MINISTRY OF AGRICULTURE

HIGHLANDS SOIL AND WATER CONSERVATION PROJECT-I (HSWCP-I)

BIR WATERSHED

WEST GOJAM REGION

PREPARATION REPORT

(IN THREE VOLUMES)

VOLUME 3 - ANNEXE C
APPENDIX 1

DEVELOPMENT PROJECT STUDIES AUTHORITY
AGRICULTURAL PROJECTS SERVICE
P.O.BOX 1224
ADDIS ABABA

In Association With:

ULG Consultants Ltd
Birmingham Road
Warwick, UK

FAO/World Bank
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Rome, Italy

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LAND RESOURCE STUDIES

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INTRODUCTION

This report deals with the land resource studies of the Bir Watershed covered under "Highland Soil and Water Conservation Project (HSWCP-I)" located in West Gojam Administrative Region of Ethiopia.. The total area studied under the project is 428.7 thousand ha which consists of two watersheds i.e., the Bir and the Upper Gilgel Abay (UGA). The Bir Watershed constitutes about 314.5 thousand ha (73.4%) of the project area. A separate report on the same lines is being prepared for the UGA Watershed.

Three kinds of land resource studies were made for the project area, which include:

a) **Generalized Land Resource Studies** covering the whole area of each watershed, intended to serve as the land resource base for:

   - selection of the sample study areas representing specifically defined landform units,

   - judicious application of the research findings from the sample study areas to other parts of the watershed area to achieve the envisaged objectives and

   - providing guidance to the Ministry of Agriculture in planning of soil and water conservation and general agricultural development in the watershed area;

b) **Sample Area Studies** intended for conducting research on specific measures needed for soil conservation and agricultural development in different landform units identified for each watershed area; and

c) **Study of Irrigation Development Sites** to assess the suitability of the tracts of land selected for irrigation development in the respective watershed area.

In addition to the objectives outlined above for each kind of study, the studies are intended to provide the APS Soils Experts with a suitable model for further such studies.

The studies were carried out by the FAO Soils Expert, Mr. M.Y. Javed Mirza, under the project "ETH/87/017-Assistance to Development Projects Studies Authority (DEPSA)", in collaboration with two experts of the Agricultural Projects Service (APS) of DEPSA i.e., the Soils Expert, Ato Zena Estifanos, and the Agricultural Engineer, Ato Abubeker Ali. The analyses of soil and water samples collected during field investigations were conducted by the National Soils Laboratories of the Ministry of Agriculture, Addis Ababa.

The findings of and the methodology adopted for each kind of study are reported separately as follows.

a) GENERALIZED LAND RESOURCE STUDIES

1. METHODOLOGY

The generalized land resource studies are based mainly on stereo-interpretation of the latest available, black & white, panchromatic, vertical aerial photographs (1982-84) of 1:50,000 scale, supported by some information given on the topographic map sheets (1987) and scanty field observations.

Preliminary general information about major landforms encountered in the project area, present land use/vegetation cover and soil erosion status was collected through desk study of the available topographic maps and other relative data and an extensive field visit of the project area along all important traverses. The first field visit ended in tentative selection, for further detailed study, of eleven sample areas representing the four (later increased to five) major landform units identified through desk study. A systematic stereoscopic study of all aerial photographs pertaining to the two watersheds of the project area was then undertaken to precisely differentiate and delineate the major landform units. The air-photo study resulted in recognition of nine major landform units and final selection of ten sample areas after rejecting three of those previously selected and including two new areas. The delineations made on the air-photos were transferred onto the respective 1:50,000 topographic map sheets, reduced photographically to 1:250,000 scale and finally drawn, along with all important geographical features, on a base map of 1:250,000 scale to produce a generalized map of "Major Landform Units".

The map of Major Landform Units was interpreted, with some additional information obtained from the aerial photographs, topographic maps, the available climatic maps and the field data, to produce three more generalized maps on "Agro-ecological Zones", "Agricultural Development Potential" and "Soil Erosion Hazard" at the same scale of 1:250,000.

The findings from detailed study of the sample areas and the additional information obtained while traversing through the project area during the later field visit (see Sample Area Studies) were exploited to refine the map unit boundaries and legends of the generalized maps, as well as for improving the description of various components of the major landform units recognized.

2. LANDFORMS AND SOILS

2.1. Major Landform Units

Based mainly on relief, slope form and gradient, kind of sediments, degree of dissection by geological erosion process and drainage patterns, nine map units of major landforms were recognized in the watershed area. These units are delineated on Map 1 of "Major Landform Units" at a scale of 1:250,000. The important characteristics of the units are described in the following.

Map unit 1: Steeply dissected to mountainous land. This map unit, representing the uppermost watershed areas (northern parts) of the watershed, comprise mountainous to steeply dissected land with elevation of the highest parts ranging between about 2,000 and 3,200 metres above sea level. The highest land surface (old plateau surface), which owes its formation probably to the middle to late Pleistocene glacio-fluvial deposits later mixed with some volcanic ash and ignimbrites, is gently to moderately sloping with its side slopes being steep to very steep. Angular to sub-rounded stones/boulders and pebbles are commonly found embedded within these sediments, which are partly exposed at surface due to washing away of the finer material. The sediments are generally very thick varying from about 3 metres to more than 10 metres. The bedrock, which is rarely found exposed, mostly in the beds of rivers, consists mainly of basaltic lava flows. The outcrops of extrusive basaltic rocks are also commonly encountered. Various rivers and their tributaries which are densely distributed in dendritic to sub-parallel patterns and are deeply entrenched, have long been down-cutting these sediments leaving behind numerous, varying sized alluvial terraces formed during different periods; such terraces presently rest at various elevations along the deeply cut valley sides. Moderately deep to very deep gullies, other than those occupied by river streams, are quite closely distributed throughout the unit.

Map unit 2: Steeply dissected and broken land. This map unit occurs only in southern parts, stretching along both sides of the Bir river. The land is steeply and intricately dissected so that any flat part or a terrace remnant is almost non-existent. It is probably a subsided area which is principally cut off from the main watershed area by means of a very steep to precipitous rocky escarpment. The gully pattern is dense to very dense and mainly dendritic. The elevation in major part of the unit ranges between about 1,100 and 1,800 metres but its eastern fringes lie about 2,000 metres above sea level. The sediments, which are postulated to be alluvial, similar to those of the old alluvial terraces, have been mostly washed away due to geological erosion and now vary in thickness from about 50 cm to more than 3 metres.

Map unit 3: Hilly to steeply dissected ridges and alluvial valleys. This unit represents fairly vast stretches along the mountainous land occurring in the form of strips of gently sloping alluvial valleys alternating with high ridges of rock outcrops covered with old alluvial, and probably some glacio-fluvial, sediments of varying thickness. The gully pattern on ridges is moderately dense to dense, mainly dendritic to subparallel, while that in the valleys is sparse to moderately dense, mainly trellis. The elevation ranges between about 1,800 and 3,000 metres.The valleys are traversed in the middle by perennial rivers with their numerous tributaries originating in the ridges. The rivers have a gentle to moderate gradient but the tributaries generally descend with a high gradient and are deeply incised; the latter form distinct alluvial fans near the ridge bases, which mostly coalesc to form gently to moderately sloping piedmont alluvial plains. Both the river and the tributaries commonly have narrow strips of floodplains. Remnants of old alluvial terraces/terracettes occur at different elevations along the valley sides of rivers and the tributaries. The sediments of the ridges vary in thickness from about 30cm to more than 2 metres and are very stony/bouldery; those of the valleys are generally more than 3 metres thick.

Map unit 4: Rolling to hilly, dissected, old alluvial terraces. This unit occurs in the form of rolling to hilly land having very thick, old alluvial, and probably glacio-fluvial, deposits deeply cut by rivers. Moderately deep to very deep gullies with a moderate density and trellis to subparallel pattern form a common feature of the landscape. The elevation varies from about 1,500 to 3,000 metres.The rivers generally have a moderate gradient and almost no floodplains. There, however, exist at different elevations a few alluvial terraces/terracettes which presently have a sloping to steep surface due to erosion effects. Thickness of sediments, which are stony and gravelly, is generally more than 3 metres but may be more than 10 metres. Remnants of gently to moderately sloping, old plateau (glacio-fluvial) surface with cover of numerous stones/boulders and gravel are commonly found at the highest positions.

Map unit 5: Gently undulating to rolling,sparsely dissected, old alluvial terraces. This unit occupies extensive areas of gently undulating to rolling land representing old alluvial terraces intersected by a few narrow strips of alluvial valleys which are somewhat distantly located. The unit is marked with shallow to moderately deep gullies having a relatively low density and subparallel to dendritic pattern. It lies at a wide range of elevations which vary from about 1,500 to 2,500 metres above sea level. The rivers generally have a gentle gradient. A few basins, commonly having impeded drainage conditions partly coupled with overwash deposits transported from the adjoining terraces, are found within the valleys. The sediments of both the terraces and the valleys are very thick, probably more than 10 metres.

Map unit 6: Undulating to rolling, closely dissected, old alluvial terraces. This unit is similar to map unit 5 except that it has an undulating to rolling, at places hilly, surface topography and the intersecting strips of alluvial valleys are relatively narrow and quite closely located. Moderately deep to very deep gullies having a moderately dense subparallel to dendritic pattern are a common feature of the landscape. The elevation varies from about 1,500 to 2,500 metres.

Map unit 7: Gently undulating basins and seasonal lakes.This unit, occurring in the form of gently undulating, mainly marshy basins and seasonal lakes, occupies the upper reaches of a few perennial rivers and serves as a part of their watersheds. Low ridges of bouldery land are commonly encountered within the basins. The down-slope openings of these basins and lakes face a broad, very bouldery and rocky, river channel which ultimately joins the main Bir river. The elevation ranges between about 2,000 and 2,500 metres above sea level. The landform is sparsely dissected by deep gullies having mainly subparallel pattern. The sediments are generally very thick (more than 3 metres) but may be thin (less than 1 metre) in some parts.

Map unit 8: Gently undulating, bouldery channels. This unit represents an old, partly abandoned, broad, very bouldery river channel with its bed formed by basaltic lava flow. It is bordered in its major part on both sides by currently active river streams originating mainly in the map unit 7. Low ridges of basalt rock outcrops with a nearly flat surface, aligned in almost parallel direction to the current river streams, and densely scattered piles of volcanic tuff boulders form a special feature of the unit. The elevation varies between about 1,500 and 2,500 metres. The sediments, which are mostly alluvial, are very shallow to moderately deep and gravelly.

Map unit 9: Gently sloping alluvial plains and basins. This unit represents almost flat to gently sloping or gently undulating alluvial plains and basins streching mainly along the middle reaches of the Bir river. While narrow strips of the plains along the river are subject to seasonal light river flooding, the major part lies beyond the reach of river water. Within the unflooded part, there exit relatively high flat parts (terraces) and lower, concave parts (basins), the latter generally getting ponded during rainy season. The unit is almost undissected but is marked with a few shallow to moderately deep gullies at places. The elevation ranges between about 1800 and 2,200 metres above sea level. The sediments which are mainly the alluvial deposits of the soil material transported from the map units 1 and 2, are generally more than 3 metres thick and nonstony.

A brief description of the sample areas studied for each major landform unit (map unit) follows under another section while the general composition of each unit with respect to different land elements and soils is described under Table 2. Their distribution within the watershed area, along with the location of different sample areas, is indicated on Map 1. The map symbols

used for different units, approximate areal extent of each unit and the representative sample areas studied for the respective unit are given in Table 1. The areal extent was estimated in two different forms i.e., i) the **geographic area** representing the true horizontal extent or the map area; calculated from the map unit delineations using a dot paper and ii) the **surface area** representing the extent of land in its own perspective; calculated by multiplying the geographic area with a factor decided by the slope (1/cos of the degree of slope) of individual components of the map unit. The figures have been rounded off to the nearest 100 ha to allow for the possible minor errors in map scale.

Table 1: Major Landform Units - approximate extent in Bir Watershed and the representative sample areas

Major landform unit	Map symbol	Extent (thous. ha)		Sample Areas
		Geog area	Surf area	
Steeply dissected to mountainous land	1	58.8	72.8	Anjene
Steeply dissected and broken land	2	21.0	27.8	Inewend
Hilly to steeply dissected ridges and alluvial valleys	3	60.6	76.9	Dabi
Rolling to hilly, dissected, old alluvial terraces	4	27.3	32.9	Fagta
Gently undulating to rolling, sparsely dissected, old alluvial terraces	5	81.7	95.4	Yechereka
Undulating to rolling, closely dissected old alluvial terraces	6	19.0	22.9	Agut
Gently undulating basins and seasonal lakes	7	7.0	7.8	Tilili
Gently undulating, bouldery channels	8	15.0	16.5	Finote Selam
Gently sloping alluvial plains and basins	9	23.9	27.6	Jiga
Total:		314.5	380.6	

2.2. Soils

The parent material, climate and relief have played the major role in determining the nature of soils encountered in the project area. Although more systematic field investigations are needed, three different kinds of parent material contributing to the formation of soils may be identified i.e., the old glacio-fluvial sediments, alluvium and volcanic sediments including ash and ignimbrites. The single most important parent material, however, appears to be the alluvium derived from a mixture of old glacio-fluvial sediments, ignimbrites and volcanic ash deposits on the mountainous land; the glacio-fluvial sediments owe their origin probably to the weathered rocks belonging to the basement complex which comprises mainly the basalt. The younger alluvial sediments of the plains are postulated to have been contributed mainly by the older alluvium with some further mixture of ignimbrites and volcanic ash at various stages.

The long-term effects of climate on the parent material are reflected by the soil characteristics including an almost complete leaching of lime to more than 2m depth, clay illuviation to more than 1.5m depth, release of iron oxide imparting reddish colours, gradual to diffuse horizon boundaries and extreme uniformity in many chemical characteristics over extensive areas.

The effect of relief is indicated mainly in the form of varying soil drainage conditions, accumulation of finer soil material, especially the volcanic ash, by movement from the upper slopes to the the plains and basins, washing away of the topsoil material from sloping land and varying distribution of organic matter content in some parts. The volcanic ash, which probably had been covering the surface of the mountain slopes, as well as of the old plateau and alluvial terraces, at different time intervals, has by now been completely washed down and partly got accumulated in the basins. In addition, most of the older soils occurring on the slopes have been truncated to varying thickness, accompanied with the formation of numerous rills and gullies.

The soil variations in the project area, in general, are not wide but significant. These may be attributed mainly to the differences in parent materials, landforms, relief and the relative physiographic positions. The important variables, in addition to the surface slope and topography, are:

- depth i.e, thickness of soil material
- stoniness/boulderiness,
- colour,
- topsoil and subsoil textures,
- subsoil structure,
- permeability/porosity,
- drainage conditions,
- organic matter content,
- reaction (pH),
- electrical conductivity (EC),
- base saturation percentage (BS%) and
- cation exchange capacity (CEC).

Within one landform, the soil variations due to chemical characteristics i.e., pH, EC, BS% and CEC, are generally insignificant while those in the other (physical and biological) characteristics may be considerable.

Soils of the older landforms (old plateau surfaces, alluvial terraces and subterrace and colluvial slopes) have a loam to clay loam surface texture which grades to silty clays or clays at lower depths within about 75 cm from the surface; the structure is mostly granular in the topsoil and weak to moderate subangular or angular blocky in the subsoil; the colour varies from dark reddish brown to brownish black for the topsoil and dusky red to dark reddish brown (rarely very dark brown) for the subsoil; the soil permeability is moderate to moderately slow; the drainage is well to moderately well; all are noncalcareous with the pH(1:1 water) varying from 4.0 to 5.5 and pH(KCl) from 3.5 to 5.0; the base saturation varies from 20 to 45 percent; the EC(1:1 water) ranges between 0.5 and 0.15 mmhos/cm; the cation exchange capacity (CEC) of the soil varies between about 35 and 50 meq/100g, that of the clay varying from 60 to more than 150 meq/100g; the organic matter content of the topsoil varies from about 4.0 to 6.0 percent.All soils are stony/bouldery to varying degrees but very deep except some occurring on colluvial slopes being moderately deep to deep.

Soils of the younger landforms (younger colluvial and subterrace slopes and lower terraces within alluvial plains) are similar to those of the older landforms in most characteristics except these have a higher (>50%) base saturation in the topsoil as well as in some parts of the subsoil and the pH(1:1 water) is a little higher ranging between about 5.0 and 6.0. The soils occurring in the alluvial plains are nonstony. All soils are very deep except those of the colluvial slopes being partly moderately deep to deep.

Soils of the older basins are invariably silty clay to clay in texture; the colour varies from brownish black to black; the structure is very fine blocky to massive in the topsoil (partly granular in the upper 5-10cm part) and weak to moderate angular blocky accompanied with common to many, distinct to prominent intersecting slickensides in the subsoil; the soil permeability is slow; the drainage is moderately well to imperfect (poor in some lake basins); they are mostly noncalcareous with the pH(1:1 water) varying from 5.0 to 6.0 and pH(KCl) from 4.0 to 5.0;the base saturation is more than 50 percent;the EC(1:1 water) ranges between 0.3 and 0.5 mmhos/cm; the cation exchange capacity (CEC) of the soil varies between about 60 and 80 meq/100g, that of the clay varying from about 80 to more than 100 meq/100g; the organic matter content of the topsoil varies from about 3.0 to 5.0 percent. All soils are very deep and nonstony and exhibit wide and deep cracks when dry.

Soils of the younger basins and piedmont alluvial plains are similar to those of the older basins in most respects except that these are generally calcareous, showing accumulation

of lime in concretionary form within 120cm depth, and the pH(1:1 water) and pH(KCl) varying from 7.0 to 8.0 and 6.0 to 7.0 respectively.

According to the FAO/UNESCO's Revised Legend for Soil Map of the World (1988), the soils of various landforms are classified as follows:

a) Soils of the old plateau surfaces

Moderately eroded soils: **Humic Alisols, Rudic phase**

Severely eroded soils: **Rhodi-Humi Haplic Alisols, Skeletic phase**

b) Soils of the older alluvial terraces

Slightly eroded soils of higher terraces: **Umbri-Humic Alisols**

Moderately eroded soils of higher terraces: **Rhodi-Humic Alisols**

c) Soils of the younger alluvial terraces (within alluvial plains)

Slightly eroded/uneroded soils: **Molli-Humic Alisols**

d) Soils of the older colluvial and subterrace slopes

Moderately eroded soils: **Rhodi-Humic Alisols, Rudic phase**

Severely eroded soils: **Rhodi-Haplic Alisols, Rudic phase**

e) Soils of the younger colluvial and subterrace slopes

Moderately eroded soils: **Luvic Phaeozems, Rudic phase**

f) Soils of the older basins

Slightly eroded soils: **Mazi-Pelli Eutric Vertisols**

g) Soils of the younger basins/piedmont alluvial plains

Slightly to moderately eroded soils: **Pelli-Calcic Vertisols**

h) Soils of the lake basins

Slightly eroded/uneroded soils: **Humi-Umbric Gleysols**

In addition to the soils classified above, a relatively minor proportion of **Umbric Fluvisols** (part with phreatic/inundic phase) and **Gleyic Cambisols** (part with inundic/phreatic phase) occur in narrow strips along the rivers.

A general relatonship of soil characteristics with the major landform units and their component land elements is described under Table 2. Detailed description of important soil profiles studied in representative sample areas of each major landform unit, as well as their laboratory analytical data, is given under Annex 1.

Table 2: Composition of Major Landform Units with respect to important land elements and soils

Map unit sym-bol	Major landform unit	Component land elements & soil characteristi		
		Land element and its pro-portion (%)	Slope range (%)	Main soil characteristics*
1	Steeply dissected to mountainous land	Steep to very steep colluvial slopes and escarpments (40-60%)	>30	Shallow to deep, wel drained, mod. perme-able, dark brown to brownish black, ston bouldery loams to clay loams
		Moderately steep alluvial terracettes and colluvial slopes (10-30%)	20-30	Mod. deep to deep,we to mod. well drained mod. slowly permeabl dark reddish brown, stony/bouldery clay loams
		Sloping to moderately steep old alluvial terracettes (15-25%)	5-20	Mod. deep to very de mod. well drained, m slowly permeable, da brown to very dark reddish brown, stony/ bouldery clay loams
		Gently to mod-erately slop-ing remnants of old plateau surfaces (5-15%)	5-15	Mod. deep to very deep, well to mod. well drained, mod. permeable, brown/dark reddish brown, stony/ bouldery loams to clay loams

* All soils are well developed, having weak to moderate subangular/angular blocky subsoil structure, dark reddish brown to brownish black loamy topsoils with weak subangular blocky to granular structure, and are noncalcareous throughout the profile unless described otherwise.

		Rock outcrops/ exposed bedrock (3-5%)	-	-
		Gullies and stream beds (5-15%)	-	-
2	Steeply dissected and broken land	Steep to very steep colluvial slopes (50-70%)	30-60	Shallow to mod. deep, well drained, mod. permeable,dark reddish brown, stony/gravelly loams to clay loams
		Very steep/ precipitous rock outcrops & escarpments (15-25%)	>200	Patchy, shallow to mod. deep, well drained, dark reddish brown, stony/bouldery loams to clay loams
		Gullies and stream beds (10-30%)	-	-
3	Hilly to steeply dissected ridges and alluvial valleys	Steep colluvial slopes (30-50%)	30-60	Deep, well drained, mod. permeable, dark brown to brownish black, stony/bouldery clay loams to clays
		Very steep colluvial slopes and escarpments (10-20%)	>60	Shallow to mod. deep, well drained, mod. permeable,dark reddish brown, stony/bouldery clay loams to clays
		Moderately steep, old alluvial terracettes (5-15%)	15-20	Very deep, well to mod. well drained, mod. permeable, dark brown, stony/gravelly clay loams
		Sloping to moderately steep alluvial plains (5-10%)	10-20	Very deep, mod. well drained, slowly permeable, mod. calc., brownish black clays showing deep and wide cracks when dry
		Gently sloping to undulating alluvial plains (10-20%)	3-8	Very deep, mod. well drained, slowly permeable, mod. calcareous, brownish black clays showing deep and wide cracks when dry

		Gullies and stream beds (5-10%)	-	-
		Rock outcrops/ exposed bedrock (5-10%)	-	-
4	Rolling to hilly, dissected, old alluvial terraces	Moderately steep colluvial slopes and escarpments (30-50%)	15-30	Mod. deep to very deep, well drained, mod. slowly permeable, dark reddish brown clay loams to clays with stony/bouldery surface
		Sloping alluvial terracettes and subterrace slopes (20-30%)	8-15	Mod. deep to very deep, mod. well drained, mod. slowly permeable, dark reddish brown clay loams to clays with stony/gravelly surface
		Gently to moderately sloping remnants of old plateau surfaces (10-20%)	5-15	Shallow to deep, well to mod. well drained, mod. slowly permeable, brown to dull reddish brown clay loams to silty clays with stony surface
		Gently sloping alluvial terraces (5-15%)	3-8	Very deep, mod. well drained, mod. permeable, dark brown to brownish black clay loams to clays with stony surface
		Gullies and stream beds (5-10%)	-	-
		Rock outcrops/ exposed bedrock (5-10%)	-	-

5	Gently undulating to rolling, sparsely dissected old alluvial terraces	**Gently sloping old alluvial terraces (40-60%)**	**2-6**	**Very deep, well to mod. well drained, mod. permeable, dark reddish brown clay loams to clays**
		Sloping to moderately steep old alluvial terraces (25-40%)	6-20	Very deep, well drained, mod. permeable, dull to dark reddish brown clay loams to clays
		Gently sloping remnants of old plateau surfaces (5-10%)	2-6	Shallow to very deep, well drained, moderately permeable, dark reddish brown clay loams, part with stony surface
		Almost flat basins and channel infills (10-20%)	<3	Very deep, mod. well drained, slowly permeable, brownish black clays showing deep and wide cracks when dry
		Concave closed basins (marsh lands) (0-10%)	1-2	Very deep, imperfectly to poorly drained, very slowly permeable, black/dark grey clays
		Gullies and stream beds (3-5%)	-	-
		Rock outcrop/ exposed bedrock (3-5%)	-	-
6	Undulating to rolling, closely dissected old alluvial terraces	Very gently sloping old alluvial terraces (10-20%)	1-3	Very deep, well to mod. well drained, mod. slowly permeable, dark brown/dark reddish brown clay loams to clays
		Sloping old alluvial terraces (15-25%)	8-15	Very deep, mod. well drained, mod. slowly permeable, dark brown/ dark reddish brown clays

		Moderately steep alluvial terracettes and colluvial slopes (10-20%)	15-30	Mod. deep to deep, well drained, mod. slowly permeable, reddish brown clays, part with stony surface
		Moderately steep to steep margins/escarpments of alluvial terraces (25-40%)	15-50	Mod. deep to deep, well drained, mod. slowly permeable, dark reddish brown clay loams to clays, part with stony surface
		Gently sloping remnants of old plateau surfaces (3-5%)	3-8	Shallow to deep, mod. well drained, mod. permeable, dark reddish brown clays with stony surface
		Gullies and stream beds (5-10%)	-	-
		Rock outcrops/ exposed bedrock (3-5%)	-	-
7	Gently undulating basins and seasonal lakes	Flat, central parts of basins (30-50%)	<1	Very deep, imperfectly to poorly drained, slowly permeable, brownish black to dark grey loams to silty clay loams underlain by clays
		Almost flat outer parts of basins (20-30%)	1-3	Very deep, imperfectly drained, slowly permeable, dark reddish brown to brownish black loams/clay loams underlain by clays
		Concave, ponded parts of basins (seasonal lakes) (15-25%)	<1	-
		Almost flat remnants of old alluvial terraces (10-20%)	<2	Very deep, mod. well drained, mod. slowly permeable, dark brown silty clay loams

		Gently sloping margins of old alluvial terraces (10-30%)	2-6	Very deep, mod. well drained, slowly permeable, dark brown clay loams to clays
		Low bouldery ridges and rock outcrops/ exposed bedrock (5-15%)	-	
8	Gently undulating bouldery channels	Almost flat to gently undulating channel infills (40-60%)	1-3	Shallow to mod. deep, well drained, mod. permeable, brown to brownish black, stony/ bouldery loams to clay loams
		Almost flat to gently undulating basins (5-10%)	1-3	Deep to very deep, mod. well drained, slowly permeable, brownish black clays, part with bouldery surface
		Gently sloping remnants of old alluvial terraces (10-20%)	1-5	Very deep, well to mod. well drained, mod. slowly permeable, dull to dark reddish brown clays
		Moderately steep stream banks/escarpments (5-10%)	15-25	Mod. deep to very deep, well drained, mod. slowly permeable, dark reddish brown clay loams to clays with stony surface
		Low bouldery ridges and rock outcrops/ exposed bedrock (20-40%)	-	-
		Permanent/ seasonal lakes (1-3%)	-	-

9	Gently sloping alluvial plains and basins	**Almost flat alluvial terraces (30-50%)**	**<2**	**Very deep,well to mod. well drained, mod. permeable,dull to dark reddish brown clays**
		Flat to very gently sloping/ concave basins (20-30%)	0-3	Very deep, mod. well to imperfectly drained, slowly permeable, yellowish grey to brownish black clays showdeep and wide cracks when dry
		Gently sloping alluvial terraces/terrace margins (10-20%)	2-6	Very deep, well to mod. well drained, mod. slowly permeable, dark reddish brown clay loams to clays
		Sloping to moderately steep margins of alluvial terraces (5-15%)	10-30	Mod. deep to very deep, well drained, mod. permeable, dark reddish brown clay loams to clays, part with stony surface
		Sloping basin margins (3-5%)	5-15	Very deep, mod. well to imperfectly drained, slowly permeable, black clays, part with stony surface
		Concave basins and channel infills (5-15%)	0.5-1	Very deep, imperfectly to poorly drained, slowly permeable, dark grey to black clays
		Gullies and stream beds (2-4%)	-	-
		Rock outcrops/ exposed bedrock (2-3%)	-	-

3. AGRO-ECOLOGICAL ZONES

Following the agroclimatic zonation made by Ministry of Agriculture's Community Forests and Soil Conservation Department in "Guidelines for Development Agents on Soil Conservation in Ethiopia" (1986) on the basis of differences in temperature regimes, chiefly determined by the elevation, and the mean annual rainfall, the watershed area is divided into five Agro-ecological Zones as defined below:

Dw Wet Dega Zone: Area with elevation 2,300 to 3,200m above sea level and mean annual rainfall more than 1,400mm
- Humid cool tropics

Dm Moist Dega Zone: Area with elevation 2,300 to 3,200m above sea level and mean annual rainfall 900 to 1,400mm
- Subhumid cool tropics

Ww Wet Weyna Dega Zone: Area with elevation 1,500 to 2,300m above sea level and mean annual rainfall more than 1,400mm
- Humid warm tropics

Wm Moist Weyna Dega Zone: Area with elevation 1,500 to 2,300m above sea level and mean annual rainfall 900 to 1,400mm
- Subhumid warm tropics

Km Moist Kolla Zone: Area with elevation 500 to 1,500m above sea level and mean annual rainfall 900 to 1,400mm
- Subhumid hot tropics

Each Agro-ecological Zone is divided into **Subzones** on the basis of differences in physiography, soils and present land use/vegetation. These Zones and Subzones are delineated on Map 2 of "Agro-ecological Zones" at a scale of 1:250,000. The areal extent of each Zone/Subzone in the watershed, as well as its relationship with the major landform (physiographic) units recognized for Maps 1 and the major kinds of land use, is indicated in Table 3. The component soils of each major landform unit unit have already been described under Table 2 in the previous section.

Table 3: Agro-ecological Zones/Subzones - their relationship with the Major Landform Units and areal extent

Agro-ecological Zone	Agro-ecological Subzone	Major Landform Unit	Areal extent (thou. ha)	Major kind of land use
Wet Dega zone	Mountainous subzone	1	45.8	Mainly rainfed cultivated, partly forested
	Ridge and valley subzone	3	12.1	Predominantly rainfed cultivated
	Rolling, dissected terrace subzone	4	0.4	Predominantly rainfed cultivated
	Undulating terrace subzone	5	3.9	Predominantly rainfed cultivated
	Undulating, dissected terrace subzone	6	11.6	Predominantly rainfed cultivated
	Basin and lake subzone	7	4.7	Mainly grass land, part seasonally under water
	Bouldery channel subzone	8	1.6	Mainly under bush forest, partly rainfed cultivated
Wet Weyna Dega zone	Mountainous subzone	1	12.1	Mainly rainfed cultivated, partly forested
	Ridge and valley subzone	3	37.0	Predominantly rainfed cultivated
	Undulating terrace subzone	5	5.0	Predominantly rainfed cultivated
	Undulating, dissected terrace subzone	6	0.5	Predominantly rainfed cultivated

	Basin and lake subzone	7	2.3	Mainly grass land, part seasonally under water
	Bouldery channel subzone	8	6.0	Mainly under bush forest, partly rainfed cultivated
	Alluvial plain subzone	9	3.0	Predominantly rainfed cultivated
Moist Dega zone	Ridge and valley subzone	3	1.6	Predominantly rainfed cultivated
	Rolling, dissected terrace subzone	4	1.0	Predominantly rainfed cultivated
Moist Weyna Dega zone	Mountainous subzone	1	1.0	Mainly rainfed cultivated, partly forested
	Steeply dissected subzone	2	10.9	Mainly bush forest, partly used for fuewood extraction
	Ridge and valley subzone	3	10.1	Predominantly rainfed cultivated
	Rolling, dissected terrace subzone	4	25.0	Predominantly rainfed cultivated
	Undulating terrace subzone	5	67.3	Predominantly rainfed cultivated
	Undulating, dissected terrace subzone	6	5.9	Predominantly rainfed cultivated
	Bouldery channel subzone	8	5.7	Mainly under bush forest, partly rainfed cultivated
	Alluvial plain subzone	9	20.9	Predominantly rainfed cultivated

Moist Kolla zone	Steeply dissected subzone	2	10.2	Mainly bush forest, partly used for fuelwood extraction
	Rolling, dissected terrace subzone	4	0.9	Predominantly rain-fed cultivated
	Undulating terrace subzone	5	5.4	Predominantly rain-fed cultivated
	Undulating, dissected terrace subzone	6	1.0	Predominantly rain-fed cultivated
	Bouldery channel subzone	8	1.6	Mainly under bush forest, partly rainfed cultivated
		Total:	314.5	

4. AGRICULTURAL DEVELOPMENT POTENTIAL

The land potential of the project area for agricultural develoment varies with the landform and the climate in general and with the land element, as well as with the physiographic position and slope within a landform, in particular. However, mapping of each land element for the whole project area at the adopted scale of 1:250,000 was not possible. The maps of "Major Landform Units" and "Agro-ecological Zones" and the information about soils of the respective landforms and their present general use were used as basis for determining and mapping the agricultural development potential of land for each watershed area. The potential can be described only for general agricultural use rather than for specific kinds of use or land utilization types for the level of studies made and the scale of mapping adopted.

Six map units of (generalized) Agricultural Development Potential are recognized for the watershed area which are delineated on Map 3.The extent of each unit is estimated as in Table 4.

Table 4: Areal extent of the Agricultural Development Potential map units

Map symbol	Map unit description	Extent (thou. ha)
1	Land with a high potential for intensive agricultural development and crop production	105.5
2	Land with a moderate potential for crop production; high potential for agro-forestry development	107.1
3	Land with a low potential for crop production; moderate potential for agro-forestry; high potential for forestry development	58.8
4	Land with a high potential for forestry, wildlife and range development; low potential for crop production	15.0
5	Land with a high potential for development as rangeland and recreational sites; very low potential for crop production	7.0
6	Land with a low potential for forestry development only	21.1
	Total:	314.5

The main characteristics of these map units are briefly described as follows:

Map Unit 1: The land representing this unit comprises extensive stretches of gently undulating to rolling, old alluvial terraces with a considerable proportion of almost flat to gently sloping alluvial plains and basins. The soils are very deep and quite fertile, locally with minor to moderate limitations of erosion in relatively sloping parts and of impeded drainage conditions in the flatter parts. The climate favours moderate to high rainfed production of common agricultural crops. Sizable areas of small to large-scale irrigable land offer further opportunities for intensive agricultural development and commecrial production of high-value crops including foodgrain, oilseeds and orchards. Almost whole area of the unit is presently under rainfed cultivation with a few narrow strips along the rivers or near the perennial springs receiving supplemental irrigation. The existing crop yields are moderate to low but two to three times increase in the yields can probably be envisaged through proper soil and water management. This unit needs highest priority for planning of any agricultural development in the project area.

Map Unit 2: This unit consists of the land which has undergone moderate to severe geological erosion process and has variable potential in its different parts. The surface topography varies from undulating to steeply dissected, with common to many gullies intersecting the area. Although there occur sizable areas of gently sloping land with very deep and fertile soils which have moderate to high potential for rainfed agriculture and partly high potential for irrigated agriculture, major part of the unit consists of eroded (though still very deep) soils with moderately sloping to steep surface topography and has a moderate to low potential for arable use; the latter part, however, has a high potential for forestry. At present, most part of unit is under rainfed agriculture, commonly with low crop yields. The unit as a whole would be best developed for agro-forestry.

Map Unit 3: The land falling under this unit comprises mainly steeply dissected to mountainous with commonly stony/bouldery, though quite deep, soils. It is commonly gullied posing severe limitations for agricultural use. At present, a considerable part of the unit is under rainfed arable use giving low to moderate yields of common agricultural crops. But the unit has a high potential for development

of forestry and a moderate potential for agro-forestry.

