INSTITUTE OF AGRICULTURAL RESEARCH

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ETHIOPIA

INSTITUTE OF AGRICULTURAL RESEARCH

IMPERIAL ETHIOPIAN GOVERNMENT

SOIL RESOURCE APPRAISAL AND EVALUATION STUDIES FOR RURAL DEVELOPMENT IN ETHIOPIA

By

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A COUNTRY REPORT PRESENTED AT THE EAST AFRICAN SOIL CORRELATION COMMITTEE

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CONTENTS

		PAGE
1.	INTRODUCTION	1
2.	PHYSICAL CHARACTERISTICS	3
2.1	GEOLOGY	3
2.2	GEOMORPHOLOGY & HYDROGRAPHY	4
2.3	CLIMATE	6
2.4	VEGETATION	6
2.5	LAND USE	7
3.	SOILS	9
3.1	SOILS OF ETHIOPIA	9
3.2	SOIL STUDIES - COMPLETED OR IN PROGRESS - BY CONSULTANTS	10
3.2.1	The Blue Nile River Basin	11
3.2.2	The Awash River Basin	13
322.1	Initial Surveys	13
322.2	Melka Sadi - Amibara	16
322.3	The Lower Awash Plains	17
322.4	Tibila	19
322.5	Angelele - Bolhamo	20
3.2.3	The Wabi Shebelle River Basin	20
3.2.4	Setit Humera Soil Study	22
3.2.5	Land Resource Study of the Rift Valley Lake Zone	25
3.3	SOIL & LAND EVALUATION STUDIES BY THE INSTITUTE OF AGRICULTURAL RESEARCH	25
3.3.1	Detailed Soil Survey of Gode Agricultural Research Station - Bale Province	26
3.3.2	Detailed Soil Survey of Holetta Agricultural Research Station - Shoa Province	27

PAGE

3.3.3 Land Resource & Evaluation Study of Wollenkomi-Addis Ababa Region 28

3.3.4 Land Resource & Evaluation Study of Sendafa-Debre Zeit Region 30

3.4 THE FUTURE OF SOIL SURVEY AND LAND EVALUATION IN ETHIOPIA 33

REFERENCES 34

1. INTRODUCTION

In Ethiopia, as in most African countries, agriculture is the major economic activity accounting for 55% of the total gross domestic product and more than 90% of the country's exports. Approximately 85% of the population are engaged in subsistence agriculture. The most important cash crop is coffee which contributes 10% to total agricultural production and 63% to agricultural exports. Other main agricultural products are cereals (34%), livestock (29%) and oil seeds (5.4%).

Practically all tropical and temperate zone crops can be grown somewhere in the country. The greatest climatic limitation is the amount and distribution of rainfall, both of which are extremely variable from one part of the country to another. Within the constraints imposed by available water, the altitude determines the types of crops grown. The inaccessibility of vast areas limits the possibilities of agricultural development through the introduction of modern technology.

Agricultural research in Ethiopia is very young. Small scale agricultural experiments were initiated by the Ethiopian Government in 1952 with the help of foreign experts. In 1956 an Agricultural Experiment Station was established at Debre Zeit, 50 km S.E. of Addis Ababa. This was incorporated in the College of Agriculture at Alemaya in Harar when the latter was started a year later. Most of the earlier recent research work was carried out by these two organizations which are still active in this field.

In 1966 the Institute of Agricultural Research (IAR) was set up with UNDP/FAO assistance to conduct and coordinate agricultural research at a national level. At present it operates 6 regional experiment stations in different agro-ecological regions and also conducts studies at some 20 other locations. The Soil Survey and Land Evaluation Section of IAR was not established until late in 1971 with the purpose of providing relevant soil and land evaluation data as an aid to agricultural research, agricultural development regional planning, and as well as the conservation of land and water resources. Another task of the Section is to assist and advise the Government in the preparation of terms of reference for foreign consultants under-taking soil and land evaluation studies in the country, and ensure a coordinated approach in matters of soil taxonomy and land classification.

Soil survey and land classification studies have mostly been undertaken either by foreign technical aid agencies or by private consultants. This approach will have to continue for some time until local facilities are built up to a level adequate to cope with development needs.

2. PHYSICAL CHARACTERISTICS

2.1 GEOLOGY

For the sake of simplicity, Ethiopian geology can be grouped into:

- Precambrian basement complex
- Mesozoic mantle sediments, and
- Cover deposits

The Precambrian basement complex includes various grades and types of dominant schists and gneisses, and to a lesser extent unaltered sedimentary rocks and igneous intrusions. Within these, a tentative separation into an older, more metamorphosed group and a younger, weakly metamorphosed group is sometimes made. Being of Precambrian age, no fossil bearing rock is found in this complex. It is intensively foliated, faulted and peneplained to a level surface. On this surface Mesozoic rocks lie unconformably. Characteristically, rocks of Paleozoic age are not found in Ethiopia.

The Mesozoic mantle sediments are rocks deposited during a transgression in the upper-Triassic to upper-Jurassic when the sea engulfed the country from the south-east, the sequence being Adigrat sandstone, shale, gypsum and Antalo limestone. The regression during the upper-Jurassic to Cretaceous produced Antalo limestone, gypsum, shale and upper sandstone.

The up-swell of the Arab-Ethiopian Massif during Eocene to early Oligocene was followed by enormous out-pourings of flood basalts and faulting of the Rift System started in Oligocene. This flood basalt rests on the Mesozoic sediments and now forms the Ethiopian plateau surfaces including the floors of the Rift System. It is referred to as the Trap Series. As rifting continued in Miocene, Pliocene and again renewed in Quarternary, continuing till the present, volcanism accompanied it and the basic lavas that emanated from the Rift-centered volcanoes are referred to as the Aden Series. With the exception of the few very locally occurring superficial deposits including aeolian, fluviatile, lacustrine, glacial and glacio-fluviatile sediments, the present surface of the country consists largely of rocks of Aden and Trap Series in which basalt and its associates, including trachyte, are dominant.

The Precambrian basement complex remnants are exposed in the northern, western and southern parts of the country, along the plateaux fringes. The Mesozoic cover deposits are found in the south-east, while the flood basalts occur on the Central Highlands and in the Rift System.

2.2 GEOMORPHOLOGY AND HYDROGRAPHY

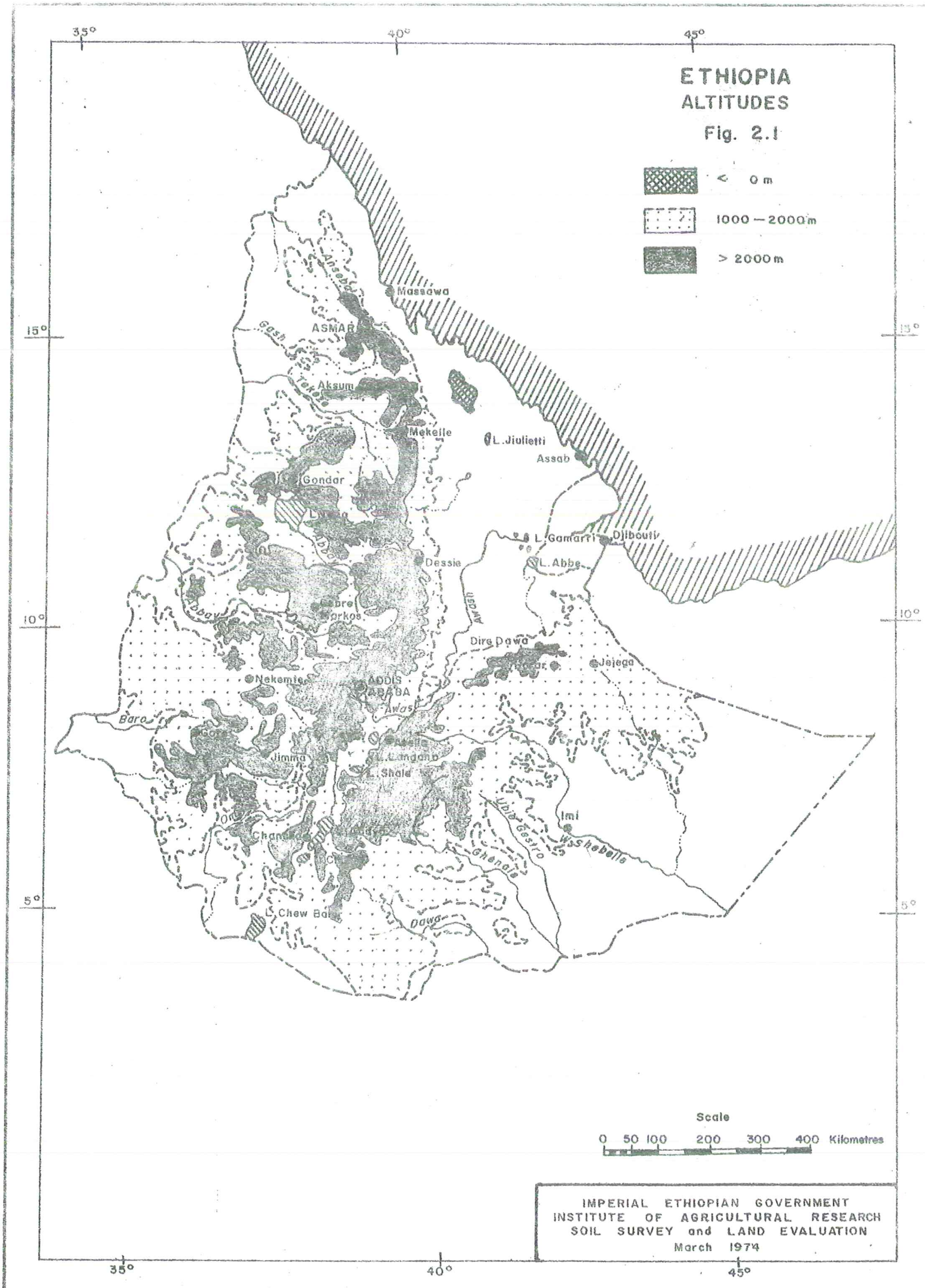
The geomorphology of Ethiopia is intimately related to its underlying geology. Except where deeply dissected by subsequent denudation and apart from the volcanic piles of the Trap Series, the Ethiopian plateau shows a flat horizontal surface which expresses the precence of a peneplained Precambrian rock basement.

