using seems inferior, especially the maize. Melka Warer Research Centre has donated some seed for the season beginning in July 1986.

All cultivation is done by hand, though several farmers said they are interested in ploughing with oxen and camels, which they could provide. They need training in animal traction.

The capability and the confidence of the Riffodda farmers seems to be increasing and in mid-1986 their gardens were flourishing.

Hiddi

Hiddi is an established village several kilometres north of the Kebena river. The same name is given a new settlement on the north bank of the river opposite Riffodda. It consists of 7 Afar (from old Hiddi) and 16 Soudani households from Tadecha Melka - an unusual if not unique combination. The Afar, whose territory this is, decided to take up irrigated agriculture, but they had no experience of it. They therefore approached the Soudanis, who have a tradition of small scale irrigation and ox ploughing. The proposition was that the Soudanis, who are short of irrigable land, would construct an intake on the river, dig a canal and prepare gardens, with Afar participation, at Hiddi. The Afar would thus learn new skills and the Soudanis would have the use of new land. The Soudanis were, in other words, to serve as indigenous extension agents, and the Afar were to learn through participation.

This arrangement seems to have worked to mutual satisfaction for the past 15 months. From the Afars' point of view it probably has more advantages than the acquisition of new skills, since the Soudanis and their oxen perform much of the hard work.

Similar arrangements between Afar and Soudanis have apparently been made in the past, usually lasting no more than a few seasons. The partnership at Hiddi seems to be working well with an increasing number of participants and an expanding area of cultivation.

Tadecha Melka

The Soudanis have some 15 to 20 ha of irrigated land on the north bank of the Kesem river in the area to be inundated by the proposed reservoir. They cultivate with oxen, having no camels, which they are said to dislike. They plant maize as a staple, with sweet potatoes, water melons, papayas and a variety of vegetables.

At one time they also irrigated land on the south bank of the river but this was washed out by a major flood, which also changed the course of the river, so that there is now no irrigable land in their vicinity other than that which they now cultivate.

C1.5.3 Organised Schemes

Doho Farmers' Association

During the drought, in about 1973, the RRC started a relief settlement for the Afar at Doho. In 1976 NOMADEP began to help some of the settlers to irrigate small gardens using the tail water from Awara Melka state farm. Apart from a few joint activities such as building and maintaining the simple structures and adhering to a water rota, each household was largely autonomous, cultivating and harvesting its own plot.

The RRC, following government policy, reorganised the scheme by amalgamating the individual holdings into a collective farm, a form retained to the present day. Many people left the scheme at this time or shortly afterwards; those who remained are said to have done so to collect the rations which the RRC provides when the scheme does not produce enough.

The area under cultivation is about 62 ha, divided about equally between cotton and maize. There are 168 members, whose work input to the scheme is recorded and their shares of the profits (if any) calculated accordingly. Several years ago the association's funds were stolen, it is alleged by the committee. The membership decreases continuously, and only two clans are now represented. There is also a women's association with 250 members, which once had its own extension worker, but that is now inactive in the field of agriculture.

Members are permitted to have their own vegetable plots, but these are few and small, partly on account of the shortage of water, which also affects the collective farm. Yields of maize and cotton are low and unreliable due to insect attack, damage to crops by wild and domestic animals, low soil fertility and lack of artificial fertilizer, increasing salinity, and irregular supplies of labour and water. The scheme rarely produces a surplus for distribution among members. In 1985, for example, 94 quintals of cotton were harvested. From the sale of this crop the costs of tractor cultivation as well as some staff salaries should be paid, which was not possible. The maize was destroyed by wild animals. The 1986 crops were better, but this did not seem to relieve the despondency of staff and members.

One of the main difficulties with the Doho scheme is the unreliable water supply, from the tail water of the Awara Melka state farm. Lack of water periodically defeats the efforts of the settlers.

The incentive for members to remain on the scheme is said to be their interest in the food relief dispensed by the RRC. But this is not always available and then most members leave the scheme and go with the livestock to drink milk. The agricultural work is then neglected.

Morale among RRC staff and members of the Doho Farmers' Association is low, and they do not anticipate a brighter future.

Yalo Cooperative

At Yalo NOMADEP encouraged a number of Afar to set up a small irrigation scheme, drawing water from the main canal, with the agreement of the state farm. At the end of the first year, 1977, 4 ha were under cultivation and a good crop was harvested. With the proceeds a consumer cooperative was established, and stores bought for sale to members at lower than the usual retail prices. NOMADEP provided a number of camels and developed a suitable harness. Subsequently the cooperative virtually collapsed due to internal quarrelling, but the president was determined to continue. He retained one camel and its equipment, which he still uses to plough the 5 ha or so cultivated by the cooperative. There is a total membership of 190, which increases annually. Of these only about 10 work on the scheme and share its crops, but they seem well established and likely to continue.

C1.5.4 Conclusions

These instances of Afar in the Kesem/Kebena area turning more or less spontaneously to irrigated agriculture may be the precursors of a wider movement. The history of previous attempts of this kind by the Afar suggests that they are liable to abandon agriculture as soon as they are able to return to their accustomed diet of milk. The good rains of 1986 provided an opportunity to test this tendency, for the animals were fat and milk was abundant. All the schemes described above continued to function, with the exception of Carré, whose closure had nothing to do with any slackening of interest by the Afar: on the contrary, they turned to rainfed cropping, hoping that their scheme would be restored before the end of the rains. This perseverance in the face of many difficulties, and of the almost inordinate amount of hard labour involved in building and maintaining these schemes with no external assistance and hardly any hand tools, is an indication that the pioneering movement in small scale irrigation is becoming established. If carefully and sensitively fostered this could be a great asset to the Afar as they prepare for the advent of the proposed Kesem Irrigation Scheme.

All the Afar in these small schemes, to whom we spoke, insisted that agriculture was not an alternative, but a complement, to pastoralism. Each activity supported the other, and in the future both would contribute to the welfare of the Afar.

C1.6 Rainfed Agriculture

The average annual rainfall in the project area is 500 to 600 mm, distributed bimodally. The short rains in February/March are too short and the amount of rain too small for any rainfed cropping. The long rains, lasting from July to September are just long enough, and the precipitation barely sufficient, to sustain certain short growing season crops.

The Soudanis have extensive rainfed fields in the immediate vicinity of their village and up to several kilometres away; for example, near the fumeroles in the valley floor. They plough with oxen and plant other (unidentified) legumes with the first planting rains in July. They also plant maize if the rains are sufficiently early, and hope they will continue long enough to bring the crop through to the flowering stage at least. Sorghum is not planted because of its susceptibility to bird damage.

Among the population of Metahara is a substantial number of highlanders. They have opened large fields on the northern side of the main road, ploughing with oxen. During July they plant maize, teff and beans, and probably other drought resistant crops.

We have no information on yields, growing seasons, seed rates etc., but assume that rainfed agriculture is economically viable in this area because it is being practised voluntarily and without subsidy on a significant scale by experienced farmers.

There is no research on rainfed agriculture in this area. The agricultural research station at Melka Warer concentrates on irrigated crops, though some of its agronomists believe it is time to begin research into this potentially relevant topic.

CHAPTER C2

SETTLING THE AFAR: A REVIEW OF THE EXPERIENCE

C2.1 Introduction

In forecasting the effects of large scale irrigation in the Kesem/Kebena area on the local Afar planners have the benefit of hindsight, for other Afar tribes, downstream along the Awash river, have had to give way to this kind of development. Their experience contains much that is relevant to all concerned with the KIP, as planners, administrators or as pastoralists. There are also many studies of the Afar in relation to proposed irrigation schemes; unanimously they show that there are few practical alternatives available to the Afar once their present grazing system is disrupted.

This brief review draws on reports and on interviews conducted in Amibara, Gewane, and the Kesem/Kebena area. It confirms the view prevailing among some Ethiopian officials, academics, and development workers that the approaches used in the past to settle, resettle, or compensate the Afar following the appropriation of their grazing lands have not provided the results desired. Rather they have led to suspicion, resistance, even impoverishment and sometimes to open conflict with the Afar. This history has also influenced the attitudes and expectations of the Afar in the project area. They are acutely aware of the fate which has befallen other Afar along the Awash river, following the conversion during the past 25 years of over 75 000 ha of dry season grazing land into irrigation schemes. They believe themselves to have been deprived of land they consider theirs by birthright, first by the Frenchman Saboure, who settled in the area soon after the turn of the century, promising the Afar a share in the prosperity he intended to create with irrigated horticulture. He was followed by other settlers, Ethiopians, but aliens to the area, who established farms around Saboure's; and finally by the Government itself which took over these private interests and extended them. The Afar consider themselves to have been deceived many times by promises of compensation, or of participation in the wealth generated by irrigation, and this conditions their views on the proposed KIP. They will be extremely hard to convince that this project, unlike all the others, will turn out for their ultimate benefit.

The following cases contain some of the reasons for the Afars' mistrust of planners' intentions.

C2.2 Tendaho

Tendaho is on the lower Awash. This excerpt is from a report written for the Livestock Marketing Board by Noel Cossins in 1972 (Ref. 2).

> The Tendaho Issue
>
> In 1961, the Mitchell Cotts Tendaho Plantations Share Company took up some 5 800 ha of land along the Awash river which has been variously described as "desert with no vegetation cover". Unfortunately for a number of Afar tribes, this area comprised a major part of their dry season grazing. Flooded seasonally by the Awash river, these riverine lands were left ungrazed for most of the year and were regarded as a kind of dry season grazing reserve.

The establishment of this plantation and its subsequent gradual enlargement has dislocated large groups of Afar who had no alternative other than to move into other already crowded dry season grazing retreats. From 1961 to 1968, when the Karima and Sugum rains were reasonably consistent and adequate the net effect of this dislocation was probably only a marginal increase in the death rate of the Afar herds concerned plus a general decrease in herd condition. The consequences have been far more serious in drought years, the ex-Tendaho herds possibly were the straw that broke the camel's back of already overloaded areas.

It seems that at the time the effect on the Afar was little considered as they were nomads and could move away to "alternative areas". This attitude and the continued lack of compensatory consideration has fixed itself deeply in the Afar mind. More than anything else it is responsible for the intense suspicion that Afar show towards the motives of any outsider and the thinly disguised antagonism they show towards actions they do not understand.

Tendaho is the root cause of almost all of the complex of intense suspicions the Afar have regarded any outside involvement in their affairs as they feel this initial take over of what they regard as their land by outsiders is really just the beginning of things to come. They feel they were cheated and suspect they may be cheated again". (Ref. 2: 62,63).

C2.3 Amibara

The Awash Valley Authority (AVA) started a settlement scheme for Afar displaced by irrigation development in the middle Awash in 1967. Each household was alloted 2.5 ha to be planted mainly to cotton. A 600 ha training farm was also established where future Afar settlers worked as labourers for a season before being allocated their own holdings. Table C2.1 shows the rate of settlement and the average income per family by year.

TABLE C2.1

Amibara Settlement Scheme: Rate of Settlement and Average Income

Season	Settler households	Average household income (E$)
1967-68	60	450
1968-69	67	500
1969-70	67	398
1970-71	67	545
1971-72	129	889
1972-73	214	2 600
1973-74	214	4 000 (est.)

Source: Halcrow 1975, Annex IV-65, Ref. 6.

Yields of cotton were initially very low but built up to over 3 t/ha. With the high price of cotton this gave some of the settlers an annual income of over 4 000 Birr. This encouraging performance was not due to the Afars' ability as farmers, for almost all the work was carried out by the AVA's machinery and workforce. Most of the 'settlers' appeared on the settlement only to collect their cotton cheques.

To engage the Afar more fully in the work of the settlement scheme the Minimum Mechanisation Afar Settlement Experimental Project (MMP) was established in 1975. As its title implies this project was designed to induce the Afar to do more work on the scheme, but their attendance remained minimal and most of the agricultural operations had still to be carried out by the AVA. Yields and income dropped sharply.

The situation in 1986 is that some 1 200 Afar families are settled on the scheme. They are organised into production brigades, each responsible for certain agricultural operations, and their attendance is registered. The land is now held in common, and each household is paid a share of the proceeds, after deduction of expenses, according to the work they have contributed. The system is said to be highly unpopular among the Afar. They complain the benefits of the irrigation scheme as a whole have been denied them, and they have lost their traditional dry season grazing. After nearly 20 years of 'settlement' the Amibara Afar, with few exceptions, are alienated from and even hostile to the settlement scheme and the adjoining state farm.

The Third Livestock Project is now (August 1986) preparing an irrigated pasture programme for the Amibara Afar, which the project document describes as follows:

> "The rapid expansion of irrigated cotton development in the Awash Valley and particularly in the middle Awash has deprived the indigenous Afar pastoralists of traditional dry season grazing resources leading to poor livestock nutrition and consequently human nutrition, due to reduced livestock productivity and increasing conflict over available feed resources with the parastatal farm management.
>
> "As a means of improving both livestock and human nutrition, and providing a more stable and productive base for the pastoralists, the Government of Socialist Ethiopia proposes to develop approximately 3 000 ha of irrigated pasture land on which to settle approximately 1 500 temporarily displaced Afar pastoralists.
>
> "The pastoralists, while based on the irrigated land development, will retain and use traditional grazing rights in surrounding dry season grazing areas. The irrigation development and pastoralist settlement would provide a more productive base for the traditional pastoralists' management system, and would enhance the opportunity for the development of the pastoralists.
>
> "... The 3 000 ha project area would be developed in a phased manner with 1 000 ha being established in year one and 2 000 in year two. Upon completion of the pasture and forage development programme the project is expected to support 15 000 mature cattle or their equivalent in LSU.
>
> "... The irrigated land would be divided into two separate and quite distinct units which would be allocated respectively to the two clans (perhaps tribes in the terminology of the present report) proposed to participate in the scheme. Land within the clan blocks would be further

"sub-divided into sub-clan (clan) units of approximately 75 ha each, but varying in accordance with sub-clan size. Land allocation to the clans would be the responsibility of the project management while sub-clan land allocation would be the responsibility of the traditional clan management system.

"... Each pastoralist family would be allowed to hold a maximum of 10 mature cattle or their equivalent in LSU on the project area at any one time. The livestock population will be monitored by RDP staff, however, the regulation of livestock numbers will be the responsibility of the clan management system. Pastoralists will be encouraged to keep their most productive stock on the irrigated pasture, particularly breeding cows and their calves, and three to four year old oxen for finishing before marketing. Goats and camels will be discouraged." (Third Livestock Project, 1986, Ref. 19).

The document gives further details on the management of the scheme, stressing the importance of full and voluntary cooperation by the Afar and the development of their own institutions gradually to assume full responsibility. It also suggests the gradual imposition of a 'poll tax' with the aim of covering the full operational costs of the project by year five. The 1 500 pastoralists would represent a total Afar population of the order of 9 000.

A notable feature of this proposal is the relatively relaxed view it takes of the way in which the irrigated pastures would be used and managed, allowing the Afar a wide range of discretion and compared with most other proposals a generous quota of livestock per household to be grazed on the scheme.

C2.4 The Angelele and Bolhamo Proposals

Two substantially different earlier sets of proposals for the compensation and settlement of Afar on the Angelele-Bolhamo Irrigation Project have been made. The first to be considered here is that of Sir William Halcrow & Partners in 1975; the second is that of NEDECO in 1982 (Refs. 6 and 11).

Halcrow proposed a comprehensive programme of irrigated pastures on the scheme and the development of the extensive rangelands known as the Alledeghi Plains. The Afar settlers were to be permitted to graze 2.5 LSUs per family on irrigated Rhodes grass pastures. An allocation of 0.5 ha of pasture per family was recommended and this was to be managed in 10 ha blocks, accommodating the livestock of 20 households. Only 'productive stocks' were to be allowed on the pastures, with milk, beef and fat sheep as the desired products. The system was to be managed by AVA officials, and individual livestock holdings were to be monitored by the settlers themselves.

The extensive rangelands were to be developed through the provision of additional water sources and the establishment of holding grounds, which would be carefully managed and improved to accommodate as many as 3 LSUs/ha. Greatly improved veterinary and extension services and a system of 'model farmers' by whom these services were to be introduced to a wider clientel were recommended. Great improvements in animal productivity were predicted: calving rate up from 50 to 80%; milk production of cattle up from 130 to 880 l per lactation; calf mortality reduced from 18 to 12% and offtake of both male and female youngstock increased by 109% per year. (Ref. 6, Annex IV:101).

Virtually none of these proposals had been implemented by the time NEDECO carried out their reappraisal and updating of Halcrow's and other reports on the area, which appeared in 1982 (Ref. 11). NEDECO's comments on the Halcrow proposals were:

> "The consultants.....cannot agree with Halcrows' proposals for development. It appears that Halcrow had underestimated the problems inherent in the settlement of nomads. Their acceptance of production patterns completely alien to their traditional methods is unpredictable and most efforts to this effect launched in Africa met with failure. In addition, Halcrow has based his calculated projection on a flawlessly executed production system involving tropical fodders which are among the most difficult crops to cultivate and manage. Allowances for failures and occurrence of diseases and pests have not been made." (Ref. 11, p 99).