Map Unit 4: This land unit represents a broad bouldery channel wherein the soil cover is scanty with its considerable part being occupied by rock outcrops and boulders. Most area of the unit is presently under moderately thick bush forest which may be regarded as its best use; a few patches given to rainfed farming have only a low potential for crop production and would be better used as grassland. The unit would be best developed for a multiple use of forestry, wild life preservation and range development.

Map Unit 5: This unit consists of broad, mainly closed, basins marked with a few seasonal lakes and low bouldery hills. The soils are generally very deep and fertile but too impeded drainage conditions disallow, except in some relatively high parts, their economic arable use. Presently, major part of the unit is under thick grass cover. The best use to which this land unit can be put is its development as rangeland and recreational sites combined with preservation of water fowls and fishery development.

Map Unit 6: The unit occurs in the form of steeply dissected land with numerous gullies and too scanty areas of flatter land usable for agriculture. It is principally cut off from the main agricultural land by a precipitous rocky escarpment so that it is almost inaccessible for the animals or farm machinery for arable use or grazing in any part. Its agricultural use is also hampered by the incidence of tsetse fly disease. At present, the land is mainly under thin to moderately thick bush forest which needs to be improved and would be the best use of the land.

5. SOIL EROSION HAZARD

The important agent of soil erosion in the project area is water. The water erosion hazard differs in different parts of the area both in its form and degree. Gully erosion, which is always combined with sheet and rill erosion, is the most distinct feature of major part of the area while a considerable part is affected only by rill and sheet erosion. The erosion hazard was interpreted from the general information obtained with respect to landforms, surface slopes, soils, drainage patterns/densities,and land use/vegetation cover from the available air-photos and the investigatins made on the sample study areas. The same map units as recognized for the map of "Major Landform Units" were used as the basis for delineation of the soil erosion hazard. Of course, the hazard varies not only with the landform unit but also with the land element within any landform unit. Since the delineation of individual land elements was not possible at the adopted scale of mapping, the map units representing the soil erosion hazard should be regarded as only indicative. Six map units of Soil Erosion Hazard recognized for the watershed area are delineated on Map 4. A brief description of each map unit is presented as follows:

Map unit 1: This map unit represents areas of almost flat to gently sloping or gently undulating land covered by the cultivated alluvial plains, the grasslands of basins and the forested bouldery channels. It is partly affected by sheet and/or rill erosion of minor degree while the major part has almost no erosion hazard. Moderate stream bank erosion is, however, evident in most parts along the streams.

Map unit 2: This unit covers gently undulating to rolling alluvial terraces which are mostly under rainfed cultivation. It is commonly dissected by deep gullies/river valleys but with a relatively low density. Although gully erosion is quite evident, the major threat to the area is by rill erosion which is encouraged by the artificial drainage ditches traditionally constructed by the farmer. The rills so developed generally get transformed to deep gullies in relatively short time. Moderate stream bank erosion occurs in the valleys.

Map unit 3: This unit has two distinct landforms i.e., steeply dissected ridges and gently sloping alluvial valleys, which are mostly under rainfed cultivation. The two landforms differ in degree of erosion hazard. While the ridges are affected by severe rill and moderate to severe gully erosion, the valleys have a moderate degree of sheet, rill and stream bank erosion. Additionally, land sliding is evident in some parts of the ridges while some slumping is noticeable in the sloping parts of the valleys.

Map unit 4: This unit is representative of steeply dissected to mountainous land with dominantly steep to very steep slopes. Being located at high elevations with a relatively cool temperature regime and humid moisture regime, the land has a fair vegetation cover as well as some stone cover at the surface. The land is mainly cultivated but partly under cover of bush forest cover; a considerable part is occupied by scrub. The upper parts of the mountain ridges mostly have moderate sheet, rill and gully erosion, while the lower parts, especially the footslopes, have severe gully erosion. Very steep escarpments are generally protected by bush cover and boulders at surface. Moderate to severe land sliding also occurs in some parts irrespective of the location. Stream bank erosion is evident in the valleys.

Map unit 5: This unit covers undulating to hilly parts of the alluvial terraces closely dissected by gullies and river vallies. Most part of the land is under rainfed cultivation with a few patches having moderately thick bush forest cover. Severe sheet, rill and gully erosion occurs in almost all parts of the unit, while land sliding is a very common feature. Some parts of very steep escarpments are protected by moderately thick bush cover. Moderate stream bank erosion occurs in valleys.

Map unit 6: The land covered by this unit comprises very steeply dissected low land with relatively warm temperature regime and low rainfall. It has a thin to moderately thick low bush cover. The land is affected by severe to very severe sheet, rill and gully erosion in almost all parts. Land sliding also commonly occurs in higher parts.

The extent of area affected by different degrees of soil erosion in the watershed area is estimated as in Table 5.

Table 5: Area affected by different degrees of soil erosion

Soil erosion hazard	Map unit	Area affected (Thou. ha)
Slight sheet and rill erosion	1	45.8
Moderate rill and gully erosion	2	81.7
Moderate sheet & rill erosion in valleys, severe rill and gully erosion on ridges	3	60.8
Moderate rill/gully erosion on upper slopes, severe gully erosion on lower slopes	4	58.8
Severe rill and gully erosion	5	46.3
Very severe gully erosion	6	21.1
Total:		314.5

b) SAMPLE AREA STUDIES

1. THE SAMPLE AREAS STUDIED AND METHODOLOGY

Based on differences in physiography which is the major determinant of the nature of soils and the soil conservation and management problems, nine sample areas representing the nine map units delineated on the "Major Landform Units" maps of the watershed area were selected and studied in detail. The location of eight sample areas occurring within the Bir Watershed and one area occurring within the Upper Gilgel Abay Watershed is indicated on the maps of "Major Landform Units", "Agro-ecological Zones", "Agricultural Development Potential" and "Soil Erosion Hazard" of the relevant watershed (Maps 1 to 4). Their descriptive location and areal extent, along with the major landform units represented, are given in Table 5.

Table 6: Sample study areas -their location, extent and representative major landform units

Sample study area	Location (Nearest coordinates)	Extent (th. ha)	Major LF unit
Anjene	6 to 8km northeast of Anjene village along Dembecha-Feres Bet road, stretching to west-northwest of the road upto Kechem river (10°44'N, 37°35'E)	250	1
Inewend	1.5 to 3 km west of Inewend village, extending to west of the escarpment (10°24'N, 37°11'E)	245	2
Dabi	5 to 6 km south of Dabi town along Jiga-Dabi road, extending to west of the Bir river (10°57'N, 37°25'E)	194	3
Yechereka	5 to 7 km west-northwest of Dembecha town, extending to southeast of the Yechereka river on both sides of Jiga-Dembecha highway (10°35'N, 37°26'E)	318	5
Agut	1.5 to 5 km northwest of Agut village, extending to southwest of Agut-Tilili main track (10°51'N, 37°08'E)	216	6
Jiga	3 to 4 km west of Jiga town along Finote Selam-Jiga highway extending to south of the highway (10°40'N, 37°21'E)	297	9
Finote Selam	3 to 4 km east of Lah river bridge near Finote Selam, extending to south of the Finote Selam-Jiga highway (10°41'N, 37°17.5'E)	178	8

Tilili	8 to 10 km northeast of Tilili town, extending to southeast of Tilili-Gish Abay road (10°55.5'N, 37°05'E)	233	7
Fagta	5 to 6 km northwest of Fagta village along Fagta-Adis Kidame road, extending on both sides of Fagtit river (11°05'N, 37°00'E)	146	4

The sample areas were studied by using the enlargements to 1:15,000 scale of the available 1:50,000 aerial photographs in all stages which include:

i) preliminary delineation of important landform elements, surface topography and slopes, land use/vegetation cover and soil ersion status;

ii) field investigation and mapping of soils, topography and slopes, land use/vegetation cover and soil erosion problems etc.; and

iii) final delineation of map units through stereo-interpretation for preparation of maps on "Physiography and Soils", "Present Land use/Vegetation Cover" and "Soil Erosion Status" for each sample area.

The soil investigations were made by landform elements, using the "Free Survey" method, based on phsiographic analysis of the air-photos, which included measurement of surface slopes, delimitation of boundaries between different kinds of land use, estimation of vegetation and stone cover at surface, judging of erosion hazard from the existing erosion features and study of important soil characteristics by augering to 1.0-1.5m depth on each important land element. Deep soil pits (to about 2m) were excavated on representative sites for detailed description of the soil profiles and collection of soil samples. On an average, two deep soil pits were prepared for each sample area; four to seven disturbed soil samples from each soil pit and three to four core samples from the important soil pits were collected for physical and chemical analyses and determination of soil moisture characteristics in the laboratory. The intensity of field observations varied widely from area to area and by land element depending on their complexity. In general, the density varied from one per 12ha to one per 25ha, except for Inewend area where only one detailed observation with soil sampling could be made due to its inaccessibility. The location of the general observation sites as well as of the detailed observation and soil sampling sites for each sample study area is indicated on the maps of "Physiography and Soils" of the respective sample areas.

2. MAIN FINDINGS

The findings of the detailed study in the sample areas are presented in the form of the following three maps of scale 1:15,000 for each sample area (Maps 5 to 31):

- Physiography and soils
- Present land use/vegetation cover
- Soil erosion status

Area-wise brief description of these maps is given on the following pages. The detailed description of the representative soil profiles sampled, along with the laboratory analytical data of the soil samples, are reported under Annex I.

2.1 Anjene Sample Area

a) Physiography and Soils. The following three main land elements with different kinds of soils were recognized:

Old plateau remnants: This represents the highest land surfaces, probably the remnants of old plateau or glacio-fluvial terrace, which have been partly eroded. It has gentle to moderate (5-15%) slopes with a few, relatively shallow gullies.

The soils consist of mostly very deep (part moderately deep), well to moderately well drained, moderately permeable, noncalcareous, brown to dark reddish brown clay loams/silty clay loams (part loams) with moderate subangular to angular blocky subsoil structure, and having brown, weak granular, stony loam topsoils (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 1)

Old alluvial terracettes and subterrace slopes: These are varying sized, sloping remnants of the alluvial terraces formed by the river at different time intervals and at different elevations while its bed continually shifted downward. The margins of some of these terracettes have by now been eroded and have merged to form nearly continuous, moderate to steep slopes (referred here as subterrace slopes). The slopes of this land element range between 8 and 30 percent.

The soils are mainly very deep (part moderately deep), well to moderately well drained, moderately slowly permeable, noncalcareous,

dark brown to very dark reddish brown clay loams with moderate subangular to angular blocky subsoil structure and weak granular, stony loam topsoils (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 2)

Colluvial slopes and escarpments: This land element includes steep to very steep parts of the area representing escarpments of the alluvial terraces with patches occupied by colluvial sediments. Exposure of numerous stones and boulders at surface due to erosion is a typical feature of this element.

The soils are mainly deep to very deep (part shallow), well drained, moderately to moderately slowly permeable, noncalcareous, dark brown to brownish black clay loams (part loams) with a weak to moderate subangular blocky subsoil structure and weak granular, very stony/bouldery loam topsoils.

Six map units of physiography and soils with varying degrees of slope recognized for the sample area are delineated on Map 5 at 1:15,000 scale.

The approximate areal extent, percentage and slope range of different map units of the sample area are as follows:

Map unit	Slope range (%)	Areal extent	
		Ha	%
1	5-15	24	9.6
2	8-10	10	4.0
3	10-20	46	18.4
4	20-30	15	6.0
5	30-60	12	4.8
6	>60	143	57.2
Total:		250	100.0

b) Present Land Use/Vegetation Cover. The following three major kinds of present land use are identified in the sample area:

i) Arable land - used for rainfed cultivation of mainly maize, teff, barley and nigerseed; part under long fallow having 60-80% grass cover; 10-30% surface occupied by stones/boulders

ANJENE SAMPLE AREA

PHYSIOGRAPHY AND SOILS - MAP UNITS

L E G E N D

Old Plateau Remnants

1 Gently to moderately sloping (5-15% slope), moderately deep to very deep, well to moderately well drained, moderately permeable, brown to dark reddish brown loams and clay loams/silty clay loams with brown, partly stony, loam topsoils

Old Alluvial Terracettes and Subterrace Slopes

2 Sloping (8-10% slope), dissected, moderately deep to very deep, moderately well drained, moderately slowly permeable, dark brown clay loams with stony topsoils

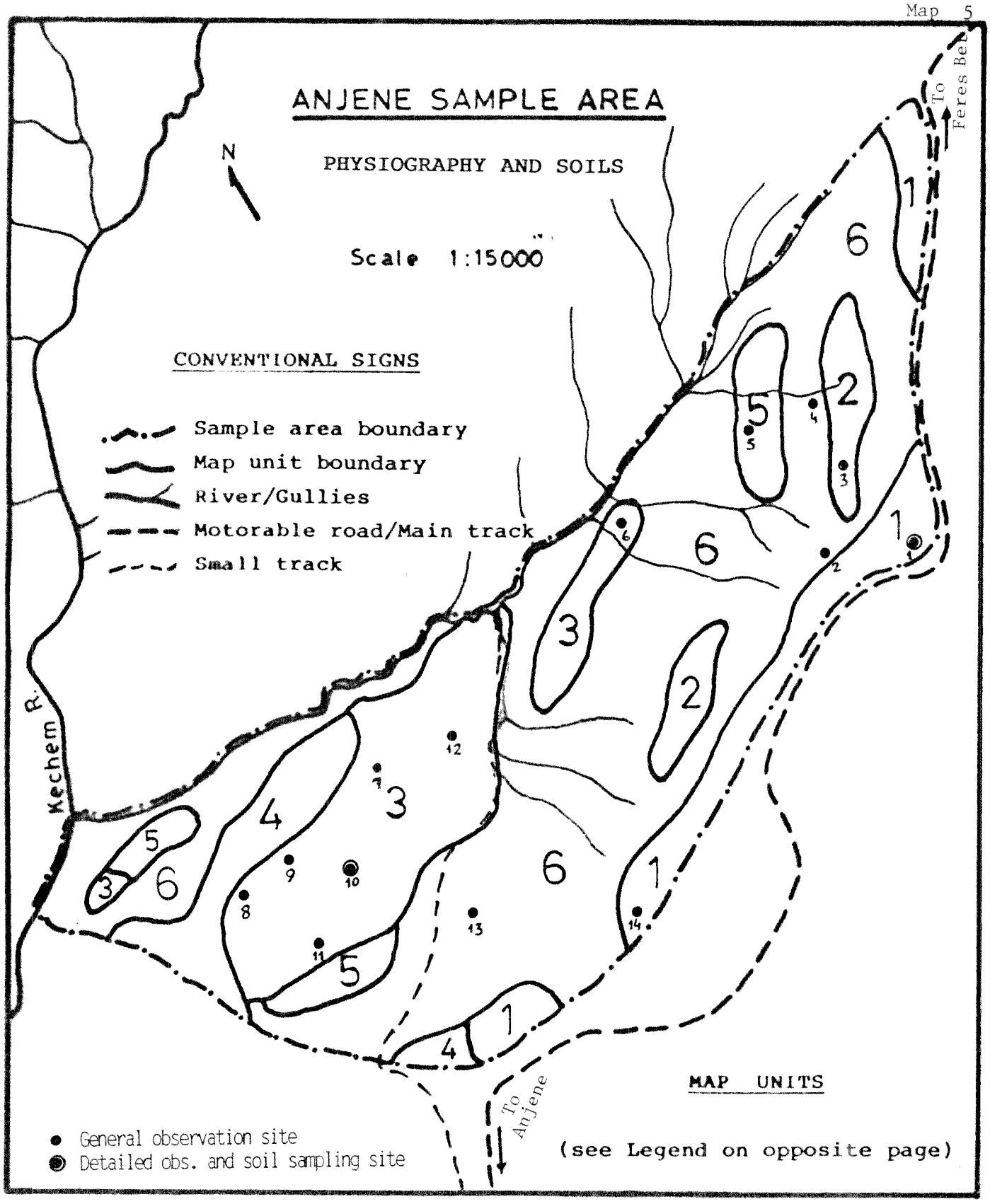
3 Sloping to moderately steep (10-20% slope), dissected, deep to very deep, well to moderately well drained, moderately slowly permeable, dark brown to very dark reddish brown clay loams with stony loam/clay loam topsoils

4 Moderately steep (20-30% slope), dissected, moderately deep to very deep, well drained, moderately slowly permeable, dark reddish brown clay loams with dark brown stony loam topsoils

Colluvial Slopes and Escarpments

5 Steep (30-60% slope), dissected, moderately deep to very deep, well drained, moderately slowly permeable, dark brown to dark reddish brown clay loams with stony loam topsoils

6 Very steep (>60% slope), dissected, mainly deep to very deep but some shallow, well drained, moderately permeable, dark brown to brownish black loams/clay loams with very stony/bouldery topsoils


ANJENE SAMPLE AREA
PHYSIOGRAPHY AND SOILS
N
Scale 1:15000
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
Kechem R.
To Feres Bet
To Anjene
MAP UNITS
General observation site
Detailed obs. and soil sampling site
(see Legend on opposite page)

ii) **Forest** - comprising mainly low to moderately high bushes and shrubs with a few trees; the canopy cover varying in different parts from 60% to over 90%; the understorey occupied by grass and low shrubs with more than 90% surface cover; 20-30% surface area occupied by stones and boulders

iii) **Grassland** - comprising mainly the running grasses with some shrubs/bushes and scattered trees; surface cover of grass varying from 70 to over 90%; 10-30% surface cover of stones/ boulders and rock outcrops

Five map units of present land use/vegetation cover recognized for the sample area are delineated on Map 6 of scale 1:15,000.

The distribution of different kinds of land use and vegetation/stone cover in various map units of the sample area is indicated by the following table.

Map unit symbol and description	Areal extent Ha	Areal extent %	Veg. cover (%)	Stone cover (%)
A - Arable land Cultivated =108 Fallow = 12	120	48.0	-	10-30
F1 - Dense forest	44	17.6	>90	30-50
F2 - Open forest	36	14.4	60-80	20-30
G1 - Grass-cum bush forest	34	13.6	70-90	15-25
G2 - Grass land	16	6.4	70-90	10-20
Total:	250	100.0		

c) Soil Erosion Status. The soil erosion in the sample area varies in different parts from moderate sheet and rill erosion in the highest parts having gentle to moderate slopes to severe/very severe in the lower and steeper parts, but some very steep slopes of escarpments are rather protected by thick forest cover and stones at their surface. Three map units of soil erosion status recognized for the sample area are delineated on Map 7 of scale 1:15,000.

The extent of each map unit, representing the soils affected by different degrees of erosion, is estimated as follows:

ANJENE AREA

PRESENT LAND USE/VEGETATION COVER - MAP UNITS

L E G E N D

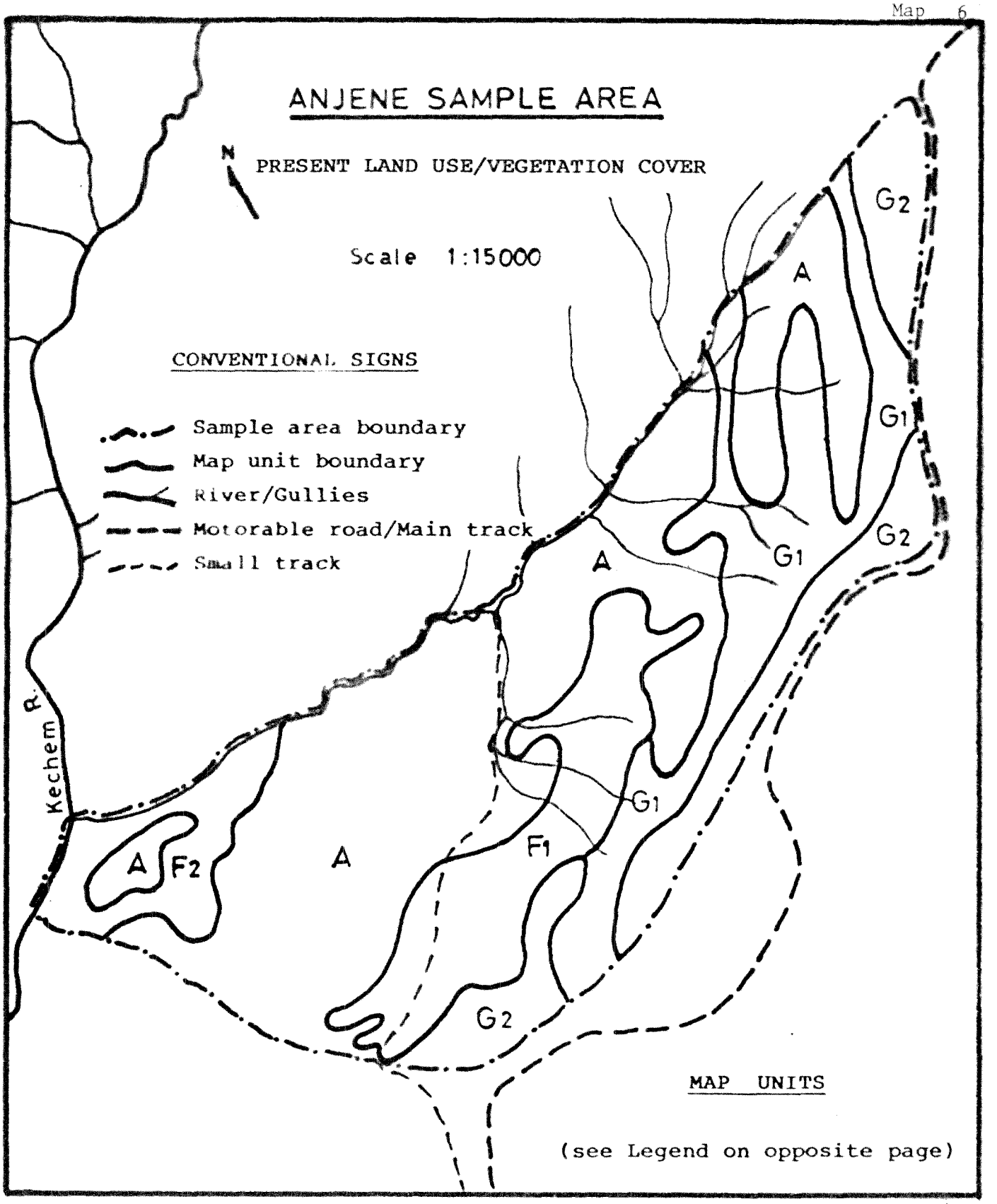
A Mainly arable land with 10-30% surface cover of stones/ boulders and 5-15% bare rock surface; few patches under long fallow with 60-80% surface cover of grass and stones

F1 Dense bush forest with >90% canopy cover; understorey with >90% cover of grass and stones

F2 Open bush forest with 60-80% canopy cover; understorey with >90% cover of grass and stones

G1 Grassland-cum-bush forest with 70-90% surface cover of grass, bushes and stones; about 10% bare rock surface

G2 Mainly grassland with >90% surface cover of grass and stones and few bushes


ANJENE SAMPLE AREA
N
PRESENT LAND USE/VEGETATION COVER
Scale 1:15000
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
Kechem R.
A
F2
F1
G1
G2
MAP UNITS
(see Legend on opposite page)

ANJENE SAMPLE AREA

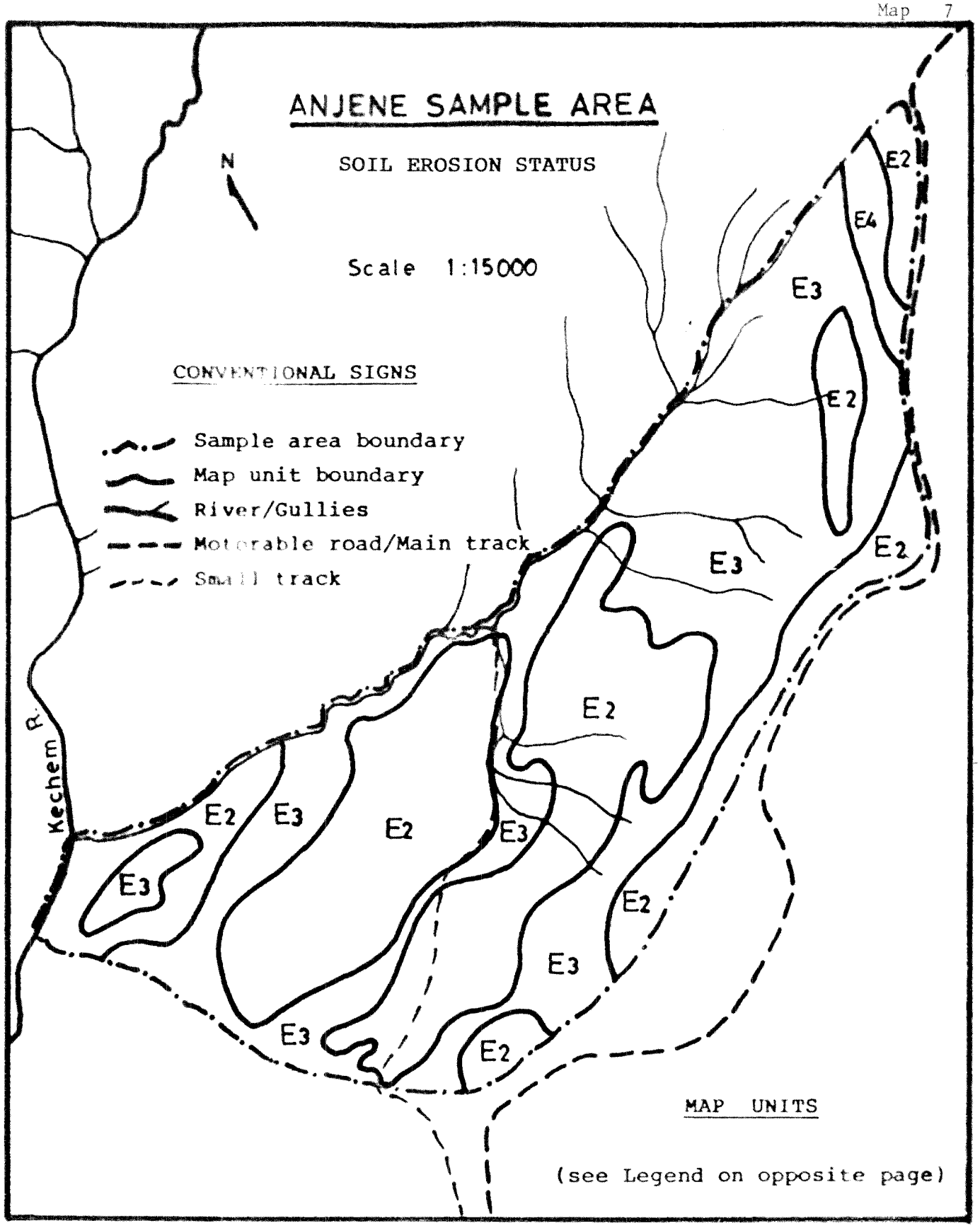
SOIL EROSION STATUS - MAP UNITS

L E G E N D

E2 Moderate sheet and rill with some gully erosion, moderate to severe stream bank erosion in some part; old tracks and traditional ditches commonly transformed into shallow to moderately deep gullies; gullies not evident in some parts due to shallow soils

E3 Severe sheet, rill and gully erosion with some land sliding/ slumping; severe to very severe stream bank erosion in some parts

E4 Very severe sheet, rill and gully erosion with frequent land sliding/slumping


ANJENE SAMPLE AREA
SOIL EROSION STATUS
N
Scale 1:15000
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
Kechem R.
E2
E3
E4
MAP UNITS
(see Legend on opposite page)

Map unit	Degree of soil erosion	Areal extent	
		Ha	%
E2	Moderate	126	50.4
E3	Severe	119	47.6
E4	Very severe	5	2.0
Total:		250	100.0

2.2 Inewend Sample Area

a) Physiography and Soils. The following one main land element comprising two sub-elememts with different kinds of soils was recognized:

Colluvial slopes and escarpments: This land element comprises steep to very steep, intricately dissected slopes with mainly colluvial sediments derived from old alluvial terraces, and precipitous very bouldery/rocky escarpments with patches of colluvial slopes.

The soils consist of shallow to moderately deep, well drained, moderately permeable, non-calcareous, dark to very dark reddish brown, gravelly/stony loams to clay loams with a weak subangular blocky subsoil structure and weak granular to massive, stony loam topsoils (See detailed description of representative soil profile and laboratory analytical data under Annex I, Pedon 3)

Two map units of physiography and soils recognized for the sample area are delineated on Map 8 at a scale of 1:15,000.

The approximate areal extent, percentage and slope range of different map units of the sample area are as follows:

Map unit	Slope range (%)	Areal extent	
		Ha	%
1	30-60	159	64.9
2	>200	86	35.1
Total:		245	100.0

INEWEND SAMPLE AREA

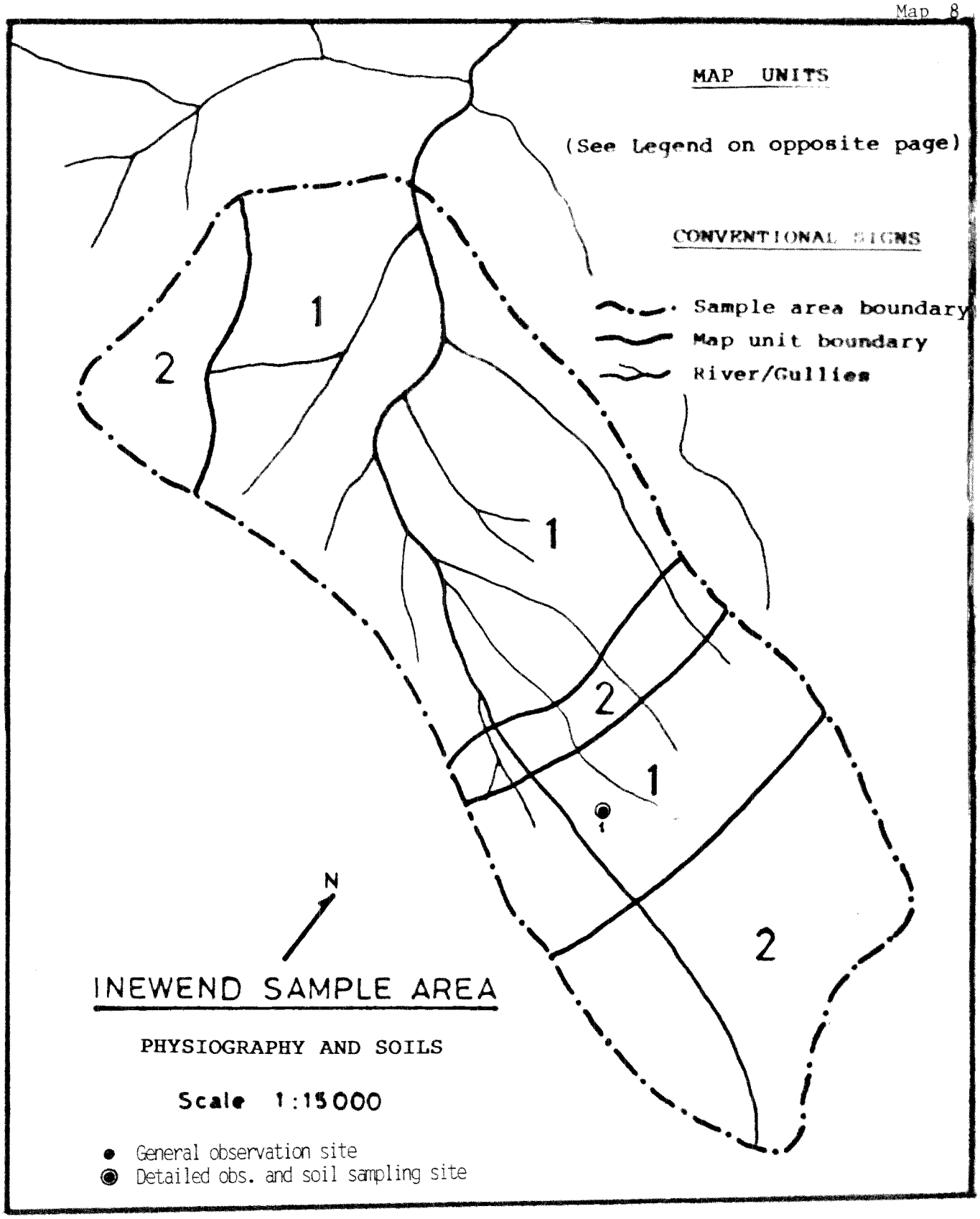
PHYSIOGRAPHY AND SOILS - MAP UNITS

L E G E N D

Colluvial Slopes and Escarpments

1 Steep to very steep (30-60% slope), dissected, shallow to moderately deep, well drained, moderately permeable, dark to very dark reddish brown, stony/gravelly loams and clay loams

2 Very steep to precipitous (>200% slope) escarpments with mainly bare rock surfaces and some patchy, shallow to moderately deep, well drained, dark reddish brown, stony/bouldery loams to clay loams


MAP UNITS
(See Legend on opposite page)
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
1
2
1
2
1
2
N
INEWEND SAMPLE AREA
PHYSIOGRAPHY AND SOILS
Scale 1:15000
General observation site
Detailed obs. and soil sampling site

b) Present Land Use/Vegetation Cover. The following two major kinds of present land use are identified in the sample area:

i) Grassland-cum-bush forest - comprising mainly low shrubs and bushes with a few low trees, the understorey being occupied by grasses having 60-80% surface cover; 15-20% surface area covered by stones; partly used only for extraction of fuel wood; naturally protected from grazing due to inaccessibility for livestock.

ii) Bare rock surface - comprising mainly bare rocky escarpments and boulders which cover 60-80% of surface area; scanty bushes and shrubs in some parts; not generally used agriculturally.

The two kinds of land use are delineated on Map 9 of scale 1:15,000.

The distribution of different kinds of land use and vegetation/stone cover in various map units of the sample area is indicated by the following table.