The Rift System divides the uplifted Ethiopian Massif into two units, the Western Plateau and the Eastern Plateau (Fig. 2.1). The former includes all the highlands between the Rift scarps in the east and the Sudan border scarps in the west. On both sides, this plateau has been subject to erosional recession starting from the original tectonic scarps. Exeept for the major river valleys, the whole of this region lies above 1000 m and about half of it reaches altitudes above 2000 m. The very great elevations of the Western Plateau above sea level induced deep canyon carving by the rivers through the sub-horizontal strata which are now strongly dissected. Many of the greatest heights of this plateau occur along the scarp facing the Rift System, although there are also a few in the interior, such as the Semien Mountains. The Semien massif is a Hawaiian type volcanic pile now bounded by gigantic erosional precipices on almost all sides. Within this massif the heighest peak in the country Ras Dashan 4620 m, is found.

The rivers on the Western Plateau generally flow west-wards, most of them tectonically controlled. The dip of the strata, being only 1^{o} or less towards the Sudan, is not the major factor. Major rivers from north to south are:

- Anseba and Barka: flowing into the Red Sea
- Mereb, Tekeze, Atbara, Abai (Blue Nile), Baro and Akobo: joining the Nile
- Omo: flowing into Lake Rudolf

The Eastern Plateau shows a much more appreciable tilt towards


ETHIOPIA
ALTITUDES
Fig. 2.1
< 0 m
1000 — 2000 m
> 2000 m
Massawa
ASMARA
Aksum
Mekelle
L. Jiulietti
Assab
Gondar
Dessie
L. Gamarri
Djibouti
L. Abbe
Debre Markos
Dire Dawa
Jejega
Nekemte
ADDIS ABABA
Awash
Baro
Jimma
L. Langano
L. Shala
Imi
Wabi Shebelle
Ghenale
Gash
Tekeze
Abbay
Awash
Dawa
L. Chew Bahir
Scale
0 50 100 200 300 400 Kilometres
35°
40°
45°
15°
10°
5°
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SOIL SURVEY and LAND EVALUATION
March 1974

the south-east and the dip of the strata is clearly reflected in the physiography. It has no clearly defined margin to the southeast but slopes gradually through Somalia and beneath the Indian Ocean. The main summits again lie close to the Rift scarp and are composed of Trap Series lavas with altitudes of over 2000 m. The rivers on this plateau have been influenced by the south-easterly surface dip but canyons, so characteristic of the Western Plateau are only found close to the Rift scarp. Further down-stream all the rivers flow sluggishly in shallow U-shaped valleys across the featureless, flat desert plateau towards the Indian Ocean.

Separating the aformentioned two plateaux, a relatively sunken, faulted, complex Rift Valley runs generally SSW - NNE from Lake Rudolf to the Red Sea. The Ethiopian Rift floor, characterised by several lake basins, rises irregularly from less than 400 m around Lake Rudolf basin to over 1800 m, north of Lake Zwai, and descends northwards in a much more regular fashion. It finally falls below sea level before reaching the Red Sea coast.

While the large scale geomorphology of Ethiopia is dominated by tectonics, such factors as denudation by rivers, volcanic structures, lava flows, etc. are important, though on a smaller scale.

Exposures of the Precambrian schists and gneisses of the Paleozoic peneplain in the north, west and south form smoothly undulating countrysides. The gigantic intrusions of siliceous rocks into these are more resistant and hence appear as sharply up-standing inselbergs.

The Mesozoic sandstones and limestones give rise to flat plains, except where affected by denudation, resulting in the formation of steep cliffs. Caves and pot-holes develop in limestone and gypsum, though vegetation is sparse on gypsum.

The Tertiary basalts of the Highlands are generally characterised by a rugged topography leading into plains that extend from them.

2.3 CLIMATE

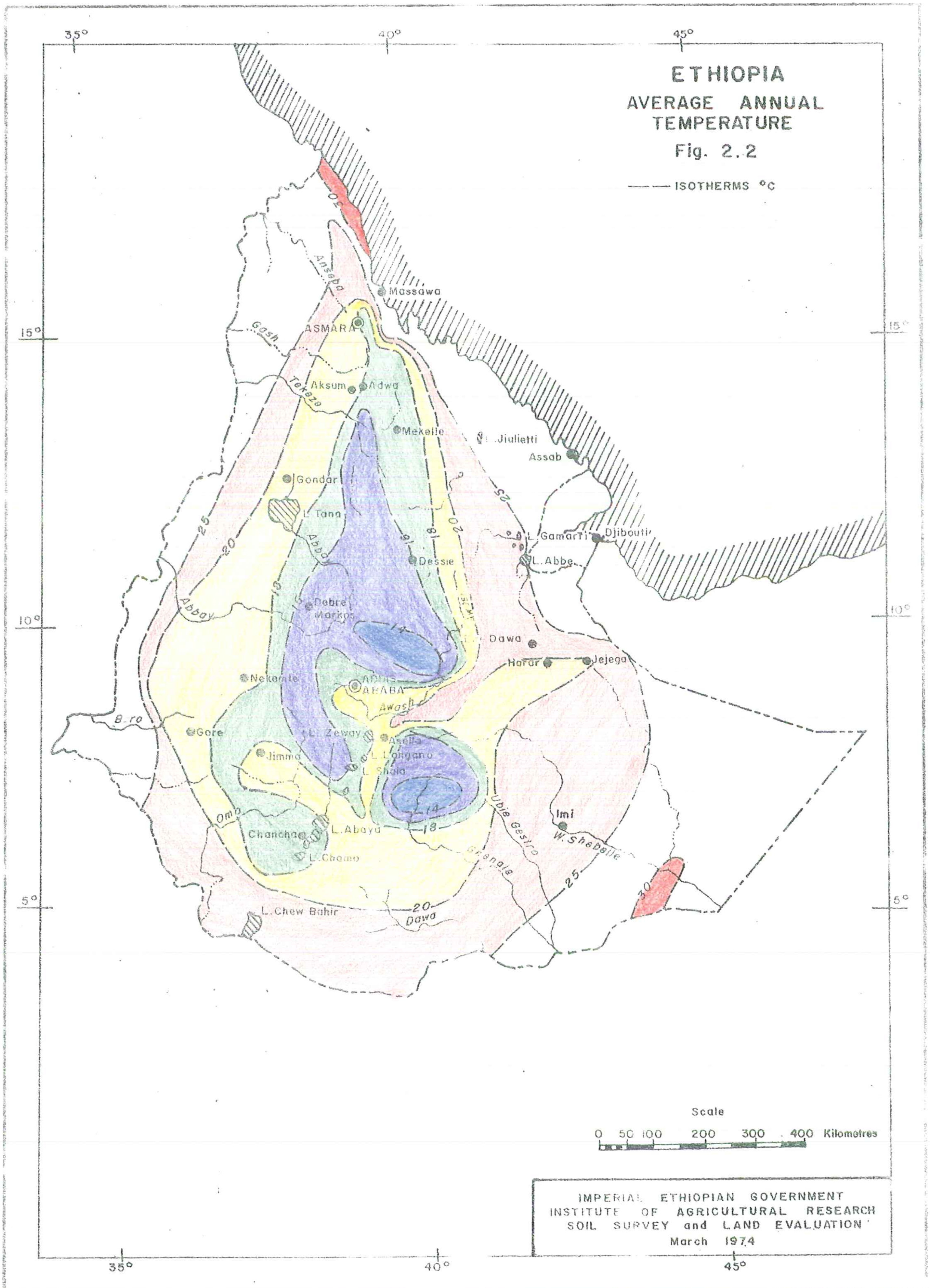
In Ethiopia areas between 1300 m and 2100 m have a temperate climate with maximum temperatures rarely rising above 25-28°C. However, temperatures over the country, where altitudes vary greatly, have a very wide range, and do not always coincide with the rainfall regions (Fig. 2.2 and 2.3). At and above these altitudes, the daily maxima and minima in periods of clear weather, may differ by as much as 22°C or more, while during the rains this range may be as low as 6°C. In most years night frosts occur between November and February at altitudes above 1800-2100 m. Frosts coincide with a low relative humidity of 20-30%. Hail may also occur, sometimes even at 1000 m.

When the Central Highlands are generally cool and daily averages less than 16°C, the border areas on all sides are warm to hot, particularly at the Red Sea coast which is also very humid.

Between October and May dry conditions prevail in most of the country due to the strong influences of two anticyclones centered one over the Sudan and the other over Arabia, both of which send dry subsiding air currents over Ethiopia. Between late June and early October these high pressure centers are replaced by cyclonic circulations. During this period two warm, moist currents move over Ethiopia: the southwesterlies from the South Atlantic coming over the humid Congo basin; and the southeasterlies from the Indian Ocean. Upon ascending the Ethiopian plateau both of these moisture laden currents yield the "Big Rains". Between October and May, occasional cold bursts from northern latitudes, penetrate southwards and coupled with the Inter-tropical Convergence Zone's normal migration produce the "Small Rains". Over the central Highlands these rains are not very reliable but are quite consistent in the southwestern part of the country. This being the overall pattern, actual conditions depend largely on the latitude, longitude and altitude of the place in question, and local topography contributes its own effect.