The alternative solution proposed by NEDECO was simply to replace the grazing lost to the Afar by irrigated pastures yielding an equivalent amount of forage. They calculated that 612 ha of irrigated pasture, with a net dry matter yield of 7.5 t/ha, would produce 4 590 t of dry matter per year, sufficient to sustain the displaced livestock for 200 days a year. This area of pasture coincided with the guidelines provided by the Government for the compensation of people displaced by large scale irrigation schemes, according to which approximately 20% of the total irrigated area should be set aside for settlement. NEDECO continues:

> "The inclusion of irrigated pasture should be considered as a way of compensating the Afar for the loss of their grazing grounds.... Irrigated pasture hardly yields any profits and this calculation is based on an allowance of only one lactating cow plus one follower (=1.5 LLU) per settler in a unit....The irrigated pasture is certainly not economically feasible, but the consultants consider it socially desirable." (Ref. 11, p45)

In their 1986 report on the same project NEDECO write:

> "Part of the production (of the irrigated pastures) would have to be stored as hay, or otherwise. In view of the traditional year round grazing habits and the required skills for hay making, it appears preferable to compensate for the wet season requirements as well. In that case approximately 1 000 ha of irrigated pasture would be needed." (Ref. 12, p83)

Even this more generous allocation would not bring the number of livestock units permitted on the scheme up to anything approaching the 10 proposed by the Government itself, through the agency of the Third Livestock Project. (See Section C2.3.) NEDECO does not provide details of the management of these pastures or of the methods of controlling the number and kind of animals brought on to the scheme by the Afar. It seems improbable that the pastoralists would accept such limitations as these with docility.

C2.5 Conclusions

Recent history provides many examples of the Afar being excluded from their dry season grazing grounds by irrigation development. Past attempts to compensate them for these losses have usually been combined with programmes for settling nomads and converting them into farmers. These attempts are now generally acknowledged to have failed. More recently consideration has been given to compensating for the loss of natural grazing by providing irrigated pasture on the schemes, but so far none of the recommendations have been implemented. The Third Livestock Project's proposals for Amibara are the most advanced. They are also in many ways the most realistic, arising from long experience of working with the Afar. They appear to be framed in a deliberately open-ended manner, allowing scope for the Afar to develop their own institutions and make their own decisions relating to the use and management of the irrigated pastures.

CHAPTER C3

RECOMMENDATIONS FOR THE KESEM IRRIGATION PROJECT

C3.1 Introduction

The recommendations made here have been influenced by a number of basic considerations:

- It is essential to establish a mutually satisfactory relationship between the Afar and the project if strife and subsequent damage to the interests of both are to be avoided.

- The Afar are not likely, unless perhaps many generations in the future, to provide significant numbers of agricultural workers for the state farms.

- Even with their pioneering efforts at agriculture the Afar are far from being prepared for integration into a large scale irrigation scheme. If they are not adequately prepared, over a sufficiently long period, there is a likelihood of their reacting against the project, with potentially harmful consequences.

- The Afar are deeply suspicious of the motives of any outsiders who try to become involved in their affairs. This colours their reaction to any proposals relating to their land, their livestock or to themselves. An external agency attempting to work with them will need several years of successful and harmonious partnership with them before this mistrust is dispelled.

- The project will occupy most of the dry season grazing currently used by the Afar. Their wet season grazing extends over an estimated 2 500 km^2, but most of it lacks surface water and cannot be used in the dry season. The only exceptions are pastures which are accessible from the perennial rivers and the few other permanent water sources.

In the event of the project occupying the dry season grazing, without providing a roughly equivalent amount and value of forage from irrigated pastures and crop residues, one of two consequences would follow:

(i) The livestock economy of the area would virtually collapse, since without dry season pasture the animals could not survive, except in greatly diminished numbers;

(ii) The entire livestock population would be thrown back onto the perennial water sources, including those on the project itself. The result would be very rapid denudation and erosion of the immediate catchments of the Kesem and Kebena rivers and constant incursions into the scheme by livestock in persuit of water and green crops.

The economic, environmental and social consequences of either of these events would be extremely severe.

The project can be designed in such a way as to support the local livestock industry and to assist in its development towards higher levels of production. At the same time the project's own considerable labour force could benefit directly from the local availability of livestock products.

It is preferable to keep livestock separate from crops not grown specifically for their consumption and from canals and other structures which they could damage. In practice this means that Afar settlements should be relocated around the periphery of the scheme, just outside its boundaries and their irrigated pastures and gardens should, as far as possible, occupy a band around the outer edge of the irrigated area.

C3.2 A Modified Grazing System

The project will deprive the Afar of approximately 17 000 ha of dry season pasture. As far as possible this loss should be compensated by forage from irrigated pastures which is equivalent in mass and quality. Ideally this would substitute for the dry season pasture in the Afar grazing system, enabling it to continue operating along the same broad lines as at present. Such a solution would produce a minimum of trauma for the Afar if it were executed with a combination of sensitivity and technical efficiency.

This approach to compensation for lost dry season grazing has been employed in virtually every report on irrigation in the Awash Valley for the past ten years, but has yet to be applied in practice. It is conceptually simple, but it is technically and organisationally complex and untried. Where it has been tried elsewhere in Africa, for example in Sudan and Egypt, yields have been low and the costs of fertilising and reseeding have been much higher than anticipated; carrying capacity has consequently been low and there have been great difficulties in regulating the numbers of animals grazing on the irrigated pastures. The technical and the management problems are inseparable and they tend to compound one another. Irrigated pastures cannot be economically viable when they are used as a substitute for natural grazing by pastoralists. They must therefore be perpetually subsidised, unless the pastoralists can be convinced that they should pay an economic rate for using them. There is no precedent for this in Africa. Consequently, irrigated pastures tend to degenerate because they are starved of the inputs necessary to keep them productive.

In Sudan crop residues play a much greater part in animal nutrition than pastures, on irrigation schemes such as Rahad and New Halfa. Currently efforts are being made to increase the forage output of these schemes through improved storage and treatment of crop residues and also through irrigated pastures. Egypt has an ancient tradition of individual farmers producing their own fodder crops. In view of the lack of experience more directly related to the KIP these examples of the integration of livestock into irrigation schemes in neighbouring countries could serve as possible approaches. The options available for compensating the Afar for the loss of their grazing are very limited. In one way or another the scheme must produce the forage, as specially grown fodders or as residues.

Most reports on this subject have recommended irrigated plots of simple pasture such as Rhodes grass (Chloris guyana) or Cenchrus ciliaris, established and managed by a Government agency on behalf of the Afar, who would participate with increasing intensity as they became more familiar with the processes. The Afar would be organised on a clan or lineage basis to regulate the number and type of stock to be given access to the pastures and to assume greater responsibility for their management over a period of some years.

We endorse this approach, while noting that it has several obvious difficulties. One is the regulation of access. The clan and lineage structure does not customarily deal with the management of resources, but confines itself largely to the resolution of conflicts and the regulation of social and political relationships. It may in time be able to adapt itself to the management of resources, but this cannot be taken for granted. Initially it is the settlement authority which is likely to have to decide who may enter the scheme with his livestock and how many he may bring and for how long he may keep them there. Tough decisions will have to be made, possibly without the support of the clan elders, on the exclusion and eviction of livestock from the scheme. These events require very delicate handling if open conflict is to be avoided.

Another difficulty is that irrigated pasture produces forage of high value, suited mainly to cattle and sheep, whereas camels and goats are also important in the Afar economy. The project area now produces natural forage suitable for all species, but the scheme will favour some species more than others. The extent to which this will alter the proportions in which the various species are kept cannot be predicted. In Sudan camels and goats graze sorghum and maize stover in the dry season, so they do not necessarily have to be excluded from the scheme on grounds that the fodder produced there is unsuited to them.

The Agricultural Research Institute at Melka Warer has conducted trials on a wide variety of fodder species, but so far these have not been subjected to continuous heavy grazing for protracted periods, which are the conditions which could be predicted for the KIP. It is thought that Cenchrus ciliaris and possibly Rhodes grass would withstand this kind of treatment and be relatively easy to manage. The ARI does not recommend mixing legumes with these grasses, in spite of their high yields and nutritive value, because they tend to be suppressed by the more vigorous grasses and also because they are selectively grazed and can cause bloat and death. But even simple grass pastures need experienced management, or their productivity falls off drastically.

By the time the KIP is implemented the Third Livestock Project's irrigated pasture programme at Amibara should have accumulated a great deal of technical and organisational experience which could be applied directly in the KIP. It is recommended that this be used as a model. No purpose will be served by speculative anticipation of this experience.

Careful consideration should be given to the storage and use of crop residues for feeding to livestock. There is the possibility that molasses from the nearby Metahara sugar estate could be applied to various stovers to increase their digestibility and nutritive value. It will be recommended that each Afar family be provided with a garden in which to grow crops of its own choice. This will also produce usable residues. The uses to which these gardens are put may also provide valuable indications as to whether individually held and managed forage plots are more productive than communally grazed irrigated pastures.

A crucial question, affecting the viability of the entire KIP, is the area of the scheme to be devoted to the Afar. There are many ways of approaching this issue and several of these have been followed in order to assess the degree of disparity in their results. Table C3.1 summarises six calculations and the assumptions on which they are based. The figures for area of present grazing lost, 17 000 ha on the plain and 3 000 in the reservoir, come from the last two paragraphs of Section C1.3.1 above.

TABLE C3.1

Area Required for Afar and Soudanis using Different Approaches

	Assumptions	Settlement area required (ha net) Garden	Pasture	Total
1.	Population 12 000. Household size, 6 = 2 000 households. Each has 0.5 ha garden plus 1.5 ha pasture	1 000	3 000	4 000
2.	20% of gross irrigated area, i.e. of 15 700 ha	-	-	3 140
3.	20% of total area lost to grazing, i.e. of 20 000 ha	-	-	4 000
4.	Following the Third Livestock Project's formula of 10 LLUs per household: 2 000 x 10 = 20 000 LLUs. ARI estimates irrigated pasture carries about 5 LLUs/ha for 365 days. 5 000 ha would be needed for whole year, and 2 740 ha for 200 days (rest of year spent off scheme)	1 000	2 740	3 740
5.	Area of natural pasture lost produces an estimated 24 000 t of dry matter annually (Section C1.3.1). If irrigated pasture yields 7.5 t/ha of DM per year, 3 200 ha are needed to compensate for lost natural grazing	1 000	3 200	4 200
6.	ARI estimates, as a rough guide, that 1 ha of irrigated pasture is equivalent to 10 to 15 ha (say, 10) of natural grazing in this area. Thus, the loss of 20 000 ha of natural grazing would require 2 000 ha of irrigated pasture as compensation	1 000	2 000	3 000
7.	NEDECO, in designing the Angelele-Bolhamo scheme (Ref. 12) allowed for 1 400 ha of gardens and 600 ha of pasture to compensate for the loss of 11 000 ha of natural grazing. Applying the same proportion to KIP's loss of 20 000 ha	2 550	1 090	3 640

Using these different assumptions and methods the range of values for the settlement area is between 3 100 and 4 200 ha of irrigated land. For the purposes of the present report an area of about 4 000 ha net is adopted as the target for the base case. (The base case land allocation is presented in Annexes L and B: for practical reasons the total allocation for Afar and Soudanis is 4 180 ha net, generally on the worst soils and including about 800 ha suitable for gardens. The 'Medium Project' case replaces much less pasture, as is explained in Annex L.)

Most of the calculations in the table use a nominal figure of ½ ha of garden per household. It has been assumed that the small groups of Afar who are now irrigating gardens of their own are a pioneering movement which, with sufficient encouragement, will awaken a wider interest. On the existing spontaneous small scale schemes a variety of field crops and vegetables are grown for sale and home consumption. Cotton is not grown, and is said to be unpopular with the Afar because it is associated with the loss of grazing land. It is recommended that a horticulture officer and two assistants be appointed to assist the Afar, many of whom are new to agriculture of any kind. Women should also be encouraged to garden. They would need a separate area from that of the main garden block which would be operated, presumably, by men. A trained female extension worker should be appointed to assist them.

The irrigated pastures are designed to replace the natural grazing occupied by the project. They could be augmented by crop residues from the state farm and from the Afars' own gardens, but reliance on state farm residues would be likely to lead to conflicts and should not be relied on at this planning stage. The growing of break crops on state farms (see Annex B) would make it more difficult than it is on monocropped schemes now.

All the Afar irrigation blocks, both for crops and pastures, would be situated on the periphery of the scheme, so that there would be no necessity for Afar stock to enter the state farm for pasture or water. The layout of the Afar irrigation blocks should be designed for maximum flexibility in operation. It should be possible to convert pasture into garden land and vice versa. Each household should be provided with a plot of garden land in a block with similar gardens belonging to clan or lineage members who occupy an adjacent settlement. Each household should be allocated grazing rights for a specific number and kind of livestock on a block of irrigated pasture designated for use by one clan or lineage who also reside in the same adjacent settlement. This arrangement is shown diagrammatically in Figure C3.1.

The daily management of the pasture blocks would be in the hands of Afar specially trained for this work. Each settlement, in collaboration with the MOA, would select a suitable trainee to manage its own pasture block. Training would be provided at Gewane Training Centre (see Section C3.7). Technical support would be provided by an MOA pasture officer with two assistants. Monitoring and control over access to the pastures would be the responsibility of each block manager and of a pasture block committee in each settlement. These proposals would be reviewed and modified in the light of experience gained by the Third Livestock Project at Amibara.

The wet season grazing would continue to be used as at present. The more efficiently it can be utilised, the easier will be the job of managing the irrigated pastures, as the pressure on them will be reduced accordingly. It is therefore recommended that a programme of wet season range development be instituted. At present the most limiting resource is water, not forage. It appears that by increasing the number of surface water sources and improving their distribution and by extending the period over which surface water is available, large amounts of grazing and browse which are at present inaccessible to livestock could be made available. This could be done by constructing small dams and hafirs in carefully selected localities. Their capacity would be such as to extend the grazing period to match the carrying capacity of the range. The possibility of using camel and ox drawn scoops in construction and of training Afar in their use, should be considered. This would open new possibilities for the subsequent maintenance and desilting of the dams and hafirs.

The range development programme should be regarded as complementary to the irrigated pastures on the scheme. They are the major components of a single system.

Before embarking on this programme an aerial and ground survey of the range, water and livestock resources of the area should be conducted. It is recommended that every effort be made to induce local Afar to participate as actively as possible in this work, not only as guards and workers, but as members of the data gathering and planning team. Their contribution is essential not only in collecting the basic information, but in considering equally important issues relating to boundaries, grazing and watering rights, the location of future water points and the whole approach to the range development programme. If Afar are not fully involved in this survey its results will have no meaning or relevance for them and they are most unlikely to accept its findings or to support the implementation of its recommendations.

The NOMADEP range survey data are available in Montpellier (see Appendix C2). ILCA could provide technical services for the survey and advice based on long experience of range development.

The MOA, through the Third Livestock Project or its successor, should appoint a Range Development Officer and two trained Afar assistants.

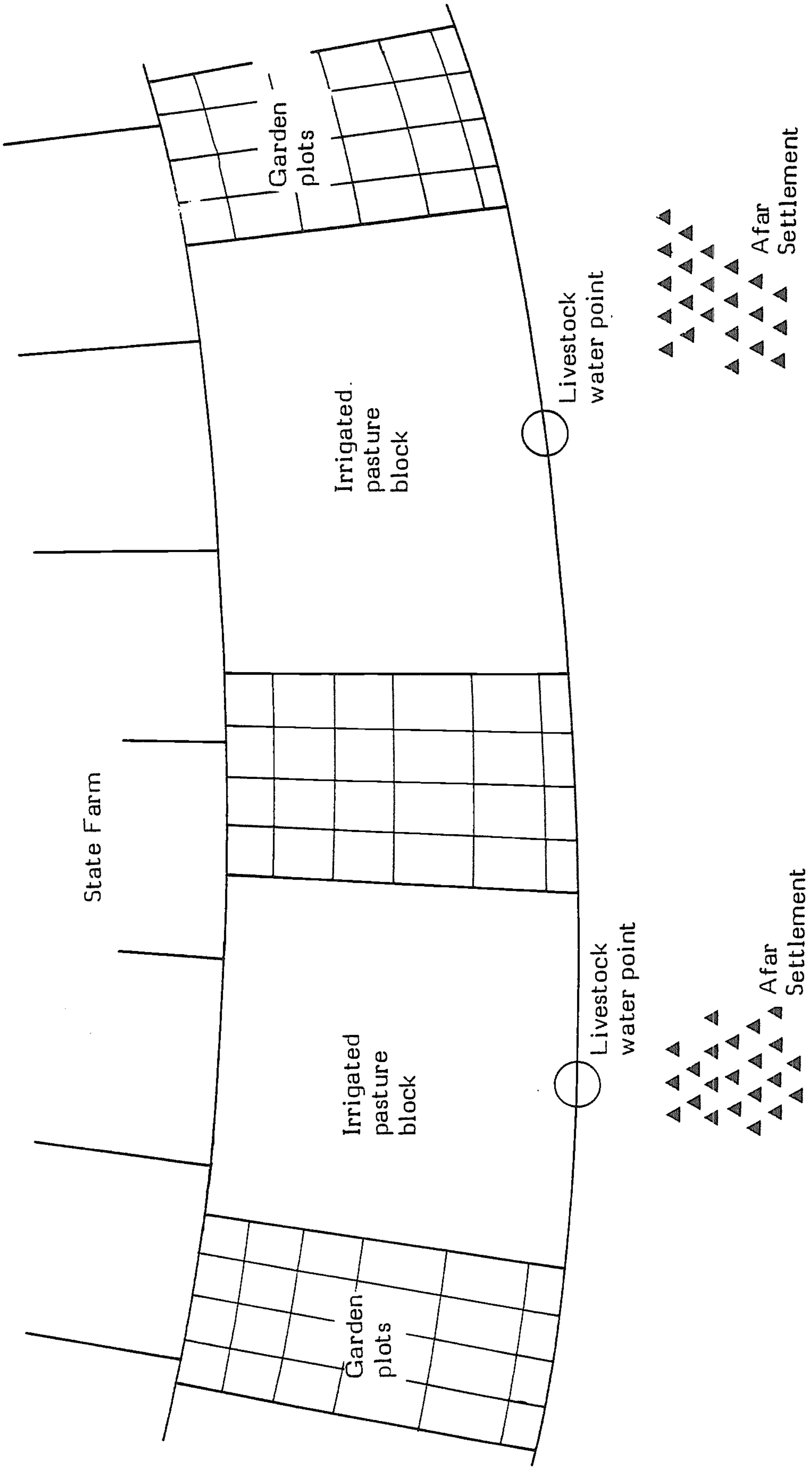
C3.3 Progressive Integration of the Afar

It is unlikely that all the Afar losing their customary grazing rights, or having to evacuate their villages, will wish to integrate themselves immediately into the irrigation scheme, or to avail themselves of the opportunities it offers, immediately. The rate of integration will depend very largely on the way in which the Afar develop during the period of preparation leading up to the implementation of the project, and on the success of the first Afar to take up the use of the irrigated pastures and gardens. They will be carefully watched by the others. There may be other factors as well which will influence the rate of integration. For example, a severe drought with heavy livestock mortality and low production could increase the attractiveness of the scheme; if the Afar are kept fully informed of the progress with the scheme, and consulted about their role in it and if the opportunities it is to offer are demonstrated to them through visits to other schemes (see Sections C1.5.1 and C2.3) they are likely to accept the KIP more readily; if the present small scale irrigation schemes in the Kesem/Kebena area and nearby flourish, and are seen to benefit from external assistance, they will stimulate interest in irrigation.