Map unit symbol and description	Areal extent Ha	Areal extent %	Veg. cover (%)	Stone cover (%)
G - Grassland-cum-bush forest	168	68.6	60-80	15-30
B - Bare land	77	31.4		
Total:	245	100.0		

c) Soil Erosion Status. The soil erosion in the whole sample area is severe to very severe and occurs in almost all its forms including sheet, rill, gully and stream bank erosion, as well as land sliding and slumping. No delineations are made to divide the area on the basis of soil erosion status (See Map 10)

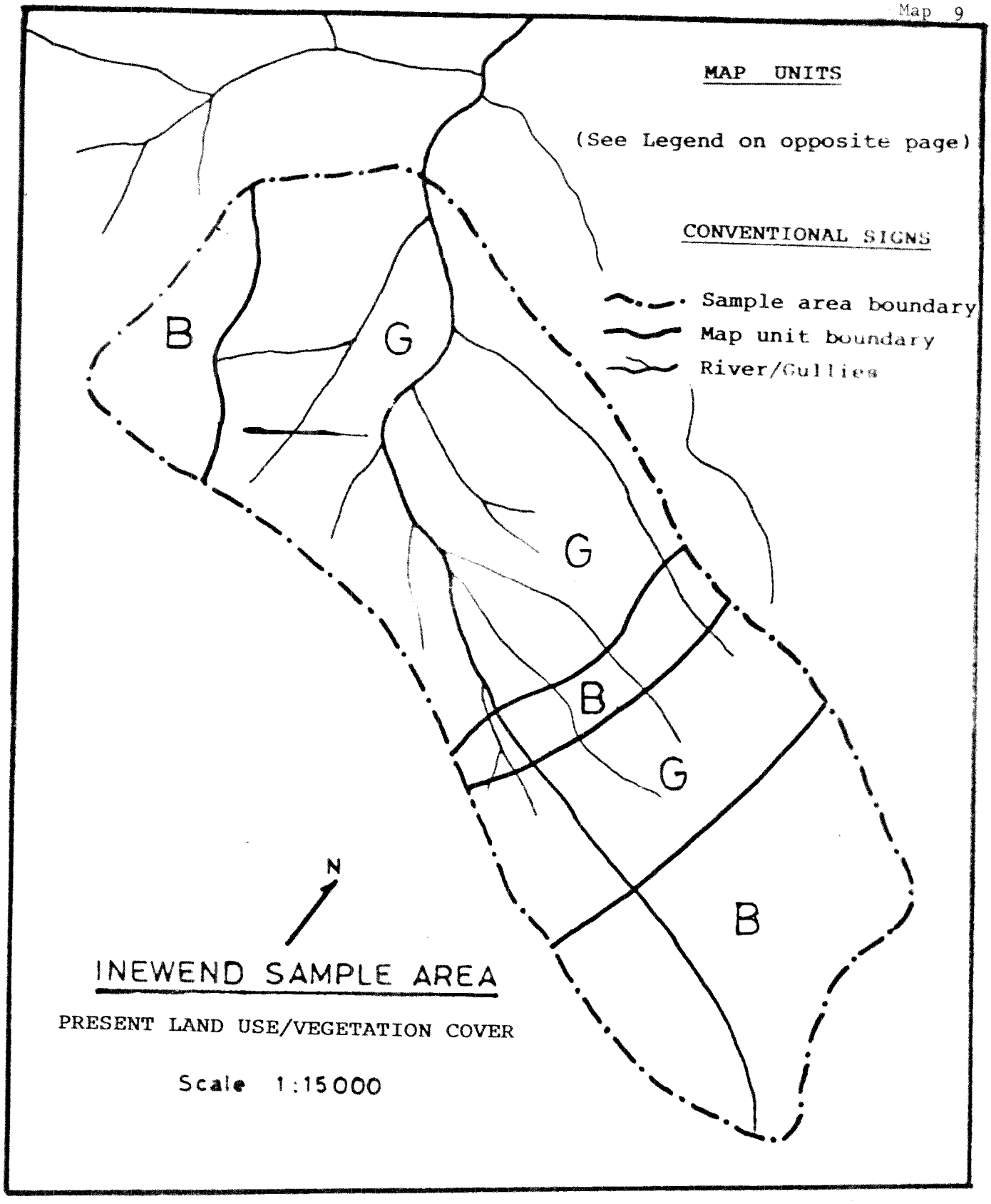
INEWEND SAMPLE AREA

PRESENT LAND USE/VEGETATION COVER - MAP UNITS

L E G E N D

G Mainly grassland-cum-bush forest with 60-80% surface cover of bushes/low trees, grass and stones; 15-20% area with bare rock surface

B Mainly bare land with some grassland-cum-bush forest having 60-80% surface cover of bushes and stones/boulders


MAP UNITS
(See Legend on opposite page)
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
B
G
G
B
G
B
N
INEWEND SAMPLE AREA
PRESENT LAND USE/VEGETATION COVER
Scale 1:15000

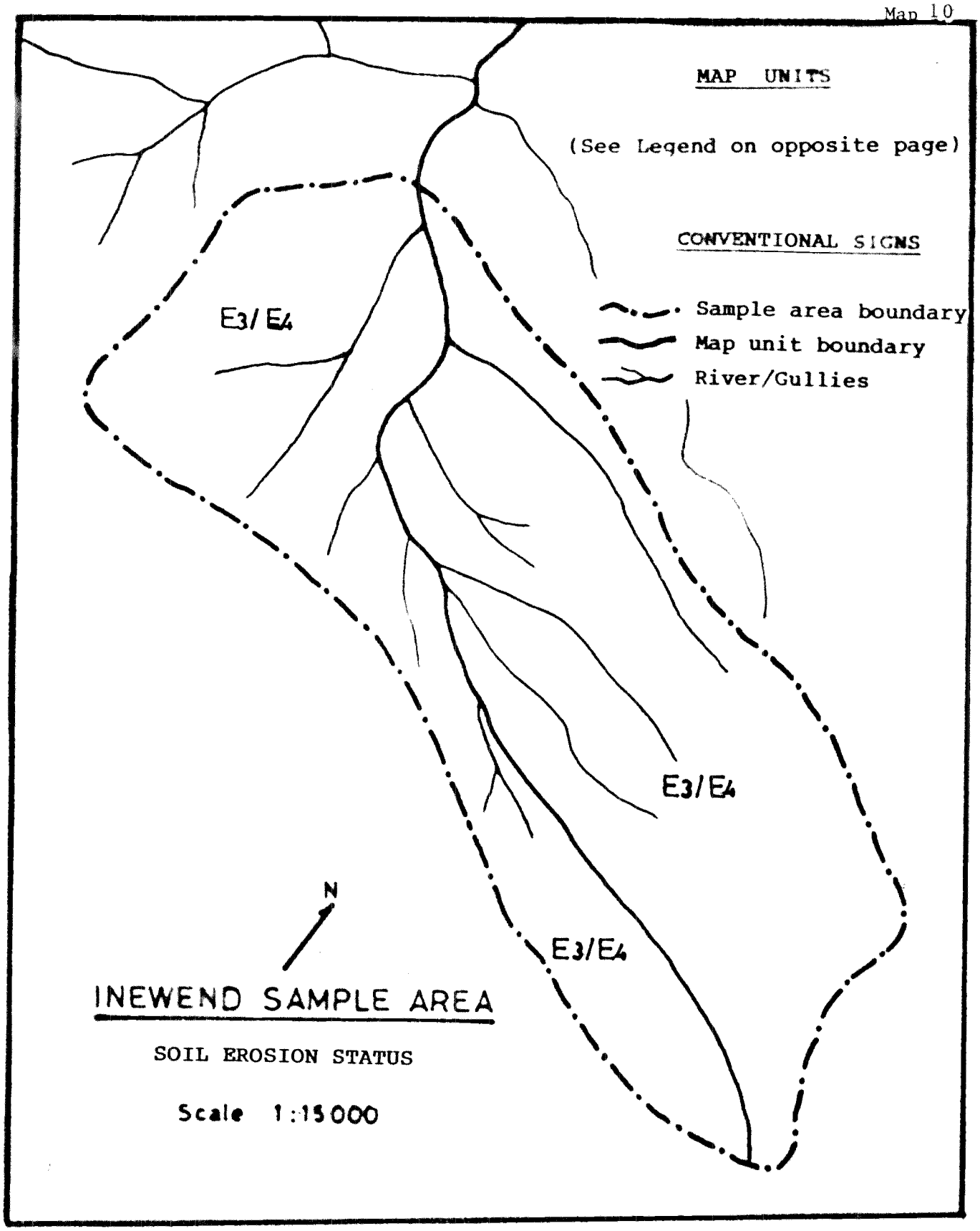
INEWEND SAMPLE AREA

SOIL EROSION STATUS - MAP UNITS

L E G E N D

E3/E4 Severe sheet, rill and gully erosion with frequent land sliding/slumping; severe to very severe stream bank erosion

Map 10


MAP UNITS
(See Legend on opposite page)
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
E3/E4
E3/E4
E3/E4
N
INEWEND SAMPLE AREA
SOIL EROSION STATUS
Scale 1:15000

2.3 Dabi Sample Area

a) Physiography and Soils. Two main land elements with different kinds of soils were recognized as follows:

Subrecent alluvial plains: This land element occurs in the form of gently undulating to moderately steep plains formed by piedmont alluvium, of probably Holocene period, derived mainly from the local volcanic ash deposits. Older alluvial or glacio-fluvial material is generally found buried at depths varying from about 100cm to 150cm. Some parts are dissected by deep gullies. The slope ranges from 3 to 8 percent in the lower parts and 15 to 20 percent in the upper parts.

The soils consist of very deep, moderately well drained, slowly permeable, moderately calcareous, brownish black clays with moderate angular blocky subsoil structure accompanied with prominent intersecting slickensides and fine/very fine angular blocky to granular, nonstony topsoils; the soil surface exhibits deep and wide cracks when dry (See detailed description of representative soil profile and laboratory analytical data under Annex I, Pedon 4)

Old alluvial terracettes and colluvial slopes: It represents a compound land element consisting of small-sized, sloping remnants of the old alluvial terraces, formed by the rivers at different elevations while their beds shifting downward, and steep slopes with mainly the colluvial deposits and partly the terrace escarpments/subterrace slopes. While the terracettes are marked with many rills, deep gullies form a common feature of the colluvial slopes. The slopes of the terracettes vary from 15 to 20 percent while those of the colluvial slopes and escarpments are more than 30 percent.

The soils occurring on the terracettes consist of very deep, well to moderately well drained, moderately permeable, noncalcareous, dark brown, gravelly/stony clay loams with moderate subangular blocky subsoil structure and weak granular, stony loam topsoils (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 5)

The soils of colluvial slopes consist of moderately deep to deep (part shallow), well drained, moderately permeable, noncalcareous, dark brown to brownish black, stony/bouldery clay loams to clays with moderate subangular/ angular blocky subsoil structure and granular, loam topsoils (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 6)

Five map units of physiography and soils with varying degrees of slope recognized for the sample area are delineated on Map 11 at 1:15,000 scale.

The approximate areal extent, percentage and slope range of different map units of the sample area are as follows:

Map unit	Slope range (%)	Areal extent	
		Ha	%
1	3-8	43	22.2
2	8-15	17	8.8
3	15-20	15	7.7
4	15-20	15	7.7
5	>30	104	53.6
Total:		194	100.0

b) Present Land Use/Vegetation Cover. The following two major kinds of present land use are identified in the sample area:

i) **Arable land** - used for rainfed cultivation of mainly maize, teff, barley and nigerseed; part under long fallow having 60-80% grass cover; part with 20-30% surface cover of planted trees; 20-30% surface of terracettes and colluvial slopes occupied by stones/boulders

ii) Grassland - comprising mainly the running grasses with some shrubs/bushes and scattered trees; 70-90% surface cover of grass; 15-20% surface cover of stones/boulders; 10-15% area occupied by exposed rock surface

Three map units of present land use/vegetation cover recognized for the sample area are delineated on Map 12 of scale 1:15,000.

DABI SAMPLE AREA

PHYSIOGRAPHY AND SOILS - MAP UNITS

L E G E N D

Subrecent Alluvial Plains

1 Gently to moderately undulating (3-8% slope), very deep, moderately well drained, slowly permeable, moderately calcareous, brownish black clays showing wide and deep cracks when dry

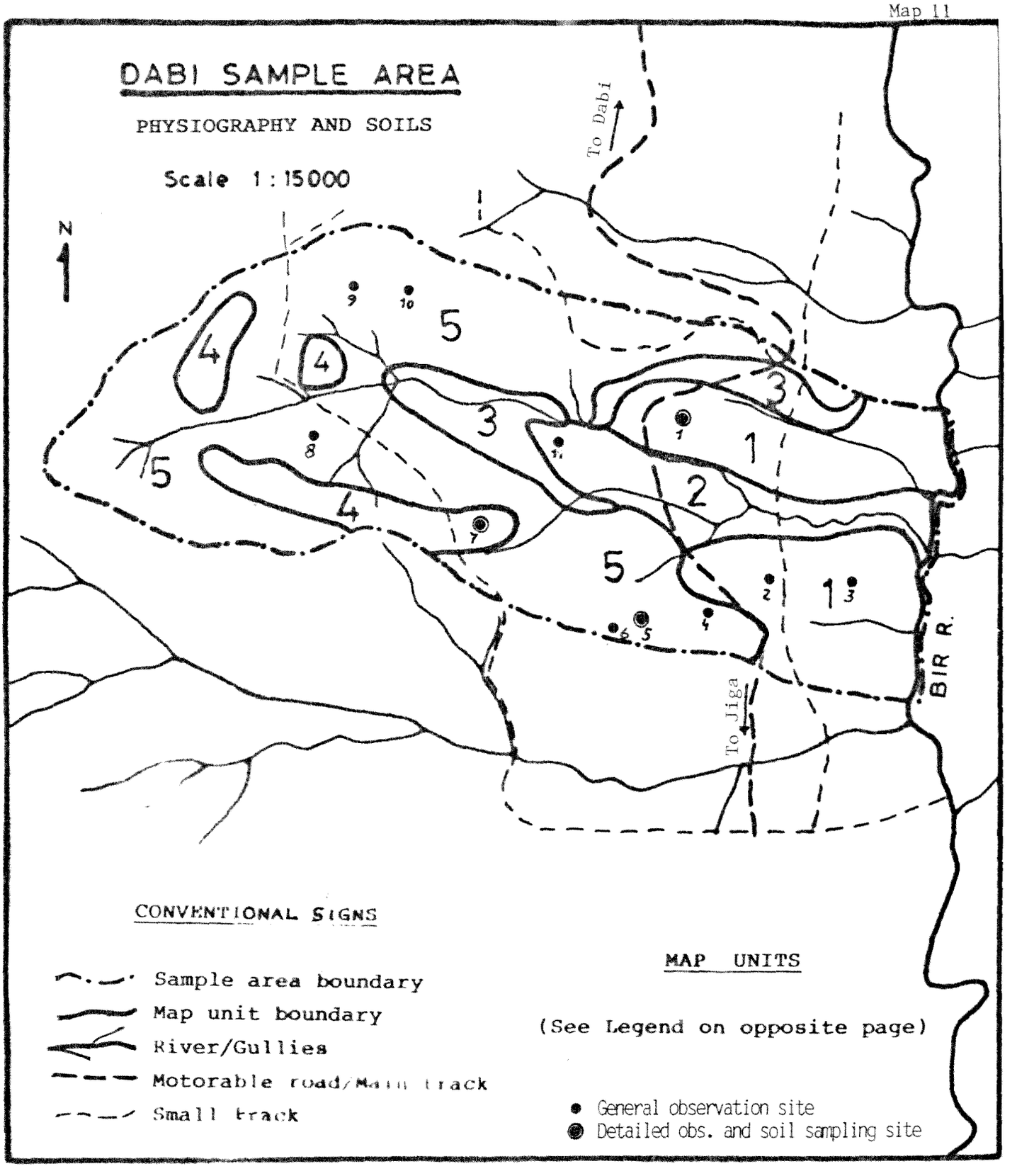
2 Sloping (8-15% slope), dissected, very deep, moderately well drained, slowly permeable, moderately calcareous, brownish black clays showing wide and deep cracks when dry

3 Moderately steep (15-20% slope), very deep, moderately well drained, slowly permeable, moderately calcareous, brownish black clays having stony topsoils

Alluvial Terracettes and Colluvial Slopes

4 Moderately steep (15-20% slope), very deep, well to moderately well drained, moderately permeable, dark brown stony/gravelly clay loams with loam topsoils

5 Steep to very steep (>30% slope), dissected, moderately deep to deep (part shallow), well drained, moderately permeable, dark brown to brownish black, stony/bouldery clay loams to clays with gravelly loam topsoils
- includes small patches of exposed bedrock


DABI SAMPLE AREA
PHYSIOGRAPHY AND SOILS
Scale 1 : 15000
N
To Dabi
To Jiga
BIR R.
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
MAP UNITS
(See Legend on opposite page)
General observation site
Detailed obs. and soil sampling site

DABI SAMPLE AREA

PRESENT LAND USE/VEGETATION COVER - MAP UNITS

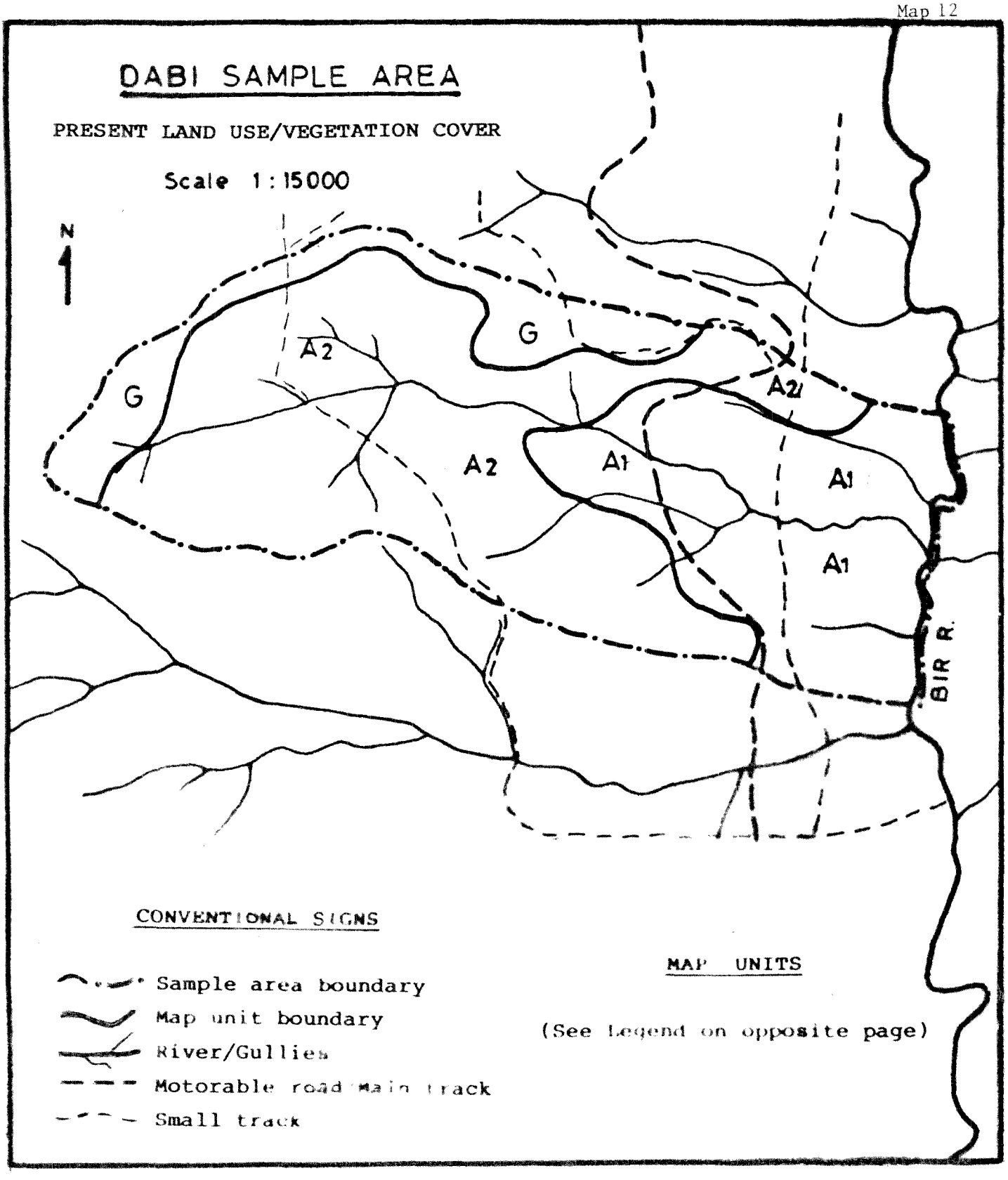
L E G E N D

A1 Mainly arable land with <2% surface cover of stones and bushes/trees; few patches under long fallow with 60-80% surface cover of grass

A2 Mainly arable land with 5-15% surface cover of stones and bushes; parts with 20-30% cover of planted trees; 5-10% area with bare rock surface

G Mainly grassland with 70-90% surface cover of grass, bushes/low trees and stones; few patches of arable land with 15-20% surface cover of stones and bushes; 10-15% area with bare rock surface

Map 12


DABI SAMPLE AREA
PRESENT LAND USE/VEGETATION COVER
Scale 1:15000
N
G
A2
G
A2
A2
A1
A1
A1
BIR R.
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/main track
Small track
MAP UNITS
(See Legend on opposite page)

The distribution of different kinds of land use and vegetation/stone cover in various map units of the sample area is indicated by the following table.

Map unit symbol and description	Areal extent Ha	Areal extent %	Veg. cover (%)	Stone cover (%)
A1 - Arable land	63	32.5		
Cultivated=57				
Fallow = 6				
A2 - Arable land	107	55.2		
Cultivated=91				
Fallow =16				
G - Grass land	24	12.4		
Total:	194	100.0		

c) Soil Erosion Status. The soil erosion in the sample area varies in different parts from slight to moderate sheet, rill and stream bank erosion in relatively flat parts of the plains to severe sheet, rill and gully erosion, accompanied with some land sliding/slumping, on the colluvial slopes. The higher parts of the colluvial slopes are, however, affected mainly by sheet and rill erosion.

Three map units of soil erosion status recognized for the sample area are delineated on Map 13 at scale 1:15,000 .

The extent of each map unit, representing the soils affected by different degrees of erosion, is estimated as follows:

Map unit	Degree of soil erosion	Areal extent Ha	Areal extent %
E1	Slight to moderate	44	22.7
E2	Moderate	47	24.2
E3	Severe	103	53.1
	Total:	194	100.0

DABI SAMPLE AREA

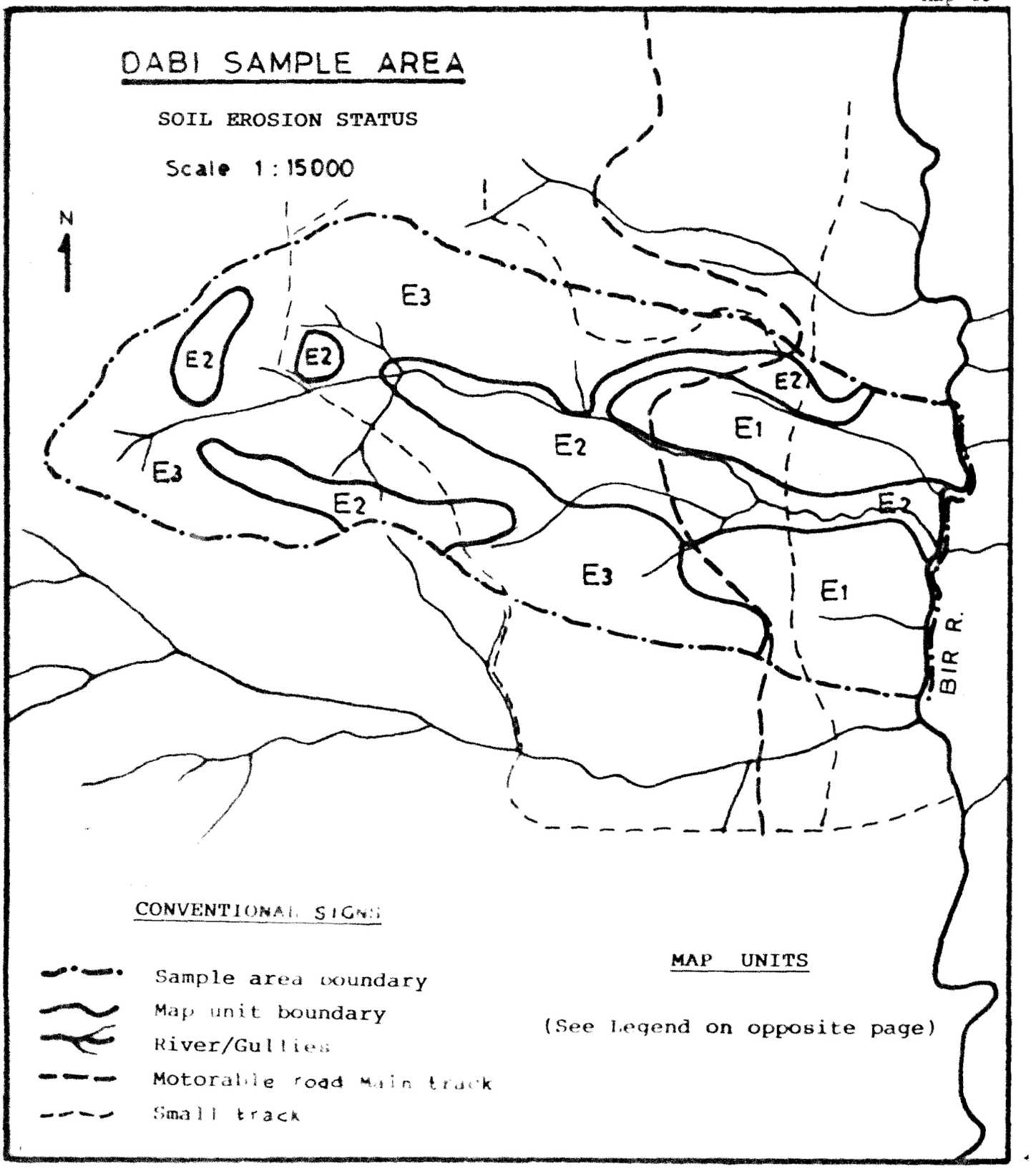
SOIL EROSION STATUS - MAP UNITS

L E G E N D

E1 Slight to moderate sheet and rill erosion; moderate stream bank erosion; few traditional drainage ditches and old tracks transformed into shallow to deep gullies

E2 Moderate sheet and rill with some gully erosion, moderate to severe stream bank erosion in some part; old tracks and traditional ditches commonly transformed into shallow to moderately deep gullies; gullies not evident in some parts due to shallow soils

E3 Severe sheet, rill and gully erosion with some land sliding/ slumping; severe stream bank erosion in some parts


DABI SAMPLE AREA
SOIL EROSION STATUS
Scale 1 : 15000
N
E3
E2
E2
E2
E1
E2
E3
E2
E2
E3
E1
BIR R.
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road Main track
Small track
MAP UNITS
(See Legend on opposite page)

2.4 Yechereka Sample Area

a) Physiography and Soils. Three main land elements with different kinds of soils were recognized as follows:

Old plateau remnants: This represents the highest land surfaces, probably the remnants of old plateau or glacio-fluvial terrace, which have been partly eroded. It has gentle (2-6%) slope with a few shallow gullies.

The soils consist of very deep, well drained, moderately permeable, noncalcareous, dark reddish brown clay loams, grading to clays at lower depths, with moderate subangular blocky subsoil structure and weak granular, gravelly loam topsoils. (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 7)

Old alluvial terraces and subterrace slopes: These are extensive, gently sloping, alluvial terraces, probably of late Pleistocene period, formed by the river at different time intervals and at different elevations while its bed shifting downward. Some part of these terraces has by now been eroded so that to modify their slopes to moderate degrees (here referred as the subterrace slopes). The slopes generally range between 2 and 12 percent.

The soils are mainly very deep (part moderately deep), well to moderately well drained, moderately to moderately slowly permeable, noncalcareous, dark reddish brown clays with moderate subangular to angular blocky subsoil structure and weak granular, part gravelly/stony, loam topsoils (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 8)

Terrace escarpments/margins: This land element includes moderately steep parts of the area representing eroded margins/escarpments of the alluvial terraces, generally located along the deep gullies/rivers. It is commonly marked with rills and shallow gullies. The slope varies from 15 to 20 percent.

The soils are very deep, well drained, moderately permeable, noncalcareous, dull to dark reddish brown clays with weak to moderate subangular blocky subsoil structure and weak granular, part stony, clay loam topsoils.

Five map units of physiography and soils with varying degrees of slopes recognized for the sample area are delineated on Map 14 at 1:15,000 scale.

The approximate areal extent, percentage and slope range of different map units of the sample area are as follows:

Map unit	Slope range (%)	Areal extent Ha	Areal extent %
1	2-6	13	4.1
2	3-8	28	8.8
3	2-5	123	38.7
4	5-12	91	28.6
5	15-20	63	19.8
Total:		318	100.0

Note: The land element 'Basins', which is another important component of the generalized Major Landform Unit represented by this sample area was found missing here. The main characteristics of this element are described under 'Basins and basin margins' of Jiga Sample Area. The element constitutes 10-20% of the relevant map unit area. (See detailed description of the representative soil profile and laboratory analytical data under Annex I, Pedon 12).

b) Present Land Use/Vegetation Cover. The following two major kinds of present land use are identified in the sample area:

i) **Arable land** - used for rainfed cultivation of mainly maize, teff and barley; part under long fallow having 50-90% grass cover; in some parts, 20-30% surface covered by stones

ii) **Grassland-cum-bush forest** - comprising mainly bushes, shrubs and low trees with the understorey covered by grasses; more than 90% surface cover of vegetation

Three map units of present land use/vegetation cover recognized for the sample area are delineated on Map 15 of scale 1:15,000.

The distribution of different kinds of land use and vegetation/stone cover in various map units of the sample area is indicated by the following table.

YECHEREKA SAMPLE AREA

PHYSIOGRAPHY AND SOILS - MAP UNITS

L E G E N D

Old Plateau Remnants

1 Gently sloping (2-6% slope), very deep, well drained, moderately permeable, dark reddish brown clay loams

Old Alluvial Terraces and Subterrace Slopes

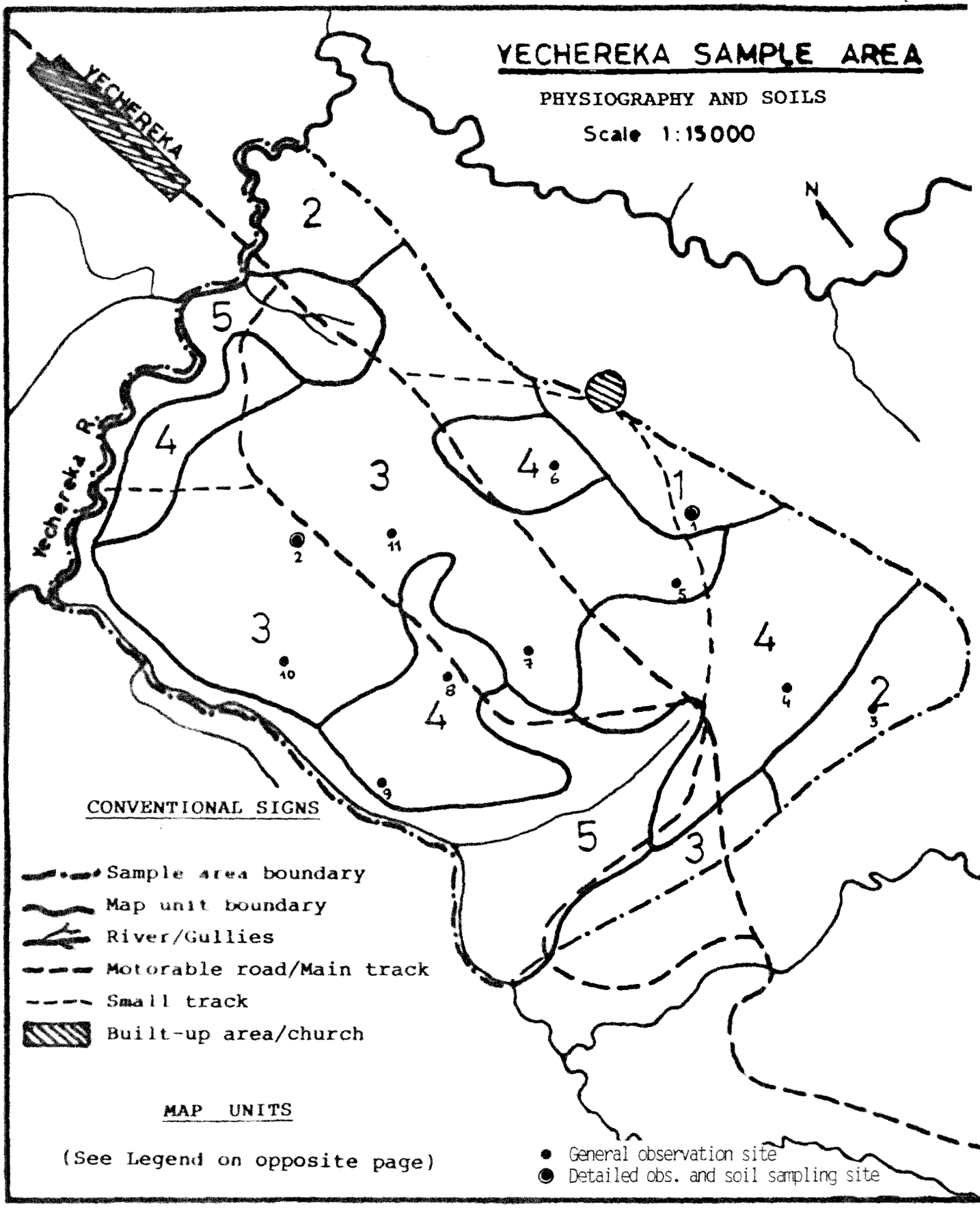
2 Gently sloping (3-8% slope), dissected, moderately deep to very deep, moderately well drained, moderately slowly permeable, dark reddish brown, gravelly clays with stony loam/clay loam topsoils

3 Gently sloping (2-5% slope), very deep, well to moderately well drained, moderately permeable, dark reddish brown clays with dark reddish brown clay loam topsoils

4 Sloping (5-12% slope), very deep, well drained, moderately permeable, dull reddish brown clays having dark reddish brown clay loam topsoils

Terrace Escarpments/Margins

5 Moderately steep (15-20% slope), very deep, well drained, moderately permeable, dull reddish brown clays with dark reddish brown, partly stony, clay loam topsoils


YECHEREKA SAMPLE AREA
PHYSIOGRAPHY AND SOILS
Scale 1:15000
YECHEREKA
Yechereka R.
N
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
Built-up area/church
MAP UNITS
(See Legend on opposite page)
General observation site
Detailed obs. and soil sampling site

YECHEREKA SAMPLE AREA

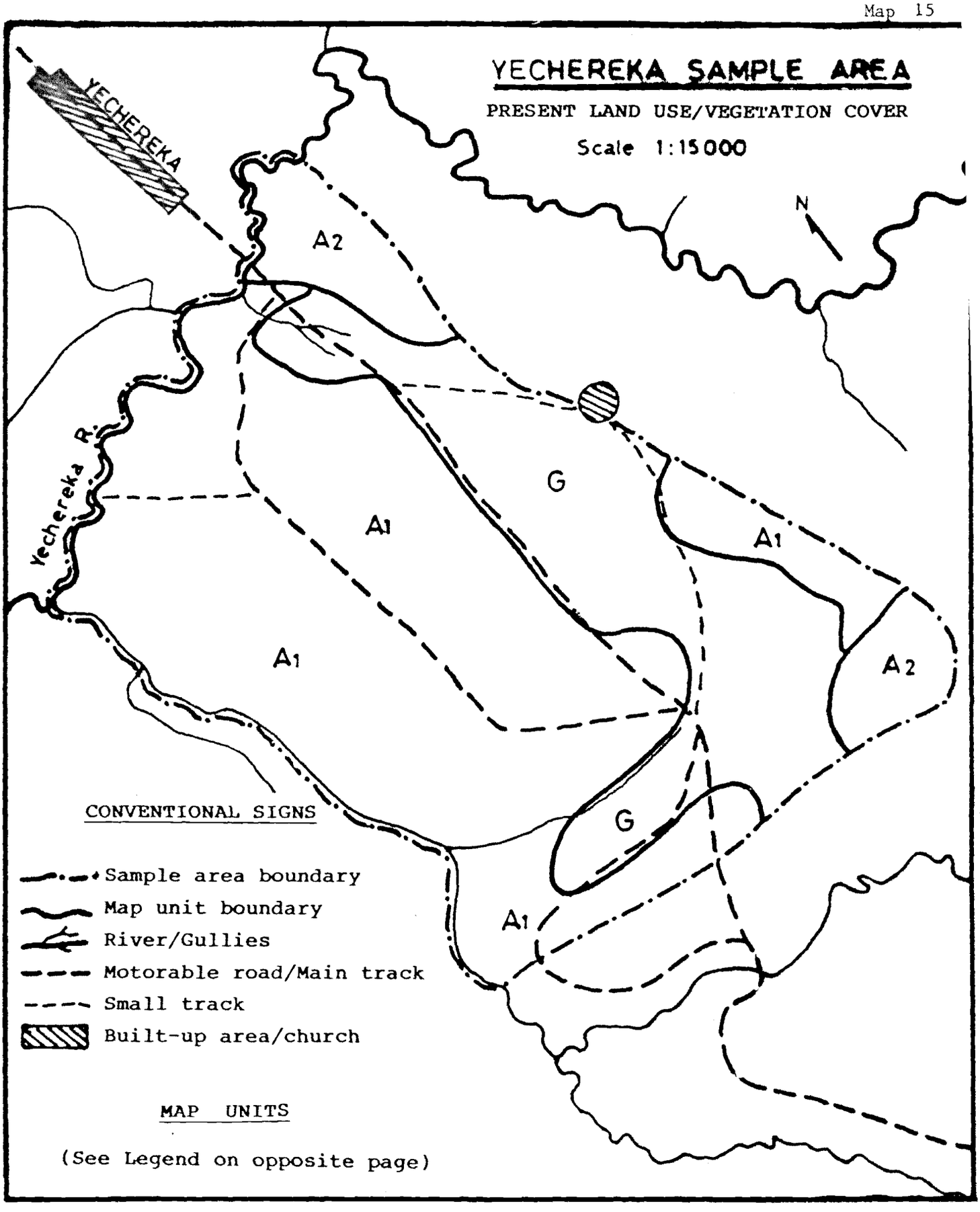
PRESENT LAND USE/VEGETATION COVER - MAP UNITS

L E G E N D

A1 Mainly arable land with <2% surface cover of bushes/stones; few patches under long fallow with 70-90% surface cover of grass and bushes

A2 Mainly arable land with 20-30% surface cover of stones and bushes; few patches under long fallow with 50-70% surface cover of grass, bushes and stones

G Grassland-cum-bush forest with >90% surface cover of grass, bushes and low trees


YECHEREKA SAMPLE AREA
PRESENT LAND USE/VEGETATION COVER
Scale 1:15000
N
YECHEREKA
Yechereka R.
A2
A1
G
A1
A1
A2
G
A1
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
Built-up area/church
MAP UNITS
(See Legend on opposite page)

Map unit symbol and description	Areal extent Ha	Areal extent %	Veg. cover (%)	Stone cover (%)
A1 - Arable land Cultivated=182 Fallow = 20	202	63.5	-	<2
A2 - Arable land Cultivated=23 Fallow = 6	29	9.1	-	15-20
G - Grass land	87	27.4	>90	10-15
Total:	318	100.0		

c) Soil Erosion Status. The soil erosion in the sample area is mainly of sheet and rill forms with slight to moderate degree of severity, except in narrow strips along the rivers where it is moderately severe and occurs in all forms including sheet, rill, gully and stream bank erosion, as well as land sliding/slumping in some parts.