2.4 VEGETATION

Marked climatic and topographic differences exist in Ethiopia and the vegetation associations follow suit. Heavy



ETHIOPIA
AVERAGE ANNUAL TEMPERATURE
Fig. 2.2
ISOTHERMS °C
Massawa
ASMARA
Aksum
Adwa
Mekelle
L. Jiulietti
Assab
Gondar
L. Tana
L. Gamarti
Djibouti
Dessie
L. Abbe
Dawa
Harar
Jejega
Nekemte
ADDIS ABABA
Awash
Gore
Jimma
L. Zeway
Asella
L. Langano
L. Shala
L. Abaya
Chancha
L. Chamo
Imi
W. Shebelle
Ubie Gestro
Genale
L. Chew Bahir
Dawa
Abbay
Tekeze
Gash
Anseba
Omo
Baro
Scale
0 50 100 200 300 400 Kilometres
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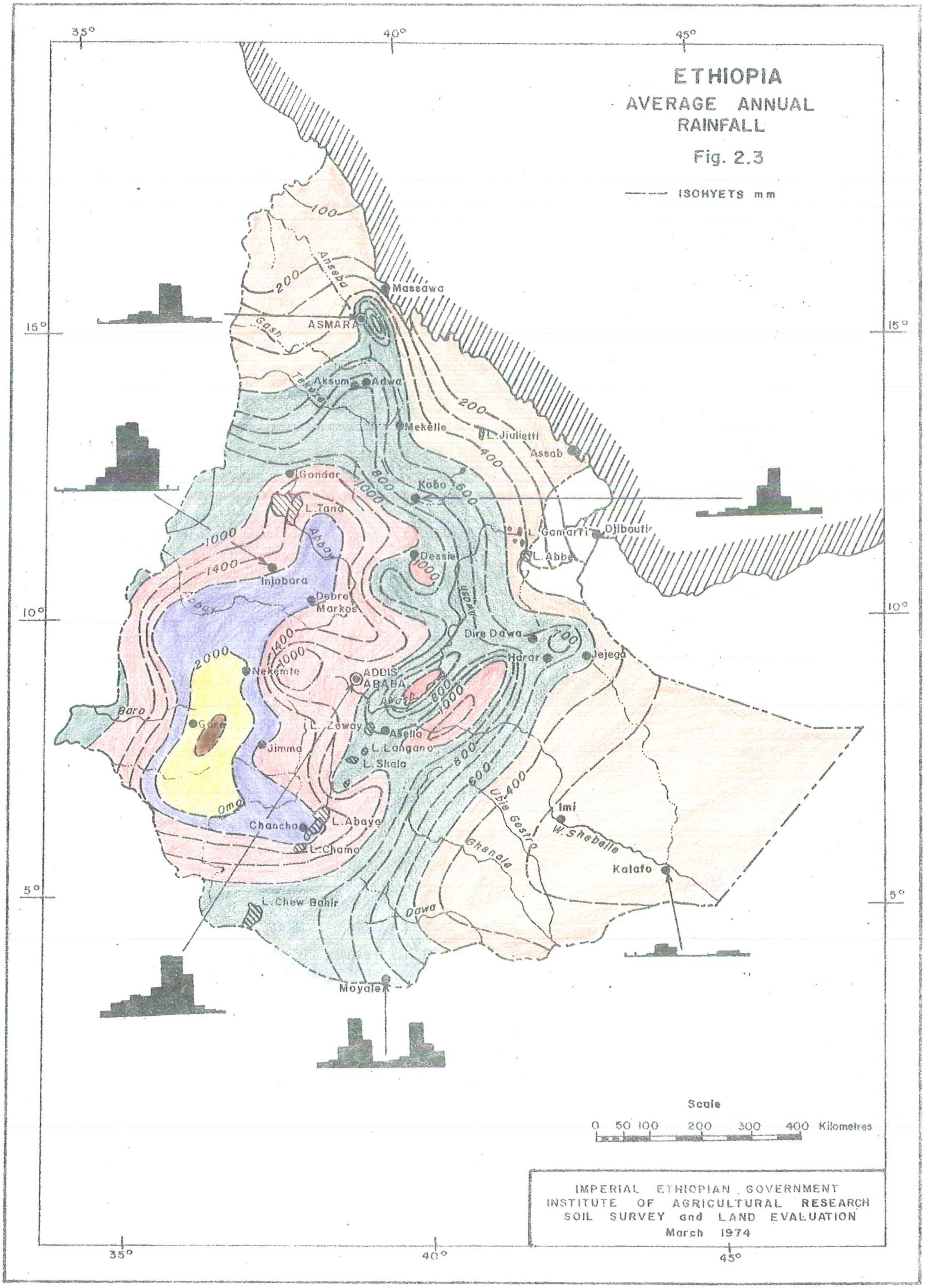
SOIL SURVEY and LAND EVALUATION
March 1974



ETHIOPIA
AVERAGE ANNUAL RAINFALL
Fig. 2.3

deforestation, intensive cultivation and expanding Eucalyptus plantations, however, have left little of the original aspects of the highlands. At present the vegetation varies from scarse desert shrubs to alpine plant association as shown in the following grouping:

The coastal and desert vegetation of the Red Sea coast area reflects a high salt concentration in the soil; the Danakil Depression is roughly similar.

The sub-desert steppe includes the areas of the northwestern, northeastern and southeastern border regions with herbs, grasses and shrubs.

The tree and shrub steppe of the southeast, south, the Rift Valley, Kobar basin, the northwest and the eastern lower slopes are characterized by semi-arid trees and grasses.

The Savannas cover a great part of northern Ethiopia, the northern, western and southeastern slopes of the Central Highlands and the alluvial plains around Lake Tana. In the degraded savanna in the north resulting from deforestation, extensive cultivation and over-grazing, only a sparse cover of grasses and trees is found.

The woodlands from which the evergreen thickets of the eastern Central Highlands are derived represent a typical slope vegetation of fairly dense grasses and shrubs. The mountain grasslands, also derived from the woodlands, vary in appearance from treeless, open undulating country to scattered tree savanna. They are dominated by a herbaceous vegetation with scattered trees.

The swamp and riparian formations include such vegetation as is normally associated with rivers, lakes and swamps.

2.5 LAND USE

The highlands with their temperate climate contain the bulk of arable and pasture lands which are cropped once or twice a year. In the extensive Central Highlands, however, there are small areas which allow crop growth all year round. The cultivated crops include cereals, oilseeds, pulses, 'enset' (false banana) and coffee. In the lower warmer regions sorghum, cotton, groundnut, sugar cane, etc. become more prevalent. (Table 2.1)

TABLE 2.1

CROPPING OF CULTIVABLE LAND IN ETHIOPIA AFTER WUNDERLICH AS QUOTED BY HUFFNAGEL (1961)

Type of Land	km^2	%
Agricultural land cropped	95,000	8.1
Coffee forests	5,000	0.6
Grazing grounds	330,000	28.0
Closed forest	40,000	3.4
Open woodland	34,000	2.9
Open brush & scrub	295,000	25.0
Deserts	370,000	31.0
Lakes & rivers	11,000	1.0
Total	1,180,000	100.0

3. SOILS

3.1 SOILS OF ETHIOPIA

The first attempt to map the soils of Ethiopia in a very general manner was made by Shantz and Marbut in 1923 at a scale of 1:25 million, as part of their publication "The Vegetation and Soils of Africa", in which they differentiated Chermozems, Tropical Prairie Soils, Laterites and other Red Tropical soils. In 1964 D'Hoore published a soil map of Africa at a scale of 1:5 million in which he mapped 10 major groups/associations in Ethiopia. A few generalized, small scale maps which included Ethiopia, were also produced by various authors and organisations.

The most recent map is the "Soil Map of Africa" produced by the UNESCO/FAO "Soil Map of the World" project at a scale of 1:5 million. Though this map contains a considerable amount of detail, it has some inaccuracies. However, since it applies the recent UNESCO/FAO Soil Classification, the Institute of Agricultural Research decided to use it as a base map on which further improvements and corrections can be made to produce a generalised soil map of Ethiopia. For this purpose the section of the map which covers Ethiopia has been enlarged to a scale of 1:2 million, superimposed on a topographic base.

This map distinguishes 13 major groups of soil associations, although there is very little factual information available to support it. Here only the most relevant mapping units will be discussed.

On the Western Plateau, with altitudes above 1000 meteres, vast areas of soil associations in which Cambisols are dominant, occur. In the western section of this plateau they are largely Humic Cambisols associated with Acrisols, whereas northwards they are mostly Eutric Cambisols associated with Luvisols. The rainfall pattern (Fig. 2.3) appears to be largely responsible for this trend; the high rainfall in the west decreases northwards. As most of the lands are subject to appreciable erosion, the Cambisols occur in all those areas where the A horizon is possibly eroded, leaving a cambic B at the surface

Truncated soils are very common in the Ethiopian Highlands and consequently from the large areas of Nitosols shown on the map one gets the impression that their extent may be exaggerated, for there is not sufficient evidence yet of the presence of an argillic B. Therefore in many places on the plateaux, the Nitosols may be Cambisols as well.

The Xerosols and Yermosols are common on and along the semi-arid to arid fringes of both the Eastern and Western Plateau, as well as in vast stretches of the Rift Valley. Often they occur side by side with the Vertisols, which are frequently either of a colluvial-alluvial origin or alternatively occur in places where drainage water from adjacent areas passes or accumulates. Vertisols are also observed on the Plateau in areas of impeded drainage.

Finally, the vast areas of Regosols and Lithosols, which may well occupy much vaster areas than actually exhibited on the map at present deserve attention. One has only to appreciate the almost dramatic dimensions of active soil erosion on both the Western and Eastern Plateau, in order to realise that the intricate soil patterns on the stepp mountain, hill and valley slopes are largely Regosols and Lithosols. In addition there are other vast areas in southeastern Ethiopia where Calcaric Regosols are particularly common on the late Jurassic limestone formations, where arid conditions prevail at present. These lands are subject to denudation by wind and water. The appreciable extent of Lithosols in central-east Ethiopia coincides with the northeastern extension of the Rift Valley towards the Red Sea. This region is largely occupied by exposed basalts, lava flows and related spatter cones of Miocene-Pleistocene age. In most places the surface is just rock with little soil in between.

No more than a broad picture can be given here and even this is not a very reliable one, due to the fact that basic data are still lacking for most of the country. But Murphy has made an appreciable contribution in collecting, on a nation-wide scale, data on soils mainly situated along main roads and thus produced a general inventory of the soils in the country.

3.2 SOIL STUDIES - COMPLETED OR IN PROGRESS - BY CONSULTANTS

Systematic soil survey and land classification studies were not undertaken until the late 1950's. Invariably, in all these studies aerial photographs have been used both in pre-field work analysis and interpretation and also during field mapping. The aerial photo coverage for the country is indicated in Fig. 3.1. Some nine major surveys have been conducted in five areas shown in Fig. 3.2. These are discussed in a chronological order in the following sections.