Bearing in mind that suspicion and resistance are likely to dominate the Afar attitude towards the KIP, an early start will have to be made in demonstrating to them that irrigation can be to their benefit, and that the KIP could provide opportunities which the present economy cannot. Even then, allowance must be made in the planning and phasing of the KIP for a variable rate of development of project facilities for the Afar, neither lagging behind nor being too far in advance of the demand by the Afar themselves.

Figure C 3.1

Diagrammatic Layout for Afar Irrigation Blocks and Settlements



As far as possible physical development of the 'settlement area' should keep pace with the demand by the Afar for irrigated holdings. For practical reasons, the larger canals and other engineering works will probably need to be constructed faster, so some areas may have to be left unused for a few years at first. The question of their use by state farms in the mean time would not arise, since the soils are not suitable for state farm crops.

Throughout this report the activities and institutions related to the support and integration of the Afar and Soudanis are referred to by the word 'settlement', although the Afar are not expected to settle completely during the lifetime of the project. This is to avoid confusion in the institutional context.

Institutional arrangements are discussed in Annex F. The settlement authority, which under present legislation would come under the Ministry of Agriculture, will need to undertake all dealings with the Afar, covering irrigation, agriculture, animal husbandry and range management.

There will be Afar who, despite the loss of their dry season grazing and their traditional villages, will not want to take up the use of irrigated pastures and gardens. The settlement authority should provide extension and training opportunities to help them to participate in the benefits of the KIP. If substantial numbers of non-participants remain too long outside the influence of the project, they are likely to oppose it, and trouble will ensue, as at Amibara. If this is to be avoided Afar should be involved as closely and as soon as possible in the planning and preparation of the settlement programme.

Further planning work will be needed on the settlement element of the project, at final design stage. This will be guided by the experience gained in the advance programme discussed in the next section.

C3.4 The Advance Programme

It will be some years before the KIP is commissioned. This period is an opportunity, which will not be repeated, for developing a working relationship between the Afar and the project authority. If this is left to the time when the bulldozers move in the chances of cooperation are minimal.

It is therefore recommended that a programme of support, assistance and basic services is mounted in the project area as soon as possible. It would begin by supporting those efforts at development that are already being made by the Afar themselves. The implementation of this advance programme should be carried out with the utmost sensitivity and care. Large or ambitious projects should be avoided at all costs, as they are more likely to engender apathy and dependency, or outright hostility among the Afar than to cultivate a spirit of self-reliance and determination to embrace new opportunities.

The advance programme would have a number of closely related objectives in the spheres of agricultural and livestock production and institutional development and training. They include:

- Providing material assistance and technical advice to the small scale irrigation schemes the Afar and Soudanis have established. An essential feature of this help is that it should not deprive the farmers of control over their own schemes, or remove the initiative from them. Large, expensive or technically complex innovations are likely to do this.

- Helping new groups of Afar and Soudanis who want to set up small scale irrigation schemes to identify suitable sites and to adopt the most appropriate methods of irrigation and agriculture.

- Investigate the possibility of rainfed agriculture, with the Soudanis' methods as a basis and to assist interested groups and individuals to apply this experience.

- Encouraging the use of oxen and camels for agriculture, earthmoving, and transport. This would require a small animal traction development unit in the project area, with facilities for making and testing equipment and for training the animals and their owners.

- Identifying and fostering those institutions among the Afar and the Soudanis which are best suited to assuming responsibility for development and change and for decisions on land use and resource management.

- Training Afar and Soudanis in technical and management skills related to agriculture, animal husbandry and health, forestry, human welfare and health, cooperative management, etc.

- Introducing clan elders and leaders to the potentialities for development, through a combination of training sessions and visits to other Afar projects, e.g. at Amibara, Gewane and Asaita.

These are examples of the activities to be undertaken in the period from the present up to the time when actual displacement of the Afar begins. It is not necessary or desirable to formulate a detailed programme for this period, since it is essential that the Afar and the Soudanis define their own requirements, and these will inevitably evolve according to the experiences of the early phase of the programme. One of the most important objectives of this phase is to give the local people the opportunity and the stimulus to develop the capability to formulate their own solutions to their problems and to implement them, while accepting external assistance without being overwhelmed by it. Accordingly, it is recommended that the advance programme be undertaken, at least in its initial phase, as a series of responses to local initiatives and requests and not as a project with planned activities and detailed budget.

The Agricultural Research Centre (ARC) at Melka Warer is actively engaged at several locations on the Awash river in helping groups of Afar to establish and operate small irrigation schemes. The ARC has already visited the Kesem/Kebena area and has seen the Afar schemes there, and has provided them with some free seed. They are prepared to continue visiting and advising as requested by local groups of farmers.

The ARC has few material resources of its own, but it has in the past persuaded the state farm authorities to provide earthmoving equipment to help groups of Afar farmers to start new schemes. For activities requiring funds, such as the training work and the animal traction unit, it is recommended that one of the non-governmental agencies be approached. Some of these have considerable operational and bugetary flexibility, and are able to respond to requests and disburse funds on the discretion of the local field director. The Oxfam field director and projects officer have visited the Kesem/Kebena area and have seen the Afar small scale irrigation schemes. They have expressed willingness to cooperate in the advance programme if this is desired.

If in the future larger scale developments, needing greater commitments of funds, personnel and resources are found to be appropriate, it will then become necessary to draw up a project document with costings and submit it to a funding agency.

The desirability of an advance programme has been discussed with Party officials in Saboret. They were strongly in favour of it and said that it is now Party policy to encourage this form of development.

The advance programme has to take into account the displacement of the Afar and Soudanis and the disruption of their normal pattern of life by the construction works, long before most of the new opportunities for irrigation can be offered them. This problem is inherent in irrigation schemes which take over land which is already occupied. A common solution is to offer the displaced people jobs in the construction of the scheme until they are able to be settled on irrigated land. This may be a partial solution for the Soudanis, but unless a very large number of jobs as guards is to be created it is unlikely to save the Afar from destitution. Their culture and their experience do not suit them to construction work. Consideration should therefore be given to opening up a number of small run-of-the-river or pump schemes, which would later be incorporated in the KIP itself, to serve as a temporary source of livelihood for the Afar until permanent holdings can be allocated to them and the first harvest is in. These preliminary schemes would aim to make good the forage deficit as the natural vegetation is cleared from the project area and to provide gardens for those who want them. The cost of this solution would be considerable, but is nevertheless calculable. The cost of doing nothing and hoping the Afar will somehow survive the construction period and then take up their irrigated holdings as planned, cannot be calculated, but is is likely to be far higher and the consequences are likely to be protracted and bitter.

Physical resettlement of the Afar will have to precede the in-field works of the irrigation scheme construction, within each phase. The loss of their dry-season grazing as the land is cleared of vegetation will have to be compensated. The sequence of construction, which is described in Annex K, is designed to ensure that irrigation of pasture areas is provided ahead of the development of the other areas whose dry-season grazing they replace. The relationship between the new areas and the clan divisions of the Afar will need to be studied carefully at the design stage, and the Afar themselves must be drawn into the process of devising a transition process.

C3.5 Resettlement of the Soudanis

The Soudani village of Tadecha Melka will become a peninsular, or possibly an island, when the Kesem dam reaches full supply level. With the exception of a few rainfed fields all their arable land will be inundated.

The population of 67 households (about 200 people) would therefore need to be resettled. On hearing of the possible implications of the KIP for them a gathering of Soudani elders suggested that if necessary they would move to a ridge they call Jebel Hallam, between Tadecha Melka and Saboret. They say there is flat ground there, suitable for rainfed agriculture.

To compensate for the loss of their irrigated land they would also need irrigated holdings on the KIP.

It is recommended that once the layout of the scheme and the full supply level of the reservoir have been fixed and the decision to proceed with the KIP has been taken, the project authority and the Soudanis together select a suitable site for a new village. When the scheme is more fully explained to them they may prefer to live closer to their irrigated holdings on the KIP rather than on Jebel Hallam, but they are constrained at the moment from making such a proposal by the hostility of the Afar to alien settlements on their territory. The Soudani presence at Hiddi is a special arrangement which does not give the Soudanis permanent residential or agricultural rights there, but only gives rights to the use of the land through their partnership with the Afar.

During the period between inundation and their first crop from the KIP the Soudanis will need alternative sources of income. They are likely to be keen construction workers and some households will be able to survive on the wages. They and the Afar should be given priority in recruitment. But there will be some households which will be unable to find construction jobs and cannot survive on rainfed agriculture. They will need irrigated holdings, which might be provided by the pump schemes proposed in Section C3.4.

At the time of writing it is not known how long the period between inundation and the first harvest from the KIP will be. Possibilities for agriculture around the shores of the reservoir, using residual moisture when the water level drops will be considered when the reservoir operation has been studied.

C3.6 Training

In the period leading up to the implementation of the KIP the Afar will have to undertake some major changes to their culture and economy. If they are successful in this and are thereby able to participate fully in the project, and to gain the maximum benefit from it, both their own future and that of the KIP would be greatly enhanced. If they remain in a state of unpreparedness, isolation and resistance they will experience much hardship, while the KIP will have to deal with their antagonism. Training provides no guarantee of smooth integration of the Afar into the KIP but without it the great majority of them will be unable to understand or benefit from the project.

It is recommended that training should start as soon as possible in the advance programme. The training staff, together with the elders, would select the trainees to attend Gewane Training Centre (see Appendix C3) for a variety of courses, including animal husbandry and health, irrigated crops and pastures, cooperative management, etc. From these trainees the Afar staff for the KIP would eventually be drawn.

CHAPTER C4

COST ESTIMATES

C4.1 General

The physical provision for the irrigation of the settlement area is an integral part of the project's irrigation, drainage and flood protection works which are described in Annex L. The capital costs within the settlement blocks are much lower than for State Farm areas, about Birr 4 700 in total (US$ 2 300 per net ha). These areas make up about 30% of the scheme area and use about 30% of the water, so it is reasonable to allocate to the settlement function 30% of the cost of common works such as the dam, diversion weir and primary canals. When this is done the share of overall capital costs attributed to the settlement function is only 106 million Birr, or 18% of the total. The proposed irrigated pasture areas mainly occupy the soils which are unsuitable for any other crops (except woodlots: General Suitability Class 5, Annex A). This means that the 'opportunity cost' of the provision for the Afars is quite low. Without the 30% share of the dam cost the allocated figure would be 70 million Birr instead of 106.

C4.2 Cost of the Advance Programme

It is recommended in Section C3.4 above that the Advance Programme should be managed very flexibly in response to local initiatives and response, not with a detailed prior plan. Nevertheless an estimate of its cost is needed for appraisal purposes. The estimate used for this study, which is set out in Table C4.1, is based on two full-time professionals with some part-time outside back-up. It provides for Type C housing for the two. A 4WD vehicle is assumed to last only 4 years and thus to be replaced once in the 8-year programme. The total estimate amounts to only 0.1% of the overall project cost and represents an essential preliminary rather than a disposable luxury. Its internal breakdown will, of course, need to be amended considerably as the programme is designed and modified. The estimate appears in Annex N as 'Package AA'. Economic pricing is explained in that Annex and timing in Annex K.

C4.3 Cost of the Range Development Programme

This progrmame, like the advance programme, must be flexible rather than rigidly planned in advance. The cost estimate presented in Table C4.2 is therefore an approximate one, but adequate for appraisal purposes for an element that only represents 0.1% of the whole project. It should be revised by specialists with local experience (such as that available in the Third Livestock Project) before implementation.

The estimate refers to range and environmental management rather than to range work alone, because in this context there is little difference and a separate environmental programme would not be cost-effective. It covers 6 years after which the KIP would be fully operational and its recurrent functions would be taken over by the settlement authority. Since large distances would be covered off-road, nominal vehicle life is reduced to 3 years in this case.

In Annex N, where the economic pricing is explained and also in Annex K, this element of project costs is referred to as Package RE.

TABLE C4.1

Cost Estimate for Advance Programme (Ethiopian Birr at 1986 Prices)(Package AA, SDU Nr 123)

Description		Amount
Staffing (8 years)	- leader	80 000
	- assistant	48 000
	- other	25 000
Periodic veterinary services		8 000
External part-time advice and assistance		90 000
One Type C housing unit (2 families)		115 000
Maintenance of house (0.4% per year)		3 680
One 4WD vehicle		40 000
Replacement of vehicle after four years		40 000
Spares and repairs (6% per year)		19 200
Fuel and lubricants		43 200
Equipment, seed, etc.		50 000
Sub-total		562 080
Miscellaneous and unforeseen (10%)		56 200
Sub-total		618 280
Supervision and administration (ca 6%)		36 420
Total Financial Cost		654 700
Breakdown of financial cost:		
- direct foreign currency		331 980
- indirect foreign currency		28 420
- local currency		294 300
Economic cost		571 800

TABLE C4.2

Cost Estimate for Range and Environmental Management (Ethiopian Birr at 1986 Prices)(Package RE, SDU Nr 122)

Description		Amount
Staffing (6 years)	- leader	60 000
	- assistant	36 000
	- other	22 500
External part-time advice and assistance		90 000
One Type C housing unit (2 families)		115 000
Maintenance of house (0.4% per year)		2 760
One 4WD vehicle		40 000
Replacement of vehicle		40 000
Spares and repairs (6% per year)		14 400
Fuel and lubricants		43 200
Equipment		50 000
Sub-total		513 860
Miscellaneous and unforeseen (10%)		51 390
Sub-total		565 250
Supervision and administration (ca 6%)		33 750
Total Financial Cost		599 000
Breakdown of financial cost:		
- direct foreign currency		367 590
- indirect foreign currency		35 740
- local currency		195 670
Economic cost		540 900

C4.4 Recurrent Costs

Once the KIP is in operation, the provision of services to the Afar and Soudanis, and the range and environmental maintenance, will be the responsibility of the settlement authority. Its staffing and equipment is discussed in Annex F (Institutions) and its housing and infrastructure costs are in Annex M. The recurrent cost for the 'Large Project' case is estimated at 264 thousand Birr for the settlement staff alone. A 30% share of the common costs of system operation and maintenance, including all staff and services, would increase this tenfold to 2.64 million Birr per year. It is, however, debatable whether the cost of services such as education and administration can or should be shared out in this way between state farm and settlement functions.

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The work would not have proceeded as smoothly as it did without the genial presence of Ato Mahamud Mohamed, our Afar coordinator, whose universal acceptance by the Afar was indispensible to our work among them.

Finally, we express our gratitude to the Afar themselves who, despite a reputation for ferocity towards strangers, received us with warmth and courtesy.

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APPENDIX C1

A SHORT HISTORY OF THE SHEK-HOGELE OF THE KESEM/KEBENA

This paper on the history of the Soudani (or Shek-Hogele) people was written as an introduction to the household survey at Tadecha Melka by Hassan, the young Soudani who carried out the survey. It has been slightly edited.

The Shek-Hogele tribes came originally from the Sudan. They migrated to Benashangul District in Wellega Province of western Ethiopia in approximately 1850.

From 1923 there were disagreements between the Shek-Hogele and Emperor Menelik and in 1936 he brought 15 Soudani men and 15 women from Assossa to Addis Ababa.

Shek-Hogele was the name of the king of Assossa, and the name passed to the people from Sudan who lived under his rule.

The 15 men who were brought to Addis became soldiers in the emperor's palace. At this time he was having trouble with the Afar and he decided to send the Soudanis as police to pacify the Afar, paying them small wages and a ration of food.

The Shek-Hogele settled at Tadecha Melka and began to raise cattle and plant maize. They dug a communal channel more than 3 km long from the Kesem river to irrigate their fields, using primitive instruments and their hands. Each year, until the present, the floods wash out the canal and the work has to be repeated. Much of the time the river is too low for them to irrigate.

The Shek-Hogele are Muslim. They make music by playing on a bamboo flute. Each man used to have the chance to take more than one wife, but now their economy does not allow them to have more than one.

Their main problems are:

(i) They do not have enough equipment to plough with.

(ii) Their gardens are washed out by the river and they get little food.

(iii) They have planted maize continuously for about 55 years in one place and the soil is exhausted.

(iv) Each year their cattle decrease due to lack of vaccinations. Many people lost their oxen and had to go to town to find a living.

(v) They have no clinic near.