Three map units of soil erosion status recognized for the sample area are delineated on Map 16 at scale 1:15,000.

The extent of each map unit, representing the soils affected by different degrees of erosion, is estimated as follows:

Map unit	Degree of soil erosion	Areal extent Ha	Areal extent %
E1	Slight to moderate	111	34.9
E2	Moderate	148	46.5
E2/E3	Moderate to severe	59	18.6
	Total:	318	100.0

YECHEREKA SAMPLE AREA

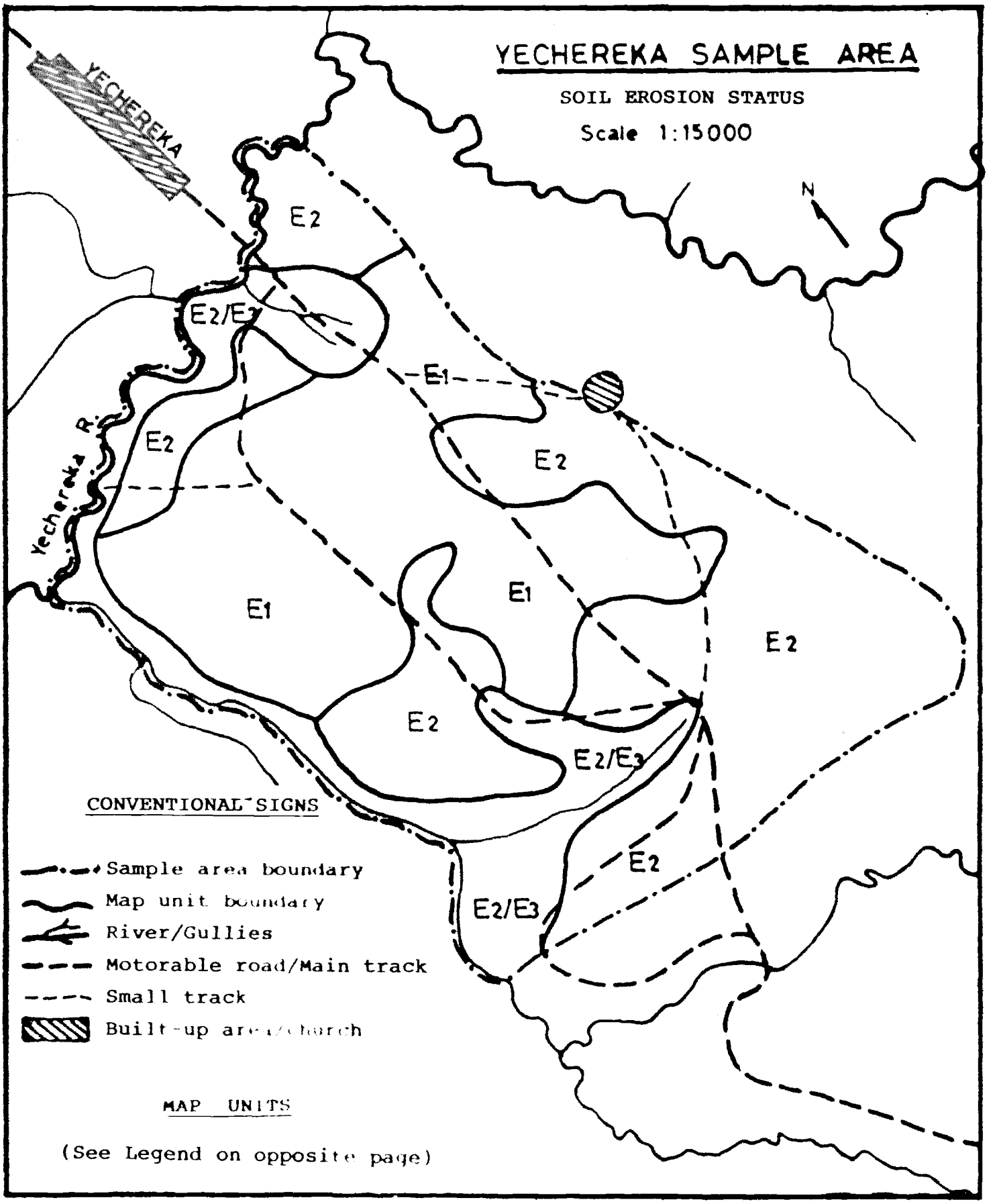
SOIL EROSION STATUS - MAP UNITS

L E G E N D

E1 Slight to moderate sheet and rill erosion; few traditional drainage ditches transformed into small gullies

E2 Moderate sheet and rill with some gully erosion; old tracks and traditional ditches commonly transformed into shallow to moderately deep gullies; gullies not evident in some parts due to shallow soils

E2/E3 Moderate to severe sheet, rill, gully and stream bank erosion with some land sliding/slumping


YECHEREKA SAMPLE AREA
SOIL EROSION STATUS
Scale 1:15000
N
YECHEREKA
Yecherera R.
E2
E2/E3
E1
E2
E2
E1
E1
E2
E2
E2/E3
E2
E2/E3
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
Built-up area/church
MAP UNITS
(See Legend on opposite page)

2.5 Agut Sample Area

a) Physiography and Soils. Four main land elements with different kinds of soils were recognized as follows:

Old plateau remnants: This represents the highest land surfaces, probably the remnants of old plateau or glacio-fluvial terrace, which have been partly eroded. It has gentle (5-8%) slope with a few shallow gullies.

The soils consist of moderately deep to deep (part shallow), moderately well drained, moderately permeable, noncalcareous, dark reddish brown clays with weak to moderate subangular blocky subsoil structure and weak granular, part stony, loam topsoils. (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 9)

Dissected alluvial terracettes and colluvial slopes: It comprises moderately steep remnants of old alluvial terraces, now partly graded to nearly continuous slopes due to erosion, and colluvial slopes at the base of the old plateau remnants and the higher alluvial terraces. The land element is dissected by moderately deep to deep gullies. The general slope varies from 15 to 25 percent.

The soils consist of moderately deep to deep, well drained, moderately slowly permeable, noncalcareous, reddish brown clays with moderate subangular/angular blocky subsoil structure and weak granular loam to clay loam topsoils. (See detailed description of Pedon 9a under Annex I)

Old alluvial terraces and subterrace slopes: This land element represents relatively extensive, almost flat to gently sloping (slope 1-3%) alluvial terraces, probably of early Holocene to late Pleistocene period, and a series of moderately sloping (10-15% slope) terracettes which have by now been partly eroded so as to give an appearance of nearly continuous slopes (here referred as the subterrace slopes).

The soils of the terraces consist of very deep, well to moderately well drained, moderately slowly permeable, noncalcareous, dark reddish brown clay loams, grading to clays at

lower depths, with moderate subangular to angular blocky subsoil structure and granular, dark brown to brownish black loam topsoils. (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 10)

The soils occurring on subterrace slopes are truncated to varying depths so that they differ from the above in being mostly clays in the subsoil and having clay loam topsoils.

Terrace escarpments/margins: This land element includes moderately steep to steep parts of the area representing eroded margins/escarpments of the alluvial terraces, generally located along the deep gullies/rivers. It is commonly marked with rills and shallow gullies. The slope varies from 15 to 50 percent.

The soils are moderately deep to deep, well drained, moderately slowly permeable, non-calcareous, dark reddish brown clay loams to clays with weak to moderate subangular blocky subsoil structure and weak granular, dark brown, part stony, loam to clay loam topsoils. (See detailed description of Pedon 10a under Annex I)

Six map units of physiography and soils with varying degrees of slopes recognized for the sample area are delineated on Map 17 at 1:15,000 scale.

The approximate areal extent, percentage and slope range of different map units of the sample area are as follows:

Map unit	Slope range (%)	Areal extent	
		Ha	%
1	5-8	5	2.3
2	15-25	34	15.7
3	1-3	42	19.4
4	10-15	34	15.7
5	15-25	34	15.7
6	25-50	67	31.0
Total:		216	100.0

b) Present Land Use/Vegetation Cover. The following three major kinds of present land use are identified in the sample area:

AGUT SAMPLE AREA

PHYSIOGRAPHY AND SOILS - MAP UNITS

L E G E N D

Old Plateau Remnants

1 Gently sloping (5-8% slope), moderately deep to deep, moderately well drained, moderately permeable, dark reddish brown clays with very dark brown stony loam topsoils
- includes small patches of exposed bedrock

Dissected Alluvial Terracettes and Colluvial Slopes

2 Moderately steep (15-25% slope), moderately deep to deep, well drained, moderately slowly permeable, reddish brown clays with dark reddish brown loam/clay loam topsoils

Old Alluvial Terraces and Subterrace Slopes

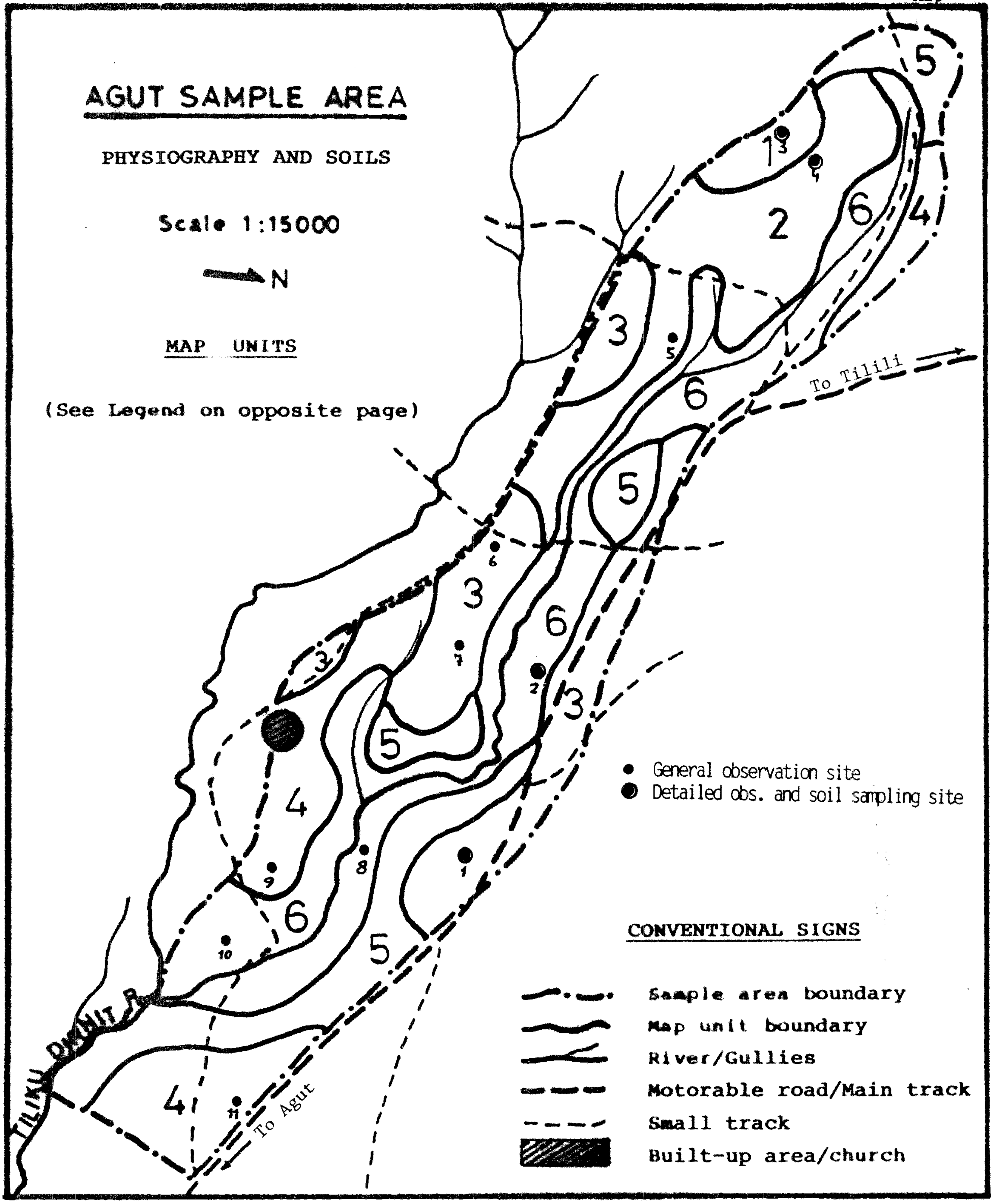
3 Almost flat to very gently sloping (1-3% slope), very deep, well to moderately well drained, moderately slowly permeable, dark reddish brown clay loams (grading to clays with depth) with dark brown to brownish black loam topsoils

4 Sloping (10-15% slope), very deep, moderately well drained, moderately slowly permeable, dark brown clays with dark brown to brownish black loam/clay loam topsoils

Terrace Escarpments/Margins

5 Moderately steep (15-25% slope), deep, well drained, moderately slowly permeable, dark reddish brown clays with dark brown loam/clay loam, part stony, topsoils

6 Mainly steep (25-50% slope), moderately deep to deep, well drained, moderately slowly permeable, dark reddish brown clay loams to clays with dark brown loam/clay loam, part stony, topsoils


AGUT SAMPLE AREA
PHYSIOGRAPHY AND SOILS
Scale 1:15000
N
MAP UNITS
(See Legend on opposite page)
General observation site
Detailed obs. and soil sampling site
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
Built-up area/church
To Tilili
To Agut
TILIKU DINNIT R.
1
2
3
4
5
6

i) Arable land - used for rainfed cultivation of mainly maize, teff and barley with some potato; part under long fallow having 60-80% grass cover; in some parts, 10-15% surface occupied by stones

ii) Forest - comprising low to high trees with 70-90% canopy cover and understorey with 75-90% surface cover of grass and stones/boulders

iii) Grassland - comprising mainly the running grasses and a few low shrubs; 50-90% surface cover of vegetation; 5-10% area occupied by bare rock

Five map units of present land use/vegetation cover recognized for the sample area are delineated on Map 18 of scale 1:15,000.

The distribution of different kinds of land use and vegetation/stone cover in various map units is indicated in the following table.

Map unit symbol and description	Areal extent Ha	Areal extent %	Veg. cover (%)	Stone cover (%)
A1 - Arable land	146	67.6	-	<2
Cultivated=138				
Fallow = 8				
A2 - Arable land	8	3.7	-	10-15
Cultivated=7				
Fallow =1				
F - Dense forest	35	16.2	70-90	10-20
G1 - Grass land	21	9.7	>90	10-20
G2 - Grass land	6	2.8	50-70	10-20
Total:	216	100.0		

c) Soil Erosion Status. The soil erosion in the sample area varies from slight sheet and rill erosion on relatively flat terraces to severe/very severe sheet, rill and gully erosion, accompanied with frequent land sliding/slumping, on the subterrace and colluvial slopes. The rills and gullies are mostly developed from the drainage ditches traditionally constructed by the farmer. Moderate to severe stream bank erosion occurs along the main river.

Five map units of soil erosion status recognized for the sample area are delineated on Map 19 at scale 1:15,000.

AGUT SAMPLE AREA

PRESENT LAND USE/VEGETATION COVER - MAP UNITS

L E G E N D

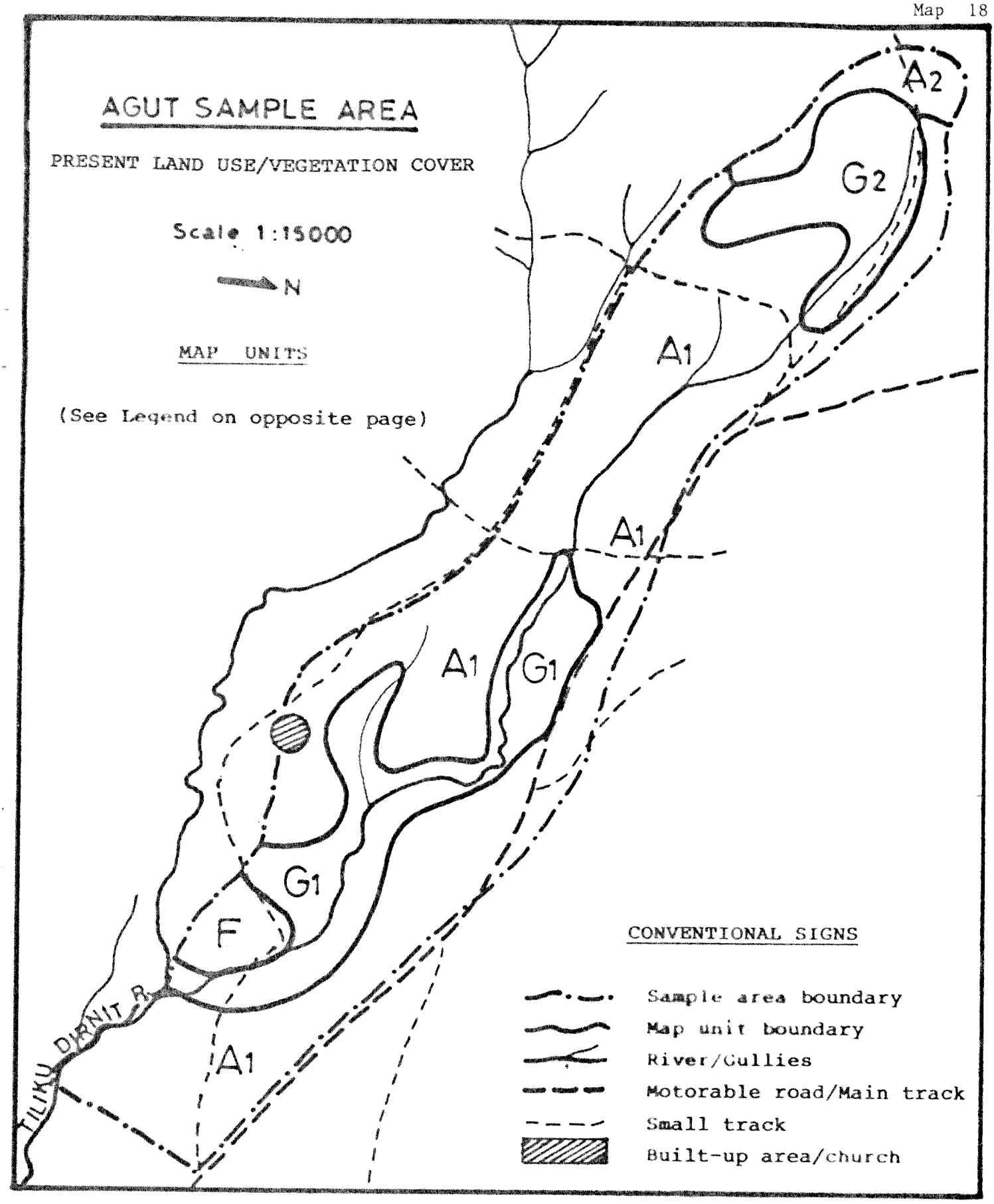
A1 Mainly arable land with <2% surface cover of stones/bushes; few patches under long fallow with 70-80% surface cover of grass

A2 Mainly arable land with 10-15% surface cover of stones; few patches under long fallow with 60-80% surface cover of grass and stones; 5-10% area with bare rock surface

F Tree forest with 70-90% canopy cover; understorey with 75-90% surface cover of grass and stones

G1 Mainly grassland, part long fallowed after cultivation, with >90% surface cover of grass and stones

G2 Mainly grassland, part long fallowed after cultivation, with 50-70% surface cover of grass and stones; 5-10% area with bare rock surface


AGUT SAMPLE AREA
PRESENT LAND USE/VEGETATION COVER
Scale 1:15000
N
MAP UNITS
(See Legend on opposite page)
A2
G2
A1
A1
A1
G1
G1
F
A1
TILIKU DRNIT R.
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
Built-up area/church

AGUT SAMPLE AREA

SOIL EROSION STATUS - MAP UNITS

L E G E N D

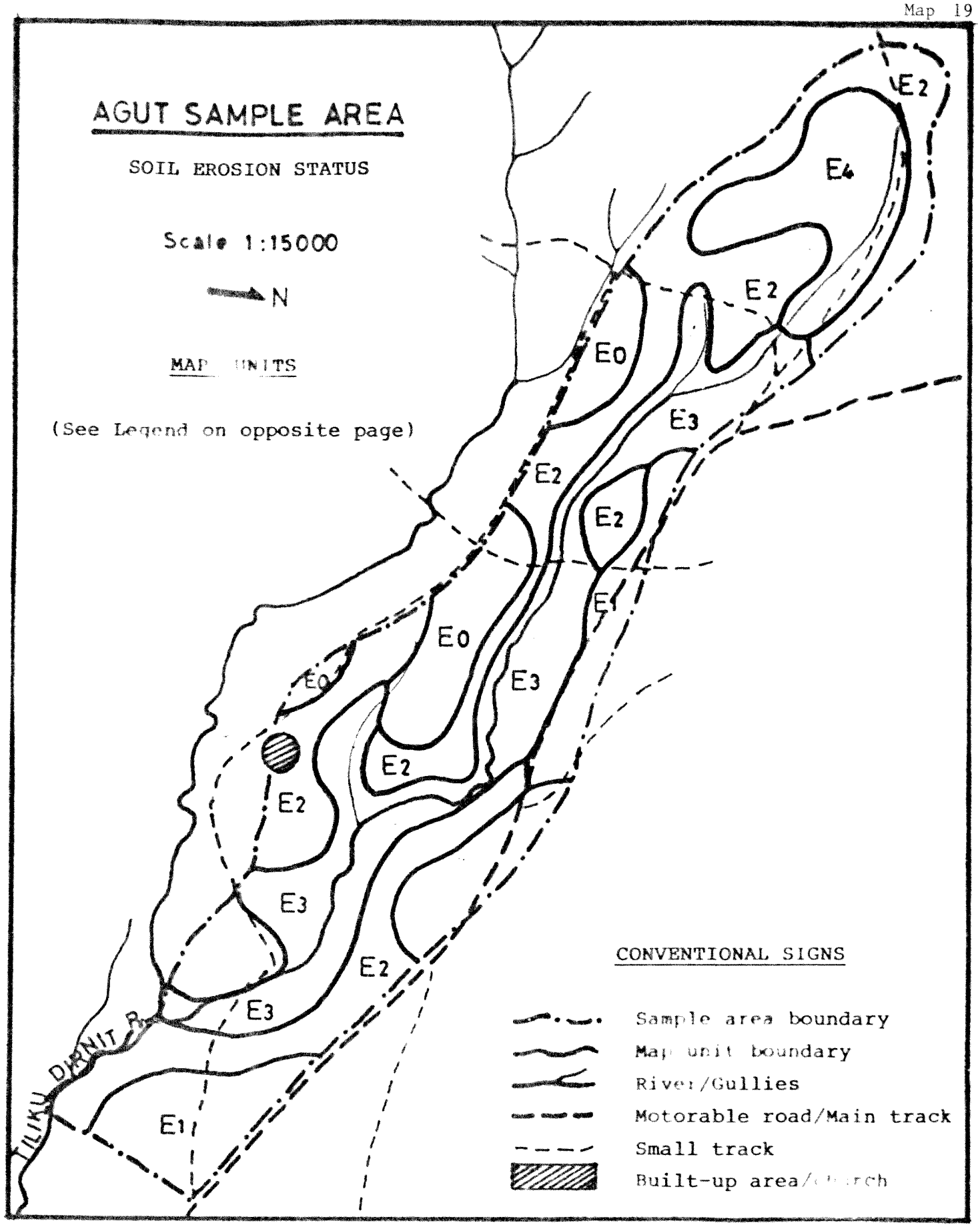
E0 No or slight sheet/rill erosion; rills formed mainly from traditional drainage ditches

E1 Slight to moderate sheet and rill erosion; few traditional drainage ditches transformed into small gullies

E2 Moderate sheet and rill with some gully erosion; old tracks and traditional drainage ditches commonly transformed into shallow to moderately deep gullies

E3 Severe sheet, rill and gully erosion with some land sliding/ slumping; severe stream bank erosion in some parts

E4 Very severe sheet, rill and gully erosion with frequent land sliding/slumping


AGUT SAMPLE AREA
SOIL EROSION STATUS
Scale 1:15000
N
MAP UNITS
(See Legend on opposite page)
E0
E1
E2
E3
E4
TILIKU DRINIT R.
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
Built-up area/Church

The extent of each map unit, representing the soils affected by different degrees of erosion, is estimated as follows:

Map unit	Degree of soil erosion	Areal extent Ha	%
E0	No or slight	32	14.8
E1	Slight to moderate	46	11.1
E2	Moderate	85	39.4
E3	Severe	65	24.5
E4	Very severe	22	10.2
	Total:	216	100.0

2.6 Jiga Sample Area

a) Physiography and Soils. Three main land elements with different kinds of soils were recognized as follows:

Alluvial plains and terraces: This land element includes extensively occurring, relatively high, flat parts of the sample area representing alluvial plains and lower alluvial terraces of probably early to middle Holocene period. It is largely undissected but may be marked at places by rills and shallow gullies. The general slope is less than 1 percent.

The soils consist of very deep, well drained, moderately permeable, noncalcareous, dull to dark reddish brown clays with moderate angular to subangular blocky subsoil structure and weak granular, nonstony clay loam topsoils. (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 11)

Terrace margins: It includes gently sloping to moderately steep parts of the area occurring along the boundaries between plains/terraces and basins. It is commonly marked with rills and shallow gullies. The slope varies from 4 to 20 percent.

The soils are moderately deep to very deep, well drained, moderately permeable, noncalcareous, dark reddish brown clay loams to clays with weak to moderate angular/subangular

blocky subsoil structure and weak granular, part stony, clay loam topsoils.

Basins and basin margins: This land element includes relatively low lying, flat to very gently sloping (slope 0.5-2.5%), extensively occurring basins, generally having impeded drainage conditions, and their sloping (8-12% slope), lower margins joining the river. The basins exhibit a few rills but their margins are gullied.

The soils consist of very deep, moderately well (part imperfectly to poorly) drained, slowly permeable, noncalcareous, yellowish grey to brownish black, nonstony clays with moderate angular blocky structure accompanied with prominent intersecting slickensides in the subsoil and moderate fine angular blocky to granular topsoils; the soils exhibit deep and wide cracks when dry (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 12).

Six map units of physiography and soils with varying degrees of slopes recognized for the sample area are delineated on Map 20 at 1:15,000 scale.

The approximate areal extent, percentage and slope range of different map units of the sample area are as follows:

Map unit	Slope range (%)	Areal extent	
		Ha	%
1	0-1	126	42.4
2	4-5	16	5.4
3	10-20	21	7.0
4	0.5-2.5	116	39.1
5	8-12	5	1.7
6	0.5-1	13	4.4
Total:		297	100.0

b) Present Land Use/Vegetation Cover. The following two major kinds of present land use are identified in the sample area:

JIGA SAMPLE AREA

PHYSIOGRAPHY AND SOILS - MAP UNITS

L E G E N D

Alluvial Terraces

1 Flat (<1% slope), very deep, well drained, moderately permeable, dull to dark reddish brown clays with dark reddish brown clay loam topsoils

Terrace Margins

2 Gently sloping (4-5% slope), very deep, well drained, moderately permeable, dark reddish brown clay loams to clays with dark brown clay loam topsoils

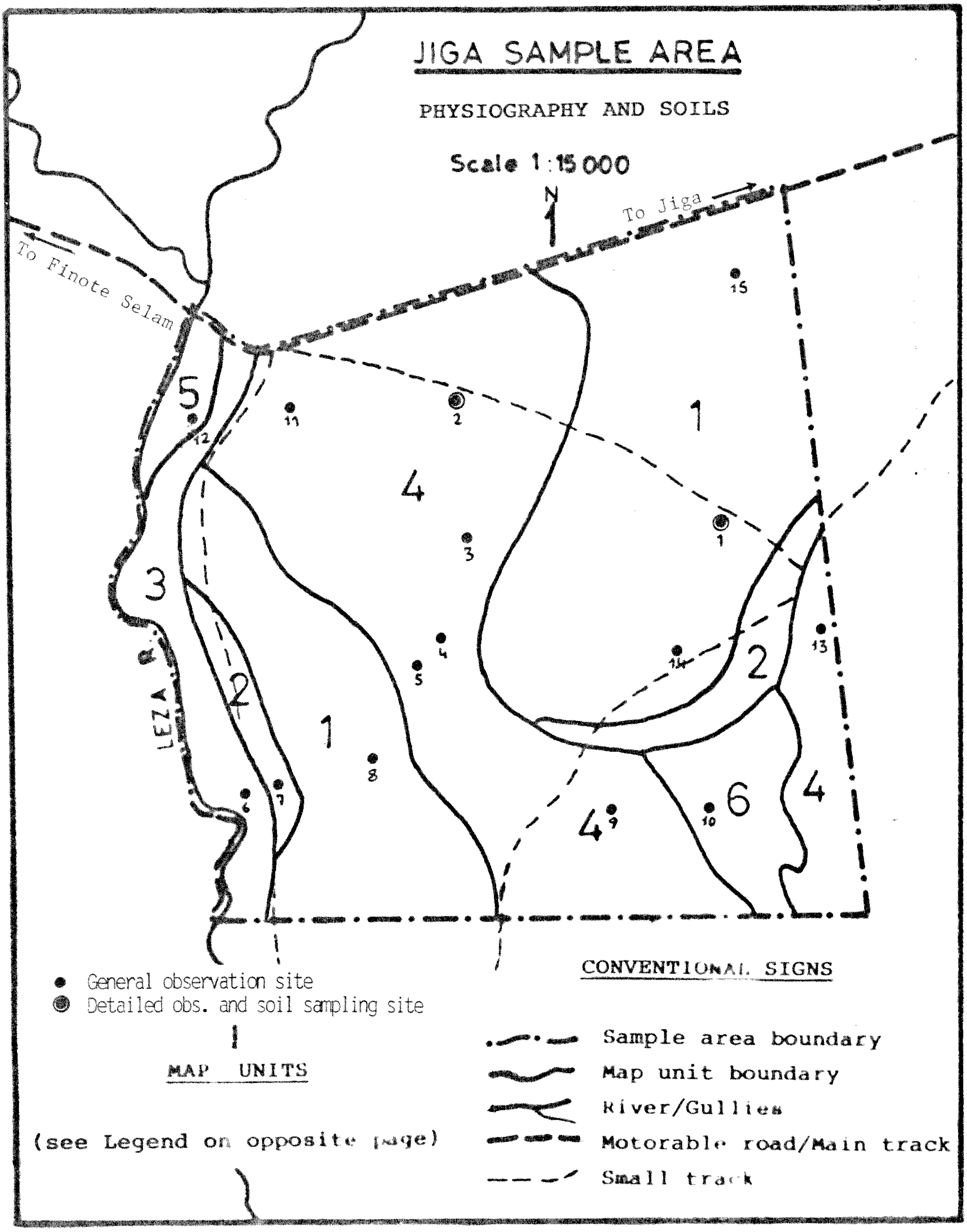
3 Sloping to moderately steep (10-20% slope), moderately deep to deep, well drained, moderately permeable, dark reddish brown clay loams, part stony/bouldery, topsoils

Basins and Basin Margins

4 Flat to very gently sloping (0.5-2.5% slope), deep, moderately well to imperfectly drained, slowly permeable, yellowish grey to brownish black clays showing wide and deep cracks when dry

5 Sloping (8-12% slope), partly dissected, very deep, imperfectly drained, slowly permeable, black clays, part with stony topsoils

6 Flat to slightly concave (0.5-1% slope), very deep, poorly (seasonally very poorly) drained, very slowly permeable, dark grey to black clays


JIGA SAMPLE AREA
PHYSIOGRAPHY AND SOILS
Scale 1:15 000
N
To Jiga
To Finote Selam
LEZA R.
5
3
2
1
4
1
2
6
4
4
General observation site
Detailed obs. and soil sampling site
1
MAP UNITS
(see Legend on opposite page)
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track

i) **Arable land** - used for rainfed cultivation of mainly maize, teff and barley; part under long fallow having more than 90% grass cover; in some part along the river, 5-15% land surface occupied by stones

ii) Grassland - comprising the running grasses with no trees or bushes; more than 90% surface cover of vegetation

Four map units of present land use/vegetation cover recognized for the sample area are delineated on Map 21 of scale 1:15,000.

The distribution of different kinds of land use and vegetation/stone cover in various map units of the sample area is indicated by the following table.