3.2.1 The Blue Nile River Basin

The Blue Nile river basin study covering an area of 20,400,000 ha was undertaken between 1958 and 1963 by the Bureau of Reclamation, US Department of Interior, Within this general project the soil study was done between 1959 and 1962. The survey was geared to identifying and to classifying irrigable areas within the river basin. However, as the basin was too vast for a complete survey within the alloted time, an initial selection based on aerial photo studies and low altitude helicopter flights was carried out and yielded 17 promising areas which were studied at sub-reconnaissance level - Table 3.1.

Within the 17 selected areas only lands suitable for irrigation were mapped according to the U.S.B.R. standards, the rest was left unclassified, thus:

Class 1: arable, highly suitable for irrigation

Class 2: arable, moderately suitable for irrigation, but well adapted to it.

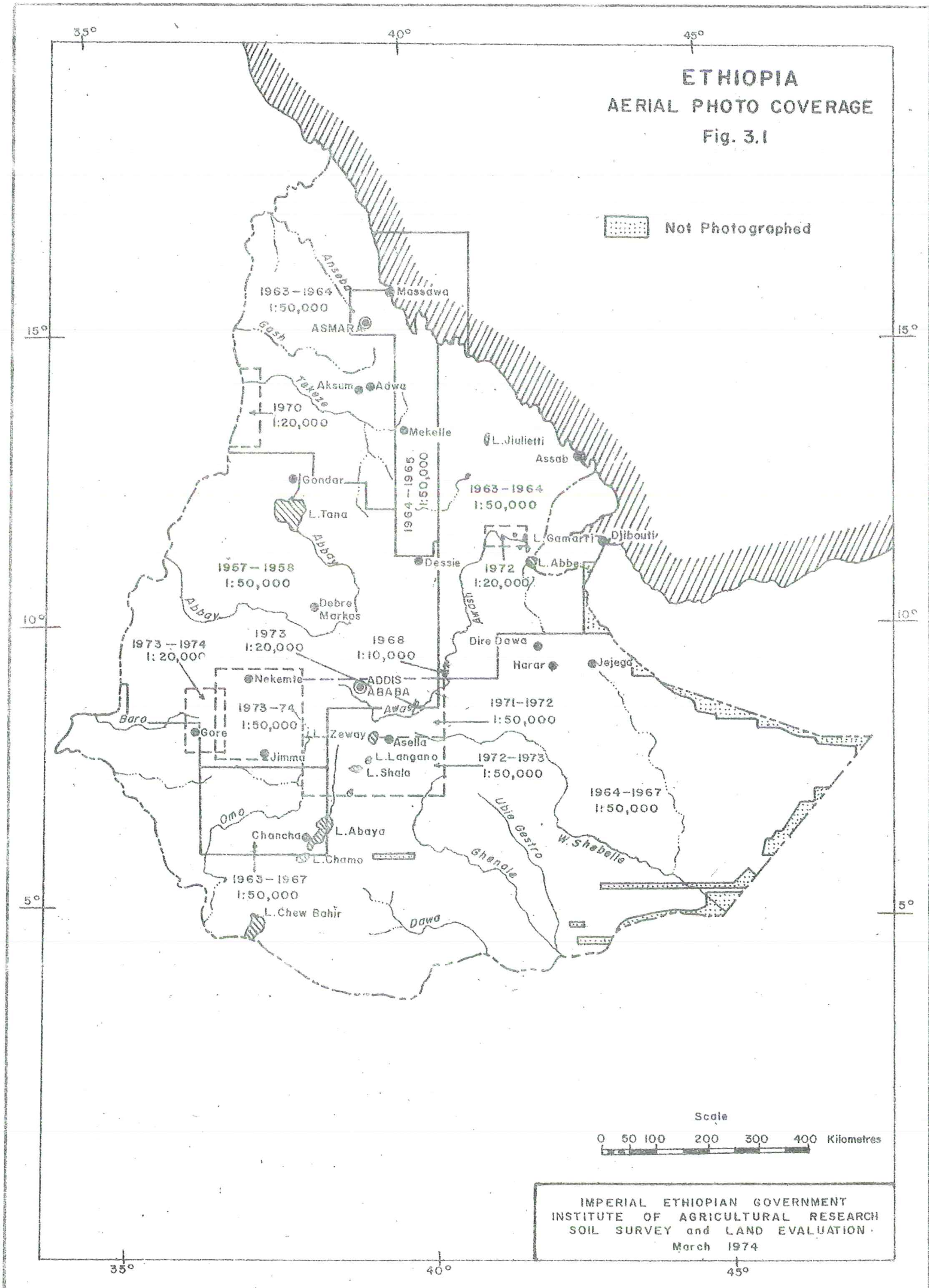
Class 3: arable, marginally suitable for irrigation, but least desirable for it.

Broadly, two groups of soils were identified in the basin:

Latosols:

These are:

- Best for irrigation, but difficult to develop because of the steep, rolling topography on which they occur.
- Clay textured with permeability and friability similar to the medium textured soils.



ETHIOPIA
AERIAL PHOTO COVERAGE
Fig. 3.1
Not Photographed
35°
40°
45°
15°
10°
5°
1963–1964
1:50,000
Massawa
ASMARA
Anseba
Gash
Tekeze
Aksum
Adwa
1970
1:20,000
Mekelle
L. Jiulietti
Assab
1964–1965
1:50,000
Gondar
1963–1964
1:50,000
L. Tana
Abbay
L. Gamarri
Djibouti
Dessie
L. Abbe
1957–1958
1:50,000
1972
1:20,000
Debre Markos
Awash
1973–1974
1:20,000
1973
1:20,000
1968
1:10,000
Dire Dawa
Harar
Jejega
Nekemte
ADDIS ABABA
1973–74
1:50,000
1971–1972
1:50,000
Baro
Gore
L. Zeway
Asella
Jimma
L. Langano
L. Shala
1972–1973
1:50,000
1964–1967
1:50,000
Omo
Ubie Gestro
W. Shebelle
Chancha
L. Abaya
Ghenale
L. Chamo
1963–1967
1:50,000
L. Chew Bahir
Dawa
Scale
0 50 100 200 300 400 Kilometres
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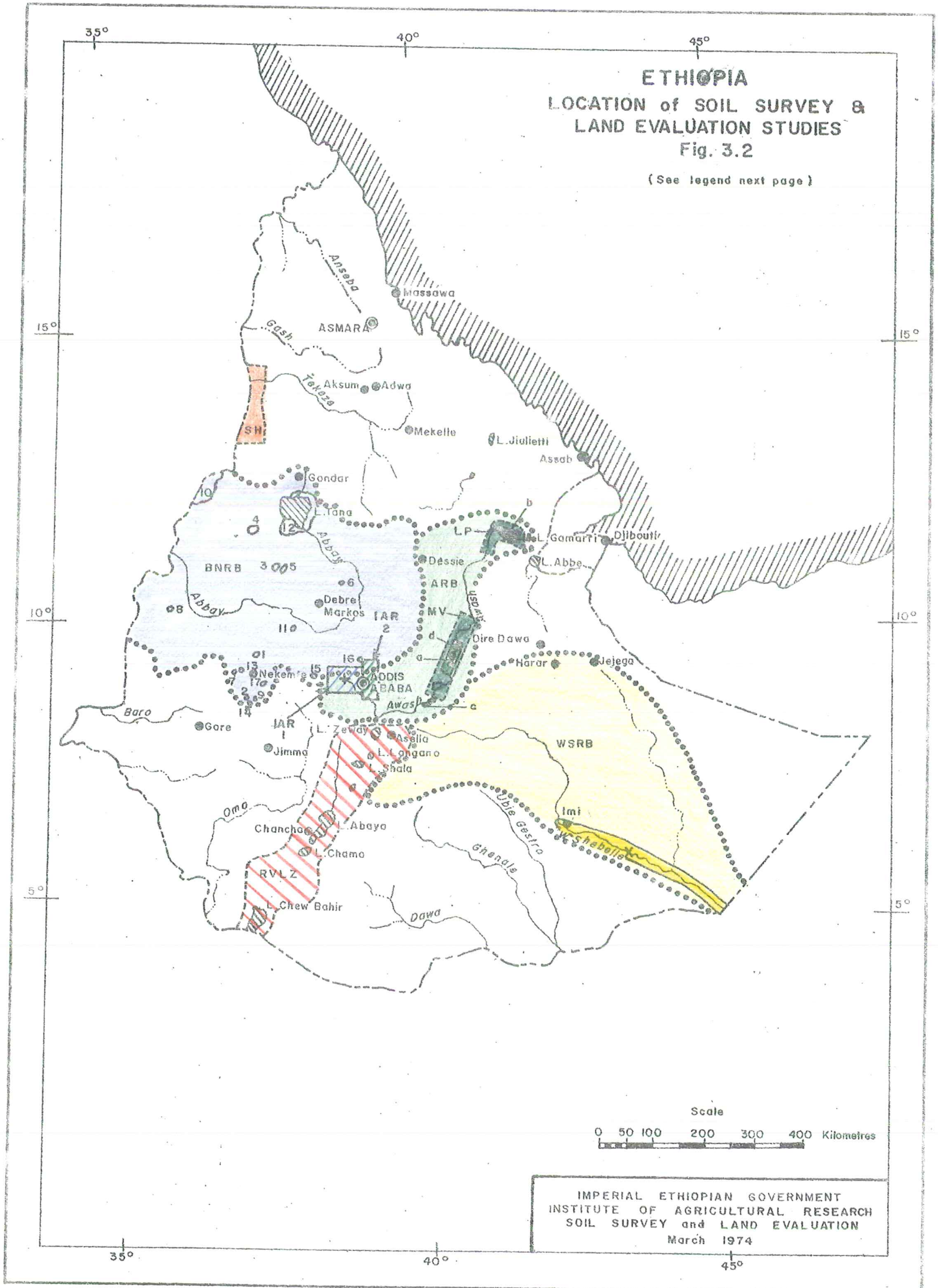

ETHIOPIA
LOCATION of SOIL SURVEY & LAND EVALUATION STUDIES
Fig. 3.2
(See legend next page)
Massawa
ASMARA
Aksum
Adwa
Mekelle
L. Jiulietti
Assab
Gondar
L. Tana
Djibouti
L. Gamarri
L. Abbe
Dessie
BNRB
ARB
LP
MV
Debre Markos
IAR
Dire Dawa
Harar
Jejega
Nekemte
ADDIS ABABA
Gore
Jimma
L. Zeway
Asella
L. Langano
L. Shala
WSRB
Imi
Chancha
L. Abaya
L. Chamo
RVLZ
L. Chew Bahir
SH
Ansaba
Gash
Tekeze
Abbay
Baro
Awash
Omo
Ghenale
Dawa
Ubie Gestro
W. Shebelle
Scale
0 50 100 200 300 400 Kilometres
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March 1974

ETHIOPIA

LOCATION of SOIL SURVEY & LAND EVALUATION STUDIES

Fig. 3.2

(Cont.)