APPENDIX C2

CONTACTS AND ADDRESSES FOR THE NOMADEP VEGETATION SURVEY

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APPENDIX C3

AMASABURE TRAINING CENTRE AT GEWANE

The centre was established by the MOA with the objective of introducing the Afar to food and cash crops. In this it was not greatly successful, and the centre was handed over at the beginning of 1986 to the Third Livestock Project. After a period of preparation and construction of new facilities it is due to reopen on 15th September 1986.

A survey of Afar attitudes towards development, conducted in 1983 by the MOA, showed a range of interests: among the priorities were:

- greater knowledge of animal health and veterinary care, plus the ability to procure the supplies to treat their animals, for which cooperative training was considered necessary;

- instruction in animal nutrition and forage and in range management and irrigated pastures;

- practical instruction in agriculture, particularly in the cultivation of maize and sorghum (cotton was specifically mentioned as a crop they did not want to grow).

The courses at the centre have been designed especially for Afar, Boran and Somali pastoralists and cover a range of subjects including animal husbandry, range management and the management of irrigated pastures and gardens.

The staff of the centre consists of a principal, three animal husbandry instructors and a general agriculturalist. The animal husbandry instructors are Afar, Boran and Somali, with qualifications from Junior Agricultural College. Each will instruct pastoralists of his own language group and will return with them to their own area to follow up the course with practical demonstrations. While he is away one of the other instructors will be holding a course at the centre.

The centre will accommodate up to 40 students at a time and the courses will last for two to four weeks. Training will be offered to pastoralists and to staff working with the pastoralists. The centre will also conduct special seminars and tours for elders and leaders of the pastoralist communities, to introduce them to the work and objectives of the centre, to help them select the right kind of trainee and to recruit their support for the innovative spirit of the trainees when they return.

No charge is made for the training, transport or accommodation. The centre is supported by funds from IBRD, French Technical Assistance and OXFAM.

APPENDIX C4

PERSONS CONSULTED DURING THE PREPARATION OF ANNEX C

Ato Adji Woldo: Afar notable, Ammadas
Ato Admasso: WRDA Livestock Specialist
Ato Ali Abdella: Afar Instructor, Gewane Training Centre
Ato Aschello: Pasture Agronomist, Melka Warer Research Station
Ato Bada Otuban: Afar clan leader
Ato Bashir: Chairman, Yalo Co-operative
Mr. Cora, Michel: ILCA
Mr. Cossins, Noel: ILCA
Mr. Sandford, Stephen: ILCA
Professor Fekadu Gedamu: University of Addis Ababa, Department of Anthropology
Ato Gebre Wolde MOA, Peasant Associations and Co-operatives Department
Gerard, Denis: French Technical Assistance, Addis Ababa
Ato Girma Bisrat: Third Livestock Project
Ato Guutu Jalleta: WRDA/PCC Amibara Irrigation Project
Ato Kabade: RRC, Doho
Ato Kidane Wolde-Yohannis: Range Management specialist, Third Livestock Project
Ato Mahamud Mohamed: Afar Co-ordinator, KIP Feasibility Study
Ato Mohammed Lo'oita: Administrator, Anibara settlement
Ato Mohammed Sagir: Airole small scale irrigation scheme, Gewane
Ato Nagash: MOA Organisation and Management Department
Ato Omar Ahmed: Amibara Peasants' Association
Ato Rasi Edaltu: Afar tribal leader, Doho
Ato Tamarat Kebebe: RRC
Dr. Tarafder Islam: WRDA, Economist
Ato Tarekegn Yacob: Manager, Awara Melka State Farm
Ato Teferra Woudeneh, WRDA/Project Engineer, KIP Study
Ato Telahoun Eshetu, WRDA/National Project Coordinator, DP/008
Ato Tekeda: MOA, Small Scale Irrigation Department
Ato Tesfaye Desta: RRC, National Projects Coordinator for Assistance to Settlement Schemes.
Ato Yebio W/Mariam: Melka Warer Research Station

Annex D:
Environmental Aspects

ANNEX D

ENVIRONMENTAL ASPECTS

CONTENTS

CHAPTER D1

INTRODUCTION

This is one of fourteen annexes which, together with the Main Report and two albums of drawings, constitute the Report on the Feasibility Study of the Kesem Irrigation Project. The study was carried out by Sir M. MacDonald & Partners Limited for the Water Resources Development Authority (WRDA) of the Government of Ethiopia, under contract to FAO as part of the UNDP-financed project DP/ETH/82/008.

This annex deals with the relationship between the project and its environment; their effects on each other and measures that can and should be taken to modify those interactions. Many particular aspects are dealt with in more detail in other annexes; the environment within the irrigation area is described in Annex A, the pastoral systems in Annex C, and the reservoir's catchment area in Annex I. For the sake of completeness, much of the relevant information contained in those annexes is summarised here, and cross-references are provided for the reader who requires further details.

Chapter 2 describes the present environmental situation. Chapter 3 discusses the various project elements in relation to their environmental interactions, and the project's specific measures to avoid adverse effects. Assuming such measures to be implemented, the environmental impact will be slight and positive, and a summary statement of that impact is given in Chapter 4.

A reference is listed at the end of the main text of the annex, and there is a list of abbreviations at the beginning of each volume of the report.

The work on environmental aspects within this study was of limited extent, sufficient to identify the main potential interactions, to formulate measures to modify adverse effects and to give a general assessment of the project's environmental impact. More detailed preparatory work and more quantitative reporting must await the final design stage. Despite these limitations, this annex goes considerably further than previous feasibility studies.

CHAPTER D2

THE PRESENT SITUATION

D2.1 General

The present environmental situation is not a static state of affairs nor an ecological balance, but a continually changing set of dynamic interactions. The physical areas involved can for convenience be subdivided as follows:

- the catchment area of the Kesem river down to the reservoir area;
- the proposed reservoir area;
- the Kesem-Kebena plain itself, which is approximately coterminous with the potential irrigation area described in Chapter A2 of Annex A and also represents the dry-season grazing area of the Afar;
- the area used by the various pastoralists for wet-season grazing, which extends to between 1 500 and 2 000 km^2;
- the Awash National Park, which overlaps partially with the pastoralists' grazing area.

These are described in turn in the next five sections, and Section 2.7 then discusses the various interactions and the current trends. The area is shown in Drawing 1, Album 1.

D2.2 The Reservoir Catchment

The Kesem river's catchment to the damsites covers about 3 000 km^2 and extends from an altitude of almost 3 600 m down to 860 m. It rises on the high Ethiopian plateau and descends the western scarp of the Great Rift Valley to join the Awash. The most prominent feature of the Kesem valley is the steepness of slopes linking the plateaux of the north, west and south extremities of the catchment with the gorges and canyons of the central area. The channels of the upper Kesem, narrow and highly sinuous features in fine sediments, cascade into narrow, flat-floored trenches where they braid amongst the boulder and cobble bed materials. For a large part of the central Kesem catchment the valley floor broadens, up to half a kilometre wide. Often, in the upper parts of this section, traditional irrigated agriculture interposes between the channels and the side-slopes. For the final section of its course the character of the Kesem changes once more as it becomes constrained in narrow gorges and canyons, interrupted at irregular intervals by wider reaches which have become depositional areas for coarse fluvial sediments.

Rainfall in the basin more than trebles with the rise in altitude from the Awash basin into the highland plateaux, though this increase is assymetrical, the north of the basin being much wetter (Figure I5.3). This is reflected in the more common incidence of terraced agriculture to the north of the main stem of the river. To the south only the high plateau area has extensive agriculture which, like that of the other plateaux, consists of a mosaic of cultivated plots. The lower parts of the basin are too dry for settled agriculture. A more detailed account of the area's geomorphology, and some photographs, can be found in Annex I, particularly Chapter I5, in the context of hydrology and sedimentation, and also in Section G2 of Annex G.

Much of the escarpment is almost unaffected by human activity, but on the plateau deforestation and agriculture have already had considerable effect. Soil erosion, though not dramatic over large areas, does occur: it is estimated (Annex I) that between 3 and 8 million tonnes of eroded soil pass the damsite annually as suspended load in the river.

D2.3 The Reservoir Area

The reservoir area, covering about 30 km^2, is generally dissimilar from the rest of the catchment area. Its topography is shown in Drawing I1 in Album 1 and its geology is described in Chapter G3 of Annex G and illustrated by Drawing G1 in Album 2. It consists of one of the river's depositional areas mentioned above, plus generally gently sloping land adjoining it. On the south side of the eastward-flowing Kesem the morphology is dominated by the rift valley's faulting, and a long arm of the reservoir extends southward into a tectonic trench: vegetation is generally very sparse. On the north side the slopes are more uniform and the drainage networks dendritic, on colluvium and old alluvium: vegetation is slightly heavier with coarse grasses and trees.

Most of the higher parts of the reservoir area are part of the pastoralists' wet season grazing areas described in Section D2.6 below. The central, low flat area includes a small patch of dense riverine forest and a small marsh. The area is the home of the Soudani group of people described in Section C1.2.3 of Annex C: they are both farmers and pastoralists, but since they number only about 200 their effect on the environment is not extensive. They live on small hills just south of the river and within the reservoir area.

D2.4 The Kesem-Kebena Plain

The plain is located on the left bank of the river Awash in the middle Awash section of the northern Rift Valley in an area known as the Afar Triangle. This part of the Valley is traversed by three significant perennial tributaries of the Awash; the Kebena, the Kesem and the Filweha rivers. In addition, several smaller ephemeral streams flow off the western escarpment of the Rift Valley, but are dissipated in the valley alluvium and never reach the Awash river. The plain is bounded to the north by Dofan Mountain, and to the south-east by the Filweha river and the immediately adjacent alkaline terrace escarpment. The Filweha rises in a series of springlines associated with a fault in the lava outcrops, which themselves form a natural southern boundary to the area.

The area is located at the base of the Rift Valley close by the series of ascending scarp faults that constitute the western side of the Rift. Following major faulting in the Tertiary and Eocene, a great thickness of complex silts, sandy silts, gravels and boulder beds have accumulated largely by deposition from successive drainage courses leading off the western escarpment.

There has been much re-working of the generally calcareous materials over time by river torrents which were, and continue to be, characterised by irregular changes in their courses. It is only close to the present Awash river meander belt that classic floodplain deposition has taken place, with heavy clays and silty clays in extensive backwater depressions and silty or fine sandy materials on river levees and other recent depositional sites. In contrast, towards the first fault scarp in the west, coarse colluvial outwash materials predominate with gravels, stonelines and boulder beds associated with local gullying.

A number of basaltic and cinder cone intrusions through the alluvial deposits indicates recent volcanic activity. In the centre of the plain, Gurmile Hill represents an inlier of basaltic lavas with several vents. Recent basalt flows also surround the Filweha springs which issue along a fault line in the lava. The soil at some sites is extremely hot, up to 60°C, within the surface 3 m.

The topography of the plain reflects the recent geomorphological history of this part of the Rift Valley. While gradients are generally west to east and flat or almost flat (0.1% to 2%), towards the west where there has been significant admixture of colluvium and/or coarse-textured alluvial outwash, slopes may exceed 4% with an undulating or gullied micro-relief.

Meandering gullies with sandy levees, and/or boulder beds, represent the former courses of rivers flowing across the area from the west. The floodplain of the Awash converges on these alluvials only in the eastern part of the area close to the Awash river, where it is characterised by level basins of heavy clay prone to seasonal flooding and locally pronounced levee formations. In the north-eastern extremity, runoff from Dofan accumulates to form a small permanent lake on the Awash flood plain, Lake Keles. A seasonal stream connects this lake with the Awash, flowing in alternate directions depending on whether the Awash is in flood or Lake Keles is overflowing. The only other major watercourse in the area is the seasonal Wadi T'unfeta which does not reach the Awash river, but ends in an outwash fan south of Dofan Mountain.

Located at about 750 m above sea level, the area experiences a typically tropical semi-arid climate with rainfall normally in the range 350 to 600 mm (mean = 470 mm). Temperatures vary from mean minima of 15°C and 21°C to mean maxima of 23°C and 38°C in December and June, respectively; frost is unknown.

The overall pattern of rainfall is weakly bimodal, approximately 60% of the annual total falling as the relatively reliable main rains between July and September, and a further 25% in a minor and less reliable period of rainfall peaking sometime during the period March to May. The driest 3-month period is November to January when only about 35 mm can be expected.

The plain lies within the Eastern Africa Ecoclimatic Zone V. The dominant shrubs and bushes of this zone have evolved a varied phenology in response to periodically severe soil water deficits developing a delicate balance between the perennial and annual species of the herbaceous communities.

The distribution of the principal vegetation types is shown on Drawings A5 and A6 in Album 1 and described in Section A2.5 of Annex A. It is governed by a complex of interacting factors such as salinity, sodicity, propensity to seasonal waterlogging, and human pressures. There have been some quite dramatic changes in vegetation over the last 20 years, seemingly associated with shifting watercourses. Most of the plain is covered by grassland, bushland and shrubland, though there are areas of woodland and forest near the Awash and Kesem rivers. Subject to intensive grazing throughout much of the year, and especially in dry seasons, the grass cover is generally short and sparse. Bare areas are common, particularly associated with intensely saline/sodic conditions, localised gullying and Afar settlements (see Section D2.6). Settlement sites are usually characterised by a surround of bare ground within which every single bush has been removed for the construction of huts and stock kraals. Seasonally wet areas have a cover of Cynodon dactylon (stargrass). There are also some swamps, both freshwater and sodic.

The soils of the plain are very variable and generally poor (Annex A). The main limitations for crop growth are the high silt contents and associated poor structure and drainage, coupled with widespread salinity and sodicity.

The present land use of the plain is for state farms with about 1 000 ha currently cultivated, and for dry-season grazing by patoralists. The farms (which are described in Sections B1.3 and L2 in Annexes B and L) grow fruit trees (270 ha), tobacco (300 ha) and cotton by run-of-river irrigation from the Kesem and Kebena rivers. There is no systematic drainage and many hundreds of hectares, mainly towards the eastern ends of the two systems, have been abandoned due to salinification. The remaining portion of the plain, more than 20 000 ha, is used by the Afar pastoralists, whose semi-nomadic system is summarised in Section D2.6.

D2.5 The National Park

The Awash National Park was established in 1966 with the avowed aim of conserving the flora and fauna of a sample of the semi-arid environment. At the time that the park was established the area was already heavily grazed by the pastoralists' ruminant animals, and indeed permanent habitations of these peoples were already well entrenched in the south-west part of the park, in the region of Fantale mountain. Apparently no provision was made to compensate these people for loss of grazing or in any way to alleviate the hardship that would be caused to them by loss of grazing rights. A fairly substantial payment was made to the land owner, but since he was not actively utilising the land in the area, this did nothing to improve the situation.

The result, as might have been predicted, is that this western area of the National Park is in fact a National Park in name only, the graziers being in de facto control. Much of the same situation exists in the northern part of the park, bordering the KIP area, where pastoralists' grazing animals periodically invade the area taking much of the available fodder. In this case however the habitations of the people (Afar) are outside the park boundary. These problems have resulted in something less than half of the park area being under full control of the park management. Even this situation has only been maintained by the tactful, patient approach of the park staff.

In spite of the problems, the park is conserving wildlife: 46 mammal species and over 400 species of birds have been identified, and over a period of one year the grazing incursion has not deteriorated and may have improved a little. However, there are losses, such as the Grevy's Zebra which has hardly been seen during the last three years.

Annually during the rainy season large amounts of standing grass are produced within the controlled part of the park. This grass cannot be fully utilised by the present game population of the park and goes to waste; it also presents a fire hazard, and if it is not used there will be a progression towards less productive species of grass and shrubs. Grass standing towards the end of the dry season tends to invite invasion by the pastoralists' herds from the overgrazed areas outside the park.

The Awash National Park is also an area of considerable natural beauty. It has three main attractions:

- the Awash falls and gorge;
- the Filweha hot springs and the associated pools;
- the crater of Fantale Mountain.

D2.6 The Pastoralists

A more or less self-contained pastoralist system exists from Dofan mountain in the north to the Fantale volcano in the south. It is bounded on the west by the foothills of the escarpment of the Rift Valley, and on the east by the Awash river. The system thus includes the foothills of the escarpment, which include the reservoir area described above and a tract of similar land to the north of it, which constitutes the catchments of the wadis described in Chapter L9 and the lower catchment of the Kebena river. All this land carries a light cover of thorny bush with sparse grass.

This whole area is populated by the Dabine tribe of Afar people, described in Annex C. They are transhumants rather than nomads, having permanent settlements in the dry-season grazing areas and moving out from there for seasonal grazing. Their grazing system covers some 2 000 to 2 500 km^2, though about 12 km^2 has already been taken by irrigation schemes and a further 440 km^2 is included in the National Park. It is estimated that some 12 000 Afar use the area, with cattle, camels, goats and sheep totalling around 50 000 livestock units.

There is another pastoralist subsystem nearby, namely, that of the Kerayu who graze their animals in the south-west part of the National Park. This however lies outside the area involved with the KIP.

The overlap of the Afar grazing land with the National Park is fairly slight, along the northern boundary of the park south of Doho. The use of part of the park by the Kerayu, mentioned above, is more significant for the park authorities but not for this project. All the pastoralist groups recognise some approximate boundaries to their grazing areas, but these are not sharp boundaries and they tend to change according to the rainfall, human and animal population fluctuations, and the outcome of conflict between neighbouring groups. The area north of Fantale volcano tends to be disputed or shared between the Afar and the Kerayu (see also Annex C; there was fighting here during 1986).

The effect of the pastoralist systems on the natural environment is varied. A degree of overgrazing tends to occur wherever the animals are concentrated for long periods. The pastoralists decide where to keep their animals at any time not only on the basis of available grazing but also that of drinking water for the animals. In particular, the drying-up of drinking water sources often governs the timing of the return to the Kesem-Kebena plain at the beginning of the dry season.