Map unit symbol and description	Areal extent Ha	Areal extent %	Veg. cover (%)	Stone cover (%)
A1 - Arable land Cultivated=185 Fallow = 10	195	65.7	-	<2
A2 - Arable land Cultivated=20 Fallow = 3	23	7.7	-	5-10
G1 - Grass land	65	21.9	>90	<2
G2 - Marsh land	14	4.7	>95	<2
Total:	297	100.0		

c) Soil Erosion Status. The soil erosion in major part of the sample area is slight with mainly of sheet and rill forms. The rills are formed mainly from traditional drainage ditches constructed by the farmer. The terrace and basin margins, however, have a moderate to severe sheet and rill erosion with some gully erosion and stream bank erosion. Some land sliding/slumping is also evidenced in basin margins.

Four map units of soil erosion status recognized for the sample area are delineated on Map 22 at scale 1:15,000.

The extent of each map unit, representing the soils affected by different degrees of erosion, is estimated as follows:

JIGA SAMPLE AREA

PRESENT LAND USE/VEGETATION COVER - MAP UNITS

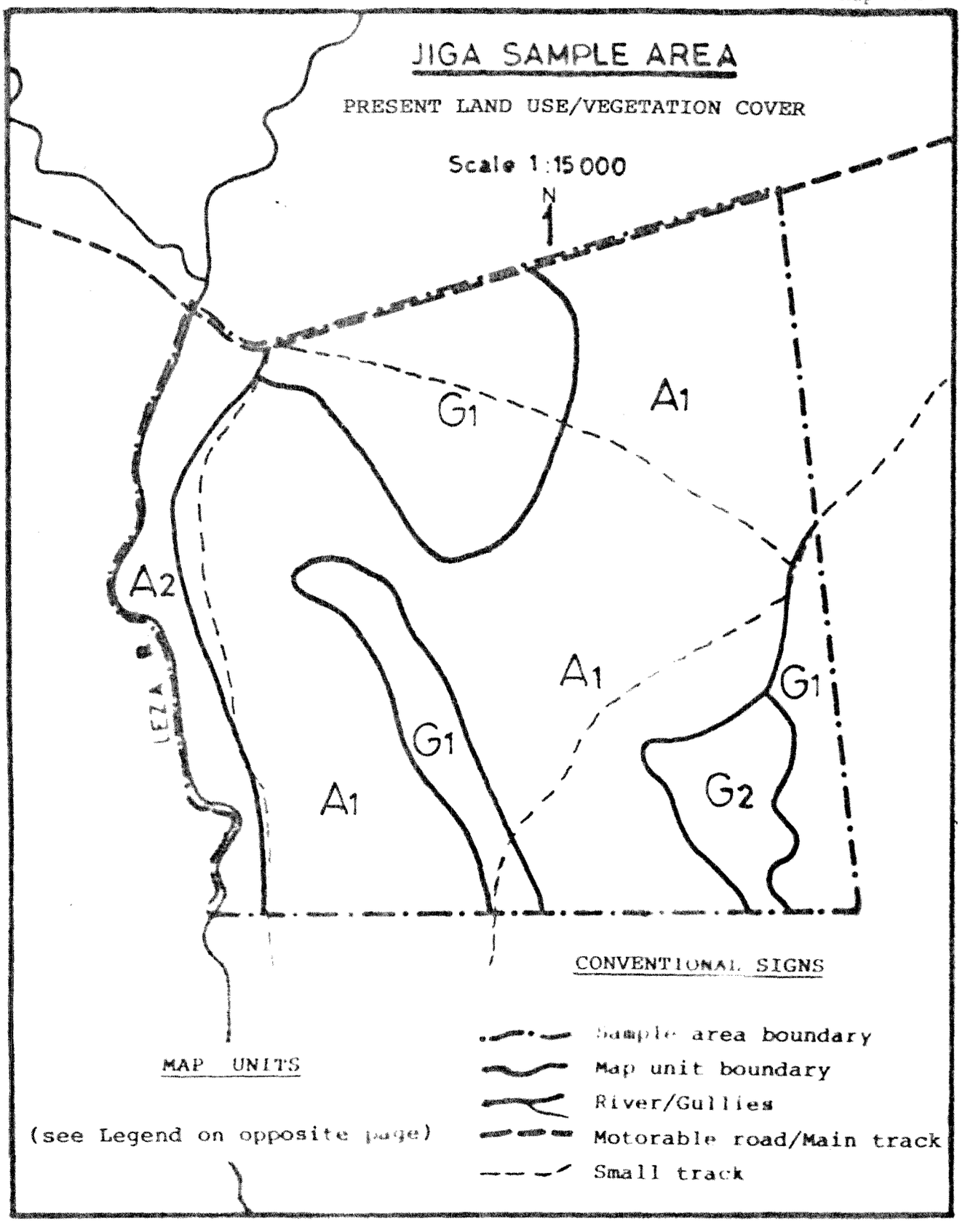
L E G E N D

A1 Arable land with <2% surface cover of vegetation/stones

A2 Mainly arable land with 5-15% surface cover of stones/ bushes; few patches under long fallow with >90% surface cover of grass

G1 Mainly grassland with >90% surface cover of grass but no trees/bushes

G2 Marshland with >95% surface cover of grass but no trees/ bushes


JIGA SAMPLE AREA
PRESENT LAND USE/VEGETATION COVER
Scale 1:15 000
N
G1
A1
A2
A1
G1
G1
A1
G2
IEZA
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
MAP UNITS
(see Legend on opposite page)

JIGA SAMPLE AREA

SOIL EROSION STATUS - MAP UNITS

L E G E N D

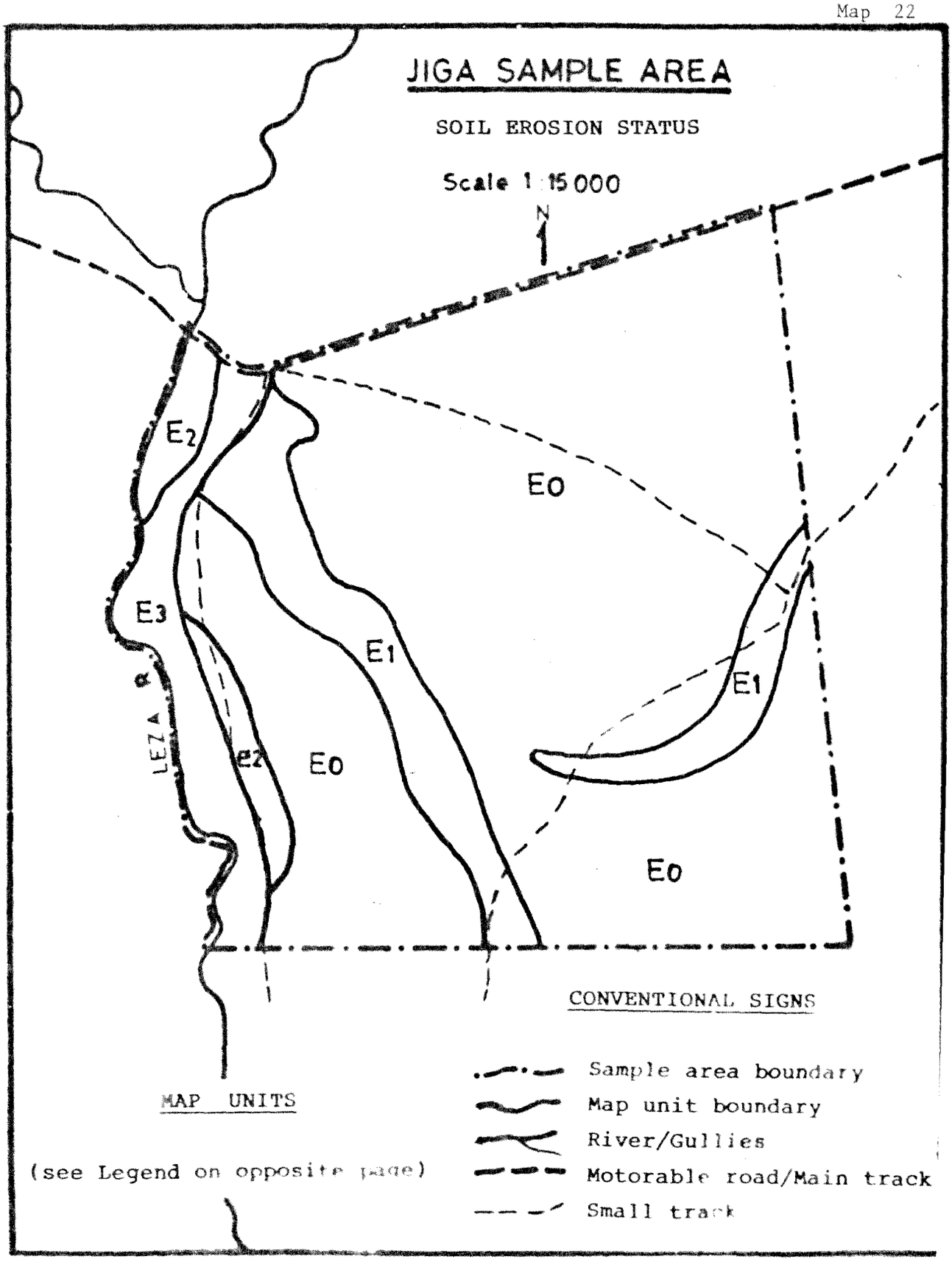
E0 No or slight sheet/rill erosion; rills formed mainly from traditional drainage ditches

E1 Slight to moderate sheet and rill erosion; few traditional drainage ditches transformed into small gullies

E2 Moderate sheet and rill with some gully erosion, moderate to severe stream bank erosion in some part; old tracks and traditional ditches commonly transformed into shallow to moderately deep gullies

E3 Severe sheet, rill and gully erosion with some land sliding/ slumping; severe stream bank erosion

Map 22


JIGA SAMPLE AREA
SOIL EROSION STATUS
Scale 1 : 15 000
N
E2
Eo
E3
E1
E1
LEZA R.
e2
Eo
Eo
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
MAP UNITS
(see Legend on opposite page)

Map unit	Degree of soil erosion	Areal extent Ha	%
E0	No or slight	230	77.4
E1	Slight to moderate	36	12.1
E2	Moderate	11	3.7
E3	Severe	20	6.7
	Total:	297	100.0

2.7 Finote Selam Sample Area

a) Physiography and Soils. Four main land elements with different kinds of soils were recognized as follows:

Old alluvial terraces: It includes relatively high, gently sloping parts of the sample area representing remnants of old alluvial terraces appearing as islands within the bouldery channel. The land element is partly intersected by shallow gullies. The general slope varies from 1 to 5 percent.

The soils are very deep, well to moderately well drained, moderately slowly permeable, noncalcareous, dull to dark reddish brown clays with moderate angular to subangular blocky subsoil structure and weak granular to massive, part stony, clay loam topsoils (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 8)

Terrace escarpments/margins: This element represents moderately steep (slope 15-25%) parts of the sample area occurring along the river. It is marked with numerous rills and few shallow gullies.

The soils consist of moderately deep to deep, well drained, moderately slowly permeable, noncalcareous, dark reddish brown clay loams to clays with weak to moderate angular/subangular blocky subsoil structure and weak granular, stony/bouldery, loam to clay loam topsoils.

Channel infills: It consists of an almost continuous, broad strip of low land representing an abandoned river channel with its bed on a lava flow surface. It is frequently interrupted by low hills of rock outcrops and scattered boulders. The surface topography is gently undulating with main slopes ranging between 1 and 3 percent.

The soils consist of mainly shallow (partly moderately deep, well drained, moderately permeable, noncalcareous, brown to brownish black, very stony/bouldery loams to clay loams with weak subangular blocky subsoil structure and weak granular topsoils.

Rock outcrops: This land element represents the exposed bedrock surfaces and bouldery land composed of mainly the volcanic tuff. the rock surface is almost flat. The soil cover is non-existent.

Five map units of physiography and soils recognized for the sample area are delineated on Map 23 at a scale of 1:15,000.

The approximate areal extent, percentage and slope range of different map units of the sample area are as follows:

Map unit	Slope range (%)	Areal extent	
		Ha	%
1	1-3	43	24.2
2	3-5	14	7.9
3	15-25	10	5.6
4	1-3	86	48.3
5	>30	25	14.0
Total:		178	100.0

b) Present Land Use/Vegetation Cover. The following two major kinds of present land use are identified in the sample area:

i) **Arable land** - used for rainfed cultivation of mainly maize and teff; part under long fallow having more than 90% grass and bush cover

FINOTE SELAM SAMPLE AREA

PHYSIOGRAPHY AND SOILS - MAP UNITS

L E G E N D

Old Alluvial Terraces

1 Very gently sloping (1-3% slope), very deep, well to moderately well drained, moderately slowly permeable, dull to dark reddish brown clays

2 Gently sloping (3-5% slope), very deep, well to moderately well drained, moderately slowly permeable, dull to dark reddish brown clays

Terrace Escarpments/Margins

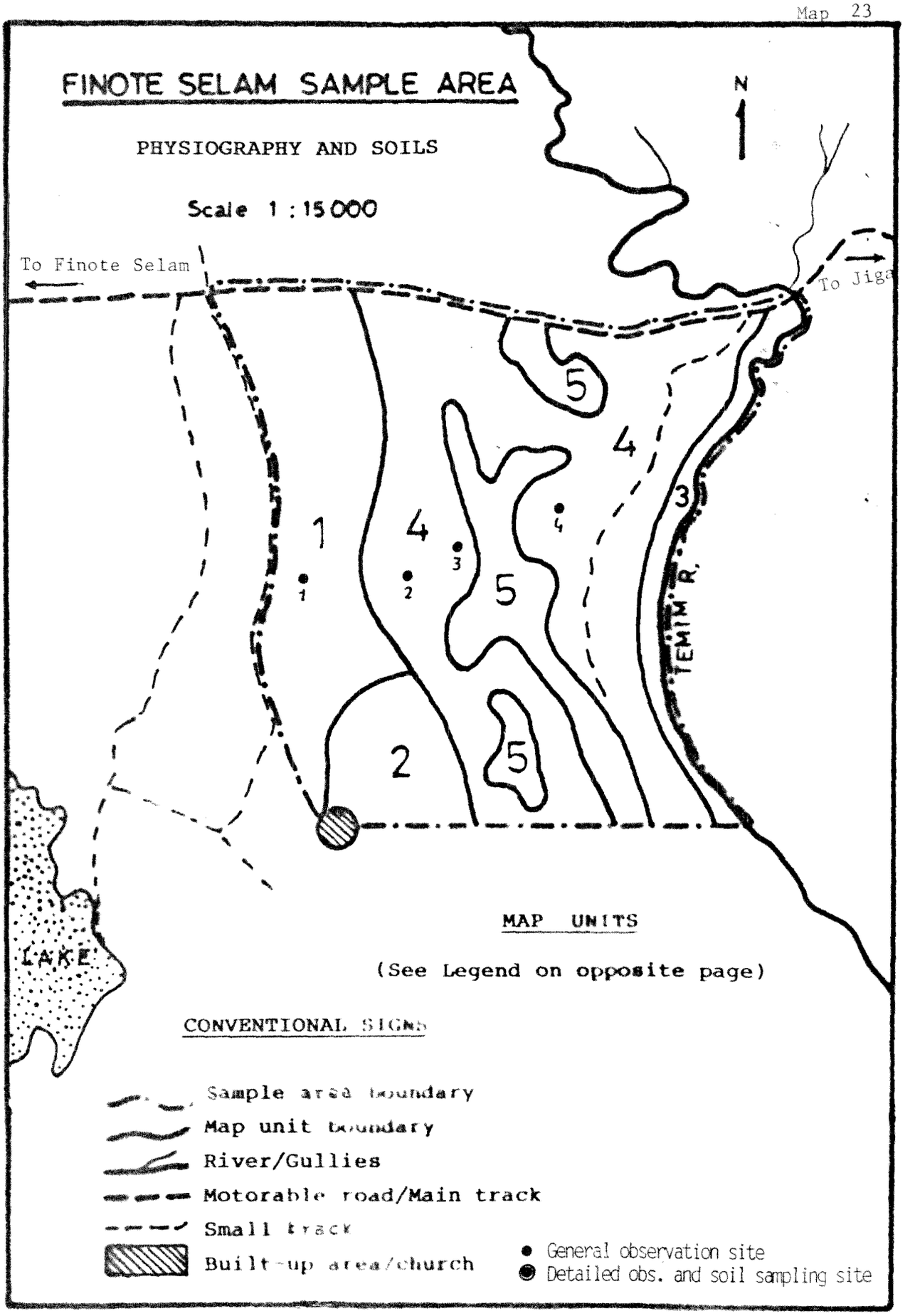
3 Moderately steep (15-25% slope), moderately deep to very deep, well drained, moderately slowly permeable, dark reddish brown clay loams to clays

Channel Infills

4 Very gently undulating (1-3% slope), shallow to moderately deep, well drained, moderately permeable, brown to brownish black, very stony/bouldery loams to clay loams
- includes small patches of exposed bedrock

Rock Outcrops

5 Exposed bedrock and bouldery land, composed mainly of volcanic tuff, with almost no soil cover


FINOTE SELAM SAMPLE AREA
PHYSIOGRAPHY AND SOILS
Scale 1 : 15000
N
To Finote Selam
To Jiga
TEMIM' R.
LAKE
1
2
3
4
5
MAP UNITS
(See Legend on opposite page)
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
Built-up area/church
General observation site
Detailed obs. and soil sampling site

ii) Bush forest - comprising mainly bushes and shrubs with some low to moderately high trees; understorey covered by running grasses; 50-70% surface cover by vegetation and stones

Two map units of present land use/vegetation cover recognized for the sample area are delineated on Map 24 of scale 1:15,000.

The distribution of different kinds of land use and vegetation/stone cover in various map units of the sample area is indicated by the following table.

Map unit symbol and description	Areal extent Ha	Areal extent %	Veg. cover (%)	Stone cover (%)
A - Arable land Cultivated=41 Fallow = 5	46	25.8	-	<2
F - Bush forest	132	74.2	50-70	20-40
Total:	178	100.0		

c) Soil Erosion Status. Slight to moderate sheet and rill erosion occurs in major part of the sample area. Moderately severe sheet and rill erosion with a few gullies occurs in a small, relatively high part of the terrace and the terrace margin. The construction of traditional drainage ditches by the farmer is the general cause of rill and gully formation. Moderate to severe stream bank erosion also occurs along the river.

Two map units of soil erosion status recognized for the sample area are delineated on Map 25 at scale 1:15,000.

The extent of each map unit, representing the soils affected by different degrees of erosion, is estimated as follows:

Map unit	Degree of soil erosion	Areal extent Ha	Areal extent %
E1	Slight to moderate	154	86.5
E2	Moderate	24	13.5
	Total:	178	100.0

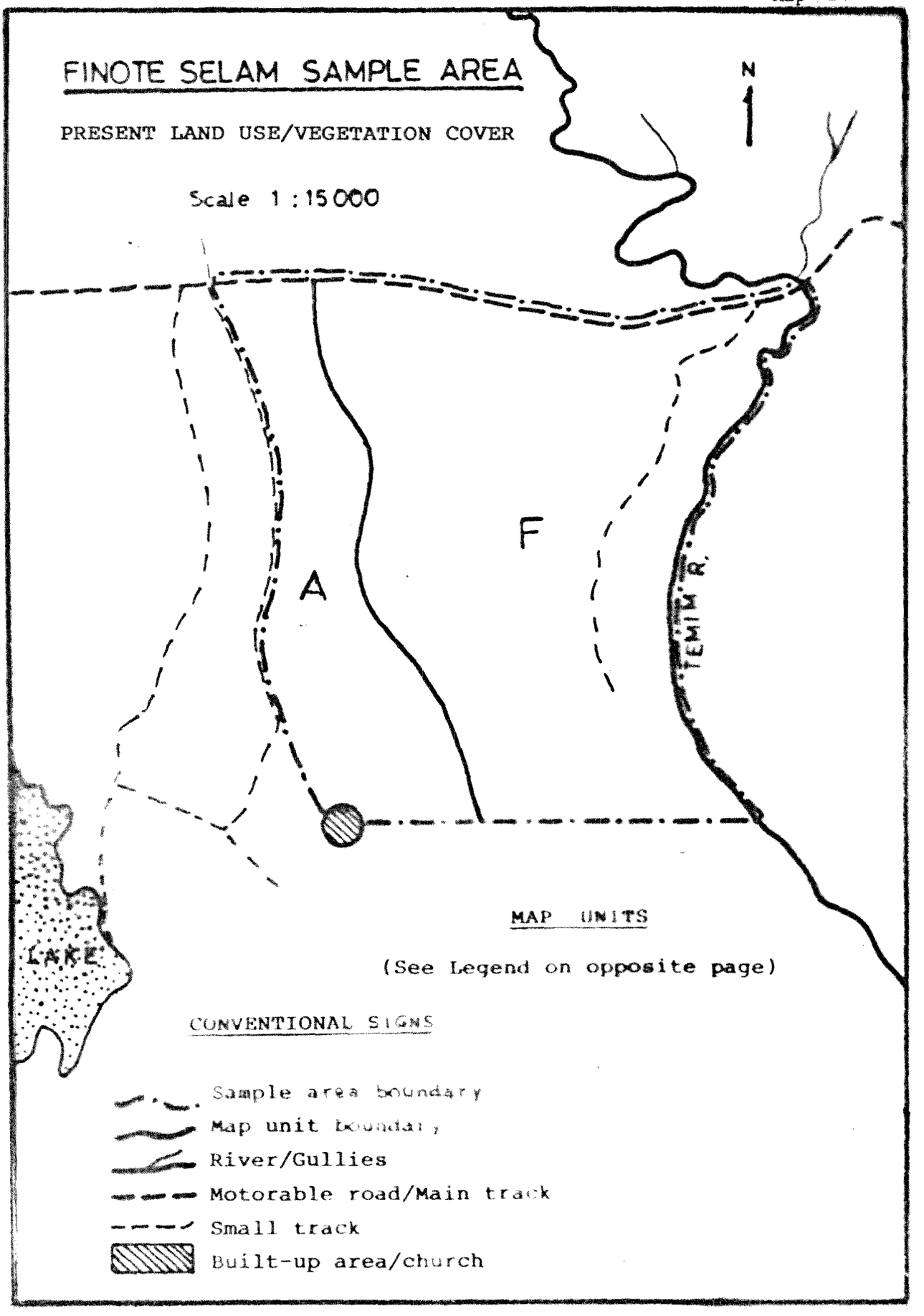
FINOTE SELAM SAMPLE AREA

PRESENT LAND USE/VEGETATION COVER - MAP UNITS

L E G E N D

A Mainly arable land with <2% surface cover of stones/ bushes; few patches under long fallow with >90% surface cover of grass/bushes

F Mainly bush forest with 50-70% surface cover of bushes/grass and stones; few patches of arable land with 20-40% surface cover of stones/bushes; 10-20% area with bare rock surface


FINOTE SELAM SAMPLE AREA
PRESENT LAND USE/VEGETATION COVER
Scale 1 : 15000
N
A
F
TEMIM R.
LAKE
MAP UNITS
(See Legend on opposite page)
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
Built-up area/church

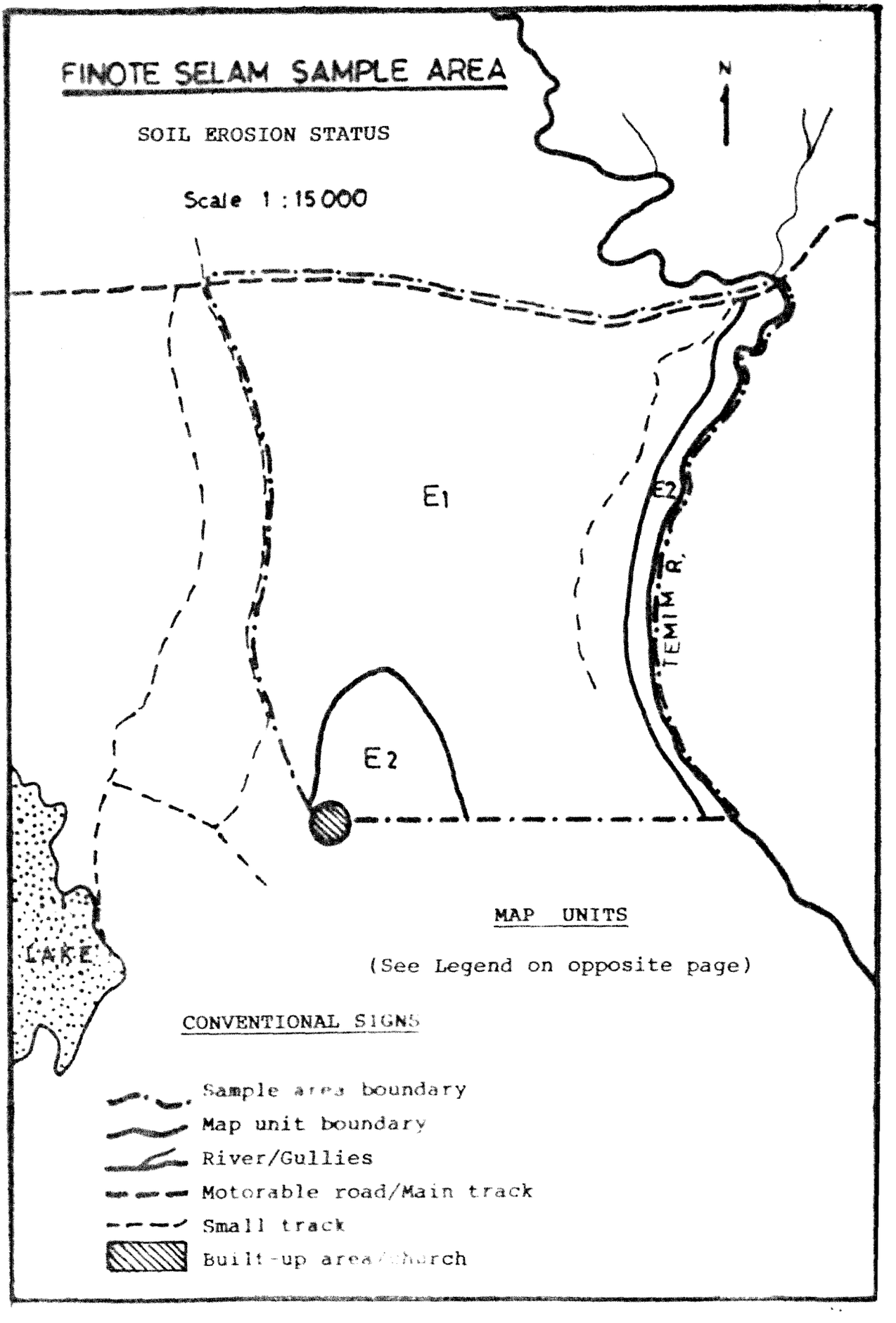
FINOTE SELAM SAMPLE AREA

SOIL EROSION STATUS - MAP UNITS

L E G E N D

E1 Slight to moderate sheet and rill erosion, moderate stream bank erosion evident in some parts; few traditional drainage ditches transformed into small gullies

E2 Moderate sheet and rill with some gully erosion, moderate to severe stream bank erosion in some part; old tracks and traditional ditches commonly transformed into shallow to moderately deep gullies


FINOTE SELAM SAMPLE AREA
SOIL EROSION STATUS
Scale 1 : 15000
N
E1
E2
E2
TEMIM R.
LAKE
MAP UNITS
(See Legend on opposite page)
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
Built-up area/Church

2.8 Tilili Sample Area

a) Physiography and Soils. Four main land elements with different kinds of soils were recognized as follows:

Old alluvial terraces and terrace margins: It represents relatively high lying, almost flat remnants of the old alluvial terraces with their gently sloping margins appearing as islands within broad basins. The land element is partly intersected by shallow gullies. The general slope varies from 1 to 6 percent.

The soils consist of very deep, moderately well drained, moderately slowly to slowly permeable, noncalcareous, dark brown clay loams/silty clay loams, grading to clays at lower depths, with moderate angular to subangular blocky subsoil structure and weak granular, brownish black loam topsoils (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 13)

Basins: This land element consists of flat to very gently sloping/concave, broad basins intersected by a few gullies. A part of the basins remains ponded for long periods, especially during the wet seasons, and takes the forms of seasonal and perennial lakes. The general slope ranges between 0 and 3 percent.

The soils are very deep, imperfectly (seasonally poorly to very poorly) drained, part permanently ponded, slowly permeable, noncalcareous, dark reddish brown to black loams and clay loams underlain by clays with weak to moderate subangular blocky subsoil structure and granular topsoils; the groundwater table fluctuates between 90 and 120 cm depth (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 14)

Rock outcrops: It occurs in the form of low hills of exposed bedrock and bouldery land, composed mainly of volcanic tuff, which are scattered within the basin, especially along the boundaries of old terrace remnants and basins. The general height of the hills varies between about 2 and 10 metres. No soil cover is found in this land element.

Note: i) The land element"Lakes", which is another important component of most delineations made for the generalized major landform unit represented by this sample area, was found missing here. The lakes include both seasonal and perennial and constitute about 15 to 25 percent of the relevant map unit.

ii) The relative extent of rock outcrops was found low, compared to the normal about 10 percent for most delineations of the map units represented by the sample area.

Five map units of physiography and soils recognized for the sample area are delineated on Map 26 at a scale of 1:15,000.

The approximate areal extent, percentage and slope range of different map units of the sample area are as follows:

Map unit	Slope range (%)	Areal extent Ha	%
1	0-2	20	8.6
2	3-6	54	23.2
3	1-3	55	23.6
4	0-1	103	44.2
5	>30	1	0.4
Total:		233	100.0

b) Present Land Use/Vegetation Cover. The following two major kinds of present land use are identified in the sample area:

i) **Arable land** - used for rainfed cultivation of mainly maize and teff; part under long fallow having more than 90% cover of grass and bushes

ii) **Grassland** - comprising mainly the running grasses and no trees or bushes; about 100% ground surface covered by vegetation

Two map units of present land use/vegetation cover recognized for the sample area are delineated on Map 27 of scale 1:15,000.

The distribution of different kinds of land use and vegetation/stone cover in various map units of the sample area is indicated by the following table.

TILILI SAMPLE AREA

PHYSIOGRAPHY AND SOILS - MAP UNITS

L E G E N D

Old Alluvial Terraces and Terrace Margins

1 Almost flat (<2% slope), very deep, moderately well drained, moderately slowly permeable, dark brown clay loams/silty clay loams (grading to clays with depth) with brownish black loam topsoils

2 Gently sloping (3-6% slope), very deep, moderately well drained, slowly permeable, dark brown clay loams to clays with loam topsoils

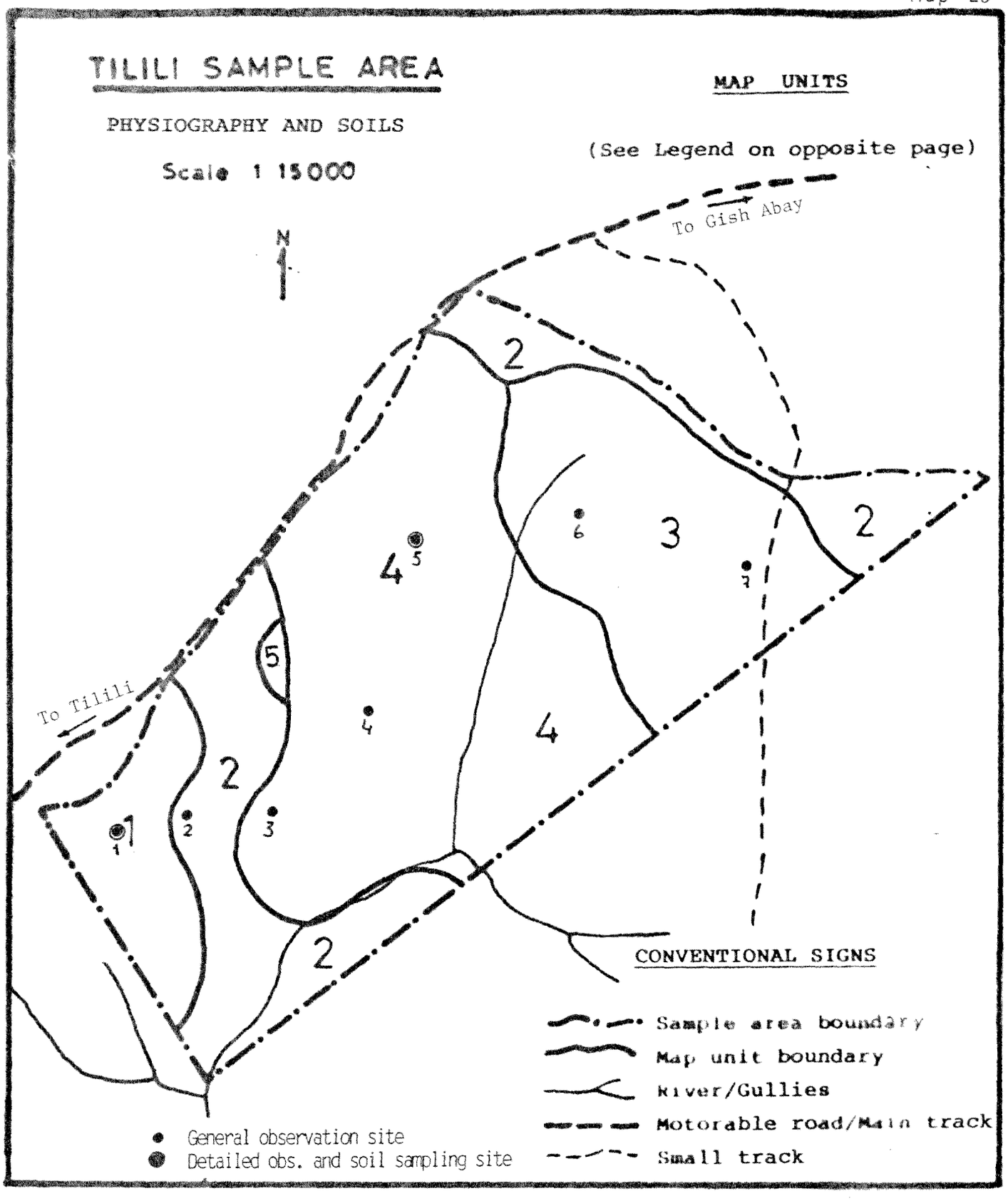
Basins

3 Very gently sloping (1-3% slope), very deep, imperfectly drained, slowly permeable, dark reddish brown to brownish black loams underlain by clay

4 Flat to slightly concave (<1% slope), very deep, imperfectly drained, part seasonally ponded, slowly permeable, black/brownish black loams to clay loams underlain by clays, water table at 90-120cm depth

Rock Outcrops

5 Low hilly land composed of boulders from volcanic tuff with no soil cover


TILILI SAMPLE AREA
PHYSIOGRAPHY AND SOILS
Scale 1 15000
MAP UNITS
(See Legend on opposite page)
N
To Gish Abay
To Tilili
2
3
4
5
6
7
1
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track
General observation site
Detailed obs. and soil sampling site

TILILI SAMPLE AREA

PRESENT LAND USE/VEGETATION COVER - MAP UNITS

L E G E N D

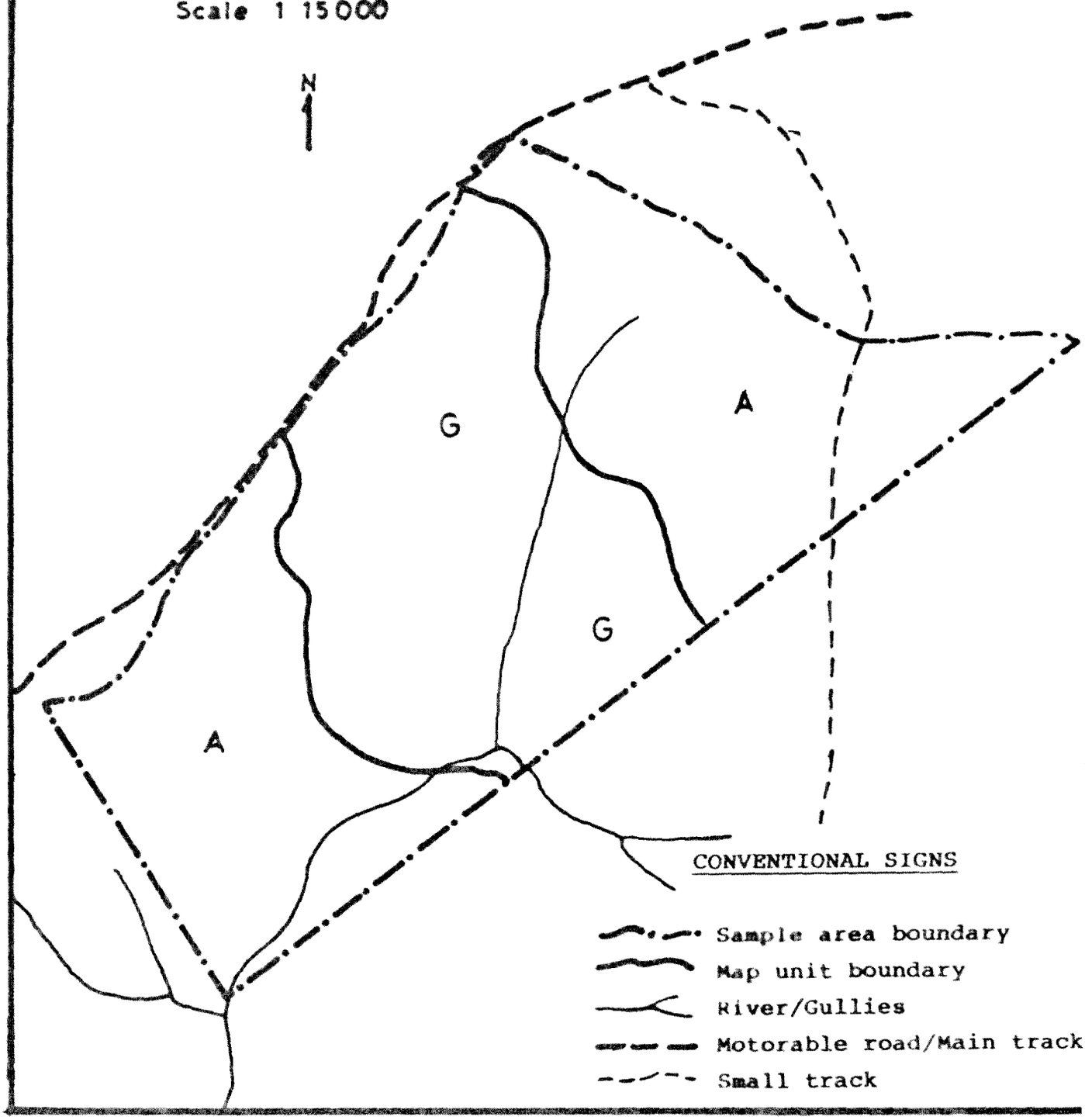
A Mainly arable land with <2% surface cover of vegetation/ stones; few patches under long fallow with >90% surfae cover of grass

G Mainly grassland with >90% surface cover of grass but no trees/bushes

TILILI SAMPLE AREA

PRESENT LAND USE/VEGETATION COVER

Scale 1 15000



Map unit symbol and description	Areal extent Ha	Areal extent %	Veg. cover (%)	Stone cover (%)
A - Arable land	138	59.2	-	<2
Cultivated=124				
Fallow = 14				
G1 - Grass land	95	40.8	>90	<1
Total:	233	100.0		

c) Soil Erosion Status. The soil erosion in most part of the sample area is slight occurring in sheet and rill forms. The basin is, however, partly intersected by a few small gullies along which moderate stream bank erosion is evident. The extreme northeastern part representing the margin of an alluvial terrace is affected by moderate sheet and rill erosion with a few shallow gullies occurring along its lower boundary.