LEGEND

River basin studies

BNRB 40 ⊂⊃6 — Blue Nile river basin:
17 project areas (Ø4, ⊂⊃6)
mapped at approx. 1: 100,000 – 1959–62

ARB — Awash river basin:
general reconnaissance 1:1,000,000 – 1961

reconnaissance, Middle Valley (MV)
– Lower Plains (LP) 1: 250,000 – 1961–64

Semi – detailed, Middle Valley –
Lower Plains 1: 100,000 – 1961–64

detailed 1: 20,000

a. Melka Sadi – Amibara – 1968–69
b. Lower Plains – 1972–73
c. Tibila – 1972–73
d. Angelele – Bolhamo – 1973–74

WSRB — Wabi Shebelle river basin:
exploratory survey 1:1,000,000 – 1969

Semi – detailed, Lower
Valley 1: 50,000 – 1969–70

Other studies

SH — Setit Humera:
Semi – detailed 1: 100,000 – 1972–73

RVLZ — Rift Valley Lake Zone
land resource study 1: 500,000 – 1973

IAR 1 — Wollenkomi – Addis Ababa (IAR)
land resource study 1: 100,000 – 1973

IAR 2 — Sendafa – Debre Zeit (IAR)
land resource study 1: 50,000 – 1974

\+ Holetta Agricultural Research Station (IAR)
detailed survey 1: 5,000 – 1973

x Gode Agricultural Research Station (IAR)
detailed survey 1: 10,000 – 1973

TABLE 3.1

BLUE NILE SURVEY

Details of 17 areas studied

	Class 1 ha	Class 2 ha	Class 3 ha	Under irrigation	Total ha
Angar	1,450	34,910	19,900		56,260
Arjo		80	22,735		22,815
Azena-Fettam	44,666	49,830	18,113	17,881	130,490
Beles	5,700	35,000	67,200		107,900
Birr	22,767	8,577	36,240	2,188	69,772
Cheye			3,400		3,400
Dabana		7,050	2,110		9,160
Dabus	1,380	16,420	12,200		30,000
Diddessa		13,360	8,665		22,025
Dinder-Rahad		31,500	197,000		228,500
Finchaa		22,921	11,262		34,183
Lake Tana	58,030	67,030	160,560		285,620
Nekemte		7,025	11,510		18,535
Upper Diddessa		1,560	4,800		6,360
Upper Guder	2,110	27,980			30,090
Upper Muger	250	8,490			8,740
Wama		23,665	19,465		43,130
Total	136,353	355,398	595,160	20,069	1,106,980

- Suitable for a wide range of crops and easy to farm because of good permeability and drainage characteristics.

- Of low natural fertility but respond well to fertilizers.

Grumusols (Vertisols):

- Usually occur on smooth topography, are fairly easy to develop for irrigation but difficult to manage.

- Severely cracking clay with very slow permeability; irrigation must wet the soil laterally after water fills the cracks rather than by normal infiltration.

- High in fertility but machinery is desirable for better exploitation of their potential.

3.2.2 The Awash River Basin

322.1 Initial surveys

The Awash basin, in contrast to most of the other major catchments in Ethiopia, is in many parts relatively open. Over much of its extent it has a limited amount of rainfall which is confined to one part of the year. However, its lands include considerable areas of high potentialities. As a preliminary step to a fuller exploitation of the basin, the Ethiopian Government requested the U.N. Special Fund for assistance in carrying out land and water resource appraisal studies and the preparation of development plans for the area. The executing agency, FAO, sub-contracted to Hunting Surveys Ltd., London, the aerial photography and to SOGREAH, Grenoble, the actual study, which was completed during the period 1961-64.

The soil and land appraisal was undertaken in three stages.

1) A general aerial reconnaissance of the entire basin, followed by ground checks. In this, 7 million hectares of land were mapped at a scale of 1:1 million and areas likely to be suitable for development under irrigation were selected, in which the following soils were distinguished:

	% of area
Alluvial soils (young soils on alluvial deposits)	2.4
Vertisols	15.2
Vertisols associated with Lithosols	19.1
Semi-arid brown soils	12.6
Saline and saline-alkali soils including Regosols	6.4
Hydromorphic soils	3.0
Regosols (eroded soils in arid regions)	15.9
Lithosols	25.4

This initial investigation led to the selection of certain areas in the Middle Valley and the Lower Plains for further study.

2) A reconnaissance soil survey of selected lands amounting to 1,121,000 ha in the Middle Valley and 836,000 ha in the Lower Plains, was conducted at a scale of 1:250,000 to locate irrigable areas more specifically. The soils were differentiated as follows:

		% area
I. Soils on recent alluvia	16.2	
Alluvial soils		9.0
Vertisols		3.2
Hydromorphic soils		1.3
Organic hydromorphic soils		2.5
Alkaline hydromorphic soils		0.2
II. Soils on old alluvia and colluvia	42.0	
Vertisols on calcareous materials		7.3
Vertisols on calcareous materials in the run-off zones		0.7
Semi-arid brown soils		15.1
Saline soils on calcareous materials		2.6
Saline-alkali soils on cala-careous materials		4.8

Regosols resulting from erosion	8.2
Saline soils and regosols on non-differentiated materials	3.3

III.	Skeletal soils on volcanic materials	41.7	
IV.	Soils on sandy deposits	0.1	

The lands were then evaluated in terms of present suitability for development under irrigation, according to three classes, i.e.:

Class A - arable land, suitable for development under irrigation

Class B - arable land, non-irrigable in its present state except under certain special conditions.

Class C - non-arable, non-irrigable land.

Summarizing the land classification gave the following results:

	Middle Valley	Lower Plains	Total	% total area
Class A	125,000 ha	75,000 ha	200,000 ha	10.2
Class B	601,000 ha	125,000 ha	726,000 ha	37.1
Class C	395,000 ha	636,000 ha	1,031,000 ha	52.7
Total	1,211,000 ha	836,000 ha	1,957,000 ha	100

3) A semi-detailed soil survey of selected irrigable lands in the Middle Valley (262,000 ha) and in the Lower Plains (240,000 ha) was then conducted and mapped at a scale of 1:100,000 for the identification of possible development projects.

The differentiation of soil mapping units followed largely the pattern described for the reconnaissance soil survey under (2) but with further sub-divisions, which are not discussed here.

For the land classification the following specifications of U.S. Bureau of Reclamation, adapted to local conditions where necessary, were used:

Class I	-	good irrigable land
Class II	-	moderately good irrigable land
Class III	-	marginal irrigable land
Class IV	-	not irrigable, except under special conditions
Class V	-	undetermined suitability for irrigation
Class VI	-	permanently non-irrigable land

The lands were differentiated into the following classes:

	Middle Valley	Lower Plains	% total area
Class I	-	-	-
Class II	56,600 ha	30,000 ha	17.2
Class III	58,000 ha	39,000 ha	19.3
Class IV	40,000 ha	33,000 ha	14.6
Class V	9,900 ha	15,000 ha	5.0
Class VI	97,400 ha	123,000 ha	43.9

322.2 Melka Sadi - Amibara

The above study indicated, at both the reconnaissance and the semi-detailed stages, the presence of class A (reconnaissance) and class II and III lands (semi-detailed) around Melka Sadi and Amibara, an area in the Middle Awash Valley, in which the Government was interested to start irrigation development. During late 1968 to early 1969 a detailed soil survey and land classification was carried out by Italconsult, Rome, covering an area of 28,548 ha and mapped at a scale of 1:20,000.

The project area lies in the Rift Valley region at an approximate altitude of 740 m with an annual rainfall of 500-600 mm. It extends over both the recent alluvial plain and old fluviatile terraces of the Awash River.

The soil mapping units have been differentiated into the following groups:

	ha	% area
Soils on very recent alluvium - Fluvents	2,784	9.8
Vertisols on recent alluvium-Orthents and Usterts	3,362	11.8
Non-calcareous Vertisols on recent alluvium - Usterts	2,035	7.1
Hydromorphic Vertisols - Usterts	3,710	13.0
Stratified soils on recent alluvium - Fluvents	8,504	29.8
Arid brown soils on terrace alluvium - Orthids	5,803	20.3
Saline and alkali soils on recent alluvium - Aquents	1,899	6.6
Calcareous soils on gravelly terrace alluvium - Orthids	451	1.6

Subsequently, the lands were classified according to their suitability for irrigated land use as specified by the U.S. Bureau of Reclamation. The following land classes were distinguished:

Class 1	- arable (good)	- 969 ha	- 3.4%
Class 2	- arable (moderate)	- 13,124 ha	- 46.0%
Class 3	- arable (marginal)	- 6,230 ha	- 21.8%
Class 4	- limited arable	- 457 ha	- 1.6%
Class 6	- non-arable	- 7,768 ha	- 27.2%

Land class 5 with undetermined suitability under existing conditions pending further special study was omitted at this stage. The land sub-classes indicated their specific major limitations.

322.3 The Lower Awash Plains

The semi-detailed survey of the Lower Awash Plains by SOGREAH (322.1-3) revealed the availability of adequate promising areas to justify a more specific formulation of a development plan. Sir Alexander Gibb & Partners, London, were requested to conduct a feasibility study of the area, which included a detailed soil survey of an area of about 114,000 ha. Hunting Technical Services provided the soil survey team, which carried out the field work in 1972-73. The final soil and land classification maps were produced at a scale of 1:20,000. The area lies at an altitude of 350 m and has an annual rainfall of 150 to 200 mm.