D2.7 Interactions and Trends

The ecological systems of the area are not in equilibrium. None of them operates without interference from its neighbours. The original overall system in the area must have been not unlike the National Park, the fodder resources being exploited solely by the wildlife. With the advent of human immigration along with domesticated grazing animals, the situation changed but the grazier initially lived in balance with the system. As the human population increased, however, the numbers of domestic animals increased to the detriment of the wild animals. Finally came the era of the irrigated farms which competed directly with both the graziers and the wildlife, in that areas of relatively high dry season productivity were taken out of the grazing system.

The present trend is one of gradual deterioration of most of the vegetal cover, though without separate, detailed studies some years apart this cannot be quantified. It may be that the sediment load carried by the ephemeral wadis that enter the western edge of the Kesem-Kebena plain (whose interaction with the project is analysed in Annex L) is increasing, so that the present extent of their terminal fans may not be a good guide to their future sediment regimes. The catchments of the Kesem and Kebena rivers, which extend up into the highlands, are also probably changing their characteristics from decade to decade. The felling of trees for firewood is not extensive at present, since the total population is only of the order of 20 000 people in the area covered by the pastoralist system and farms (i.e. about 2 500 km^2: an average density of only 8 per km^2), and because there is no major road passing through the area such as would encourage a trade in charcoal and fuelwood. With increasing demand in urban centres, this may change in the long term.

The present irrigation activities, being on a limited scale, do not have a large impact on water resources either in terms of quantity or of quality.

D2.8 Proposals in Other Reports

The most relevant existing report is NEDECO 1986 (Ref. 1), which in its Annex 10 gives estimates and recommendations concerning afforestation and fuelwood demand and production. Among the options discussed are:

- Trees combined with irrigated pasture, such as Eucalyptus camaldulensis planted in rows 10 m apart.

- Managed forests on seasonal flood plains, for fuelwood and grazing: for instance Acacia albida, Leucaena leucocephala and Prosopsis juliflora spaced 3 x 3 m with improved drainage in some areas.

- Managed forests on higher ground in conjunction with water harvesting: Eucalyptus spp., Acacia albida, or Prosopsis juliflora are suggested, but these woodlots would need to be fenced.

- Planting of tolerant tree species on saline soils: Tamarix aphylla, Prosopsis juliflora or Salvadora persica.

- Managed afforestation in swampy areas, with Eucalyptus camaldulensis or E. robusta, and Acacia spp. (particularly A. nilotica which is already established on the Kesem-Kebena plain).

It shall be noted that this NEDECO report is a final design document. None of the previous feasibility studies in the area has included significant material on environmental aspects.

CHAPTER D3

THE PROJECT ELEMENTS AND THEIR ENVIRONMENTAL EFFECTS

D3.1 General

The main elements of the proposed project are:

- the dam, described in Annex J;
- the irrigation scheme, described in Annex L;
- the buildings, services and infrastructural developments, described in Annex M;
- the measures concerned with livestock, pastoralists, and range management, described in Annex C.

This chapter considers each in turn and describes its potential environmental effects and the measures proposed to modify them. It also includes the necessary monitoring, and mentions the costs of the measures.

It is neither necessary nor appropriate to define the arrangements for environmental protection in great detail at feasibility study stage, provided that significant effects are identified and estimated costs are adequate. As with the physical construction details of the dam and irrigation scheme, such matters can and should be worked out at final design stage, though this should be done early in that work rather than as an afterthought.

D3.2 The Dam and Reservoir

The proposed reservoir will flood an area of about 30 km^2 at top retention level, and 40 km^2 briefly during extreme floods. The main dam will be confined to the Kesem gorge, but there will also be a separate spillway, a saddle dam, and a few low banks on minor saddles in the reservoir rim. The water level will vary widely, the reservoir being almost empty by the end of some dry seasons and spilling by the end of some wet seasons.

The reservoir will trap river-borne sediment and release almost sediment-free water which potentially can cause degradation of the river bed downstream. In view of the coarse and armoured bed deposits, however, the latter effect will be minimal.

Vegetation in the reservoir will die and water quality will be affected by its decay, but this will be a passing phase in the first few years and will not cause major problems.

There will be occasional brief flooding of the land between top storage level and top flood level. This will preclude the establishment of permanent settlements on such land but not its use for grazing, and will not have a marked effect on vegetation (depth will not exceed 10 m and duration will be a few hours or, at most, a day or two).

The full reservoir will form four islands but none of them will disappear during floods. A few other islands will form and then be submerged during filling, and wildlife could become trapped on these. The distances to dry land will not be great, and it is suggested that most of the wildlife should be driven off such areas, by means of controlled grass-burning, just before each one becomes an island. This will only need to be done during initial filling, and perhaps once or twice more in early years, since thereafter the effect of inundation on vegetation will discourage the return of significant numbers of fauna.

The reservoir will offer scope for fishery development on a modest scale, and this should be investigated at final design scale. The extreme level fluctuations will however limit the fishery potential.

Tne tourism potential of the reservoir will be small because of the relatively remote location and the water level fluctations: the new lake is unlikely to compete with natural Rift Valley lakes and with crater lakes. The lake would, however, marginally increase the attractiveness of the north-west corner of the National Park, both to animals and to tourists.

Deliberate measures to modify these environmental effects are few. Trees growing close to the dam and the large trees in the small patch of forest, should be removed before impounding to avoid debris problems at intakes, and it will probably be worthwhile to remove trees over most of the reservoir area as well, in order to facilitate fishing and reduce the effects on water quality of their gradual decay. The value of the timber is assumed to cover the cost of removal, which can be done by authorising and encouraging the making of charcoal and the extraction of fuelwood during the construction phase and the dry seasons of the first few years of operation.

The reservoir will flood the land inhabited and used by the Soudanis, who number about 200. They are able and willing to move to another area and to take advantage of irrigated pasture and gardens on the irrigation scheme.

The safety of the dam will be dealt with by appropriate design: it is proposed to design for the PMF (probable maximum flood), although the probability of occurrence of a flood approaching that magnitude is remote. Spillway discharge will cause local erosion in the gorge, which will be closely monitored and will not represent a significant threat.

D3.3 The Irrigation Scheme

The proposed irrigation, drainage and flood protection works are described in Annex L and the agricultural proposals are in Annex B. Although the main design work in this study is for the so-called Large Project, affecting some 16 000 ha, economic considerations are likely to lead to the selection of only about 10 000 ha of the plain for irrigated development, as in the Medium Project analysed in this report. In the latter case most of the forest and woodland would remain outside the scheme. A proportion of the irrigated area, generally on the poorer soils and around the periphery of the scheme, is to be devoted to the Afar who would initially use almost all of it for irrigated pasture (to compensate the loss of some of their present dry season grazing) while gradually developing up to 20% of it for smallholder food and cash crops.

The environmental impact of the irrigation scheme within its own boundaries will, of course, be enormous. In place of bushland, shrub land, grassland and bare patches on varying and largely saline or sodic soils, there will be large expanses of agricultural land provided with irrigation supplies and also effective drainage: more than half the area will be served by buried field drains. Most of this land will support crop rotations with intensities of around 150%, involving cotton, tobacco and cereals. A small area will grow fruit trees and isolated patches will be devoted to irrigated woodlots harvested for fuelwood. Saline and sodic soils will, where practicable, be reclaimed by leaching. Flooding will be prevented, except for occasional brief flooding of some low-value and low-lying pasture or woodlot areas. Agricultural chemicals will be used, both for pest and disease control and as fertilisers.

The drainage water from this scheme will discharge into the Awash river, where it will be diluted manifold and carried away downstream. During early years it will contain significant quantities of salts from the leaching operation, but in those years there will also be surplus dry season flow from the Kesem reservoir which will dilute such drainage water and keep salt concentrations down. The concentrations of chemical residues will depend on management practices, but provided reasonable care is taken the dilution and chemical changes in the Awash river, will prevent serious consequences for downstream users (the Amibara intake is on the Awash, upstream of all Kesem drain outfalls, and is not affected).

The main environmental protection measures required within the irrigation scheme concern these agricultural chemicals. They are mentioned in relevant places throughout Annex B and health aspects are covered by Section E3.6.10 and Appendix EV in Annex E. In addition to the usual care and good professional practice required in the use of such chemicals, the Consultant strongly recommends that the insecticide DDT should not be used for agricultural purposes at all, being reserved for malaria control and then used in relatively small amounts. Failure to take these precautions could lead to a build-up of persistent residues and to the development of insect strains with immunity to this chemical.

Provided that this report's recommendations on reclamation of sodic and saline soils, and on soil management generally, are followed, the scheme will improve the soils it uses.

In the irrigated pastures it is recommended that improved grass species be gradually introduced and that a few large trees be left standing (and replaced when they die) to provide shade. This represents an improvement on the present sparse vegetal cover of these areas.

D3.4 Infrastructure and Health

The proposed project includes housing, water supply and sanitation for the immigrant population, and also services such as administration, police, health and education. Water supply will probably be from groundwater, though treated river water could also be used: present fluoride levels in groundwater are acceptable, and significant increases on sustained pumping are possible but not probable. Sanitation is to be water-borne for the major and denser settlements and by improved pit latrines elsewhere, with due consideration given to the direction of groundwater flow. Health services are to be extensive, with some 18 clinics in the Large Project case: environmental health and health services are covered in some detail by Annex E.

The project is to have one main access road, the present one from Metahara to Saboret round the west and north of the Fantale volcano. This passes through the fringe of the National Park, but that part of the park is not effective for consrvation purposes at present anyway. The existing track from Awash Town to Doho and Yalo is to be kept open but little used: it also crosses the fringe of the park. The existing central track via Filweha springs is to be closed to all traffic at its northern (project) end, to avoid any impact on the core area of the park through which it passes. The transmission line is to be routed along the park's eastern edge for the same reason, though it will anyway be very inconspicuous in comparison with the existing steel pylon line through the park near the east-west highway.

The potential environmental effects of these project elements have thus already been minimised by appropriate design decisions. It was considered that the main access road might be routed round the west and north of the reservoir, so as to enable the lake's southern side to be developed as an effective part of the National Park, but the road and bridge would have been very costly indeed (passing through a heavily faulted zone south and west of the reservoir) and the exclusion of pastoralists from the area would have been very difficult, so this was not incorporated in the project.

During the operation of the project, great emphasis must be placed on the measures proposed for disease prevention and health education. Of particular importance are the control of malaria and schistosomiasis, by insect control and by good canal maintenance, drainage and water management.

D3.5 Livestock and Range Management

The area currently supports about 12 000 transhumant pastoralists with up to 50 000 cattle, sheep, goats and camels. The proposed project includes elements to support them, described particularly in Annex C but also in Annexes B and L, notably the following:

- irrigated pasture to replace lost dry-season grazing;
- an advance programme of assistance and advice to encourage and enable the Afar to take up the new opportunites the project offers (Section C3.4);
- a range and environmental management programme to maintain and develop the wet-season grazing area, i.e. the surrounding lands and the escarpment and volcano foothills.

The potential environmental effects of the project in this context could include destruction of the pastoralist system if the project it did not compensate the loss of dry-season grazing, ecological disturbance locally if it causes the pastoralists to be concentrated in small areas, and deforestation if the immigrant population draws fuelwood from the surrounding area.

In fact, however, the project's formulation and design include measures to avoid all these negative effects. The irrigated pasture will replace the lost grazing and the woodlots within the state farms will satisfy the fuelwood demand. The advance assistance programme will help the Afar to adapt and to use the new opportunities. The range and environmental management programme will maximise the benefit obtained from the surrounding country and safeguard its ecology. The monitoring programme will watch for any incipient problems throughout the project's life.

The main features of the range and environmental management programme are:

- water conservation, to extend the use of existing grazing both in time and space by removing the drinking water constraint and also to increase grass growth: contour bunds, small dams and hafirs can store water for a few weeks or months after the rains, and also spread water efficiently;

- soil conservation, by the usual means and enhanced by the other features;

- improvement of grass species: the invasive but useless Tacazza yetotacela (called Anlemaro by the Afar) should be discouraged by severing a few centimetres below the ground and more productive fodder plants should be introduced, initially just uphill of the water harvesting bunds (e.g. Atriplex, Styloxanthes, Cenchrus ciliaris).

Afforestation outside the irrigation scheme is not proposed as part of the project: the woodlots within the scheme will provide sufficient fuelwood.

It is not proposed to design these elements of the project in this feasibility study, since their details are not vital to its feasibility and since there is no provision to collect the necessary field data. A study of the affected areas by a well qualified ecologist and other technical experts as needed, should be included at the design stage after a decision on the project's implementation has been made. By that time valuable experience should have been gained on the neighbouring Angelele-Bolhamo scheme. A process of progressive experimentation and learning should be followed, starting with a wide variety of pilot trials, rather than attempting to design the complete package in advance.

D3.6 Effects of Environmental Changes on the Project

Any change in the vegetation of the catchment areas of the two rivers and the various wadis could have a very serious effect on the project. Loss of protective vegetation in the Kesem catchment, most of which will be outside the control of the project, would increase flood flows, decrease dry season flows and increase sediment transport: in all these ways it would reduce the reliable yield of the reservoir, and its useful life. Similar changes in the catchments of the Awash, the wadis and the Kebena would at best make the maintenance of the flood control works more difficult and costly, and at worst require their redesign and modification or extension. The range and environmental management programme will help to protect the nearer catchments.

The measures needed to preserve the soils and vegetation of the Kesem river's catchment area are generally outside the scope of the project itself, and will have to be left to the relevant national authorities. Once the decision is made to build the Kesem dam, it would be in the national interest to give its catchment high priority within the national soil conservation effort.

D3.7 Monitoring

Although the project is not expected to have large negative effects on the environment, it will be necessary to establish and maintain, throughout the project's life, a monitoring procedure to check on this and to provide early warning of any incipient problems. The main parameters to be monitored will be:

- vegetation populations in the surrounding areas, corresponding roughly to the wet-season grazing area of the Dabine Afars (both overall cover and the balance of different species should be watched);

- water quality in drain outfalls and the Awash river downstream, noting any seasonal fluctuations;

- wild animal, bird and insect populations in the area, particularly the National Park;

- any tendency to wind erosion;

- sediment load of all the natural watercourses in the area, especially the two rivers and the various wadis;

- land use and vegetal cover in the Kesem reservoir catchment;

- incidence of disease vectors, particularly those associated with water;

- groundwater levels and quality, both in the locally recharged aquifers and the various hot springs of volcanic origin.

This monitoring will need to be centrally organised, though the routine work can be delegated. Since water is the linking factor between KIP's constituent parts, the Kesem Water Resources Office (KWRO, see Annex F), should be responsible for seeing that all the monitoring is done and for bringing together a brief report each year. Some of the field work, data collection, and preparation of specialised parts of the report would be entrusted by KWRO to appropriate specialists such as the National Park authorities, health services, and livestock authorities.

D3.8 The Construction Phase

Unless conscious efforts are taken to avoid them, the project could have bad effects on the environment during the construction phase. Displacement of livestock before compensating pastures are ready could cause livestock losses, pressure on other grazing and serious social tensions. Access roads, borrow pits and temporary works could cause erosion, health hazards and disruption of the pastoralist system.

The project formulation has already dealt with the first problem by ensuring that the sequence of commissioning of the various irrigated blocks is such that irrigated pasture is always commissioned before construction begins on corresponding significant areas of existing grazing land (Annex L, Sections L3.4 and L11.2.2). The other aspects must be borne in mind during the final design and construction periods, but will not cause serious constraints or problems.

D3.9 Costs

It is impossible to state the cost of the measures to protect the environment because they are integral parts of many of the project's elements. The tentative cost estimate for the range and environmental management programme is Birr 540 900 and the details are given in Annex C (Section C4.3) because of the close connection with livestock: this covers the first six years, and thereafter the on-going work is covered in the recurrent costs.

CHAPTER D4

SUMMARY OF ENVIRONMENTAL IMPACT

The previous chapter has considered the project's potential effects on the environment, and its built-in measures to modify or limit those effects. In this chapter, the environmental impact of the project is summarised, on the assumption that all the proposed measures will be implemented.

(a) Land Use

The main impact will, of course, be the complete transformation of a part (probably between 9 000 and 16 000 ha) of the Kesem-Kebena plain from sparsely vegetated, partly salinised, partly seasonally flooded grazing land to a permanently and systematically irrigated area which will include irrigated pasture to replace the lost grazing. The surrounding area will continue to be used for wet season grazing, but the length of season and the use of forage will be improved. Tree planting will be confined to the irrigation scheme. An area of about 30 km^2 (3 000 ha) will be occupied by the reservoir instead of sparse grazing land, and the small areas of rainfed and irrigated agricultural land used by the 200 Soudanis will also be lost: the Soudanis will receive irrigated land on the scheme in more than adequate compensation.

(b) Vegetation

Apart from the obvious effect on the irrigated area itself, the project will improve the grass species in the wet season grazing areas. It will not have any direct effect in the rest of the Kesem catchment, but may influence national priorities in favour of that area and thus indirectly result in conservation measures.

(c) Soil

Soils within the irrigation scheme will, in many parts, be improved by reclamation from sodic and/or saline conditions. Prolonged cultivation of the siltier soils will require special management efforts to counteract the tendency towards deterioration of soil structure. In the surrounding areas the range and environmental management programme will improve soil conservation and help to limit soil erosion. In the Kesem catchment there may be an indirect effect, as mentioned above in connection with vegetation, through influence on national priorities in the soil conservation field.