Three map units of soil erosion status recognized for the sample area are delineated on Map 28 at scale 1:15,000.

The extent of each map unit, representing the soils affected by different degrees of erosion, is estimated as follows:

Map unit	Degree of soil erosion	Areal extent Ha	Areal extent %
E0	No or slight	123	52.8
E1	Slight to moderate	91	39.0
E2	Moderate	19	8.2
	Total:	233	100.0

TILILI SAMPLE AREA

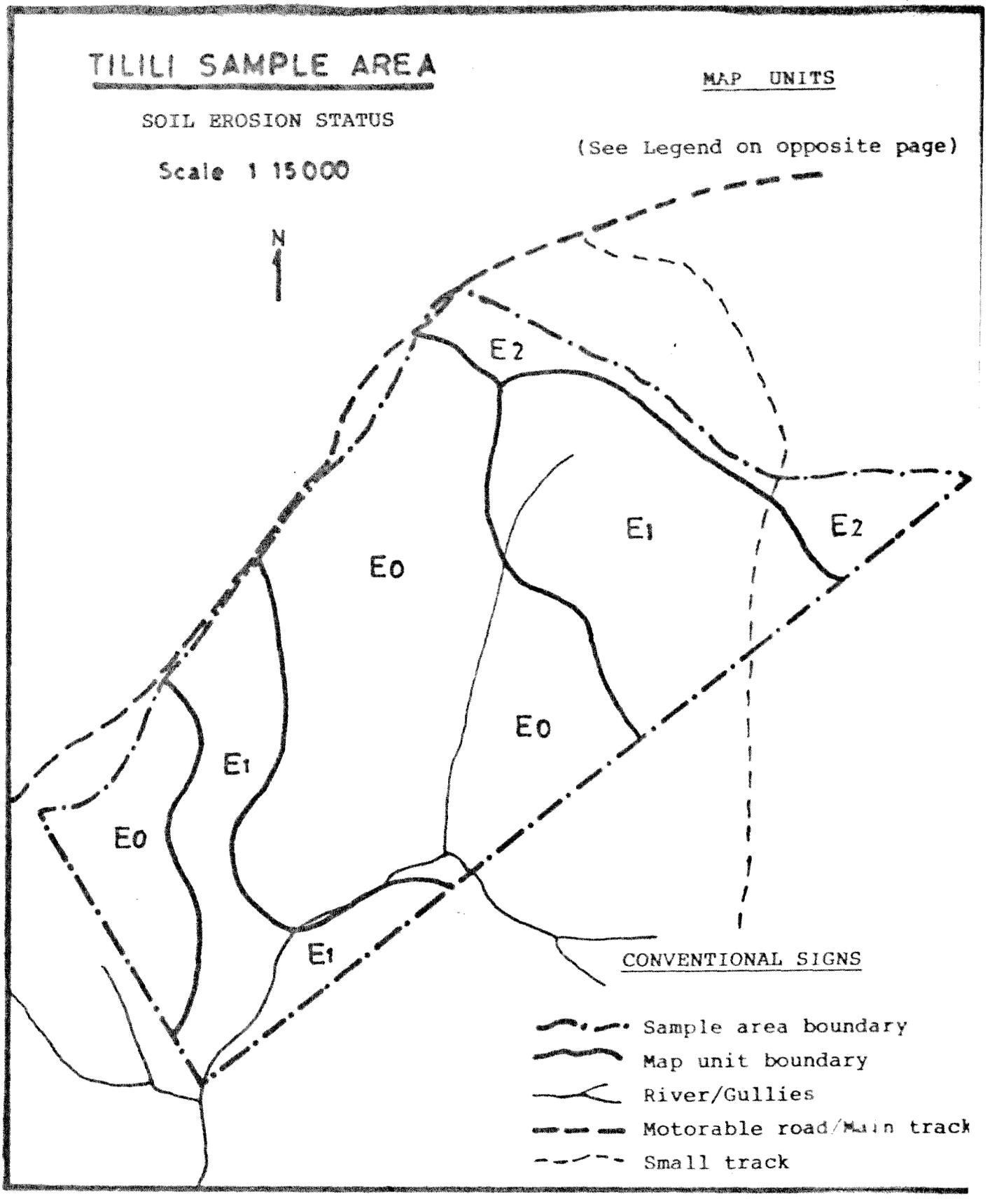
SOIL EROSION STATUS - MAP UNITS

L E G E N D

E0 No or slight sheet/rill erosion; moderate stream bank erosion in some part

E1 Slight to moderate sheet and rill erosion; moderate stream bank erosion in some part; few traditional drainage ditches transformed into small gullies

E2 Moderate sheet and rill with some gully erosion; old tracks and traditional ditches commonly transformed into shallow to moderately deep gullies


TILILI SAMPLE AREA
SOIL EROSION STATUS
Scale 1 15000
N
MAP UNITS
(See Legend on opposite page)
E2
E1
E2
E0
E0
E1
E0
E1
CONVENTIONAL SIGNS
Sample area boundary
Map unit boundary
River/Gullies
Motorable road/Main track
Small track

2.9 Fagta Sample Area

a) Physiography and Soils. Three main land elements with different kinds of soils were recognized as follows:

Old plateau remnants: This represents the highest land surfaces, probably the remnants of old plateau or glacio-fluvial terrace, which have been partly eroded. It has moderate (8-12%) slopes with a few shallow gullies.

The soils consist of mainly moderately deep to deep but some shallow, well to moderately well drained, moderately slowly permeable, noncalcareous, brown to dull reddish brown clay loams, grading to clays/silty clays at lower depths, with weak to moderate angular/ subangular blocky subsoil structure and weak granular, stony loam to clay loam topsoils.

Old alluvial terraces/terracettes and subterrace slopes: It includes gently sloping remnants of old alluvial terraces and subterrace slopes representing the erosion surfaces with nearly continuous slopes formed by merging of a series of terracettes. The land surface is marked with numerous rills and common shallow to deep gullies. The slope varies from 3 to 12 percent.

The soils of the terraces consist of very deep, moderately well drained, moderately permeable, noncalcareous, dark brown to brownish black clay loams, grading to clays with depth, with moderate subangular blocky subsoil structure and granular, stony loam topsoils (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 15)

The soils occurring on subterrace slopes are moderately deep to very deep, well to moderately well drained, moderately slowly permeable, noncalcareous, reddish brown to dark reddish brown clays with moderate subangular to angular blocky subsoil structure and weak granular, stony/gravelly loam to clay loam topsoils. (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 16)

Colluvial slopes and escarpments: This land element represents moderately steep to steep parts of the sample area representing mainly the erosion surfaces or escarpments with some

colluvial slopes. It is marked with numerous rills and common shallow to deep gullies. The surface slope ranges between 15 and 50 percent.

The soils consist of moderately deep to very deep, well drained, moderately slowly permeable, noncalcareous, dark reddish brown clay loams, grading to clays at lower depths, with moderate angular blocky subsoil structure and weak granular to massive, stony/gravelly loam to clay loam topsoils (See detailed description of typical soil profile and laboratory analytical data under Annex I, Pedon 17)

Four map units of physiography and soils with varying degrees of slopes recognized for the sample area are delineated on Map 29 at a scale of 1:15,000.

The approximate areal extent, percentage and slope range of different map units of the sample area are as follows:

Map unit	Slope range (%)	Areal extent	
		Ha	%
1	8-12	20	13.7
2	3-8	5	3.4
3	10-12	67	45.9
4	15-50	54	37.0
	Total:	146	100.0

b) Present Land Use/Vegetation Cover. The following two major kinds of present land use are identified in the sample area:

i) Arable land - used for rainfed cultivation of mainly maize, teff and barley; part under long fallow having 50-80% surface cover of grass and low shrubs; in some parts, 30-50% surface occupied by stones

ii) Grassland - comprising mainly the running grasses, bushes and low shrubs; 60-80% surface cover of vegetation and stones

Three map units of present land use/vegetation cover recognized for the sample area are delineated on Map 30 of scale 1:15,000.

FAGTA SAMPLE AREA

PHYSIOGRAPHY AND SOILS - MAP UNITS

L E G E N D

Old Plateau Remnants

1 Sloping (8-12% slope), mainly deep and some shallow, well to moderately well drained, moderately slowly permeable, brown to dull reddish brown clay loams to clays/silty clays with brown, stony loam/clay loam topsoils

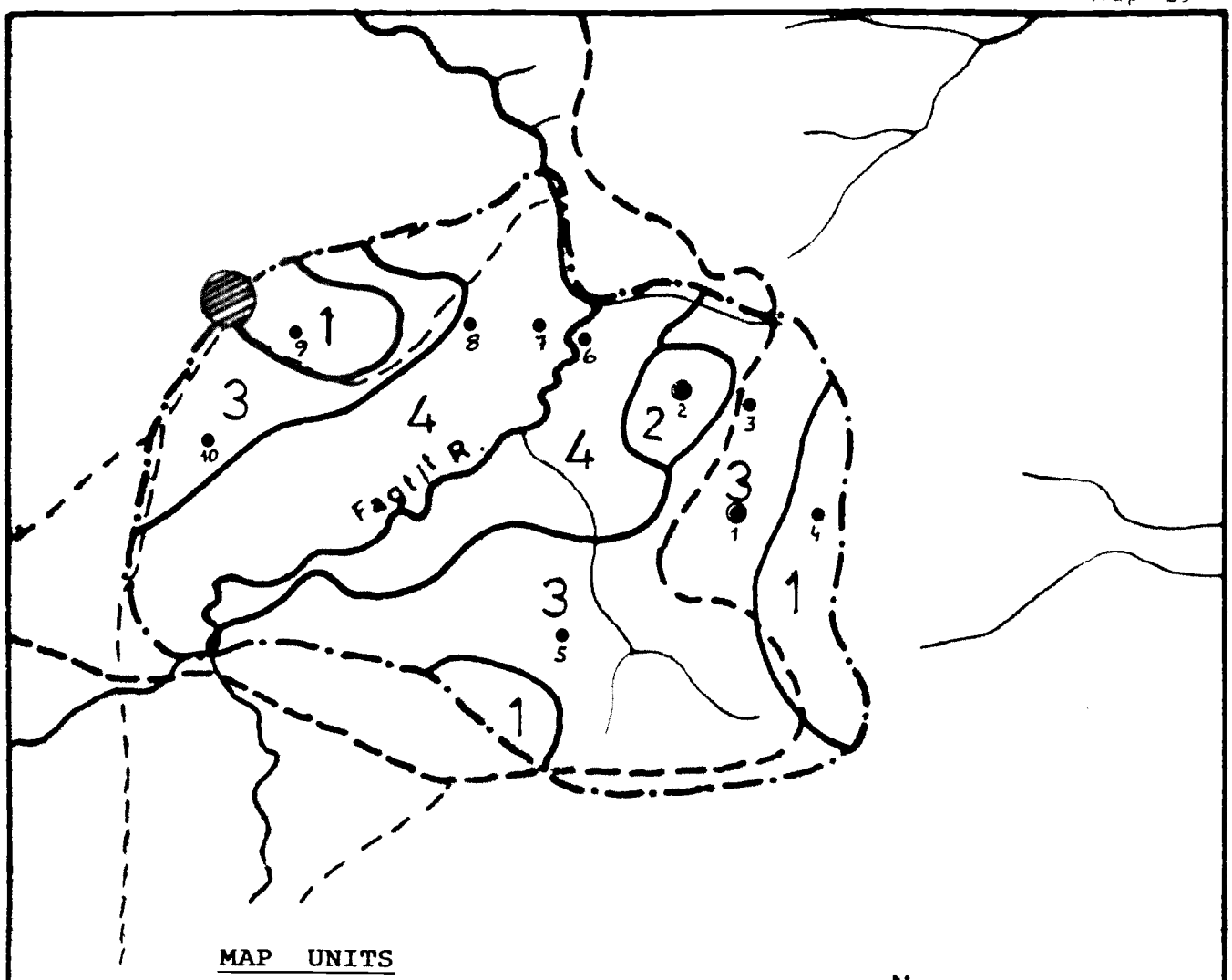
Old Alluvial Terraces/Terracettes and Subterrace Slopes

2 Gently sloping (3-8% slope), very deep, moderately well drained, moderately permeable, dark brown to brownish black clay loams (grading to clays with depth) with dark brown stony loam topsoils

3 Sloping (10-12% slope), moderately deep to very deep, well drained, moderately slowly permeable, reddish brown to dark reddish brown clays with stony/gravelly loam/clay loam topsoils

Colluvial Slopes and Escarpments

4 Moderately steep to steep (15-50% slope), moderately deep to very deep, well drained, moderately slowly permeable, dark reddish brown clay loams (grading to clays with depth) with dark reddish brown, stony/gravelly loam to clay loam topsoils



MAP UNITS

(See Legend on opposite page)

N

FAGTA SAMPLE AREA

PHYSIOGRAPHY AND SOILS

Scale 1:15000

CONVENTIONAL SIGNS

- Sample area boundary
- Map unit boundary
- River/Gullies
- Motorable road/Main track
- Small track
- Built-up area/church

- General observation site
- Detailed obs. and soil sampling site

FAGTA SAMPLE AREA

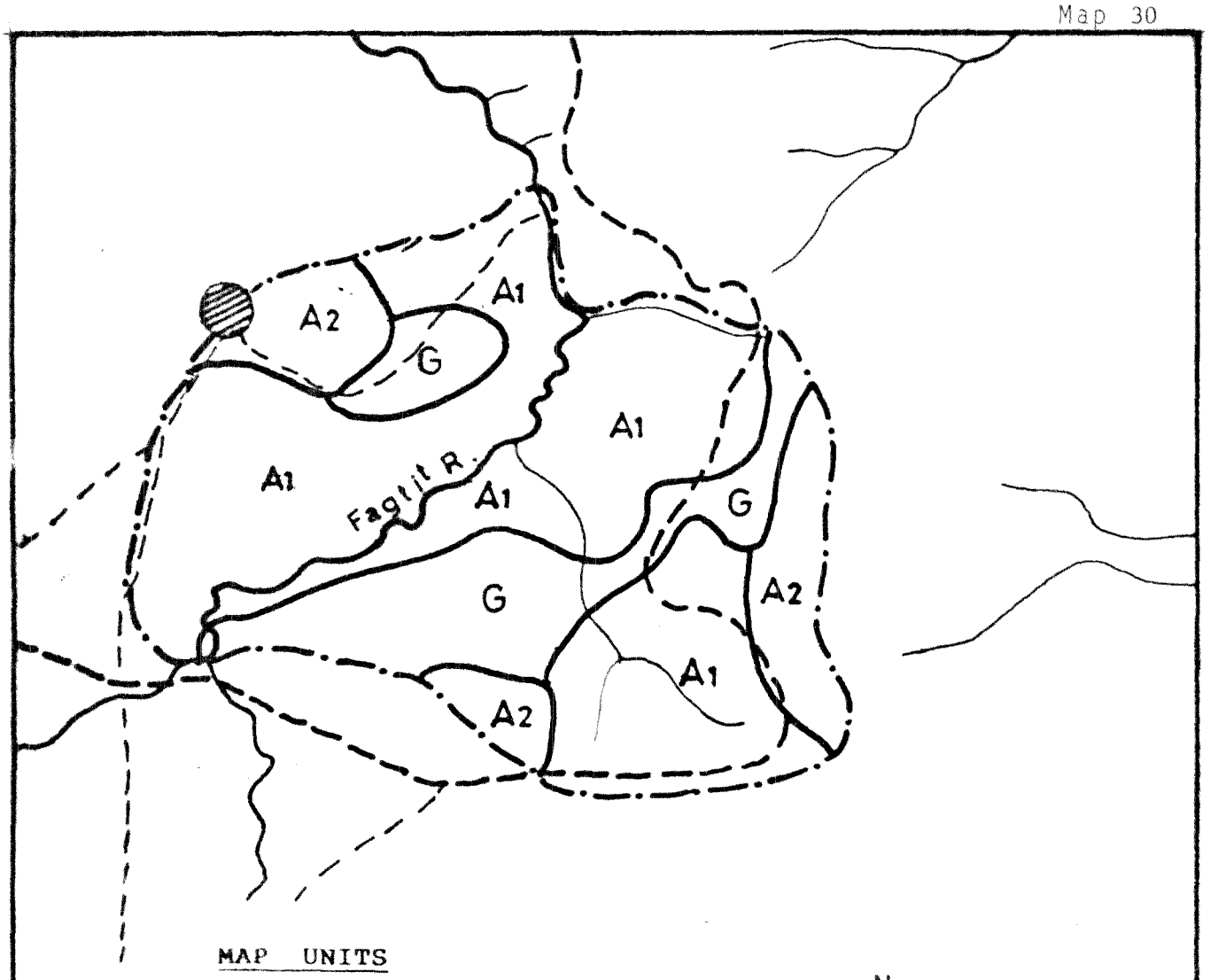
PRESENT LAND USE/VEGETATION COVER - MAP UNITS

L E G E N D

A1 Mainly arable land with 5-10% surface cover of stones; few patches under long fallow with 50-70% surface cover of grass and stones

A2 Mainly arable land with 30-50% surface cover of stones; few patches under long fallow with 60-80% surface cover of grass and stones

G Mainly grassland, partly under long fallow after cultivation, with 60-80% surface cover of grass, bushes and stones



MAP UNITS

(See Legend on opposite page)

N

FAGTA SAMPLE AREA

PRESENT LAND USE/VEGETATION COVER

Scale 1:15000

CONVENTIONAL SIGNS

- Sample area boundary
- Map unit boundary
- River/Gullies
- Motorable road/Main track
- Small track
- Built-up area/church

The distribution of different kinds of land use and vegetation/stone cover in various map units of the sample area is indicated by the following table.

Map unit symbol and description	Areal extent Ha	Areal extent %	Veg. cover (%)	Stone cover (%)
A1 - Arable land Cultivated=76 Fallow =19	95	65.1	-	5-10
A2 - Arable land Cultivated=16 Fallow = 5	21	14.4	-	30-50
G - Grass land	30	20.5	60-80	20-30
Total:	146	100.0		

c) Soil Erosion Status. The soil erosion in the sample area is generally severe but varies from slight sheet and rill erosion to severe rill and gully erosion accompanied with some land sliding and slumping. The erosion process is largely accelerated by the farmer by construction of traditional drainage ditches which gradually transform into gullies.

Three map units of soil erosion status recognized for the sample area are delineated on Map 31 at scale 1:15,000.

The extent of each map unit, representing the soils affected by different degrees of erosion, is estimated as follows:

Map unit	Degree of soil erosion	Areal extent Ha	Areal extent %
E1	Slight to moderate	5	3.4
E2	Moderate	35	24.0
E3	Severe	106	72.6
	Total:	146	100.0

FAGTA SAMPLE AREA

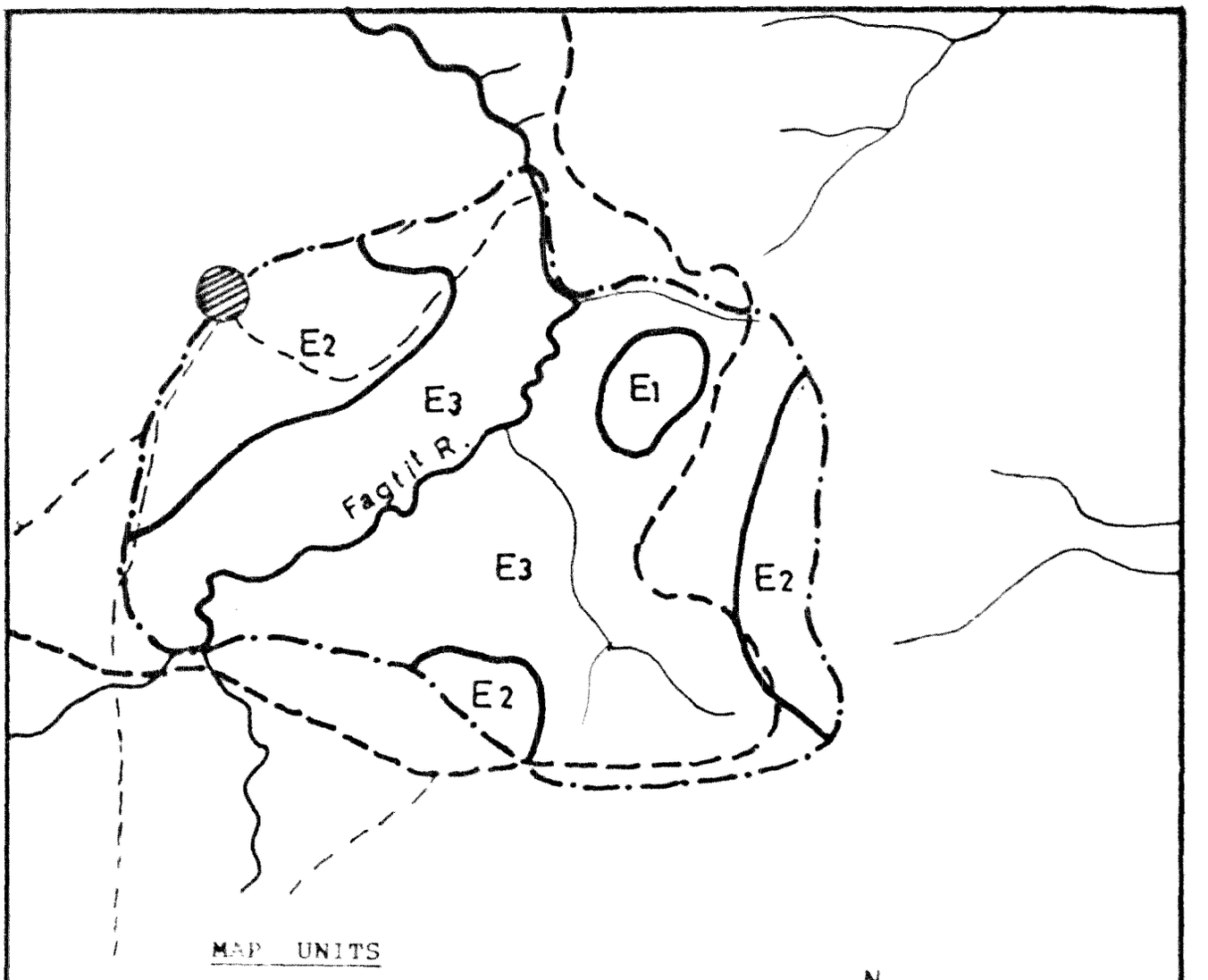
SOIL EROSION STATUS - MAP UNITS

L E G E N D

E1 Slight to moderate sheet and rill erosion; few traditional drainage ditches transformed into small gullies

E2 Moderate sheet and rill with some gully erosion; old tracks and traditional ditches commonly transformed into shallow to moderately deep gullies; gullies not evident in some parts due to shallow soils

E3 Severe sheet, rill and gully erosion with some land sliding/ slumping; severe stream bank erosion in some parts



MAP UNITS

(See Legend on opposite page)

N

FAGTA SAMPLE AREA

SOIL EROSION STATUS

Scale 1:15000

CONVENTIONAL SIGNS

- Sample area boundary
- Map unit boundary
- River/Gullies
- Motorable road/Main track
- Small track
- Built-up area/church

3. GENERAL CONCLUSIONS

The following general conclusions may be drawn from the sample area studies:-

i) Most soils are moderately well drained due to somewhat restricted water movement in the lower parts of theirprofiles. This characteristic is understood to have adverse effects on the growth of most crops. In order to offset this effect, the farmer generally constructs small drainage ditches, occasionally in a criss-crosspattern, having dimensions of about 20 to 30cm both in depth and width and placed about 4 to 6 metres apart; it is done even on slopes which may be as high as 20 percent. The continual scouring by the fast flowing rain water through these ditches, which virtually are the man-made rills, gradually transforms them into deepgullies - one of the various causes of gully formation in the two watersheds. As the drainage ditches are essentially required to dispose off excess rain water from the fields, proper guidance needs to be provided to the farmer as to how these should be aligned to minimise the scouring effects of water and check their conversion to gullies.

ii) The soil erosion is less severe at higher altitudes due probably to cooler and wetter climate effecting better vegetation cover at surface, as well as because of a higher percentage of stones/boulders present at the soil surface. Most of the gullies encountered in the mountainous land have an extremely bouldery bed with a dense bush and tree cover on their banks and are, therefore, fairly stabilized. Severest erosion at high altitudes occurs on the cultivated land ranging in slope from about 15 to 60 percent. The slopes steeper than about 60 percent are generally under moderately dense to dense bush and grass cover since these are the least disturbed by man and livestock and are very stony/bouldery which provide them a fair protection against erosion; furthermore, the runoff water approaching very steep slopes commonly gets concentrated in the existing stabilized channels/gullies and is understood to be relatively ineffective towards the erosion process.

iii) The most important soils affected by erosion and those further prone to severe erosion hazard occur mainly on the old alluvial terraces. These soils, along with those of the alluvial plains, however, form the prime agricultural lands and must be protected from degradation by this menace. The first priority for soil conservation measures should be given to these soils.

iv) The steeply dissected and broken land (major landform unit 2 of Bir watershed) has reached extremes of the soil erosion process and would be impractical to make intensive efforts towards erosion control on this land. Redepostion of the eroded soil material from the steep slopes of the landform is likely to create fertile soils at the bottoms of valleys. It would, therefore, be better leave this land unit in its present natural state; even acceleration of the erosion process, along with construction of suitable structures (check dams) to promote deposition of the eroded material, may be desirable for certain parts.

v) Impeded drainage conditions restrict realization of high crop yields in a considerable part of the arable land, especially in the alluvial plains and valleys occurring within the major landforms representing old alluvial terraces. The provision of an effective drainage system and introduction of special cultural techniques (including quick disposal of rain water, timely tillage and selection of most appropriate crops withstanding excessive wetness) are the major requirements of soil conservation for these parts. As these soils form part of the prime agricultural land, priority should be given to such measures.

vi) The general causes understood for soil erosion in the project area are:-

a) Surface topography dominated by moderately steep to very steep slopes

b) Extensive clearance of natural vegetation cover from the land surface for its arable use, fuel wood extraction and over-grazing by livestock etc.

c) Somewhat slow soil permeability compared to high-intensity rainfall resulting in

- high runoff causing sheet and rill erosion and

- saturation of subsoil causing slumping and land sliding

d) High gradient of the drainage ditches traditionally constructed by the farmer promoting gully formation

e) The farmer's common practice of ploughing along the land slope providing high-velocity flow of surface runoff

f) Occasional earth tremors causing landsliding

c) STUDY OF IRRIGATION DEVELOPMENT SITES

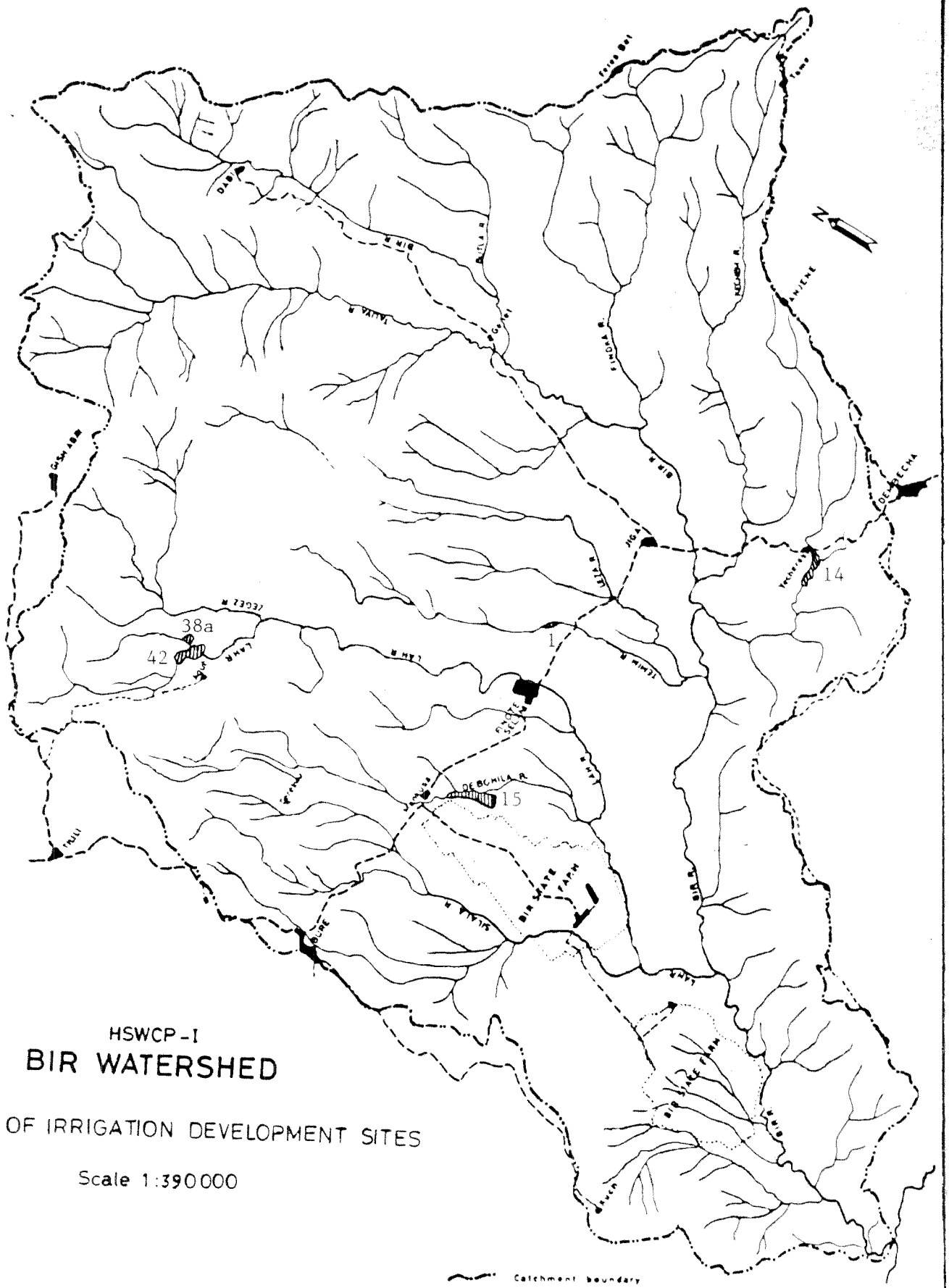
1. THE IRRIGATION SITES STUDIED AND METHODOLOGY

Five sites were studied at semi-detailed (prefeasibility) level for development of small to medium scale irrigation schemes in the Bir Watershed area. These sites, along with their location and areal extent, are listed in Table 6. Their location is also indicated on Map 32.

Table7: Irrigation sites - their location and areal extent

Irrigation site	Location (with the (nearest coordinate)	Extent (ha)
1. Agut 'A' area	About 2.5km northeast of Agut village, along left bank of Yingri river (10°52'N, 37°10'E)	30
2. Agut 'B' area	About 1.5km north-northeast of Agut village, along right bank of Lah river (10°51'N, 37°10'E)	115
3. Mankusa area	About 3.5km southeast of Mansuka town, along right bank of Debohila river (10°41'N, 37° 11'E)	87
4. Yechereka area	About 500 metres southeast of Yechereka town, along right bank of Yechereka river, south of the river bridge (10°35'N, 37°25'E)	66
5. Finote Selam area	About 4.5km east of Finote Selam town, along right bank of Temim river (10°41'N, 37°18'E)	19
Total:		317

These irrigation development sites were selected out of the 38 sites tentatively marked as potential areas on the basis of desk study from the available topographic and hydrological information, coupled with physical field checking. Further selection of the sites and demarcation of area boundary for semi-detailed study was made through stereo-interpretation of 1:50,000 scale aerial photographs (1982-84), enlarged to 1:15,000 scale, for landforms, surface topography, soils and accessibility.