The Awash River is confined to the Rift Valley. It does not reach the sea, but after crossing the Tendaho - Asayita plain it enters the area occupied by the lakes Gamari, Afembo and Bario none of which have an out-let. It is building up a delta projecting into this through and gradually filling it with alluvium. As a result of the delta formation, the course of the Awash has changed frequently, currently draining into Lake Gamari.

In the Tendaho-Asayita basin and the present lake area, there are vast lacustrine and littoral sediments associated with the presence of an extensive lake in early Holocene times, dated from 10,000 to 5,000 years BP. Following the drying-up of the lake, the Awash eroded a meander belt through the lake-bed sediments and filled it up with riverine alluvium, which in places was uplifted. In the immediate vicinity of the Asayita basin basaltic lava flows form outcrops from which alluvial fans stretch into the survey area. In a few locations fumaroles occur.

The soil mapping units in close relationship with their geomorphology and parent material have been differentiated into:

- Soils developed on riverine alluvium
- Soils developed on colluvial material
- Soils developed on lacustrine sediments in situ
- Dune sands
- Soils developed on lava ridges
- Soils affected by fumarole activity

Among the above soil groups the first is the most common in the survey area; it has been divided into 9 mapping units.

The land classification follows the U.S. Bureau of Reclamation specifications for irrigated land use. This study distinguishes only land classes 1,2,3 and 6 corresponding with good, moderate, marginal arable and non- arable respectively. A further distinction in sub-classes indicates the nature of major limitations within each class, but the details of these are not presented here.

Class	Area, ha	%
Class 1	3,471	3.1
Class 2	35,566	31.2
Class 3	54,438	47.8
Class 6	20,314	17.9

322.4 Tibila

Tibila is an area in the Upper Awash Valley which has also been selected for a feasibility study. This was done by B.D.P.A., Paris. The investigation included a soil survey and land classification at scale 1:20,000, and was carried out in the period between late 1972 and early 1973. It covered an area of 18,000 ha, lying at an altitude of 1200-1350 m with an annual rainfall of 600-700 mm.

At Tibila, the Awash River, flowing northwestwards, has incised a relatively narrow and shallow valley with young terraces. The project area is on the southern bank and consists largely of an old upper terrace formation, with a few alluvial fans and a narrow zone of colluvial material along the foot of the mountain scarp in the south. The mountains are mainly composed of ignimbrites, welded tuff and occasionally pumice. Farther northeast, where the plain narrows, protruding basaltic lava flows are common.

The most common soils in the area are medium to fine textured Xerosols. Vertisols occur in places, while Fluvisols are found on the young terraces along the Awash.

The land classification follows the U.S. Bureau of Reclamation specifications for irrigated land use. Only land classes 1,2,3,5 and 6 were distinguished, corresponding to good, moderate, marginal arable, tentatively non-arable and non-arable land respectively. A further distinction at the sub-class level indicates the nature of major limitations within each land class. Details of these are not presented here.

Class	Area, ha	%
Class 1	4,280	23.7
Class 2	7,701	42.4
Class 3	1,206	6.6
Class 5	1,768	9.7
Class 6	3,198	17.6

322.5 Angelele and Bolhamo

Angelele and Bolhano plains in the Middle Awash Valley are yet another place in which the Government is interested to develop irrigated agriculture. Bolhamo area is situated on the west bank of the Awash and Angelele on the east bank, more or less opposite each other, just downstream of Amibara (322.2). These project areas are at an altitude of about 750 m, and have an annual rainfall of 500-600 mm. The total area of about 14,000 ha is being mapped at a scale of 1:20,000. The land classification, according to the U.S. Bureau of Reclamation specifications for irrigated land use, intends to differentiate land classes 1,2,3 and 6.

The survey team from Hunting Technical Services started operations at the end of 1973 and will complete field work in the first half of 1974. It is too early to report on results.

3.2.3 The Wabi Shebelle River Basin

The study of the Wabi Shebelle catchment, started in 1969 by ORSTOM-BDPA, Paris, was meant as a land resource inventory of the entire basin in order to select promising areas for which more specific development plans could be formulated.

The initial general reconnaissance covered about 18 million ha and revealed appreciable stretches of irrigable land in the Lower Valley, between Imi and the Somali border. A semi-detailed soil survey and land classification of this stretch was required for the preparation of a development plan. This survey covered 382,000 ha, mapped at a scale of 1:50,000 and was completed at the end of 1970.

About 40 km north of Imi the Wabi Shebelle leaves the mountains and meanders into an alluvial plain which is a few kilometers wide. Between Imi and Kalafo the river has incised its bed some five metres into the alluvial plain. However, downstream from Kalafo a wide braided river flood plain, in places with permanent papyrus swamps, is formed.

The climate is semi-arid with an annual rainfall of about 300 mm, concentrated in two two-monthly periods, April-May and October-November.

The soils of the Lower Valley have been tentatively differentiated as follows:

- Undeveloped soils on colluvia

- Weakly developed soils

i) Xerosols:
   - on the limestone plateau and its colluvia,
   - on the sandstone plateau,
   - on the gypsiferous lower hills and their colluvia,
   - on large gypsiferous alluvial flats,
   - on basalt hills and their colluvia.

ii) Weakly developed soils derived from alluvia of the Ogaden limestone plateau:
   - on hillocks in the alluvial fans,
   - on the lower alluvial fans,
   - on recent alluvia of small streams,
   - on recent alluvia of larger streams.

iii) Weakly developed soils on alluvia-colluvia from Ogaden limestone and Ferfer gypsum.

iv) Weakly developed soils on Wabi Shebelle alluvia

v) Weakly developed soils on Wabi Shebelle alluvia over Ogaden limestone colluvia.

- Vertisols:
   - on alluvia from Ogaden limestone
   - on alluvia from basalts
   - on Wabi Shebelle alluvia

- Hydromorphic soils, organic

- Sodic soils with salt efflorescence

As the consultant's report has not been published yet, one can only guess what these soils would be in the UNESCO/FAO Soil Classification. It seems that between Imi and Kalafo, Vertisols and Regosols are most common, while in the braided river flood plain below Kalafo Fluvisols, Gleysols and Solonchaks are prominent.

The lands have been classified in three classes:

Class I	- very suitable for irrigation
Class II	- low suitability for irrigation
Class III	- Unsuitable for irrigation

The land Classes I and II have been divided into sub-classes according to their suitability for various cropping systems and each of which is then graded according to the nature and severity of major land limitations. Land Class III is sub-divided with respect to the nature of major limitations only.

It has been tentatively estimated that about two thirds of the land would come into Class I, while the rest would be Class II and III land.

3.2.4 Setit Humera Soil Study

The Setit Humera surveys area is situated in the North West low lands of Ethiopia adjoining the Sudanese border at 13°02'N - 14°39'N and 36°20'E - 37°08'E.

The climate is influenced by the Inter-Tropical Convergence Zone movements and altitude. Rainfall ranges from 500 mm in the northwest to 1000 mm in the southeast and temperature from 24°C - 28°C. The difference between the absolute maxima and minima is of the order of 40°C.

The geology includes Precambrian schists and granite intrusions covered by Mesozoic sediments over most of which occur Trap Series basalts from which the soils are actually derived.

With the altitude ranging from 550 m in the north to 1000 m in the southeast, five sets of geomorphological units are distinguished:

1. Low river terrace - discontinuous and up to 400 m wide along main rivers

2. Terrace escarpment - degraded clay plain between 1 and 3

3. Medium terrace - extensive aggradational clay plain up to 30 km away from rivers.

4. Eroded parts of high terrace - degraded clay plain between 3 and 5

5. High terrace - plateau remnants occurring in 3 or at the end of it.

An area of a 1,000,000 ha was studied on 1:20,000 scale aerial photographs from which 77 mosaics were compiled and reduced to 1:100,000 scale; all information was transferred onto these mosaics. An area of 782,000 ha was selected for systematic study and within this key locations were chosen for more detailed work.

Except for the non-arable lands, the largest portion of the area is taken up by Vertisols. Although small in area coverage, Entisols and Alfisols are also present - Table 3.2

TABLE 3.2

SETIT HUMERA SURVEY

Soil Series

Series	Order	Subgroup	Family
Humera	Vertisols	Typic Chromustert	Fine, montmorillonitic, isohyperthermic
Khadra	Vertisols	Typic Chromustert	Fine, montmorillonitic, isohyperthermic
Lugdi	Vertisols	Entic Pellustert	Very fine, montmorillonitic, isohyperthermic
Marzinab	Vertisols	Typic Chromustert	Very fine, montmorillonitic, isohyperthermic
Rubassa	Vertisols	Entic Pellustert	Very fine, montmorillonitic, isohyperthermic
Setit	Entisols	Typic Ustifluvent	Loamy, mixed, calcareous, isohyperthermic
Tebeldi	Alfisols	Udic Haplustalf	Loamy, mixed, isohyperthermic

Broad correlation between climate, natural vegetation and soils exist. Accordingly three ecological zones termed A,B, and C are distinguished - Table 3.3.

TABLE 3.3

ECOLOGICAL ZONES AND THEIR CHARACTERISTICS

Eco-Zones	Area, ha	Rain mm Period	Vegetation	Soils
A	133,890	570; June-Oct.	Acacia Mellifera Thorn Land	Humera clay
B	135,600	570-800; May-Oct.	Acacia Seyal - Balanites Savanna	Khadra-Lugdi clay
C	512,510	800-1000; May-Nov.	Anorgeissus - Combretum Savanna Woodland	Marzinab-Rulassa clay

Three land types exist in the area - arable and cultivated, arable and not cultivated, and non-arable lands each making the following respective percentages of the total area: 39, 15 and 46 - Table 3.4. The crops grown include: sesame (45)+, sorghum (35), cotton (12), and other crops, millet, maize, peppers (8).

TABLE 3.4

SETIT HUMERA SURVEY

Land types in each eco-zone

eco-zone	Cultivated		Cultivable		non-cultivable		Total	
	ha	%	ha	%	ha	%	ha	%
A	78,150	10.0	24,000	3.1	31,740	4.0	133,890	17.1
B	85,220	10.9	8,000	1.0	41,280	5.3	134,000	17.2
C	140,755	18.0	85,000	10.9	287,855	36.8	513,610	65.7
Total	304,125	38.9	117,000	15.0	360,875	46.1	782,000	100.0

+ figures in brace refer to % of cultivated land covered by the respective crops.