(d) Water

The project will conserve water from the rainy season and use it in the dry season. Both the discharge of extra water down the Kesem and the return of drainage flows will increase the dry season flows and decrease the flood flows in the Awash river, to the benefit of downstream users. The effect on water quality is expected to be slight, provided that this report's recommendations on agricultural chemicals are followed: drain return flows will be heavily diluted in the Awash, and deterioration of water quality due to rotting of vegetation in the Kesem reservoir will be transitory and without severe effects. The discharge of extra salts during leaching will also be a brief and passing phase.

(e) Livestock

Conditions for livestock will improve, due to the irrigated pastures, the range improvements, and the services provided to the pastoralists. Livestock numbers will probably increase, but not beyond the carrying capacity of the grazing land and pasture. The whole pastoralist system will become much less vulnerable to drought.

(f) Wildlife

Impact on the Awash National Park will be slight: the existing roads to the east and west of the park will carry more traffic than at present, but the north - south road through the middle of it, which now links the Awash - Metahara highway with Saboret via Filweha spring, will be closed at the north end. There will be a power line along the park's eastern edge, but this will be much less obtrusive than the existing steel-pylon one that runs across the middle of it. Wildlife outside the park may encounter more competition for grazing due to larger livestock numbers, or less due to rangeland improvements, but the effects will be slight. The crocodiles now inhabiting the Kesem river, which lay eggs within sight of the existing diversion weir, will probably continue to co-exist with the project.

(g) Environmental Health

In this respect conditions will at least be better than without the project, since extensive provisions are included in the proposals. (Schistosomiasis is not a major problem now, but could well become one in the future on the existing irrigation areas, in the absence of the KIP.) The project will include active measures against specific diseases such as malaria and schistosomiasis, and also health education and community health programmes both among immigrant farm workers and among the indigenous pastoralists.

(h) Social Interactions

Though perhaps beyond the scope of this annex, these should be mentioned for the sake of completeness. The main issue is the interaction of the 12 000 Afar with the project. Taking advantage of extensive and sometimes unfortunate experience on other projects, this project will make realistic and extensive efforts to bring the Afar willingly into a new and advantageous relationship with the outside world, at the same time introducing them to agriculture and thus making their livelihood much less vulnerable to droughts, diseases and other natural hazards. The project will bring tens of thousands of others, mainly highlanders, into the area and will provide them not only with a livelihood but also with services such as education, health and recreation facilities.

(i) Tourism

Recreational use of the Kesem reservoir will be very limited because of the water level fluctuations, and with several more attractive lakes in and near the Rift Valley the touristic potential of the project is expected to be very slight.

(j) Fisheries

There will be a small scope for fishery development in the reservoir, but this is not expected to reach a significant scale because of the level fluctuations. The distance to any large market centre is also considerable.

(k) Monitoring

The project proposals include a monitoring programme so that any adverse interactions that may begin to develop can be detected early and thus effectively countered.

REFERENCE FOR ANNEX D

1. NEDECO 1986 Angelele-Bolhamo Irrigation Project, Consulting Services for Final Project Design.

Annex E: Health

ANNEX E

HEALTH

CONTENTS

APPENDICES

LIST OF FIGURES

CHAPTER E1

INTRODUCTION

This is one of fourteen annexes which, together with the Main Report and two albums of drawings, constitute the Report on the Feasibility Study of the Kesem Irrigation Project (KIP). The study was carried out by Sir M. MacDonald & Partners Ltd. for the Water Resources Development Authority (WRDA) of the Government of Ethiopia, under contract to FAO as part of the UNDP-financed project DP/ETH/82/008.

This annex covers general and environmental health aspects of KIP. Chapter 2 reviews the present situation and available information, while Chapter 3 discusses the needs of KIP and makes recommendations. Chapter 4 reproduces some detailed costs provided by the MOH. References are listed at the end of the main text of the annex, and there is a list of abbreviations at the beginning of each volume of the report.

The work of the Consultant on these matters has been complemented and greatly assisted by field survey carried out by WRDA's Environmental Health Unit in April 1986. It covered parasitology, malacology and entomology in the project area. The survey was the source for much of the quantitative data in this annex, including that given in the first four appendices.

The proposed Kesem Irrigation Project includes an area of land traditionally grazed by Afar people. Various estimates have been made of the population (Ref. 2, 3, 4) to be about 12 000 with an average family size of 6, increasing by 2% per annum. Within this area there are two state farms which have attracted settlers mainly from the highland regions. This would seem to be the probable pattern when the irrigation scheme is completed. Basing the number of workers on the amount of irrigable land there will be approximately 60 000 when the scheme reaches its full potential. Allowing for the increase in population, a rough estimate of 70 000 can be made for the population needing health facilities. However, the needs and types of facilities are quite different. The easier group are the settlers who are comparatively static, but the more difficult problem is to bring some form of health care to the mobile Afar. In attempting to integrate the Afar with the settled communities, responding to their health demand, will be a crucial factor. It is important to understand these two different types of requirements and health care must be provided on this basis.

As well as the larger undertaking of the irrigated area, it must not be forgotten that the dam on the Kesem river and the reservoir that will be created will also have health implications. These will be briefly mentioned.

CHAPTER E2

AVAILABLE INFORMATION AND FACILITIES

E2.1 Local

Five clinics exist within the project area, one each run by the state farms in Awara Melka and Yalo respectively, and three by the Ministry of Health. These are the two constructed by NOMADEP (Ref. 5) (one in Awara Melka and the other in Yalo) and a small satellite clinic at Doho in the south of the area. They each have one health assistant except for Yalo which has two. There are also cleaners and other untrained helpers.

The health assistant at Awara Melka State Farm Clinic is to be commended on keeping excellent statistics, which showed the following disease pattern:

	1974 EC (1981-82 in European calendar)		1975 EC (1982-83 in European calendar)	
	Number	Per cent	Number	Per cent
Malaria (unconfirmed)	6 684	18.6	2 900	12.7
Respiratory infections	6 000	16.7	3 000	13.2
Dysentery	4 600	12.8	2 350	10.3
Accidents	4 200	11.7	1 000	4.4
Intestinal parasites	4 000	11.1	1 600	7.0
Gastroenteritis	2 200	6.1	1 000	4.4
Others	8 316	23.1	10 900	47.9
TOTAL	36 000		22 750	

In addition trachoma, sexually transmitted diseases (STD) and anaemia were common. The majority of the patients were settled workers, the wandering Afar being particularly susceptible to trachoma and tuberculosis (including glandular), and suffering from malnutrition (Ref. 4). There was a similar pattern in the other clinics. An unexpected finding was the large amount of dysentery, particularly amoebic.

The health assistant had also mapped out the seasonal pattern of disease both in total number and for the predominant problem, malaria. These are illustrated in Figure E1.

This shows a seasonal pattern with maximum attendance in November, December and January and least in May and June. Although malaria has its lowest number in May, it does not follow this seasonal pattern.

A health problem that is often forgotten yet demands more attention than any other single entity is maternal and child health. (Infant mortality was reported to be 200 per thousand amongst the Afar (Ref. 4).) None of the clinics provided ante-natal care or did vaccinations, and deliveries in the clinic amounted to about 2 to 6 per month. Clearly the majority of deliveries took place outside any medical care and the Consultant was fortunate in meeting a traditional midwife of the Afar people who described the service she provided.

There were two such women in the village and between them they had delivered all the children. Delivery was in the squatting position and because of the practice of female circumcision, the vulva had to be cut on each occasion (this was not repaired). The cord was ligated and cut off to about 2 inches, but no poultice (such as with cow dung) was placed on the stump (Ref. 4). She observed rudimentary hygiene and knew how to handle some complications (such as breech delivery, retained placenta and twins). She examined patients antenatally and knew which ones to refer. She also knew how to treat trachoma and other medical conditions following basic training by NOMADEP (Ref. 5). Clearly she provided an important and effective service that was largely ignored by the established health services. Afar interpretations and attitudes to illness have been reviewed in Reference 4.

E2.2 Regional

The adjacent irrigation project at Amibara provided a very good model on which Kesem was likely to develop. There were 5 clinics, three run by the state farms, one by the Ministry of Health and one by the Relief and Rehabilitation Commission (RRC). In constrast to the clinics described above they were all, except for two, grossly overstaffed with the wrong type of categories.

Melka Sadi (SF)	had 2 health officers, 1 nurse, 10 health assistants and 1 laboratory technician.
Melka Warer (MoH)	had 4 nurses, 3 health assistants and 1 sanitarian.
Amibara (RRC)	had 1 nurse, 1 health assistant, 1 trainee HA.
Amibara (SF)	had 4 health assistants, 1 nurse, 1 laboratory technician.

The disease pattern was very similar with malaria as the most important, but diarrhoeal diseases a close second. Amoebiasis was particularly high (third most common problem in Amibara RRC clinic) and these were in confirmed cases from stool examination. Respiratory infections, especially tuberculosis in the Afars were important. STD (in the settlers) and eye infections, trachoma in the Afars and severe conjunctivitis in cotton pickers.

The state farm clinics provided essentially curative services and despite electricity and excellent facilities did no vaccinations, antenatal care or environmental health. In contrast the Ministry of Health clinic which was inferior in both structure and equipment provided comprehensive maternal and child health care and employed a sanitarian who endeavoured to visit the whole estate advising on water supplies and sanitation. It is proposed that Melka Sadi should become a 60 bed hospital.

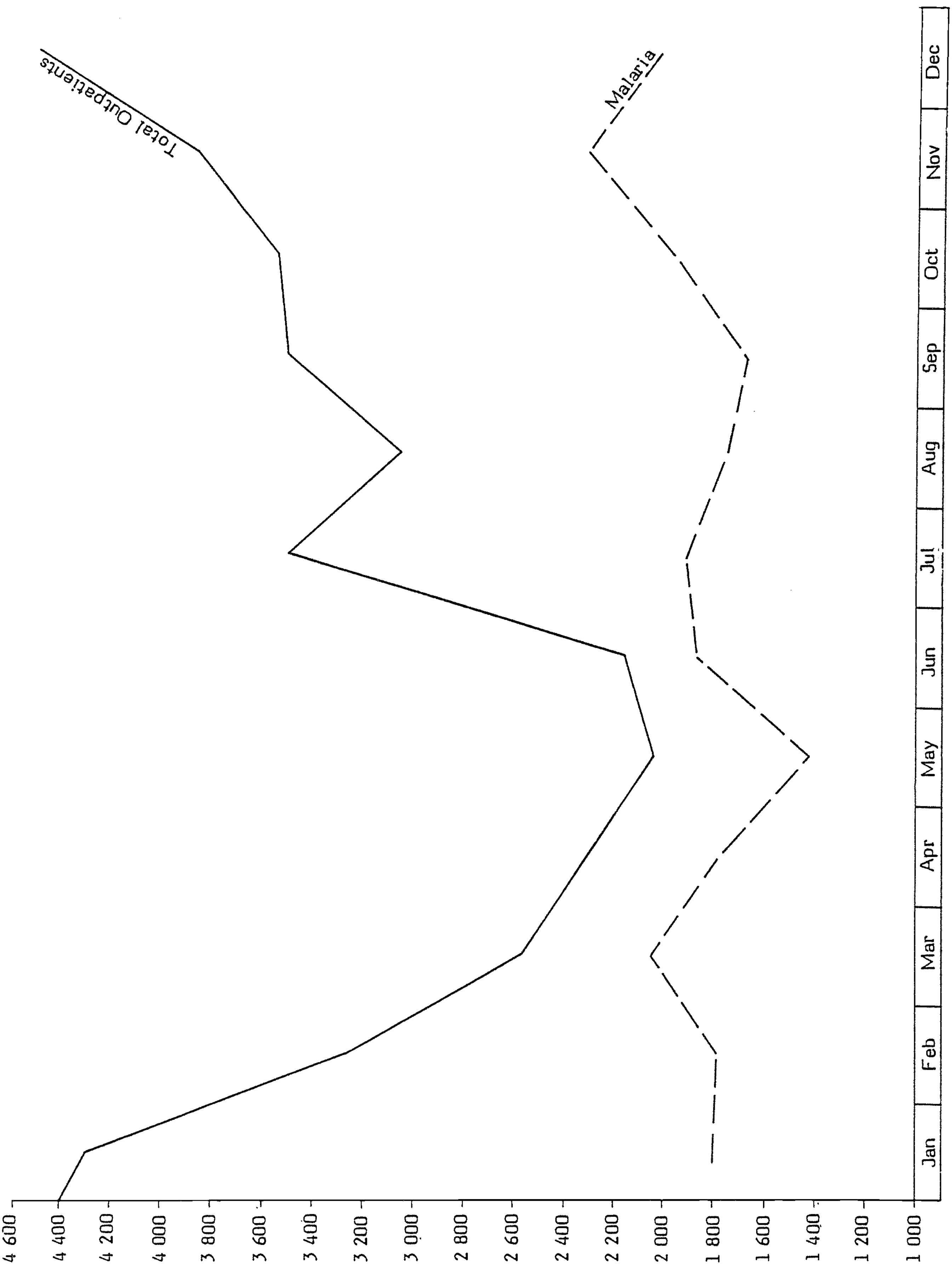
An excellent feature of Amibara was the member of the WRDA environmental health unit (Ato Asafa) who toured the whole estate once a month sampling canals (7 sites), drains (6) and ponds (18) for the snail intermediate host of schistosomiasis (Bilharzia). His efforts had reduced snail breeding sites to a minimum and only the extreme north (Dehetele area) remained infected.

Drinking water supplies had been poorly thought out and most of Amibara depended on canal water run into collecting ponds. This was full of sediment and heavily polluted. In one area canal water was run directly into a slow sand filter, but because of the considerable amount of sediment it soon blocked and ceased to function.

An attempt has been made to drill wells and install piped supplies near the project offices. Fluorosis did not appear to be a problem and clinics had not seen any cases.

Figure E.1

Seasonality of Outpatients and Malaria Cases at Awara Melka Clinic 1983 - 84



Open pit latrines are constructed by the people. No other system has been installed.

E2.3 Metahara Health Centre

This excellent clinic is run by Franciscan Sisters and is a model of efficiency and high quality health care. It has two trained nurses and an expatriate volunteer, with others in training. Two out-patient and MCH clinics are held once a week, the rest of the time being devoted to mobile vaccination clinics. Unfortunately they are already stretched to their limits, but would make an excellent training centre.

E2.4 Metahara Sugar Estate Hospital (Polyclinic) (Ref. 6)

This is the nearest hospital to the project area. It has 1 doctor, 2 health officers, 9 nurses, 31 health assistants, 2 laboratory technicians and 1 x-ray technician. Its main function is as a polyclinic offering all out-patient facilities, x-ray, laboratory, MCH, etc., but has 44 beds for in-patients. Minor operations are carried out, but not caesarean section.

Its laboratory results of stools for 1984/85 (Ref. 6) are interesting:

Parasite	Number
Giardia	1 560
Ascaris	1 450
E. histolytica	1 420 (Amoebiasis)
Hookworm	350
Schistosomiasis	125
Strongyloides	66
Tenia saginata	55

The incredibly high level of amoebiasis confirms the findings in Amibara. Schistosomiasis is low, although S. mansoni occurs. The beef tape worm is found occasionally.

The hospital serves an estimated population of 40 000 and is very busy.

E2.5 National

A study by the Water Resources Development Authority (Ref. 7) recorded disease patterns in three areas. That for Amibara (RRC) in 1982 was:

	Number	Per cent
Dysenteries	13 402	14.7
Malaria	12 386	13.6
Parasitic	5 967	6.5
Skin	5 638	6.2
Respiratory diseases	5 422	5.9
Digestive diseases	4 209	4.6
Conjunctivitis	2 111	2.3
Other	42 113	46.1
Total	91 248	

Supporting the findings made locally that malaria and the dysenteries were the most important health problems.

Ministry of Health policy is on Primary Health Care in line with the World Health Organisation objective to provide health for all by the year 2000. This includes the training of Primary (or "Community") Health Agents, traditional midwives and preventive services of MCH, Expanded Programme on Immunisation and Water and Sanitation. There is no hospital planned for the Middle Awash Valley. For planning purposes the Ministry has defined the following ratios of population to health structure:

Health Station for 10 000 people
Health Centre for 50 000 people.

CHAPTER E3

PROPOSED HEALTH INFRASTRUCTURE

E3.1 Clinic Network

The approach by the state farms so far has been to provide curative services, while the main disease problems, malaria and diarrhoeal diseases are largely preventable. Also the migratory Afar people who have the greatest health needs can make little use of static clinics. The emphasis then should be given to preventive health services, developing ways that can serve all segments of the population.

There has been considerable repetition of facilities with virtually no co-ordination between units and greater emphasis needs to be given to designing a comprehensive health network. The proposed Project Centre will be near the centre of the Kesem-Kebena irrigation area. This would seem the logical place to base a central Health Centre that would supervise all clinics within the area and be the centre for referral. A purpose-built Health Centre would need to be built with the following facilities:

- outpatients;
- maternal and child health clinic;
- delivery room;
- minor operations theatre;
- wards to accommodate about 16 patients (4 maternity, 6 female and children and 6 male);
- laboratory;
- office and store for environmental health;
- offices and accommodation for administration (see plans in Appendix V). In addition housing will need to be provided for staff.

Suggested staff are:

- 2 senior nurses (or Health Officers), 1 in charge of the Health Centre and the other (community health) responsible for supervising health care in the whole area;
- 4 health assistants;
- 6 nurses (4 of whom to work in MCH);
- 1 laboratory technician;
- 1 sanitarian responsible for environmental health;
- 1 sanitarian for controlling malaria and schistosomiasis;
- supporting staff of cleaners, drivers, environmental health labourers, etc.

This Health Centre will have supervising functions with one of the senior nurses, 2 to 3 of the MCH nurses and the two sanitarians having extension duties. This will require transport: one car plus two motorcycles will probably be adequate.