HSWCP-I

BIR WATERSHED

LOCATION OF IRRIGATION DEVELOPMENT SITES

Scale 1:390000

14 Irrigation Site No. 14

After final selection, the sites were surveyed through field investigation of soils and other important land characteristics with a general observation density of one per 8 to 10 ha, which varied in different areas depending on the complexity of the landforms. The soils were studied by augering to a depth of 100 to 150cm while the representative ones were characterized in detail and sampled by exposing soil pits to a depth of about 200cm and deep augering below to about 250cm. Disturbed soil samples were collected from all important soil horizons to the full profile depth for physical and chemecal analyses in the laboratory while core samples were taken from all horizons above 100cm depth for determining the soil moisture characteristics. The soil mapping was accomplished by final stereo-interpretation of the air-photos supported by the data collected from the field.

Water samples from the rivers considered for irrigation water supply for laboratory analyses and assessment of water quality. The results of laboratory analyses of water samples are given under Annex I after the laboratory analytical data of the respective soil profiles (pedons). All the water samples were, in general, found highly suitable for irrigation purposes. Water infiltration tests, using water from the same rivers which are to be used for supply of irrigation water, were carried out by means of a Double-ring Infiltrometer on most of the soils described and sampled from deep pits. The results of infiltration tests are presented in graphical forms after the water analytical data under Annex I.

The soil map units were evaluated, by integrating with the available climatic data and the water analytical results, for general irrigated agricultural use and the results of evaluation are presented in the form of maps of "Land Suitability and Soils" at a scale of 1:15,000 for each irrigation site. The location of general observation sites as well as of the detailed observation and soil sampling sites is indicated on the respective maps.

The symbols used for the map units are self-explanatory in the sense of land suitability, which are explained as follows:

- The "Suitable" land is designated by the symbol "S" and the "Not suitable" land by "N".

- The Suitable land (S) is divided into three suitability classes using an arabic numeral suffix as defined below:

  S1: **Good irrigable land** - the land which is highly suitable for irrigation development; the development costs will be low and the expected yields of commonly grown agricultural crops after development with an average level of management and inputs will be high

  S2: **Moderate irrigable land** - the land which is fairly suitable for irrigation development; the development costs will be relatively high and the expected

yields of commonly grown agricultural crops, after development, will be moderate with an average level of management and inputs; achievement of high yields would involve high input costs and special management

S3: **Marginal irrigable land** - the land which is poorly or marginally suitable for irrigation development; either the development costs will be too high or the expected yields of commonly grown agricultural crops, after development, will be low with an average level of management and inputs; occasional crop failures may be expected in some cases; moderate crop yields would be obtained only with high input costs and/or special management

- The Not suitable land (N) is divided into two classes by using the arabic numeral suffix as defined below:

  N1: **Currently not suitable** - may be improved to moderately or marginally suitable land by incurring high costs which under present conditions are prohibitive

  N2: **Permanently not suitable** - not suitable for irrigation development for any forseeable future time

- The land suitability classes S2 and S3 are divided into various subclasses by using small letter suffixes representing the major kind of limitation posed to the land for development of irrigation or its potential use for irrigated agriculture. The class S1 is not subdivided as it has no major limitation. The letter symbols used are defined as follows:

  d - impeded drainage conditions; may be accompanied with periodic surface ponding by run-off water

  t - topographic limitations; may pose difficulty in lay-out of irrigation system or cause soil erosion problems after development

  f - seasonal flooding by the river

  n - surface stoniness; stones may be present also below the soil surface

- The land suitability subclass is further divided, where necessary, into land suitability units, on the basis of differences in land development requirements or in soil management after development, by using arabic numerals after the subclass limitation symbol separated from the latter by a hyphon.

2. FINDINGS

2.1 Agut 'A' Area (Site No. 38a)

a) Physiography and soils: The area represents a part of level alluvial plain which is partly subject to occasional light sheet flooding by the river. The flooding is short-lived with no significant fresh sedimentation or damage to the standing crops in major part of the area. A few small patches may remain ponded for significant periods after heavy rain storms. The groundwater table generally fluctuates between 120 and 200 cm. The surface slope varies from 1.0 to 1.5 percent.

   The soils consist of very deep, moderately well drained, moderately slowly permeable, noncalcareous, dark reddish brown loams to clay loams with weak to moderate subangular blocky subsoil structure and a weak granualar, dark reddish brown to brownish black topsoil (See detailed description and laboratory analytical data of representative soil profile under Annex I, pedon 20).

b) Present land use: Major part of the area is presently under rainfed cropping with supplemental irrigation by diverted canal. The important crops grown are maize, teff and barley with some potato at a few places. A small northern part is given to open grass land used for communal grazing.

c) Major limitations and land suitability: The land has a favourable surface topography and nutrient-rich soils but the possibilities of irrigation development are restricted due to somewhat impeded drainage conditions. Any such development must be accompanied with installation of a drainage system and flood protection embankment. The land is moderately suitable for irrigation.

The studied area is quite uniform with respect to physiography, soils and land suitability. It, therefore, comprises only one map unit delineated on Map 33 of "Land Suitability and Soils" at a scale of 1:15,000.

Agut 'A' Area

LAND SUITABILITY AND SOILS - MAP UNITS

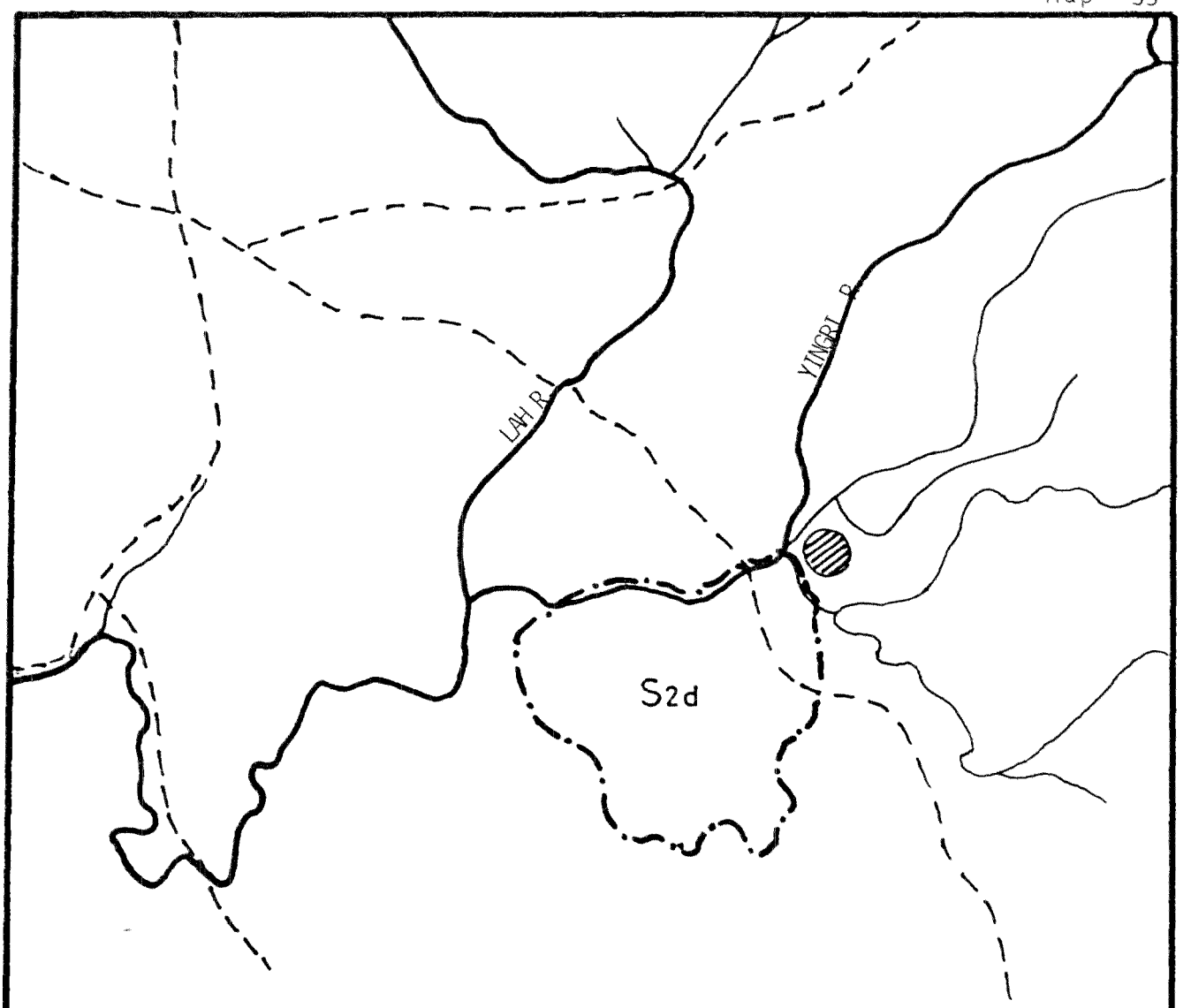
L E G E N D

Moderate Irrigable Land

S2d Almost flat (0.5-1.5% slope), very deep, moderately well drained, moderately slowly permeable, noncalcareous, dark reddish brown loams to clay loams with dark reddish brown to brownish black topsoils

- moderate limitation of somewhat impeded drainage conditions; groundwater table fluctuating between 120 and 200 cm depth; casual, very short-lived, light sheet flooding by river

Map 33



AGUT 'A' AREA

(IRRIGATION SITE NO:38 a)

LAND SUITABILITY AND SOILS

Scale 1 : 15,000

MAP UNITS

(See legend on opposite page)

CONVENTIONAL SIGNS

- Irrigable area boundary
- Map unit boundary
- River and tributaries
- Motorable road/Main track
- Small track
- Built-up area/Church

2.2 Agut 'B' Area (Site No. 42)

a) Physiography and soils: The area forms a lower part of the gently sloping old alluvial terrace. It is not flooded by the river and has deep (deeper than 3 metres in most part) groundwater table. The slopes which generally vary from 2 to 6 percent are partly modified by the farmer through construction of terraces with 2 to 4 percent slopes.

The soils consist of very deep, well to moderately well drained, moderately slowly permeable, noncalcareous, dark reddish brown clays with moderate subangular to angular blocky subsoil structure and a weak granular to massive, dark reddish brown to brownish black clay loam topsoil (See detailed description and laboratory analytical data of representative soil profile under Annex I, pedon 21).

b) Present land use: The area is presently used for cultivation of mainly maize, teff and barley under rainfed conditions with some part receiving supplemental irrigation from diverted canals.

c) Major limitations and land suitability: The land is divided into two map units on the basis of land suitability as described below:

Moderate irrigable land. This land unit has a moderate limitation of somewhat impeded internal drainage due to relatively slow soil permeability which may cause surface ponding for significantly long periods during rainy season if the land is levelled. Maintaining 1 to 2 percent slope, coupled with construction of an open ditch drainage system, would be required for irrigation development (Map unit S2d on Map 34).

Marginal irrigable land. It has somewhat severe limitation of unfavourable surface topography (3-6% slope) and a moderate limitation of somewhat impeded internal drainage due to relatively slow soil permeability. The soil cut for reducing the surface slope to the required 1-2% (see discussions for the previous unit above) would be too great to justify the costs and would drastically reduce the soil fertility in considerable area. A higher surface slope (3 to 4%) would, therefore, have to be maintained (Map unit S3t on Map 34).

Agut 'B' Area

LAND SUITABILITY AND SOILS - MAP UNITS

L E G E N D

Moderate Irrigable Land

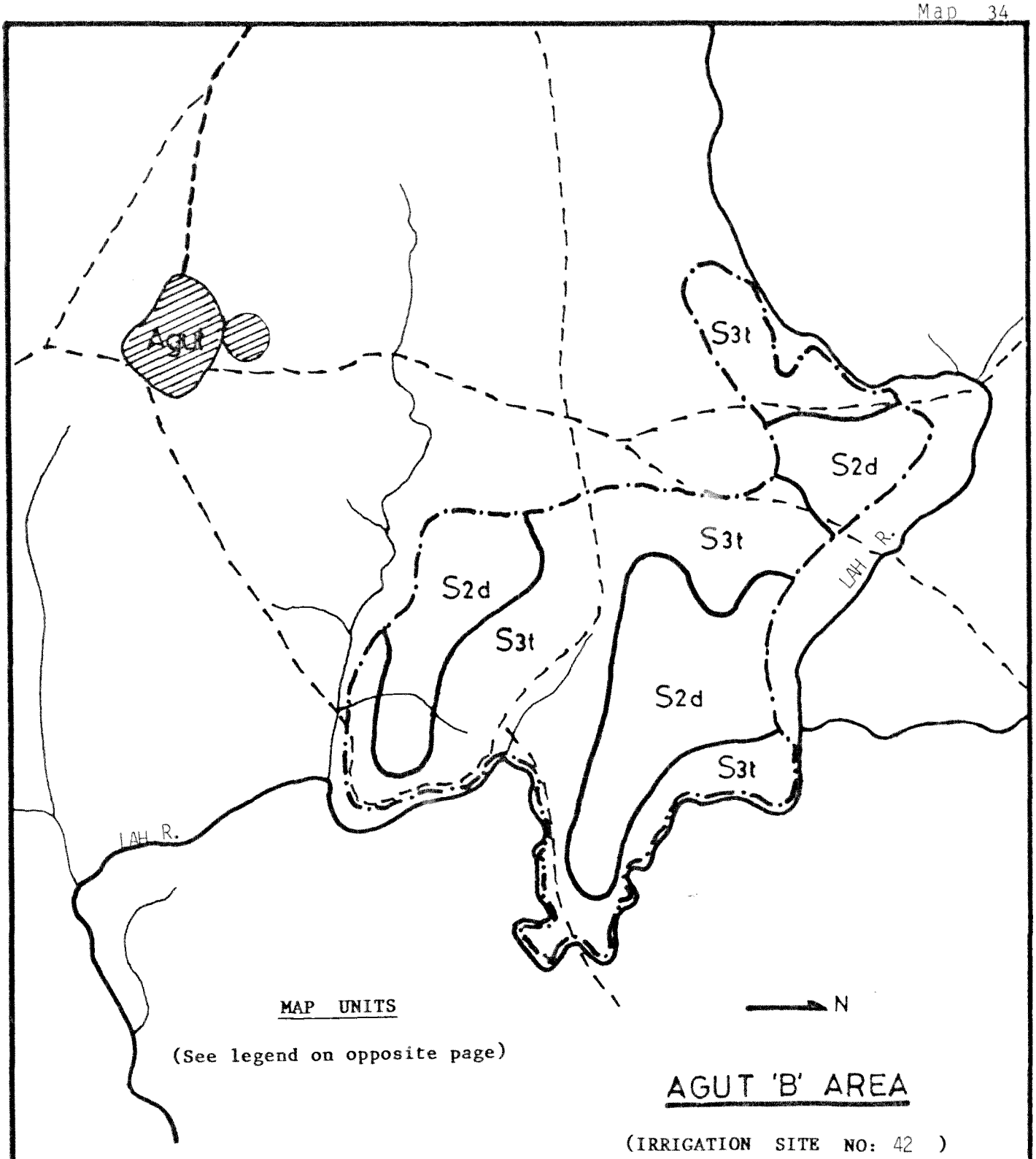
S2d Very gently sloping (1-3% slope), very deep, moderately well drained, moderately slowly permeable, noncalcareous, dark reddish brown clays with dark reddish brown to brownish black clay loam topsoils

- moderate limitation of somewhat impeded internal drainage conditions; groundwater table below 2 metres depth

Marginal Irrigable Land

S3t Gently sloping (3-6% slope), very deep, well to moderately well drained, moderately slowly permeable, noncalcareous, dark reddish brown clays with dark reddish brown to brownish black clay loam topsoils

- somewhat severe limitation of unfavourable surface topography and minor limitation of somewhat impeded drainage conditions; groundwater table below 2 metres depth



MAP UNITS

(See legend on opposite page)

AGUT 'B' AREA

(IRRIGATION SITE NO: 42)

LAND SUITABILITY AND SOILS

Scale 1: 15,000

CONVENTIONAL SIGNS

- Irrigable area boundary
- Map unit boundary
- River and tributaries
- Motorable road/Main track
- Small track
- Built-up area/Church

2.3 Mankusa Area (Site No. 15)

a) Physiography and soils: This area represents the lower parts of gently sloping old alluvial terrace. It is not flooded by the river and has deep (deeper than 2 metres in most part) groundwater table. The slopes which range mostly between 1 and 5 percent (upto 8% in small parts along shallow gullies) are partly modified by the farmer through terracing.

The soils consist of very deep, well drained, moderately permeable, noncalcareous, dark reddish brown clays with moderate subangular to angular blocky subsoil structure and a weak granular, dark brown to dark reddish brown clay loam topsoil (See detailed description and laboratory analytical data of representative soil profile under Annex I, pedon 22).

b) Present land use: The area is presently under arable use with the main crops grown being maize, teff, barley and oilseeds. The area is principally rain-fed but has supplemental irrigation supplies through diverted canals, which are used to grow a few high-delta crops including sugarcane, banana, potatoes and some other vegetables and orchards.

c) Major limitations and land suitability: On the basis of suitability, the land is divided into two map units as described below:

Good irrigable land. This map unit has no significant limitation except slightly higher slopes in some parts. It requires minor levelling to grade the slopes between 1 and 2 percent which presently is upto to 3 percent in some parts. Reducing the slopes below 1 percent is likely to create drainage problems (Map unit S1 on Map 35).

Moderate irrigable land. It has a moderate limitation of somewhat unfavourable surface topography (3-5% slope). The soil cut for reducing the surface slope to the required 1-2% would be rather high, which would considerably reduce the soil fertility of some part. A higher surface slope (3-4%) would, therefore, have to be maintained (Map unit S2t on Map 35).

Mankusa Area

LAND SUITABILITY AND SOILS - MAP UNITS

L E G E N D

Good Irrigable Land

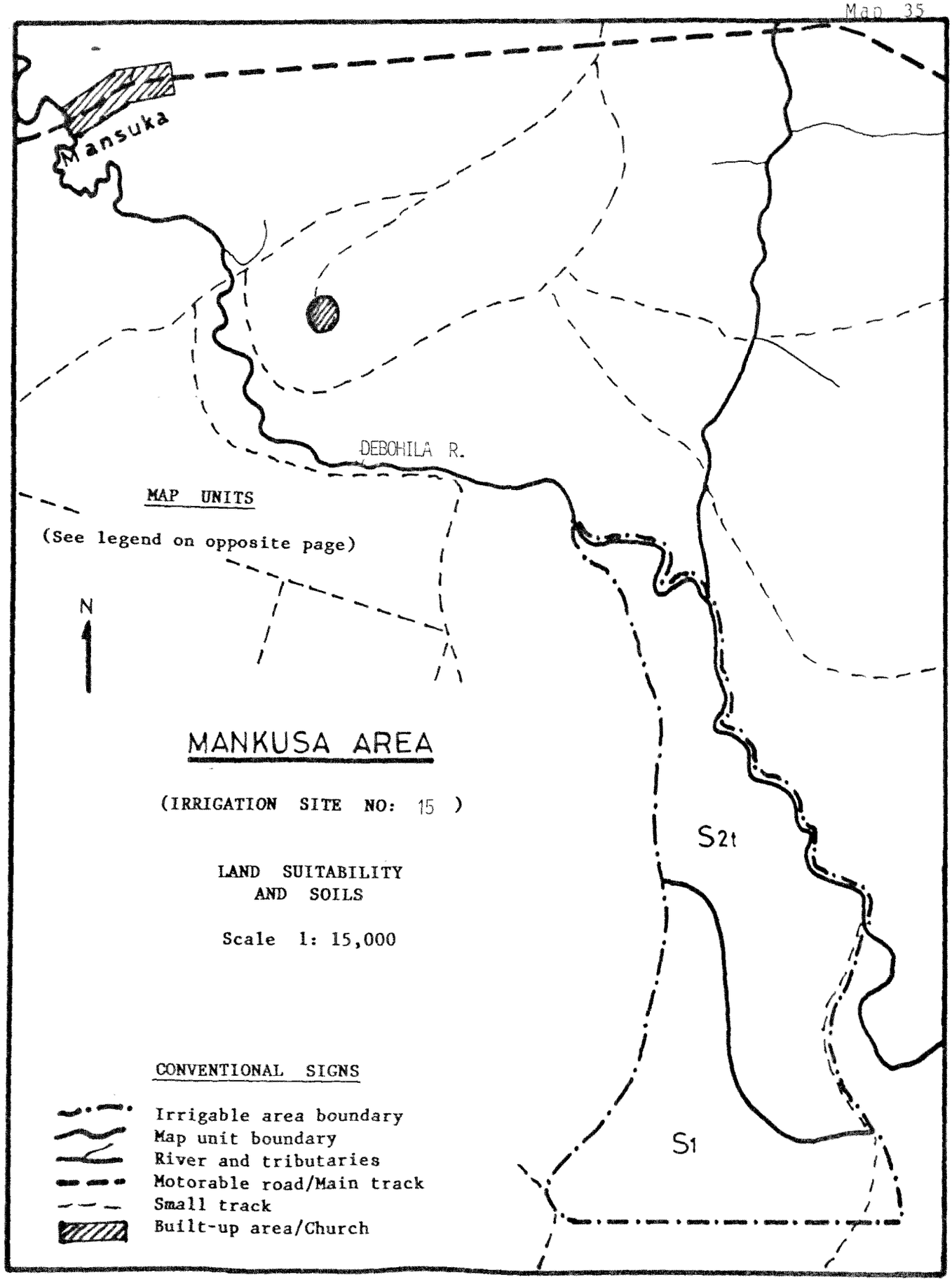
S1 Very gently sloping (1-3% slope), very deep, well drained, moderately permeable, noncalcareous, dark reddish brown clays with dark brown to dark reddish brown clay loam topsoils

- no significant limitation; groundwater table below 2 metres depth

Moderate Irrigable Land

S2t Gently sloping (3-5% slope), very deep, well drained, moderately permeable, noncalcareous, dark reddish brown clays with dark brown to dark reddish brown clay loam topsoils

- moderate limitation of somewhat unfavourable surface topography; groundwater table below 2 metres depth


Mansuka
DEBOHILA R.
MAP UNITS
(See legend on opposite page)
N
MANKUSA AREA
(IRRIGATION SITE NO: 15)
LAND SUITABILITY
AND SOILS
Scale 1: 15,000
S2t
S1
CONVENTIONAL SIGNS
Irrigable area boundary
Map unit boundary
River and tributaries
Motorable road/Main track
Small track
Built-up area/Church

2.4 Yechereka Area (Site No. 14)

a) Physiography and soils: The area forms a part of the recently abandoned floodplain of Yechereka river. It is subject to seasonal light sheet flooding but the flood water recedes quickly without any significant fresh sedimentation or doing much harm to the standing crops except in some lower parts. Its extreme northwestern part (along the river) consists of very gently sloping (1-2% slope) levees while the southeastern part constitutes the fringes of a basin occupying the back swamp position. The groundwater table fluctuates between 100 and 150cm depths in the levee part and between 75 and 120cm depths in the lower, basinal part.

The soils of the levees consist of very deep, moderately well (seasonally imperfectly) drained, moderatey slowly permeable, noncalcareous, brown to dark reddish brown clay loams, grading to clays at lower depths, with weak to moderate subangular blocky subsoil structure and a weak granular, dark brown to brownish black loam/clay loam topsoil (See detailed description and laboratory analytical data of representative soil profile under Annex I, pedon 23).

The soils of the basin consist of very deep, moderately well to imperfectly (seasonally poorly) drained, slowly permeable, noncalcareous, brown to dark reddish brown clay loams to clays with weak to moderate subangular/angular blocky subsoil structure and a granular, brownish black loam/clay loam topsoil (See detailed description and laboratory analytical data of representative soil profile under Annex I, pedon 24).

b) Present land use: Major part of the area is presently under rainfed cultivation of mainly maize and teff. A few patches are under grass land.

c) Major limitations and land suitability: On the basis of suitability, the land is divided into two map units as described below:

Moderate irrigable land. This map unit has a moderate limitation of somewhat impeded internal and external drainage. The groundwater table is rather high for most crops excluding teff, but the latter may be affected by light flooding caused by the river. Irrigation development in the area must be accompanied with the provision of a drainage system to lower the groundwater table and quickly dispose off the flood water (Map unit S2df on Map 36).

Yechereka Area

LAND SUITABILITY AND SOILS - MAP UNITS

L E G E N D

Moderate Irrigable Land

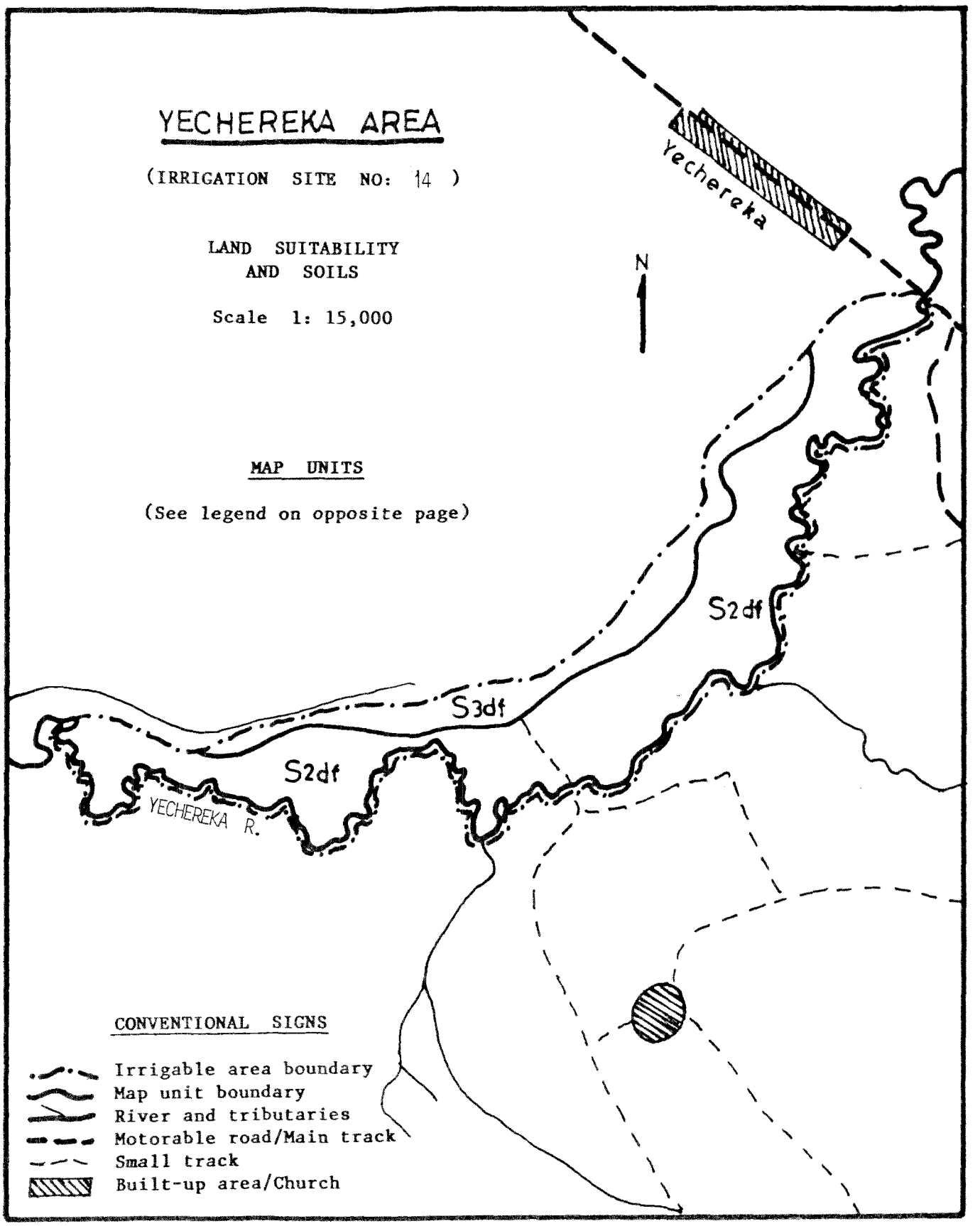
S2df Very gently sloping (1-2% slope), very deep, moderately well (seasonally imperfectly) drained, moderately slowly permeable, noncalcareous, brown to dark reddish brown clay loams to clays with dark brown to brownish black loam/clay loam topsoils

- moderate limitation of somewhat impeded drainage conditions; groundwater table fluctuating between 100 and 150 cm depth; casual, short-lived, light sheet flooding by river

Marginal Irrigable Land

S3df Flat (<1% slope), very deep, moderately well to imperfectly (seasonally poorly) drained, slowly permeable, noncalcareous, brown to dark reddish brown clay loams to clays with brownish black loam/clay loam topsoils

- somewhat severe limitation of impeded drainage conditions; groundwater table fluctuating between 75 and 120 cm depth; casual short-lived, light sheet flooding by river


YECHEREKA AREA
(IRRIGATION SITE NO: 14)
LAND SUITABILITY AND SOILS
Scale 1: 15,000
MAP UNITS
(See legend on opposite page)
Yechereka
N
S2df
S3df
S2df
YECHEREKA R.
CONVENTIONAL SIGNS
Irrigable area boundary
Map unit boundary
River and tributaries
Motorable road/Main track
Small track
Built-up area/Church

Marginal irrigable land. It has the same limitations as the unit described above but these are of somewhat severe degree; the water table is higher and the flooding is deeper and of relatively long duration adversely affecting most of the standing crops. provision of a drainage system and protection from floods would be a basic requirement for irrigation development on this land (Map unit S3df on Map 36).

2.5 Finote Selam Area (Site No. 1)

a) Physiography and soils: This area represents two different kinds of landforms i.e., the fringes of an old bouldery channel in the southwestern part and the recent floodplain of Temim river in the northeastern part; the former is relatively high with 3 to 6 percent slope towards northeast while the latter is a low land with 1-2 percent slope and is subject to light but short-lived seasonal flooding by the river, with water stegnating in some part for considerably long periods. The groundwater table is very deep (below 2m) in the higher part but is rather shallow, fluctuating between 100 and 180 cm, in the lower part.

The soils of the higher part consist of moderately deep to deep, moderately well drained, slowly permeable, brownish black clays with moderate angular blocky subsoil structure and a fine blocky to fine granular, stony/bouldery topsoil showing deep and wide cracks when dry (See detailed description and laboratory analytical data of representative soil profile under Annex I, pedon 4).

The soils of the lower part consist of ver deep, moderately well (seasonally imperfectly) drained, moderately slowly permeable, noncalcareous, brownish black clay loams to clays with weak to moderate subangular blocky subsoil structure and a weak granular, dark brown to dark reddish brown clay loam topsoil (See detailed description and laboratory analytical data of representative soil profile under Annex I, pedon 25).

b) Present land use: Major part of the area is presently under rainfed cultivation of mainly maize and teff. A considerable part is, however, put under long (roofing) grass.

c) Major limitations and land suitability: On the basis of suitability, the land is divided into two map units as described below:

Moderate irrigable land. This map unit has a moderate limitation of somewhat impeded internal and external drainage. The groundwater table is somewhat high for most crops excluding teff, but the latter would be affected by light flooding caused by the river. Irrigation development in the area must be accompanied with the provision of a drainage system to lower the groundwater table and to quickly dispose off the flood water (Map unit S2d on Map 37).

Finote Selam Area

LAND SUITABILITY AND SOILS - MAP UNITS

L E G E N D

Moderate Irrigable Land

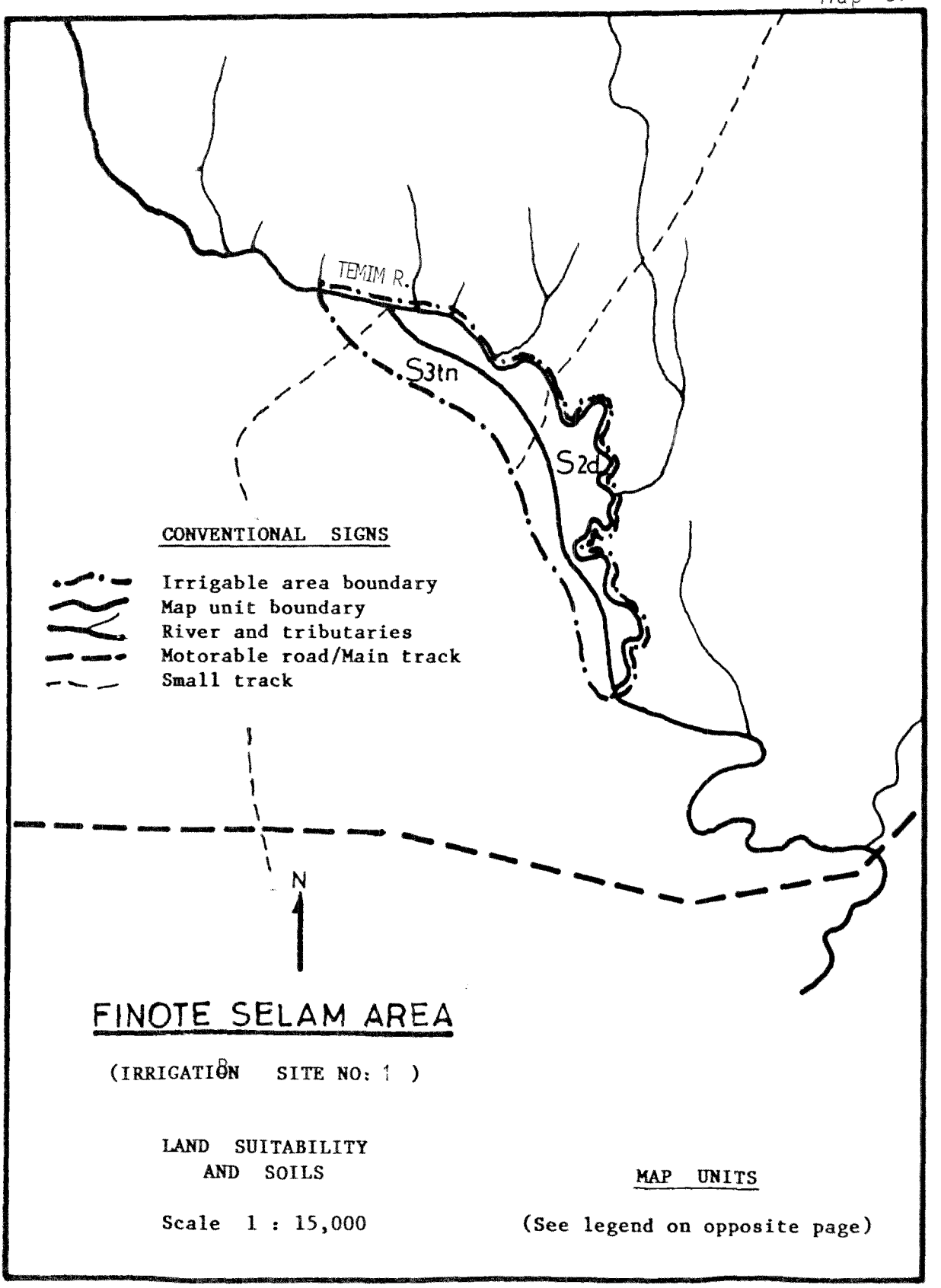
S2d Almost flat (1-2% slope), very deep, moderately well (seasonally imperfectly) drained, moderately slowly permeable, noncalcareous, brownish black clay loams to clays with dark brown to dark reddish brown clay loam topsoils

- moderate limitation of somewhat impeded drainage conditions; groundwater table fluctuating between 100 and 180 cm depth; light, short-lived sheet flooding by river in some lower parts

Marginal Irrigable Land

S3tn Gently sloping (3-6% slope), moderately deep to deep, moderately well drained, slowly permeable, brownish black, deeply cracking, stony/bouldery clays

- Somewhat severe limitations of unfavourable surface topography and stoniness; moderate limitations of somewhat impeded internal drainage and difficult workability



FINOTE SELAM AREA

(IRRIGATION SITE NO: 1)

LAND SUITABILITY AND SOILS

Scale 1 : 15,000

MAP UNITS

(See legend on opposite page)

Marginal irrigable land. It has the major limitations of somewhat unfavourable surface topography and surface stoniness/boulderiness, as well as the impeded internal drainage. The topsoil cut required for reducing the surface slope should not be more than 30cm, otherwise it would be too detrimental to the soil productivity to justify it; a surface slope of about 3 to 4 percent would, therefore, have to be maintained, not only to safeguard the soil productivity but also to ensure proper drainage (Map unit S3tn on Map 37).