3.2.5 Land Resource Study of the Rift Valley Lake Zone

This study is meant to assess the resources and development opportunities of the whole of the Rift Valley Lake Zone in sufficient detail to subdivide the region into discrete development areas. The project area of 5.5 million ha stretches from Lake Zwai in the north to Lake Stefanie (Chew Bahir) near the Kenyan border. A team of specialists from the Land Resources Division, Overseas Development Administration of the British Government's Foreign and Commonwealth Office started operations in early 1973. The results of the study, contained in a report to be submitted to the Ethiopian Government in early 1974, are not available yet.

To begin with, the Rift Valley Lake Zone was divided into 33 land regions with the help of aerial photo analysis. Within and across these regions the study identified:

9 regional development areas

8 local development areas

3 special development areas

Each of these development areas are defined in more detail in terms of land resources and development potential, accompanied by maps at a scale of 1:500,000. The soils have been classified in broad associations according to the recent UNESCO/FAO Soil Classification.

As a follow-up of the present broad study, the team will undertake a feasibility study of the Lake Zwai special development area in appreciably greater detail and map it at 1:50,000.

3.3 SOIL AND LAND EVALUATION STUDIES BY THE INSTITUTE OF AGRICULTURAL RESEARCH

As mentioned in the introductory chapter, it was not until late 1971 that a soil survey and land evaluation section was established within the I.A.R. Financial and man-power resources are limited and only a small unit has been set up. At present this consists of one Assistant Research Officer - a university graduate- three field technical Assistants, one analyst and one draughtsman and for the time being, an FAO Technical Officer is attached to this unit. It is hoped that in the near future two additional Assistant Research

Officers can be recruited. Laboratory analyses for soils are undertaken by the Analytical Services Section of the Institute.

It has been decided in this early stage to restrict operations to the preparation of detailed soil maps of the I.A.R. research stations and to a land evaluation study of an area of 100,000-200,000 ha surrounding each station, in order to determine the representativeness of the station location and to evaluate the applicability of its research findings to the areas concerned (Fig. 3.2). The study may also detect possible significant agricultural research problems which deserve to be taken up by the I.A.R.

For the time being the results are being compiled in tentative maps pending the completion of analyses when final maps and reports can be prepared.

3.3.1 Detailed soil survey of Gode Agricultural Research Station - Bale Province

Gode Agricultural Research Station of 450 ha, is situated in the Wabi Shebelle Valley, a warm semi-arid region in south-eastern Ethiopia at approximately 43°E and 6°N and an altitude of 300 metres. The annual rainfall of about 320 mm is concentrated in two two-monthly periods, April-May and October-November. The station covers some 450 ha of which 200 have been opened and canalized. A detailed soil survey was undertaken in early 1972 and mapped at a scale of 1:10,000.

The Wabi Shebelle has incised a wide valley in the Eastern Plateau, which consists largely of gypsiferous Antalo Limestone. The station is situated on the river alluvial plain with clearly visible, silted-up, former meander branches and levees. This is a lower terrace in which the river incised its present bed some five metres deep. The plain is practically level with a slope gradient of only 0.07%.

The water of the river is of reasonably good quality during the main irrigation seasons. The groundwater, is of very high salinity (4-7 mmhos/cm) though of low sodium hazard. It occurs at 5 to 10 m depth and needs to be closely watched.

The soils have been differentiated broadly as follows:

i) Chromic Vertisols of the former back-swamps - 65% of the area.

ii) Calcaric Regosols, alongside the former levees, often forming a transition towards the Chromic Vertisols; the clay layer is not thick enough to qualify as Vertisols - 15% of the area.

iii) Calcaric Regosols of the former levees - 18% of the area.

iv) Calcaric Regosols of the silted-up, former meanders - 2% of the area.

The land classification, which will take into consideration actual crop yield data, will be finalized as soon as analytical soils data are made available. Soil and land evaluation information of the station's surroundings are available from the Wabi Shebelle River Basin study (3.2.3).

3.3.2 Detailed soil survey of Holetta Agricultural Research Station-Shoa Province

Holetta Agricultural Research Station is situated in the Central Highlands of the Western Plateau at approximately 38°30'E and 9°N and an altitude of 2400 metres It serves the rain-fed highland areas growing mainly cereals with pulses and oil seeds as secondary crops. Livestock is also important. The station, which covers 390 ha was surveyed in detail in mid 1972 and mapped at a scale of 1:5,000.

The climate is characterized by a cool dry season with frequent night frosts from October to February, followed by a period of light rains in March and April. May is dry and warm, while from June to September the main rainy season occurs. The mean annual temperature is 13.5°C and the annual rainfall 1100 mm Fig. 3.3.

The station forms part of a degraded middle plateau on alkali olivine basalt of the Trap Series, which is of Paleocene -Oligocene-Miocene age.

In the absence of detailed analytical data the soils have been tentatively differentiated as follows:

i) Chromic Cambisols of the lava plateau remnants--37% of the area.

ii) Pellic Vertisols of the degraded plateau footslopes--25% of the area.

iii) Gleyic-Pellic Vertisols of the degraded plateau lower foot slopes--17% of the area.

iv) Eutric Fluvisols of the Holetta River former flood plain-19% of the area.

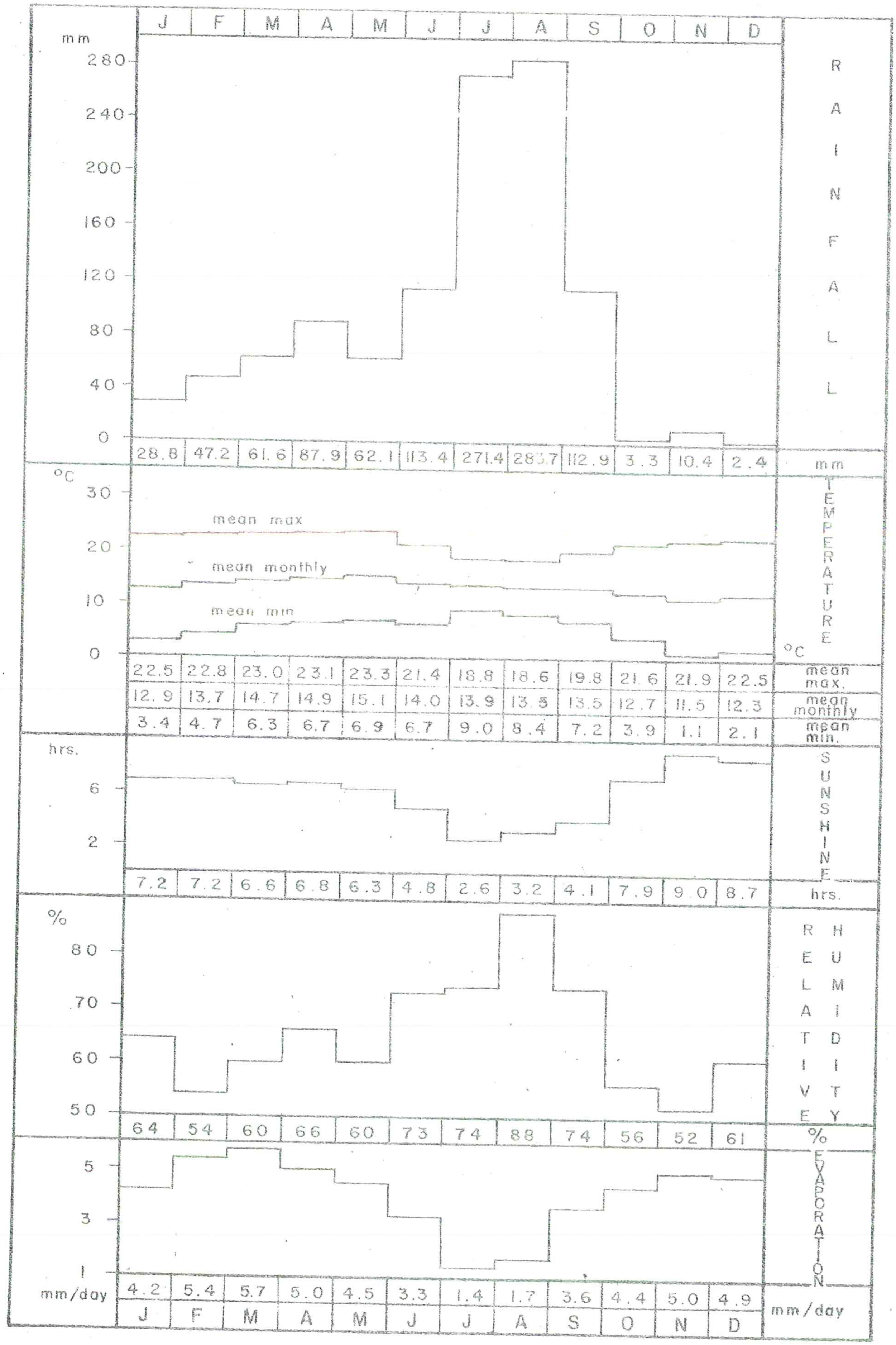

Fig. 3.3 HOLETTA CLIMATE DIAGRAMS 1968–72

v) Rocky and stony lands and marsh land - 2% of the area.

As soon as detailed analytical soil data become available a land evaluation will be prepared in consultation with the several research disciplines operating on the station taking into consideration the various relevant land utilization types.

As a follow-up of the detailed survey summarised above a land resource and evaluation study was made of the surrounding area of the station, which is reported on below.

3.3.3 Land Resource and Evaluation Study of Wollenkomi-Addis Ababa region

This land resource and evaluation study concerns an area of nearly 200,000 ha, between 38°15'E to 38°45'E and 8°50'N to 9°10'N, extending roughly 30 km westwards and eastwards and 15 km northwards to 25 km southwards of Holetta Station. The fieldwork was done during 1973.

The climate is in general the same as for the station. The altitudes vary between 3400 m at Wachacha Mountain summit and 1950 m in the "lowlands".