NOMADEP (Ref. 5) built the clinic at Saboret (Awara Melka) to serve the Afar people. They also trained 21 health motivators (similar to Primary Health Agents) and 23 traditional midwives from the Afar. (The terms "Primary Health Agent" and "Community Health Agent" are, in this report, treated as synonymous.) These people obtained their medical supplies from the clinic and dispensed in the villages or on the move when the people changed their grazing grounds. This system worked well, was both economical and effective and should be copied.

The state farm clinic could continue as a curative outpatient centre, staffed as it is at present, while the Ministry (ex NOMADEP) would become the medical centre for the Afar people. The present structure could be extended or a new purpose-built clinic constructed. It needs to have the following facilities:

- outpatients;
- maternal and child health;
- delivery room and about 4 beds for maternity cases;
- laboratory;
- store for drugs and supplies;
- a large office for administration and teaching.

An important function of this clinic will be the training of further Afar Primary Health Agents and traditional midwives, so accommodation needs to be provided for them. This could be two rooms, one for a male trainee and one for a female, but they might prefer to set up their own houses in the vicinity for the period of instruction.

Staffing of this clinic will require one or two people who are highly motivated teachers and if suitable persons cannot be found within the health network, then it may be preferable to ask for a volunteer nurse from an international organisation. Staff then will be:

- 1 senior nurse (trainer);
- 3 nurses (MCH);
- 2 health assistants;
- 1 laboratory technician;
- 1 sanitarian.

The emphasis of this clinic will be with the 12 000 Afar people, so staff must be prepared to work mainly with them. MCH services, (ante-natal, delivery, vaccination, family planning and under 5 clinics) will be offered to them and trainee traditional midwives will work with them. A complement of 3 MCH nurses will allow extension services to surrounding villages. The sanitarian will be expected to devote the majority of his time to village visiting and practical training to the trainee Primary Health Agents. One car and two motorcycles will be needed for transport.

It would seem likely that the contractor involved in building the Kesem dam would base most of his labour force accommodation near Awara Melka where there is water, food and services already available. A road to the dam site should be made from Awara Melka for initial construction work and subsequent maintenance. It seems unlikely that the contractor would choose to base most of his settlement close to the dam. If this supposition is correct then medical facilities for the work force and the family will need to be made at Awara Melka. The State Farm clinic has the essentials, so could be boosted with extra staff and equipment to cope with the addition. Either the existing building could be renovated and refurbished or a new building made. This will depend upon the terms negotiated with the contractor. If a new building is constructed it would be sensible to combine it with the Afar clinic as long as none of the functions of the latter are displaced. This clinic will require two to three health assistants and a nurse. An ambulance type vehicle will be required to evacuate accident cases. A first aid post at the construction site can provide emergency first aid.

The small group of Soudanis settled in the reservoir area will also use Awara Melka to obtain their health care. The Soudanis would be able to nominate one of their people to be trained as a Primary Health Agent.

The clinics at Gurmile and Awara Melka will be the main centres of health care, Gurmile as the administrative centre and place of final referral, while Awara Melka will principally be a training centre. In addition peripheral health stations will be required, three initially, but others could be considered if the population increases. One of the clinics at Yalo (probably the Ministry one as it is the better building) could continue.

As there is a clinic at Doho this would seem to be a logical place to put one of these peripheral health stations. The existing building is quite inadequate and a new structure needs to be built. It should have two clinic rooms, one for outpatients and one for MCH with necessary stores and offices (see Appendix EV). Staff required will be one health assistant and one nurse. The other health station will be along the same lines and sited in north Kebena.

There has been suggestion from several sources that the new scheme should contain a hospital, as if by providing a hospital health care is immediately catered for. The Consultant has gone to some length in collecting data to show that the common diseases are eminently treatable at a peripheral level and could effectively be prevented. Hospitals are extremely expensive places to run, not only in drugs and equipment, but the number of staff required (compare the total number of staff in the above proposed network with the number in Metehara hospital). Also the referral aspect of a hospital is grossly over-stated and in reality serves much the same area as a clinic with only a very small proportion requiring the additional laboratory or x-ray facilities that they offer. The proposed 16 beds at Gurmile Health Centre should be sufficient for the kind and number of cases that require admission, with the few serious cases being referred. A 60 bed hospital with a doctor is proposed at Melka Sadi in the neighbouring Amibara irrigation scheme. Access will be by ferry or bridge as in the proposed road network. This arrangement would seem to be more than adequate. If the population of the larger area increases from 150 000 to 200 000, as has been suggested, then it may be justified to build a hospital similar to that at Nazaret, but it would be sited in a more central place such as Awash. However, this is not in the overall plan of the Ministry of Health, who quite rightly place their emphasis on primary health care.

This leads to another difficulty and that is who is the best authority to organise and run the clinic network. At present there are three Government organisations running clinics in Amibara and two in the Kesem Irrigation Project area. The state farms concentrate on static curative services with expensive equipment and a complete lack of consideration for mothers and children. Its poor cousin, the Ministry of Health, has shortages of equipment and humble facilities, but with its emphasis on preventive health achieves more in improving the total health of the community. As the Ministry of Health is charged with the national responsibility, it would seem preferable that the policy, organisation and administration rests with it. The state farms with their greater resources could be asked to build and equip the clinics. Staffing should ideally be by the Ministry of Health, but in order to attract the right kind of staff, some additional supplement might be payable by the state farms.

This dual authority has led to another difficulty and that is the question of fees. Any state farm employee can attend one of its own clinics free of charge, while all others must pay (e.g. Birr 20 for a delivery). This discriminates against the very segment of the population who most need health services, the migratory Afar and particularly pregnant women and children. Ministry of Health policy is to charge lower rates of fees, but to exclude from all payment certain categories such as pregnant women, children under five, TB and leprosy patients. If this policy was applied universally, so that all had to pay fees of the same amount whether state farm employee or not, but services were free for every pregnant woman, child under five, TB, leprosy and other special category of patient, this would be a preferable distribution of health care, yet unlikely to cost any more.

E3.2 Water Supplies and Sanitation

The system of supplying drinking water in Amibara has already been mentioned. The seriousness of this bad water supply is reflected in the disease pattern, with diarrhoea and dysentry being particularly common. A good indicator is Amoebiasis which is essentially a highland disease requiring cool, moist conditions for the infective stage to survive. The middle Awash valley is certainly not cool, but with the use of easily polluted canal water for drinking, suitable conditions are available for it to persist as an important health hazard.

In the proposed scheme, drinking water should be obtained from infiltration or wells as being the most feasible ways to provide water of acceptable quality. A centralised system, could be feasible in a well maintained supply to the main settlement areas, with reliance on wells for isolated rural communities.

A drawback to well water may be its high fluoride level, a known problem in the Awash valley. There is no evidence of fluorosis in the population of this part of the valley, so it would appear that there are some wells which are safe. Fluoride content will therefore need to be measured from each well site. If this does appear to be a problem then consideration could be given to collecting rainwater. There will certainly be a large area of roofing with the number of houses to be built, so guttering and storage tanks only need to be paid for.

Chemical treatment of wells is not required provided they are protected from pollution. The easiest way to do this is to seal the well and install a pump. Like all things mechanical, pumps break down and the people will be forced to obtain water from another source, probably direct from the canals. Maintenance therefore becomes extremely important and a team of workers will be required to frequently check and repair pumps.

Sewerage is even more difficult to provide. A centralised sewerage scheme is very expensive and quite inappropriate unless there is a concentration of the population. (Senior management will require a water carriage sanitation system). A dry system would seem preferable for the remainder of the area. Highland people tend to build their own latrines, while the Afar have no system at all. Providing ready made latrines is often a fruitless exercise as they are misused and may provide a greater health hazard. Settlers should therefore be encouraged to build their own latrines to a recommended pattern such as the Ventilated Improved Pit Latrine (Ref. 8). This has a pipe that carries away the bad smells and attracts flies to a piece of netting where they are caught and asphyxiated. Specifications will be found in the reference (Ref. 8). Encouragement can be given to people to build latrines by providing ready made squatting slabs and subsidised cement and materials.

Where some sort of sanitation has to be provided, such as for the labour lines, then it is imperative that somebody is made responsible for them, keeping them clean and in working order. A series of VIP latrines would be the best system.

Rubbish disposal can be by incineration or burying with the responsibility placed on the household or labour-line unit. The sanitarian should carry out frequent inspections.

E3.3 Housing

Housing should be provided in neighbourhood units where other facilities such as a clinic, school and shops will be available. There will be permanent buildings for senior members of staff, whereas settlers may be happier and more responsible if they build their own. Perhaps the most important facility will be water and sufficient supply points should be provided at planned settlement sites. Subsidised cement could be supplied to encourage good quality housing. The important features are a firm floor (rammed earth, or cement and earth mix) and an internal wall surface that has no cracks. Poor surfaces can provide hiding places for ticks and bed bugs which can be vectors of disease.

Migrant labour needs to be accommodated in housing when they come for the cotton picking. It is estimated that some 2 500 migrant labourers will come every year, some bringing their wives and children. (Women often pick the cotton.) It is difficult to lay down strict criteria except to state that there should be adequate rooms and proper water and sanitation. Everyone should have a bed and sufficient space between them and the next person, as respiratory diseases, tuberculosis and meningitis spread rapidly in overcrowded conditions. Each family should have their own room and then they will feel responsible for it, tending to its cleanliness. With single workers, they can be accommodated in barrack type accommodation, but overcrowding must not be permitted and reasonable standards of hygiene must be maintained. With such community facilities, somebody must be employed to keep them clean. Adequate sanitation and water has been mentioned above. Due to the fluctuating numbers it is difficult to give accommodation figures, but it should be the responsibility of the Senior Nurse in charge of community health, through the sanitarian, to continually monitor these living quarters and report to the health committee.

E3.4 Health Committee

Providing static health facilities does not answer the problem of changing health needs. New diseases may appear and health hazards occur. The only way to monitor this and effect change is through an active health committee. The responsible person will be the Senior Nurse in charge of community health. He or she will set up monitoring systems through the sanitarians, the MCH staff, the unit responsible for the Afar clinical services, and the laboratory. Information obtained and deductions from them will be reported to a committee containing members of sufficient importance to effect change. The committee should preferably meet once a month.

E3.5 Health Hazards

E3.5.1 Schistosomiasis (Bilharzia)

A considerable amount of research has been conducted into this disease in the Awash valley and much data are available. According to Lemma (Ref. 9) Schistosoma mansoni is a disease of the highlands and S. haematobium of the lowlands, including the middle Awash valley. He surveyed Melka Warer in 1967 and found 21.3% of the population examined positive. Males were more commonly infected than females and children more than adults. All the infected were Afar. In a survey of Afar who were living by the extensive swamps of Gewani 60.7% of 272 tribesmen were found infected. The intermediate host Bulinus abyssinicus was found infected with S. haematobium. Although S. haematobium is the main problem of the middle Awash valley, in the nearby sugar estates of Metahara S. mansoni was reported (Ref. 6) as the principal species. The intermediate host for S. mansoni is Biomphelaria pfeifferi which Kloos and Lemma (Ref. 10) found in irrigation canals in Metahara and Amibara amongst others. Neither species of snail were, however, found in Awara Melka, Kesem-Kebena, Melka Sadi or Melka Warer. They suggest that B. pfeifferi is invading new territory at the limits of its habitat. It normally survives in cooler areas, but where continuous irrigation such as with sugar cane is practised, then it can establish itself. Seasonal irrigation such as with cotton, and especially when the canals are able to dry out are less conducive to invasion. Similarly, speed of water flow and suspended sediment markedly affect both species. The ideal is stationary water and low sediment, so snails are found in drains, eroded canals and swamps, but not in well maintained canals. Salinity was particularly conducive to B. pfeifferi (Ref 11).

With the extension of the Melka Sadi and Amibara irrigation schemes, further surveys were conducted. In 1975 to 76 2.1% of the 192 migrant farm workers were found positive for S. mansoni in Melka Sadi and 3.7% of 161 in Amibara (Ref. 12). None of the 47 Afar who agreed to be tested were found positive for this parasite. In contrast the high level of S. haematobium in the Afar mentioned above had declined to 19.8% following drying out of the swamps produced by the Amibara irrigation project (Ref. 12). The environmental health unit of WRDA kindly offered to undertake a detailed study of the project area in April 1986.

Some 391 persons were examined representing an even sample of the population: 150 were Afar while the remaining 241 consisted of state farm workers and Soudanis. Stool specimens were examined from all 391 and urine samples from 384. All were negative for schistosomiasis.

In the malacological survey, 20 water bodies were carefully examined and 14 found to be breeding sites of snails. Of serious importance were three sites were B. pfeifferi, the intermediate host of S. mansoni was found. These were all in canals in the existing irrigation works at Awara Melka. Kloos and Lemma (Ref. 11) did not find this species when they searched the area in 1977, so this finding indicates recent invasion. None of the snails were found infected which agrees with the examination of the human population. Detailed results will be found in Appendix EI.

Summarising the data above shows:

B. pfeifferi, the intermediate host of S. mansoni, is established in the canals of the existing state farm watered by the Kesem river. It is likely to expand into the proposed irrigation network and up the river to the reservoir. Selective use of moluscicides to colonies so far discovered and careful search for others along the Kesem river is recommended to prevent this from happening. Continuous use of irrigation canals seems to be favouring invasion by B. pfeifferi and they should be allowed to dry out in the off-season.

Neither S. haematobium nor its intermediate host B. abyssinicus has been found in the recent survey, but previous data suggest that this could be a problem.

Continued control can be effectively achieved by simple measures of drainage and proper water management as well shown in the Amibara scheme (Ref. 13). These are:

- careful design, especially with adequate drainage to prevent areas of stagnent water;
- water flow rates of 0.4 m/s or greater (Ref. 12);
- reduction of salinity;
- regular maintenance of canals and drains to remove weed and irregularities of the banks;
- intermittent irrigation and possibly drying out of the canals at non-season times;
- regular monitoring of canals, drains and other areas of water by a person trained in snail catching and identification (sanitarian).

In addition, human water contact can be reduced by:

- providing accessible and acceptable drinking water points;
- sufficient and available water for washing (clothes and person);
- encouragement of the use of latrines;
- health education of school children.

Treatment of all diagnosed cases of schistosomiasis requires adequate stocks of Metrifonate for S. haematobium and Praziquantel for S. mansoni. All new workers coming into the scheme must be monitored by having them produce a urine and stool specimen when they are signed on.

The swamps at Filweha and between the Dofan hills are likely to be a serious problem and as they will be largely outside the drainage system, other technologies such as planting eucalyptus trees (which have a very high transpiration rate) should be considered. This will have a secondary benefit of providing firewood.

A further area more likely to be seriously affected by schistosomiasis is the reservoir created by the dam. At present there are between 300 and 400 Soudani people living in the reservoir area. With the still clear water of the lake it is probable that B. pfeifferi and possibly B. abyssinicus will multiply in these conditions. If the lake does not attract additional populations then all the Soudanis could be treated and monitored from time to time. A borehole could also be provided to reduce their need to go to the lake for water. Otherwise measures could be taken to discourage settlement on the lake. All existing and new residents to the reservoir must be screened for both S. haematobium and S. mansoni.

E3.5.2 Malaria

Malaria appears to be the most serious problem in the middle Awash, with the increase in water throughout the year providing additional sites for mosquito breeding.

Clinic data show that between 12 and 19% of all outpatient attendances are suspected malaria which is non-seasonal (Figure E1). However, survey data show that malaria is less of a problem. A malaria control programme has been in operation throughout the country for the last 20 years and samples from groups of people are examined from time to time. In Melka Warer a mass blood-slide examination was carried out (Ref. 14) and a rate of 2.9% positive was found (out of 1 492 slides). In the proposed project area the following rates were obtained in 1985:

Place	Population	Number examined	Number positive	Rate (%)	Species
Yalo	626	163	5	3.07	4F 1V
Awara Melka	1 458	401	5	1.25	5F
Doho	1 335	319	9	2.82	6F 3V
Others	878	172	4	2.33	4F
Total	4 297	1 055	23	2.18	19F 4V

Note : F = P. falciparum
V = P. vivax

Data from other localities within the project area for 1984 will be found in Appendix EII.

Mosquito catches at Melka Warer (Ref. 14) and at Abibeti, Doho, Fairo Guli, Gurmile, Hergeda and Tedecha Melka during 1986 show that Anopheles gambiae (arabiensis) is the principal vector with A. funestus hardly being found. A. pharoensis is reasonably common and the most frequently collected in larval surveys. It especially breeds in irrigation drains and canals but fortunately is considerably less important as a vector than A. gambiae. Details of the entomology findings are in Appendix EIII.

Breeding places for mosquitoes are produced in much the same way as desirable conditions for snail intermediate hosts. These conditions are created by stagnant water, poor water management and badly maintained canals. However, A. gambiae takes advantage of any temporary collections of water such as car tracks and puddles after rain storms, tin cans or containers.

Control should be directed at:

- Proper canal construction and maintenance as covered in the section on schistosomiasis.

- Checking for breeding places, filling in pools or draining of swamps, (regularly monitored by the sanitarian).

- Residual house spraying. This is carried out by the malaria services using DDT every six months.

Night biting catches showed that the vector is biting more outdoors than indoors and that susceptibility has declined from 97.5% to 92.5% mortality with 4% DDT after 1 hour indicates a slight tolerance to DDT and other uses such as in agriculture should be discontinued.

- The national policy is treatment of all confirmed malaria cases with Chloroquine.

Prophylaxis is given to pregnant women. This should be followed in all the clinics. In view of the low level of malaria and the malaria control programme, prophylaxis to migrants from highland areas is unnecessary.