The lands have been differentiated according to geomorphological land types, sub-divided where relevant into topographically more homogeneous land units, which in fact form the basic mapping units. For each mapping unit the geology, topography, soils, drainage conditions, erosion status, vegetation and land use are described. If significant differences in climate can be detected these will be indicated. Finnally, a synthesis incorporating the limitations and hazards would be produced. The final map is being prepared at a scale of 1:100,000. The collection of the land resource data has not been done by a multi-disciplinary team. The interpretation of this information and especially the evaluation of various land utilization types, however, will be undertaken in consultation with specialists in, among other disciplines, agronomy, animal production, range management and farm management. The interpretation and evaluation phase of this study is about to begin. It is envisaged that the "Background Document" for the 1972 FAO sponsored expert consultation will be followed as a general guide.

A general appraisal of the land resources in the area is given below:

i) Mountains and hills, altitude 2100-3400 m.
- commonly on basalt and trachyte, in places on rhyolite or ashes.
- Moderately steep to very steep and often moderately dissected; gently sloping footslopes.
- upper slopes: Phaeozems and Cambisols.
middle slopes: Regosols and Lithosols.
lower slopes: Cambisols.
- major limitations and hazards: topography, soil depth and stoniness, erosion.

ii) Upper plateaux and their remnants, altitudes 2600-2750 m.
- commonly on basalt and trachyte.
- gently slopping, undulating, slightly dissected.
- Cambisols dominant, Vertisols in shallow depressions.
- major limitations and hazards: erosion.

iii) Degraded middle plateaux, altitudes 2200-2500 m.
- commonly on basalt, in places on trachyte.
- gently sloping, undulating, slightly or moderately dissected.
- Cambisols dominant, Vertisols on gentle lower slopes.
- major limitations and hazards: erosion.

iv) Degraded lower plateaux, altitudes 2100-2200 m.
-commonly on basalt.
- gently sloping, slightly undulating and slightly dissected.
- Vertisols.
- major limitations and hazards: erosion and drainage.

v) Piedmont alluvial plains - altitudes 1950-2100 m.
- colluvial-alluvial from basalt and trachyte.
- almost level, gilgai, slightly dissected.

- Vertisols.
- major limitations and hazards: drainage, in places seasonal ponding.

vi) River alluvial plains - altitudes 2000-2150 m.

- river alluvium from basalt and trachyte.
- almost level, in places very slightly undulating due to remnants of former levees, etc.
- Vertisols, Cambisols, Fluvisols.
- major limitations and hazards: drainage, in places seasonal flooding.

In the absence of analytical data the taxonomic classification of the soils is tentative. For example, some of the Cambisols could well be Nitosols as indicated on the soil map of Africa for this particular region.

A common hazard in this region is seasonal night frost which is a wide-spread hazard for most mapping units. A few units are unaffected, such as the mountain slopes, large exposed valley slopes, etc. There is, however, an appreciable lack of climatic data in the region. Besides Addis Ababa and Holetta which produce detailed meteorological data, only a few rainstations exist in this area.

Land use varies considerably between the mapping units, largely due to altitude, topography and soil differences.

3.3.4 Land Resource and Evaluation Study of Sendafa-Debre Zeit region

This area is located immediately east of Addis Ababa between longitudes 38°45'E and 39°00'E and latitudes 8°45'N and 9°12'N. It covers an area of about 136,000 ha with an altitude range of 1850 to 3200 m. The climate is humid temperate. The main rainy season is between June and September. Mean annual temperature varies from 15.9°C in Addis to 18.8°C at Debre Zeit in the southeast. In the high lying areas, night frost may occur after the rainy period. Aerial photo analysis shows the whole area to be divided into five major geomorphological land types within which smaller units are identifiable on the basis of degree of dissection, slope, vegetation cover, land use etc. The homogeneous land units so delineated total 36. For these descriptions of soils, geology, vegetation, and land use are given.

The present mapping scale is 1:50,000 and this may be used as the publication scale.

The major geomorphological units identified are:

i) Mountains: These rise to appreciable heights above the surrounding areas either as single units, groups of units or as interconnected chains. They generally have cool temperatures and higher rainfalls. The main characteristics are:

- Basalts, trachytes, rhyolites, and consolidated ashes of basic composition.

- Summit areas are flat to gently sloping while the entire slopes with numerous interfluvial ridges are moderately steep to very steep with convex upper slopes and concave footslopes. The longitudinal slopes are steeper than the transversal.

- Very shallow to moderately deep soils include stony and rocky varieties of Regosols and Phaeozems (Entisols, Inceptisols and Mollisols). In most parts the soils are less than 20 cm deep, often being only about 10 cm deep - Lithosols.

- Sparse grass cover and few trees and bushes.

- Most parts are cultivated with barley and lentils (50% fallow) while the remainder is left for grazing and hay harvesting. Forested lands make less than 10% and even these are limited to the rivers.

ii) Hills: These also rise to significant heights above the surrounding area but to a lesser extent than the mountains. They are either remnants of mountains, strongly dissected plateaux or plains or are cones produced by volcanic activity. As seen from the earial photos they appear largely similar to the mountains with respect to geology, soils, vegetation and land use.

iii) Plateaux: These include the slightly undulating to rolling landscapes with gently sloping to flat interfluvial ridges. Only small areas are found in the survey area.

- Basalt and its associates.

- Gently undulating to rolling with steep peripheral slopes referred to as plateau footslopes.

- Reddish brown soils of high clay content that may qualify as Cambisols, Phaeozems, Nitosols (Inceptisols, Mollisols, Alfisols) and in places Vertisols.

- Dominantly grasses of various composition and few scattered eucalyptus trees. On the footslopes where the soils are shallow, stony and rocky, bushes are common.

- Largely cultivated with barley, wheat, beans and peas. The remaining area is reserved for grazing and hay.

iv) Plains: These are areas extending from the foot of mountains, hills or plateaux with gentle to very gentle slopes. They can be of two types - piedmont plains or depositional such as pyroclastic and alluvial plains. Only the latter are identified in the survey area.

- Basalt, consolidated to semi-consolidated ashes of basic composition (trachytic) and alluvium.

- Generally gently sloping but locally moderately steep, particularly along rivers and fault scarps.

- Mostly Vertisols (Pellusterts) while Fluvisols, Cambisols and Phaeozems (Entisols and Mollisols) may be found along rivers and eroded areas.

- Except for the very few scattered eucalyphtus trees nearly all areas are cultivated with few grazing areas. Crops grown include wheat, barley, teff (Eragrostis abyssinica), bean, pea, lentil, chick pea, vetch and 'noog' (Guizota abyssinica). The remaining area left for grazing and hay is usually poorly drained land.

As the survey of this area is still in progress the information given here is very tentative and may undergo some change when the survey is completed and more data are available. The description presented here is largely based on aerial photo analysis and pre-reconnaissance trips.

3.4 THE FUTURE OF SOIL SURVEY AND LAND EVALUATION IN ETHIOPIA

From the above it is clear that soil survey and land evaluation work in Ethiopia is still in its initial stage. Except for the few reconnaissance surveys of some river basins and minor semidetailed studies, no important national scale surveys have been conducted so far. However, the demands for this type of study is great by the various organizations and institutions of the Government. These include the Soil and Water Conservation Division (SWCD). Extension and Project Implimentation Division, Awash Valley Authority, National Water Resources Commission, Chilalo Agricultural Development Unit, Wolamo Agricultural Development Unit, Ministry of Land Reform and Administration, College of Agriculture, and others who either undertake some of these studies or require data of this nature. The IAR is not yet ready to cater for the various demands, though it does render assistance and advice whenever possible. For the time being, close cooperation with the other organizations offers the best opportunity to satisfy the urgent needs.

As soil survey activities expand, there should be more joint studies, particularly with the Soil Fertility Section of IAR, EPID and SWCD both of the Ministry of Agriculture, as a contribution to establishing land evaluation criteria for various parts of the country. This work would benefit from Ethiopia's participation in the FAO-sponsored East African Correlation Committee for soil taxonomy and land evaluation.

As the College of Agriculture at Alemaya is just establishing a soil science department, it is not yet producing the required personnel. Therefore, the building up of a cadre of qualified soil scientists is currently a slow process. As a result the expansion of soil survey and land evaluation work in Ethiopia in the foreseeable future can proceed only at a slow pace.

REFERENCES

B.D.P.A. (1973): "Tibila Area feasibility study", Vol. III, draft report Soils.

D'Hoore J.L. (1964): "Soil Map of Africa". Publ. 93, Joint Project 11, Comm. for Techn. Coop. in Africa, Lagos, Nigeria.

Donahue R.L. (1972): "Ethiopia; Taxonomy, Cartography and Ecology of Soils," Mon. No.1, African Studies Center, Inst. of Intern. Afric., Michigan State University.

FAO/UNSF (1965): " Report on the Survey of the Awash River Basin."

Gibb, Sir Alexander, & Partners (1973): "Feasibility Study of the Lower Awash Valley," draft final report, I.E.G., Awash Valley Authority.

Huffnagel, H.P. (1961): "Agriculture in Ethiopia", FAO, Rome.

Italconsult,(1969): "Melka Sadi - Amibara proposed irrigation project", feasibility Study, I.E.G., Awash Valley Authority.

Kebede Tato, (1964): "Rainfall in Ethiopia", Eth. Geogr. J. Vol.II, No. 2, M.G.I., Addis Ababa.

Mesfin Woldemariam, (1970): "An Atlas of Ethiopia", Il poligrafico, Asmara, Ethiopia.

Mohr, P.A., (1971): "The Geology of Ethiopia", Haile Selassie I University Press, Addis Ababa.

Murphy, H.F.,(1959): "A Report on the Fertility Status of Some Soils of Ethiopia,"Exp. St. Bull. No.1, Imp. Eth. College of Agriculture and Mech. Arts.

Segalen, P., Riche G., Zewde Tillahoun, Ameha Getachew, (1970): "Information on Irrigable Areas in the Lower Wabi Shebelle Valley", I.E.G., Water Resource Dept., Addis Ababa.

Shantz H.L. & Marbut C.F., (1923): "The Vegetation and Soils of Africa," Amer Geog. Soc. Res. Series 13, New York.

TAMS A.D.G., (1973): "Humera Agriccultural Development Project", I.E.G., Min. of Agric., Addis Ababa.

UNESCO/FAO, (1973): "Soil Map of Africa", FAO, Rome.