While there is a national malaria control service, monitoring of the malaria situation needs to be carried out by the senior nurse (community health) and her staff. The sanitarian will be responsible for checking on breeding places. Good co-ordination needs to be built up with the national malaria control programme.

E3.5.3 Diarrhoea and Dysentery

Diarrhoeal diseases equal and sometimes exceed malaria in importance. Gastroenteritis is frequent in children and bacillary and amoebic dysentery common in all ages. In a survey in 1967 in Awash Station (Ref. 9) only 6.7% were found positive for cysts of E. histolytica (Amoebiasis), yet out-patient data recorded above would suggest that the infection is much more common. It would seem most likely to be spread by contaminated drinking water as occurs in the Amibara project. The provision of clean drinking water can be expected to reduce the amount of diarrhoea and dysentery considerably. Adequate supplies of oral rehydration salts should be available for treatment.

E3.5.4 Intestinal Parasites

Microscopic examination of 391 stool specimens revealed 54 positive with a wide range of parasites. Ascaris, ancylostoma, trichuris and strongyloides were found (see Appendix EIV). Proper disposal of faeces is the most effective control measure and although it is difficult to convince people of proper latrine usage, it should nevertheless be persevered with.

E3.5.5 Trachoma

The common and chronic eye infection that can lead to blindness, trachoma, is noted in a high proportion of the Afar and Soudanis. It is transferred within family groups by the mother wiping the eyes of one child with her hand or a piece of cloth that she also uses for the next child. Flies are also important. Poor hygiene conditions, large families and the aggravation of dry dusty conditions all help to increase the incidence of trachoma.

While it is hoped that the general hygiene of these people will improve with the development that will be brought to this area, active control should be practised. Mothers can be taught how to apply tetracycline eye ointment to the eyes of their children. This should be done to all children in the family twice a day until the tube of ointment runs out. NOMADEP was already teaching health motivators and traditional midwives how to do this. Training needs to be continued as mentioned above (mainly via Saboret clinic) and adequate supplies of tetracycline ointment need to be made available.

E3.5.6 Respiratory Diseases and Tuberculosis

Respiratory diseases, as in most countries, are a leading cause of morbidity. While many different organisms are responsible, damage from measles and whooping cough can be prevented by vaccination (see below).

Tuberculosis is reported to be common among the Afar, where it is suspected that bovine tuberculosis also plays a part. If milk is boiled (Ayeb) or curdled (Iti iti han) rather than drunk fresh (Han), this would reduce the transmission of bovine tuberculosis.

The senior nurse (community health) should negotiate with Nazaret hospital about the diagnosis and treatment of tuberculosis cases. To send suspect cases to Nazaret when diagnosis of sputum positive cases and treatment could easily be started in the health centre, seems quite unnecessary. The introduction of BCG vaccination (mentioned in the next section) can be hoped to reduce the level of tuberculosis.

E3.5.7 Maternal and Child Health

If a pregnant woman is examined ante-natally, most difficulties that are likely to happen to her can be detected and dealt with. She can be immunised against tetanus to protect her new born infant and be given simple instructions on nutrition and child care. Delivery is the commonest reason for admission of any condition to hospital. The woman who has received care during her pregnancy will be motivated to bring her child for vaccinations and will be responsive to family planning advice. Children under five form almost 20% of the population, which combined with the needs of maternal health mean that MCH services cater for virtually the same number of persons as all other medical conditions put together.

The importance of MCH services cannot be overstressed and hence the divergence from traditional State Farm practice by suggesting an important component of MCH in the proposed health network. This includes vaccination for the six childhood diseases.

A cold chain network needs to be established to take vaccination into every clinic. The Afar system of traditional midwives can be boosted by emphasising hygienic delivery. Only then when people see their children surviving and growing up to healthy adults will the message of family planning be accepted.

E3.5.8 Sexually Transmitted Diseases (STD)

A large migrant labour force, predominantly male and earning money, encourages the spread of STD. No figures are available, but STDs were reported common by all the clinics. The problem will only be reduced by encouraging settlement of family units. Workers will be encouraged to bring their families if they can provide adequate housing for them. Free health care to mothers and children will be an added incentive.

E3.5.9 Accidents and Occupational Diseases

Minor accidents, cuts, wounds and fractures are common in irrigation schemes as shown by the out-patient statistics from Awara Melka clinic. More serious accidents can be expected to occur in major constructional work, such as at the dam. The essence is rapid evacuation to a hospital with full surgical facilities such as Nazaret or Addis Ababa. Ambulance vehicles can be used for this purpose or the small airstrip at Awara Melka.

If cotton is to be the major crop, then a cotton picker's conjunctivitis can occur. This is due to fine strands of cotton getting lodged in the eye and is easily treated with eye ointment and rest. If a cotton ginnery ever becomes established then bysinnosis with lung damage and chronic asthma can occur in workers who are not protected from the cotton dust.

E3.5.10 Insecticides

Insecticides used for agricultural purposes could pose a risk to all those involved in applying them. Manufacturers' safety instructions must be followed and protective clothing worn by all persons using the insecticides. Insecticides likely to be used will be found in Appendix EV. None of these is sufficiently toxic to pose a threat to humans in the area, but they could cause environmental damage, especially to birds and fish. If drinking water is provided from a sub-surface source then there should be little risk of contamination.

In the list of insecticides to be used for agricultural purposes is DDT. This is the only insecticide used for malaria control, to which the Anopheline mosquito is still sensitive. However, the larger amounts of insecticides used in agricultural application will increase the likelihood of resistance developing. There is already some indication in susceptibility tests carried out at Saboret that this might be happening as a 92.5% mortality was recorded whereas in other areas it is 100%. DDT should therefore not be used for agricultural purposes, but reserved exclusively for malaria control.

E3.6 Management

The suggested institutional arrangements and staffing are set out in Annex F, though they do not of course need to be fixed at feasibility study stage. The division of responsibility between the Ministry of Health and the three main organisations on the project (water resources, state farms, and settlement) is debatable. The Ministry of Health should provide at least the senior health officer for the whole area, based at the Project Centre. On the state farms it is probably best for the health assistants to be employed by the MSFD through its local offices, as is now done elsewhere. For planning and costing purposes at this stage, Chapter F5 assumes the following staffing, for the Large Project:

Central health centre, at Project Centre	10 persons
State farms	16 persons
Settlement outstations	11 persons
Total	37 persons

This excludes drivers and a few other support staff. A different division of staff between the various entities would not make any difference to cost estimates, which are made (in Annex N) with estimated salary levels rather than the relatively low current Ministry of Health salaries.

The management policy of the whole health service on the project should place particular emphasis on two aspects:

(a) preventative measures, especially those aimed at water-related diseases like schistosomiasis and malaria;

(b) health education, both of adults and of children, through schools and employers as well as by direct action in the communities.

Details need to be worked out at project design stage.

E3.7 Estimated Costs

The Consultant was kindly provided by the financial division of the Ministry of Health with estimated costs for buildings, equipment and salaries, together with some uncosted suggestions for vehicles and housing. These were, however, found to be inconsistent with the methodology and unit rates used in other aspects of this study, and were not used.

The relevant cost estimates for this study are in Annexes F and M (buildings, vehicles and services) and Annex N (staff). The main elements pertaining directly to health are:

Clinics	-	18 Nr at Birr 100 000 each (net);
Houses	-	Type C at Birr 57 000 per employee (net); Type D at Birr 42 500 per employee (net); Type G at Birr 22 500 per employee (net);

(These net costs are increased by 10% for miscellaneous costs and then 3% for supervision and administration.)

Equipment and vehicles	-	Combined with other services in the estimates.
Health staff	-	Average Birr 280 month i.e. Birr 3 360 per year.

Since the majority of staff are health assistants, this represents a slightly higher salary level than that quoted by the Ministry of Health for 1986, namely Birr 2 184 for a health assistant.

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Much of our fieldwork could not have been done without the excellent help of Ato Mahmoud Mohammed, the traditional midwife Haridakaliday, and Ato Werku Tesama at Saboret State Farm clinic.

We were very impressed with the friendly reception and time spared to discuss the work done by all the clinics in the project area and the neighbouring Amibara scheme. Those further afield such as the clinic of the Franciscan Sisters at Metehara and the Sugar Estate Hospital provided much valuable information.

Ato Asafa, the sanitarian of Amibara, has shown how schistosomiasis can be controlled and reduced and it is hoped that the excellent work he has been doing there can be copied in the new irrigation project.

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APPENDICES

APPENDIX EI	SHOWING WATER HABITATS VISITED FOR SNAILS (1986)
APPENDIX EII	MALARIA BLOOD SLIDE SURVEYS
APPENDIX EIII	ENTOMOLOGY RESULTS
APPENDIX EIV	RESULTS OF STOOL EXAMINATION BY AGE, SEX AND NATIONALITY (1986)
APPENDIX EV	PESTICIDES LIKELY TO BE USED IN THE KESEM-KEBENA PROJECT AREA

APPENDIX EI

WATER HABITATS VISITED FOR SNAILS (1986)

Name or symbol	Location	Distance	Nature of habitat	Altitude (m)	Temperature °C Air	Water	Time	pH	Vegetation	Snails collected	Remarks
1. Damagona	Northern side of Dofan hills	Approximately 58 km from Sabure	Swampy						grass	Bulinus forskalii	
2. Dofan swamp	Dofan hills	Approximately 51 km from Sabure	Swamp						water lily algae grass	Bulinus forskalii Lymnaea natalensis small planorbids	potential habitat
3. Kebena	at Yalo	31 km from Sabure	River (sandy)						no vegetation	-	-
4. Foro	North end of main hot spring	20 km from Sabure	River						grass algae	Melanoides tuberculata	
5. Kolba	Between Foro and main hot spring	20 km from Sabure	Swamp						grass	Bulinus forskalii (shell)	
6. Main hot spring	National Park (Awash)	20 km from Sabure	Spring								
7. 7	By the side of Farm G, on the main road	9½ km from Sabure	Canal	860	31.5	23.5	5 pm		grass	Biomphalaria pfeifferi B. forskalii M. tuberculata	Actual habitat
8. Feeder canal	Farm E	9½ km from Sabure	Canal							Biomphalaria pfeifferi B. forskalii M. tuberculata	Actual habitat
9. Feeder canal	Between Farms E and F	9½ km from Sabure	Canal							Biomphalaria pfeifferi B. forskalii M. tuberculata	Actual habitat
10. Main distribution canal	Between B6 and C	9½ km from Sabure	Canal						grass	M. tuberculata	
11. Feeder canal	Between Farm B and Alibeti village	5 km from Sabure							grass range		
12. 12	Between Blocks 2 and 3	1 km from Sabure	Canal	30.5	25.5	8.05 am		7	grass range	B. pfeifferi M. tuberculata B. forskalii	
13. 13	Between Blocks 2 and 3	1 km from Sabure	Main canal	880	28	25	8.20 pm	7	grass range algae	B. pfeifferi B. forskalii Lymnaea natalensis small planorbids	
14. Canal	Between Blocks 2 and 1	½ km from Sabure	Main canal						grass range	B. pfeifferi (shell) M. tuberculata B. forskalii	
15. Canal	Between Blocks 3 and 4	½ km from Sabure	Main canal		31	27	9.25	6		M. tuberculata B. forskalii	
16. Canal	Between Blocks 4 and 5	½ km from Sabure	Main canal							-	
17. Canal	Between Blocks 5 and 6	½ km from Sabure	Main canal								
18. Swamp	Below Block 1	½ km from Sabure	Swamp							M. tuberculata B. forskalii	
19. Tadecha	Soudani community near reservoir	½ km from Sabure	Spring							-	
20. Kesem	Between Yalo and Sabure	½ km from Sabure	River							-	

APPENDIX EII

MALARIA BLOOD SLIDE SURVEYS

	Soudani villages	Afar villages
Year	1980	1983
Population	156	392
Number examined	84	204
Number positive	10	22
Rate	11.9%	10.8%
Species	8F 2V	12F 10V
Age group rate:		
1 to 4	23.5	25
5 to 9	3.7	18.5
10+	12.5	7.2

Note: F = P. falciparum
V = P. vivax

APPENDIX EIII

ENTOMOLOGY RESULTS

MELKA WARER July 1984 to June 1985[12]

Species	A. gambiae	A. pharoensis	A. funestus
Daytime collections			
Caught inside	254	57	0
Caught outside	10	1	1
Night biting			
Biting indoors	45	20	0
Biting outdoors	170	50	0
Larval collections	26	263	0

Results of Light Trap Collections 1986

Serial Nr	Locality	Site of trap	Findings	Remarks
1	Alibeti	Outdoor	Few Culex spp.	No sand fly attracted by light trap
2	Sabure	Outdoor (eve of a house)	1 Culex spp. plus too many psychodids	No sand fly attracted by the trap
3	Sabure	Indoors mixed dwelling (animal and human)	Too many Culex spp.	No anopheline and/or any other fly including sand flies
4	Alibeti	Indoor		No anopheline and/or any other fly including sand flies
5	Alibeti	Indoor	Large number of culicines caugh	No anopheline and/or any other fly including sand flies

Source: WRDA Environmental Health Unit

APPENDIX EIII (cont.)

Results of Mosquito Survey in Kesem Kebena Project Area by Indoor Resting Collection (1986)

Serial Nr	Locality	Altitude (m)	Type of house	Species found	Remarks
1	Alibeti	860	Afar Ariss (tukuls)	An. gambiae and An. pharoensis	too many
2	Doho	840	Afar Ariss (tukuls)	An. gambiae and An. pharoensis and Culex Spp	too many and others few
3	Faris gubi	820	Afar Ariss (tukuls)	An. gambiae	too many
4	Gurmile	810	Afar Ariss (tukuls)	An. gambiae An. pharoensis	only 2 specimens 1 specimen
5	Hengeda	810	Afar Ariss (tukuls)	An. gambiae An. pharoensis Culex Spp.	many few only 2 specimens
6	Tedecha Melka	930	normal tukuls	An. gambiae	only 3 specimens

APPENDIX EIII (cont.)

Night Biting Collection - Results Using Human Bait in one of the Afar Localities (1986)

Locality Alibete

Altitude 860 m

Number of baits 4 (2 in door and 2 outdoor)

Collection time	Relative humidity						Number of specimens								Density man/h	
	Wet		Dry		RH%		An.gambiae		An. pharoensis		Culicin		Total			
	in	out	in	out	in	out	in	out	in	out	in	out	in	out	in	out
6 - 7	69	74	90	93	33	40	8	7	-	-	1	20	9	27	1.13	3.37
7 - 8	74	68	90	86	46	38	3	6	-	2	1	21	4	29	0.5	3.63
8 - 9	74	69	91	85	44	44	3	13	-	-	4	38	7	51	0.87	6.37
9 - 10	74	69	90	82	46	50	5	4	-	-	3	10	8	14	1.0	1.75
Total							19	30	0	2	9	89	28	121		

Note: Collection was discontinued because of some inconveniences.

APPENDIX EIII (cont.)

Susceptibility Test Results Made on An. gambiae Complex using 4% DDT (1986)

Species	Mosquito conditions during exposure	Time of exposure	Total number exposed	Total dead	Mortality (%)
An. gambiae S1	Blood fed	1 hour	120	111	92.5

Note: 40 specimens used for control and all survived during the test.

Source: WRDA Environmental Health Unit.

APPENDIX EIV

RESULTS OF STOOL EXAMINATION BY AGE, SEX AND NATIONALITY (1986)

Age (years)	Sex	AFAR Type of parasite 1	2	3	4	5	6	Total	NON-AFAR Type of parasite 1	2	3	4	5	6	Total	All total
0 to 1	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1 to 4	M	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5 to 14	M	-	-	2	-	-	1	3	2	2	-	-	-	3	7	10
	F	-	-	-	1	-	-	1	-	6	1	-	-	1	8	9
15 to 44	M	1	2	-	-	1	1	5	4	1	2	-	5	1	13	18
	F	-	-	-	1	-	-	1	2	2	1	3	1	6	15	16
45+	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
All positive		1	2	2	2	1	2	10	8	11	4	3	6	12	44	54

Note: Key to parasite identification numbers

1 - Ascariasis
2 - E. hystolitica
3 - stroqloides
4 - trichuriasis
5 - ancylostomiasis
6 - others (Taenia, S. hymenolepsis)

Total number sampled = 391

APPENDIX EV

PESTICIDES LIKELY TO BE USED IN THE KESEM-KEBENA PROJECT AREA

Trade name	Official name	Comment
Aspore	-	Used on tobacco
Azodrin	Monocrotophos	Used on tobacco
Barisitin	Carbendazim	Fungicide
Cidal	Phenthroate	Used on citrus
Codal	Motolachlor	Herbicide
Decis	Deltamethrim	Aerial spraying on cotton
Dimecron	Phosphasidon	Aerial spraying on cotton and tobacco
Dursban	Chlorpyrifos	Aerial spraying on cotton
Endosulfan	Endosulfan	Used on cotton and tobacco
Gobox	-	Used on citrus
Maltine	-	Used on citrus
Medopar	-	Spray oil
Mitac	Amitraz	Aerial spraying on cotton
Mitgan		Used on cotton and tobacco
Ridomil	Metalaxyl	Used on citrus
Rogor or Rogol	Dimethoate	Aerial spraying on cotton
Round up	Glyphosate	Used on citrus
Tedion	Tetradifon	Used on cotton and citrus
Thiodan	Diquat	Aerial spraying on cotton
Thiorex	-	Aerial spraying on cotton
Ultracide	Methidathion	Used on citrus
Volhthion Gusothion	-	Used on cotton

Plus various broad spectrum pyrethroides.

Also * DDT 10% dust for Broom sorghum
DDT 25% EC is also used for maize

Note: * It is recommended that all agricultural use of DDT be discontinued.