3. EXTENT OF DIFFERENT CLASSES OF IRRIGABLE LAND IN THE AREAS STUDIED

The areal extent of different classes/subclasses of the irrigable land studied for each irrigation site in the watershed is estimated as in Table 7.

Table 8: Extent of different classes/subclasses of irrigable land by irrigation sites

Irrigation site	Extent (hectares)								
	S1	S2d	S2df	S2t	S3df	S3t	S3td	S3tn	Total
1. Agut 'A' area (Site No. 38a)	-	30	-	-	-	-	-	-	30
2. Agut 'B' area (Site No. 42)	-	47	-	-	-	68	-	-	115
3. Mankusa area (Site No. 15)	40	-	-	47	-	-	-	-	87
4. Yechereka area (Site No. 14)	-	-	52	-	14	-	-	-	66
5. Finote Selam area (Site No. 1)	-	9	-	-	-	-	-	10	19
							TOTAL:		317

ANNEX I: DETAILED DESCRIPTION AND LABORATORY ANALYTICAL DATA OF TYPICAL SOIL PROFILES

1. METHODOLOGY FOR SOIL SAMPLING AND LABORATORY ANALYSES

All important soils identified from the study of sample areas representing different landform units within the watershed area were described in detail, along with their landscape characteristics, mostly by exposing soil pits to about 2 metres depth and then augering to 2.5 to 3 metres depth. In a few cases, however, it was done by making mini-pits to about 50cm depth and augering below to about 150cm depth. The soils were sampled from all important horizons in the following two different forms:

i) Disturbed samples, collected in plastic bags for various physical and chemical determinations in the laboratory and

ii) Core (undisturbed) samples collected in specially prepared steel cylinders (core rings) to determine the bulk density and moisture charateristics (moisture content at different tensions and the available water capacity)

All physical, chemical and moisture determinations were done in the National Soils Laboratories of the Ministry of Agriculture (MOA), Addis Ababa. The methods used were as follows:-

a) Physical determinations:

Soil texture (mechanical analysis) - by hydrometer method

Bulk density - by using the same core samples which were used for moisture determinations

b) Chemical determinations:

pH - by using pH meter electrode in soil suspensions of 1:1 soil-water and soil-KCl solution

Electrical conductivity (EC) - by using the electrical conductivity meter electrode in 1:1 soil-water suspension

Cation exchange capacity (CEC) - by extracting the adsorbed cations with ammonium acetate solution

Exchanageable cations: Ca, Mg - by using spectrophotometer
Na, K - by using flame photometer

Base saturation percentage (B.S%) - calculated as percentage of total exch. cations in relation to the CEC.

Soluble ions - generally not determined when the EC found too low; done for three samples from the saturated extract, while for others regarded as "trace".

Organic matter content - By W. Black method

Total nitrogen - By Micro-Djeldahl method

Available phosphorus - By Bray II method

Available potassium - By extracting with sodium acetate

Available micronutrients -By extracting with DTPA solution

c) Soil moisture determinations: By gravimetric method; moisture contents were determined at 0.1 bar, 0.33 bar (field capacity), 3.0 bars and 15 bars (permanent wilting point) moisture tensions

2. PROFILE DESCRIPTIONS, LABORATORY ANALYTICAL DATA AND WATER INFILTRATION TESTS

The detailed description of different pedons sampled, long with their laboratory analytical data of soil and water amples (the latter only where applicable),as well as the results f water infiltration tests carried out on three soils of the rrigation development sites, is reported in the following pages. ll the characteristics reported in the profile descriptions are ased on the tests and measurements made in the field except for H and EC which could not be measured in the field due to unavailbility of portable pH meter (or pH indicator) and EC meter and ad, therefore, to be incorporated from the laboratory results.

It may be noted that a few minor contradictions between he results given by the laboratory and those observed in the ield exist which may be reasoned out briefly as follows.

i) The soil texture reported by the laboratory has, in general, a higher silt fraction than that estimated by field tests which may be attributed to the fact that some (finer part) of the very fine sand fraction commonly behaves like silt when analysis is done by using the hydrometer; this resuls in higher silt fraction at the expense of very fine sand fraction. In some cases, the clay content is also reported by the lab. higher than that estimated in the field. A little under-estimation of clay content in the field is possible due to strong aggregation of clay in the form of sand/silt-sized particles in highly weathered soils like those found in the watershed area;such particles are not easily broken by working with water in the field but special chemical treatments given to the soil samples in the laboratory can break them and, consequently, a higher clay content

may be determined. However, the field tests of texture generally match the soil behaviour towards its management better than the lab. tests which implies that the field description of texture must be given more weightage than that reported by the laboratory.

ii) The pH reported by the laboratory, in case of both the soil-water and the soil-KCl suspensions, appears to be at least one unit lower than what can be estimated from the general crop response observed in the project area. This probably owes to some laboratory testing errors.

iii) The results of bulk density determinations give unexpectedly low values, occasionally reported as less than 1.0 g/cc. Whereas some topsoils having high organic matter content may have a bulk density between 1.0 and 1.2, the subsoils and most of the topsoils are expected to have bulk density of more than 1.2 g/cc because of their lower porosity and not having adequate mixture of the pyroclastic material which is generally the main cause of so low bulk density. Since the same samples as used for moisture determinations were used for this determination, possible disturbance of the samples could have resulted in erratic results.

iv) The organic matter content, which generally occurs in well decomposed form, with a probable C:N ratio of less than 10, is reported to be rather too high as compared to the total nitrogen (organic + inorganic) content which, in most cases, is reported to account for less than 1/12th of the organic matter content indicating a much wider C:N ratio. It appears that either the actual organic matter content is lower or the total nitrogen content is higher than the ones reported. It may be due to some analytical errors.

v) The results reported for available water capacity (difference in water content between F.C. and P.W.P) vary drastically, occasionally by a factor of about 3, within the same profile, even though having gradual horizon boundaries, which is not generally expected from field observations. Such contrasts are possibly due to laboratory determination errors.

vi) The results for CEC in certain cases disagree with the logical estimation from the changes in clay and organic matter content in the same profile. In certain cases, it was noted that the soil samples having higher clay and organic matter content, as well as a higher base saturation, are reported to have a lower CEC (occasionally upto about 50%) than those having lower clay and organic matter contents. In a few cases, the total CEC determined is less than the sum of exchangeable cations which is illogical. Such discrepancies also owe possibly to the laboratory analytical errors.

PEDON 1 (SITE NO. AJC1)

LOCATION: About 8km NE of Anjene village in West Gojam Admn. Region, on a gently sloping, high land surface, approx. coordinates 10°43.8'N and 37°35.2'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Slopping remnants of old plateau surface; highest part with 10 to 15 slope; about 150m away from the escarpment; elevation 2,750m amsl.

Soil parent material: Mainly silty alluvium/glacio-fluvium derived propably from weathered basalt mixed with some volcanic ash and ignimbrite

Present land use/vegetation cover: Grass land with a few low trees/bushes with >90% cover; probably fallowed after long rainfed cultivation; about 5% (locally upto 50%) stones and boulders cover at surface.

Present erosion status: Moderate sheet and rill erosion; few shallow gullies.

Drainage conditions: Externally well drained; internally moderately well drained.

FAO soil classification: Humic Alisols, rudic sloping phase.

PROFILE DESCRIPTION:

Ah 0-30cm Brown (7.5YR 4/4) moist, dull orange (7.5YR 6/4) dry; loam that approaches clay loam; massive to weak fine granular; slightly sticky, slightly plastic, very friable moist, slightly hard dry; few fine tubular pores; few stones; noncalcareous; EC(1:1) 0.1 dS/m; few medium, many fine roots; gradual smooth boundary; pH(H_2O) 4.7. (Sample No. AJC1-1)

Bw 30-64cm Dark brown (7.5 YR 3/4) moist; clay loam; weak medium subangular blocky; slightly sticky, slightly plastic, friable moist, hard dry; few medium, common fine tubular pores; few angular to subrounded, fresh, medium and fine pebbles; few fine Mn concretions in lower part; noncalcareous; EC(1:1) 0.04 dS/m; few medium, common fine roots; clear smooth boundary; pH(H_2O) 4.7. (Sample No. AJC1-2)

2Btb 64-85/95cm Brown (7.5YR) moist; silty clay; moderate fine and medium angular blocky; sticky, plastic, firm moist, very hard dry; very thin patchy clay cutans and moderately thick reddish brown and black Fe-Mn coatings on ped faces; few medium, common fine tubular pores; abundant crystalline accumulation of fine, medium and coarse, black Mn concretions; noncalcareous; EC(1:1) 0.03 dS/m; few earth worm casts; few fine roots; clear wavy boundary; pH(H_2O) 4.9. (Sample No. AJC1-3)

2Btbg 85/95-180cm+ Variegated, brown (7.5YR 4/6 and 4/4) and dark reddish brown (5YR 3/6 & 3/3) moist, dull reddish brown (5 YR 4/4) moist when crushed; silty clay; strong fine and medium angular blocky; sticky, very plastic, very firm moist, very hard dry; thin nearly continuous clay cutans on ped faces; few medium, few fine tubular pores; abundant crystalline accumulations of fine, medium and coarse, black Mn concretions; noncalcareous; EC(1:1) 0.05 dS/m; common thin vertical infillings of fine silty material; very few very fine roots; pH(H_2O) 5.2. (Sample No. AJC1-4)

LABORATORY ANALYTICAL DATA (PEDON 1)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1)	Exch. cations (meq/100g)						CEC (meq/100g	Base sat. (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL	(dS/m)	Na	K	Ca	Mg	Al	H		
2593/90	AJC1-1	0-30	3	67	30	SiCL	4.73	3.60	0.10	0.83	0.28	4.09	1.10	nd	nd	49.31	12.78
2594/90	AJC1-2	30-64	2	54	44	SiC	4.72	3.57	0.04	0.85	0.28	2.78	0.74	nd	nd	39.29	11.84
2595/90	AJC1-3	64--85/95	3	51	46	SiC	4.85	3.55	0.03	0.83	0.24	3.27	1.02	nd	nd	37.20	14.41
2596/90	AJC1-4	85/95-180+	2	52	46	SiC	5.15	3.76	0.05	0.81	0.20	8.37	2.75	nd	nd	38.54	31.47

Lab No.	Sample No	Depth (cm)	Organ Matte (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/1)				Soluble anions (meq/1)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2593/90	AJC1-1	0-30	5.34	0.36	2.81	27.50	2.74	8.40	0.11	0.19	tr	tr	tr	tr	tr	tr	tr	tr
2594/90	AJC1-2	30-64	2.99	0.19	10.17	23.86	2.19	2.99	0.08	0.15	tr	tr	tr	tr	tr	tr	tr	tr
2595/90	AJC1-3	64--85/95	0.96	0.09	12.44	23.25	1.32	15.27	0.11	0.13	tr	tr	tr	tr	tr	tr	tr	tr
2596/90	AJC1-4	85/95-180+	0.57	0.06	2.55	24.22	2.42	7.92	tr	0.13	tr	tr	tr	tr	tr	tr	tr	tr

Lab No.	Sample No	Depth (cm)	Bulk dens. g/ccm	Water Content (%)				
				0.1 bar	0.33 bar (F.C.)	3 bar	15 bar (P.W.P)	Avail. Water Capac.
2593/90	AJC1-1	0-30	1.09	74.37	49.83	38.57	36.74	13.09
2594/90	AJC1-2	30-64	0.96	54.43	46.69	35.46	26.29	20.40
2595/90	AJC1-3	64--85/95	1.23	37.23	30.52	26.01	23.67	6.85
2596/90	AJC1-4	85/95-180+	0.84	46.82	38.83	31.94	30.81	8.02

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiCL = Silty Clay Loam
SiC = Silty Clay
ppm = parts per million
meq/1 = milliequivalents per litre
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electrical Conductivity

PEDON 2 (Site No. AJC10)

LOCATION: About 8.5km NE of Anjene village, about 600m on the left side of Dembecha-Feres Bet road, in West Gojam Admn. Region, on a sloping cultivated terrace; approx. coordinates 10° 43.9'N and 37° 34.4' E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Sloping middle part of a lower alluvial terrace with 10 to 12 percent slope; elevation 2,405m amsl.

Soil parent material: Mixed river alluvium drived probably from old glacio-fluvial deposits and weathered basalt, mixed with some colluvial material.

Present land use/vegetation cover: Arable land (ploughed), used for rainfed cultivation of mainly maize, teff, wheat, barley and horse beans; about 10-30% surface cover of stones and boulders; few low trees and bushes.

Present erosion status: Moderate sheet and rill erosion; few shallow gullies developed mainly from the traditional/drainage ditches.

Drainage conditions: Externally well, internally moderately well drained.

PROFILE DESCRIPTION:

Ap 0-15cm — Dark brown (7.5YR 3/3) moist, dull brown (7.5YR 5/4) dry; loam that approaches clay loam; massive to weak granular; slightly sticky, slightly plastic, friable moist, hard dry; few fine and medium tubular pores; few pebbles and stones; noncalcareous; EC(1:1) 0.4 dS/m; common medium and many fine roots; clear smooth boundary; pH(H_2O) 5.3. (Sample No. AJC10-1)

BA 15-45cm — Dark reddish brown (5YR 3/3) moist; clay loam; moderate medium subangular blocky; sticky, plastic, friable moist; few fine and medium tubular pores; few pebbles and stones; noncalcareous; EC(1:1) 0.1 dS/m; few fine roots; gradual smooth boundary; pH(H_2O) 5.3. (Sample No. AJC10-2)

Bt 45-100cm — Very dark reddish brown (5YR 2/3) moist; clay loam that approaches clay; moderate to strong fine and medium subangular blocky; sticky, plastic, friable moist; few coarse, few medium and common fine tubular pores; thin patchy clay cutans on ped faces; few pebbles and stones; noncalcareous; EC(1:1) 0.1 dS/m; no roots; gradual smooth boundary; pH(H_2O) 5.5. (Sample No. AJC10-3)

Btg 100-125cm+ — Very dark reddish brown (5YR 2/3) moist, common medium and coarse prominent yellowish brown mottles; clay; moderate to strong fine and medium subangular blocky; sticky, plastic, friable moist; few coarse and medium, common fine tubular pores; thin patchy clay cutans on ped faces; common fine, black Fe-Mn concretions; noncalcareous; EC(1:1) 0.13 dS/m; no roots; pH(H_2O) 5.6. (Sample No. AJC10-4)

LABORATORY ANALYTICAL DATA (PEDON 2)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1)	Exch. cations (meq/100g)						CEC (meq/100g	Base sat (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL	(dS/m)	Na	K	Ca	Mg	Al	H		
2597/90	AJC10-1	0-15	6	78	16	SiL	5.27	4.28	0.37	0.91	1.17	16.55	5.84	nd	nd	54.59	44.83
2598/90	AJC10-2	15-45	14	54	32	SiCL	5.29	4.07	0.14	0.89	0.48	16.83	6.31	nd	nd	58.59	41.83
2599	AJC10-3	45-100	9	55	36	SiCL	5.49	4.09	0.12	0.99	0.51	16.37	5.61	nd	nd	59.71	39.32
2600/90	AJC10-4	100-125+	4	52	44	SiC	5.58	4.20	0.13	0.85	0.63	16.53	5.70	nd	nd	44.23	53.61

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail. P (ppm)	Avail K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/l)				Soluble anions (meq/l)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2597/90	AJC10-1	0-15	3.97	0.28	27.00	186.30	29.50	11.83	0.43	0.46	tr	tr	tr	tr	tr	tr	tr	tr
2598/90	AJC10-2	15-45	2.93	0.22	10.67	56.55	17.60	2.98	0.20	0.38	tr	tr	tr	tr	tr	tr	tr	tr
2599	AJC10-3	45-100	2.88	0.23	12.46	61.27	16.70	2.76	0.36	0.42	tr	tr	tr	tr	tr	tr	tr	tr
2600/90	AJC10-4	100-125+	1.57	0.11	12.07	85.50	17.70	2.07	0.41	0.57	tr	tr	tr	tr	tr	tr	tr	tr

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiCL = Silty Clay Loam
SiC = Silty Clay
Sil = Silt loam
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre
(equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capability
EC = Electrical Conductivity

PEDON 3 (Site No. IWC1)

LOCATION: About 3km NW of Inewend town in West Gojam Admn. Region, on a steep slope about 80m away from a very deep gully; approx. coordinates 10° 24.3'N and 37° 10.8'E.

LANDSCAPE CHARACTERISITCS:

Landform and physiographic position: Steep, middle part of a colluvial slope, upward and downward slopes ranging from about 30 to 40 percent.

Soil parent material: Sandy colluvium mixed with some local alluvium, drived mainly from weathered sandstone and basalt and partly from the higher lying old alluvial terraces.

Present land use/vegetation cover: Grassland with common bushes and shrubs; surface cover by grass about 20% and by bushes 60-70%; about 20% area under rock outcrops.

Present erosion status: Severe rill and gully erosion; moderately dense to dense, dendritic to subparallel gully pattern; land sliding evident along very steep slopes/escarpments.

Drainage conditions: Externally well, internally moderately well drained.

PROFILE DESCRIPTION:

A	0-30 cm	Dark reddish brown (5YR 3/3) moist; loam; weak fine granular; slightly sticky, slightly plastic, friable moist, slightly hard dry; common pebbles and few stones; noncalcareous; EC(1:1) 0.1 dS/m; few medium, common fine roots; clear smooth boundary; pH(H_2O) 5.4. (Sample No. IWC1-1).
Btg1	30-65cm	Very dark reddish brown (5YR 2/3) moist, common medium and coarse distinct reddish brown mottles; sandy clay loam; few fine and medium weathered rock fragments; noncalcareous; EC(1:1) 0.1 dS/m; few medium and fine roots; pH(H_2O) 5.3. (Sample No. IWC1-2).
Btg2	65-100cm	Dark reddish brown (5YR 3/4) moist, many distinct reddish brown and common prominent black (Mn segregation) mottles; sandy clay loam; abundant Mn segregations below 80cm; many weathered fine rock fragments; noncalcareous; EC(1:1) 0.1 dS/m; pH(H_2O) 5.5 (Sample No. IWC1-3).
C/R	100-150cm+	Variegated, dull yellowish brown (10YR 5/4) moist when crushed, common red, reddish brown and yellowish brown mottles due to weathering rock material; sandy loam; abundant Mn segregations; many weathered fine fragments of sandstone; noncalcareous; EC(1:1) 0.1 dS/m; pH(H_2O) 5.7 (Sample No. IWC1-4).

Remarks: The soil was described and sampled from a minipit to about 40cm depth and by angering below.

LABORATORY ANALYTICAL DATA (PEDON 3)

Lab No.	Sample No	Depth (cm)	TEXTURE Sand (%)	Silt (%)	Clay (%)	Class	pH(1:1) H2O	pH(1:1) KCL	EC(1:1) (dS/m)	Exch. cations (meq/100g) Na	K	Ca	Mg	Al	H	CEC (meq/100g	Base sat (%)
2609/90	IWC1-1	0-30	45	29	26	L	5.36	4.40	0.14	0.86	0.24	8.07	2.67	nd	nd	19.23	61.57
2610/90	IWC1-2	30-65	47	23	30	SCL	5.33	4.49	0.13	0.84	0.20	15.67	2.41	nd	nd	18.61	102.74
2611/90	IWC1-3	65-100	56	20	24	SCL	5.50	4.72	0.12	0.80	0.20	6.26	1.97	nd	nd	14.98	61.62
2612/90	IWC1-4	100-150+	65	21	14	SL	5.72	4.90	0.09	0.70	0.14	4.05	1.60	nd	nd	8.50	76.35

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail P (ppm)	Avail K kg/ha	Extratcable micro-nutrients (ppm) Fe	Mn	Zn	Cu	Soluble cations (meq/l) Na	K	Ca	Mg	Soluble anions (meq/l) CO3	HCO3	Cl	SO4
2609/90	IWC1-1	0-30	2.57	0.09	0.30	46.53	22.50	63.90	0.66	1.13	tr	tr	tr	tr	tr	tr	tr	tr
2610/90	IWC1-2	30-65	1.18	0.07	tr	32.57	23.53	51.70	0.57	1.24	tr	tr	tr	tr	tr	tr	tr	tr
2611/90	IWC1-3	65-100	0.60	0.04	0.40	33.86	17.30	42.27	0.22	0.80	tr	tr	tr	tr	tr	tr	tr	tr
2612/90	IWC1-4	100-150+	0.42	0.01	2.67	55.66	11.19	21.85	0.24	0.36	tr	tr	tr	tr	tr	tr	tr	tr

Abbreviations:

nd = not determined
tr = traces
L = Loam
SCL = Sandy Clay Loam
SL = Sandy Loam
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capability
EC = Electricaly Conductivity

PEDON 4 (Site No. DBC1)

LOCATION: About 5 km south of Dabi town along Jiga-Dabi main road near Areg River bridge (about 750m away from Bir river) in West Gojam Admn. Region, on a gently undulating plain; approx. coordinates 10° 57.3'N and 37° 2.9'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Undulating, middle parts of the subrecent alluvial plain with 5-8% slope; elevation 2,150m amsl

Soil parent material: Local (piedmont) clayey alluvium derived mainly from volcanic ash.

Present land use/vegetation cover: Arable land used for rainfed cultivation of mainly teff with some maize and barley; <2% surface cover of stones; big clods commonly formed at surface.

Present erosion status: Moderate sheet, rill and gully erosion; in some parts slumping is evident; stream bank erosion occurs along the steam/gully courses.

Drainage conditions: Moderately well drained.

FAO soil classification: Pelli-Calcic Vertisols, undulating phase.

PROFILE DESCRIPTION:

Ap 0-12cm Brownish black (10YR 2/2) moist and dry; clay; massive to weak fine granular; very sticky, very plastic, friable to firm moist, extremely hard dry; few fine tubular pores; common medium and fine limestone pebbles; moderately calcareous; EC(1:1) 0.7 dS/m; few fine roots; clear smooth boundary; pH(H_2O) 7.1 (Sample No. DBC1-1).

Bw1 12-40cm Brownish black (10YR 2/2) moist; clay; moderate medium subangular blocky; very sticky, very plastic, firm moist; very few fine tubular pores; few pressure faces; common medium and fine limestone pebbles; moderately calcareous; EC(1:1) 0.7 dS/m; few fine roots; gradual smooth boundary; pH(H_2O) 7.4 (Sample No. DBC1-2).

Bw2 40-80cm Brownish black (10YR 3/2) moist, few medium faint reddish brown mottles; clay; moderate medium and coarse angular blocky; very sticky very plastic, very firm moist; no tubular pores; many distinct slickensides; common medium and fine limestone pebbles; moderately calcareous; EC(1:1) 0.6 dS/m; few very fine roots; gradual smooth boundary; pH(H_2O) 7.3 (Sample No. DBC1-3).

Bb 80-130cm Brownish black (7.5YR 3/2) moist, few medium dark grey and reddish brown mottles; clay; moderate coarse angular blocky with many wedge-shaped peds; very sticky, very plastic, extremently firm moist; no tubular pores; many prominent intersecting slickensides; few fine limestone pebbles; moderately calcareous; EC(1:1) 0.5 dS/m; few very fine roots, gradual smooth boundary; pH(H_2O) 7.4 (Sample No. DBC1-4).

Bbg1 130-160cm Very dark reddish brown (5YR 2/3) moist, many fine and medium faint reddish brown and few medium distinct dark grey mottles; clay; moderate medium and fine angular blocky with few wedge-shaped peds; very sticky, very plastic, very firm moist; no tubular pores; many prominent slickensides; few weathered limestone pebbles; moderately calcareous; EC(1:1) 0.1 dS/m; no roots; gradual smooth boundary; pH(H_2O) 7.2 (Sample No. DBC1-5).

Bbg2 160-200cm+ Dull reddish brown (5YR 4/4) moist, few fine distinct olive yellow and prominent black mottles; clay loam tending to clay; friable to firm moist; few fine Mn concretions; EC(1:1) 0.4 dS/m; no roots; pH(H_2O) 7.1 (Sample No. DBC1-6).

LABORATORY ANALYTICAL DATA (PEDON 4)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1)	Exch. cations (meq/100g)						CEC (meq/100g	Base sat (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL	(dS/m)	Na	K	Ca	Mg	Al	H		
2613/90	DBC1-1	0-12	3	33	64	C	7.12	6.17	0.74	0.46	0.63	56.61	15.87	nd	nd	68.38	107.59
2614/90	DBC1-2	12-40	6	28	66	C	7.44	6.32	0.71	0.17	0.55	57.89	18.52	nd	nd	73.55	104.87
2615/90	DBC1-3	40-80	3	33	64	C	7.34	6.21	0.55	0.20	0.48	55.06	19.19	nd	nd	68.63	109.18
2616/90	DBC1-4	80-130	2	38	60	C	7.35	6.21	0.48	0.27	0.49	60.37	11.75	nd	nd	72.77	100.15
2617/90	DBC1-5	130-160	3	45	52	SiC	7.31	6.10	0.14	1.31	0.63	47.85	34.85	nd	nd	69.91	121.07
2618/90	DBC1-6	160-200+	5	51	44	SiC	7.07	5.82	0.44	0.28	0.36	44.50	9.51	nd	nd	60.85	89.81

Lab No.	Sample No	Depth (cm)	Organ Matte (%)	Total N (%)	Avail P (ppm)	Avail K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/l)				Soluble anions (meq/l)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2613/90	DBC1-1	0-12	1.74	0.06	2.16	112.10	13.20	6.72	0.47	1.14	tr	tr	tr	tr	tr	tr	tr	tr
2614/90	DBC1-2	12-40	1.92	0.07	8.25	85.30	11.44	5.90	0.45	1.11	tr	tr	tr	tr	tr	tr	tr	tr
2615/90	DBC1-3	40-80	1.42	0.06	3.17	74.10	13.95	6.84	0.43	1.11	tr	tr	tr	tr	tr	tr	tr	tr
2616/90	DBC1-4	80-130	0.59	0.04	11.28	79.59	12.43	7.36	0.38	1.04	tr	tr	tr	tr	tr	tr	tr	tr
2617/90	DBC1-5	130-160	0.52	0.04	26.27	80.22	11.20	11.21	0.56	1.38	tr	tr	tr	tr	tr	tr	tr	tr
2618/90	DBC1-6	160-200+	0.98	0.03	11.02	67.86	16.64	15.38	0.45	0.81	tr	tr	tr	tr	tr	tr	tr	tr

Lab No.	Sample No	Depth (cm)	Bulk densi g/ccm	Water Content (%)			
				0.1 ba	0.33 b (F.C.)	15 bar (P.W.P	Avail Water Capaci
2613/90	DBC1-1	0-12	0.63	53.30	46.96	37.61	31.33	15.63
2614/90	DBC1-2	12-40	0.98	61.83	50.41	43.25	31.33	19.08
2615/90	DBC1-3	40-80	0.88	63.31	52.94	46.59	31.49	21.45
2616/90	DBC1-4	80-130	1.05	67.16	59.22	51.56	38.55	20.67
2617/90	DBC1-5	130-160	nd	nd	nd	nd	nd	nd
2618/90	DBC1-6	160-200+	nd	nd	nd	nd	nd	nd

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiC = Silty Clay
c = clay
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electrical Conductivity

PEDON 5 (Site No. DBC7)

LOCATION: About 5km south of Dabi town (about 600m SW from Jiga-Dabi main road) in West Gojam Admn. Region, on a moderately steep side of a ridge; approx. coordinates 10° 57.1'N and 37° 25.6'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Moderately steep, highest old alluvial terrace with 15-20% slope; elevation 2,250m asl.

Soil parent material: Local alluvium mixed with some colluvium derived probably from weathered basalt.

Present land use/vegetation cover: Mainly rainfed cultivated for barley and nigerseed (ploughed); 5-15% surface cover of stones.

Present erosion status: Moderate sheet and rill erosion, few shallow gullies.

Drainage conditions: Externally well, internally moderately well drained.

FAO soil classification: Luvic-Phaeozems, rudic sloping phase.

PROFIELE DESCRIPTION:

Ap	0-15cm	Dark brown (7.5YR 3/3) moist, dull yellowish brown (10YR 5/4) dry; loam; weak granular; common fine and medium gravel and few stones (weathered); noncalcareous; EC(1:1) 0.4 dS/m; common medium and many fine roots; pH(H_2O) 5.9 (Sample No. DBC7-1)
Bt	15-50cm	Dark brown (7.5YR 3/3) moist; loam; moderate medium subangular blocky breaking into fine granular; common medium and fine tubular pores; common fine and medium gravel and many stones below 50 cm; noncalcareous; EC(1:1) 0.2 dS/m; few fine roots; pH(H_2O) 6.1 (Sample No. DBC7.2)
Btg	50-100cm+	Dark brown (7.5kYR 3/4) moist, many medium and coarse distinct olive grey, brown and black mottles; loan that approaches clay loam; moderate medium subangular blocky breaking into fine granular; common pockets of weathered rock material and many fine medium pebbles; noncalcareous; EC(1:1) 0.1 dS/m; few fine roots; pH(H_2O) 6.4 (Sample No. DBC7-3).

Remarks: The soil was described and sampled by making a pit upto about 50 cm depth and angering below.

LABORATORY ANALYTICAL DATA (PEDON 5)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1)	Exch. cations (meq/100g)						CEC (meq/100g	Base sat (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL	(dS/m)	Na	K	Ca	Mg	Al	H		
2622/90	DBC7-1	0-15	16	62	22	SiL	5.86	4.43	0.35	0.19	1.23	26.58	11.49	nd	nd	45.80	86.22
2623/90	DBC7-2	15-50	19	57	24	SiL	6.06	4.38	0.24	0.19	0.55	27.54	13.52	nd	nd	55.80	74.91
2624/90	DBC7-3	50-100+	36	56	8	SiL	6.43	4.25	0.11	0.37	0.78	29.47	14.65	nd	nd	54.00	83.83

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/l)				Soluble anions (meq/l)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2622/90	DBC7-1	0-15	3.28	0.24	13.05	254.60	29.50	23.85	0.61	0.45	tr	tr	tr	tr	tr	tr	tr	tr
2623/90	DBC7-2	15-50	2.31	0.14	65.53	126.30	32.20	7.90	0.72	0.57	tr	tr	tr	tr	tr	tr	tr	tr
2624/90	DBC7-3	50-100+	0.31	0.03	7.30	219.80	16.00	71.14	0.67	0.31	tr	tr	tr	tr	tr	tr	tr	tr

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
Sil = Silt loam
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre
(equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capability
EC = Electrical Conductivity

PEDON 6 Site No. DBC5)

LOCATION: About 5.5 km south of Dabi town (along Jiga-Dabi main road near crossing of Areg River, about 300 m west from Jiga-Dabi road) in West Gojam Admn. Region, on a very steep side of a ridge; approx. coordinates 10° 57'N and 37° 25.8'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Lower parts of a very steep colluvial slope with 65-70% gradient; elevation 2,180m amsl.

Soil parent material: Mixed colluvium derived probably from weathered basalt.

Present land use/vegetation cover: Mainly rainfed cultivated for barley and oilseeds, 5-15% surface cover of stones/boulders.

Present erosion status: Moderate sheet and rill erosion; gully erosion, as well as landsliding/slumping is evident in some parts.

Drainage conditions: Externally well, internally moderately well drained.

FAO soil classifications: Rudi-Luvic Phaeozems, steep phase.

PROFILE DESCRIPTION:

Ap 0-15cm Brownish black (5YR 2/2) moist; gravelly loam; slightly sticky, plastic, friable moist, hard dry; noncalcareous; EC(1:1) 0.2 dS/m; common medium and many fine roots; clear smooth boundary; pH(H_2O) 6.2 (Sample No. DBC5-1).

Bt 15-100cm+ Brownish black (7.5YR 3/2) moist, few fine distinct yellowish brown mottles below 60cm; clay loam; moderate medium and coarese angular blocky; very sticky, very plastic, very firm moist, common medium and fine tubular pores; very thin nearly continuous clay cutans on ped faces; few Mn segregations/spots; common partly weathered stones and pebbles; many boulders below 50cm (not augerable below 100 cm due to boulders); noncalcareous; EC(1:1) 0.3 dS/m; few medium and fine roots; pH(H_2O) 6.3 (Sample No. DBC5-2).

Remarks: The soil was described and sampled by making an about 60 cm deep pit and augering below.

LABORATORY ANALYTICAL DATA (PEDON 6)

Lab No.	Sample No	Depth (cm)	TEXTURE Sand (%)	Silt (%)	Clay (%)	Class	pH(1:1) H2O	pH(1:1) KCL	EC(1:1) (dS/m)	Exch. cations (meq/100g) Na	K	Ca	Mg	Al	H	CEC (meq/100g	Base sat (%)
2619/90	DBC5-1	0-15	9	65	26	SiL	6.15	4.59	0.21	0.31	0.22	32.22	10.83	nd	nd	56.75	76.79
2620/90	DBC5-2	15-100+	6	58	36	SiCL	6.26	4.53	0.28	0.22	0.17	34.44	12.77	nd	nd	56.00	85.00

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm) Fe	Mn	Zn	Cu	Soluble cations (meq/1) Na	K	Ca	Mg	Soluble anions (meq/1) CO3	HCO3	Cl	SO4
2619/90	DBC5-1	0-15	4.67	0.24	1.87	48.74	29.00	26.42	0.88	0.47	tr	tr	tr	tr	tr	tr	tr	tr
2620/90	DBC5-2	15-100+	1.72	0.11	8.06	27.75	13.70	13.09	0.22	0.26	tr	tr	tr	tr	tr	tr	tr	tr

Lab No.	Sample No	Depth (cm)	Bulk densi g/ccm	Water Content (%) 0.1 ba	0.33 bar (F.C.)	15 bar (P.W.P	Avail Water Capaci
2619/90	DBC5-1	0-15	0.72	43.22	28.78	26.46	14.71	14.07
2620/90	DBC5-2	15-100+	0.85	60.84	41.84	30.50	30.47	11.37

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiCL = Silty Clay Loam
SiC = Silty Clay
Sil = Silt loam
dS/m = deci-Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capability
EC = Electrical Conductivity

PEDON 7 (Site No. YCC1)

LOCATION: About 2-3 km ENE of Yechereka town (about 450-500m on the right side of Dembecha-Yechereka main road) in West Gojam Admn. Region, on a gently sloping, high land surface; approx. coordinates 10° 35.3'N and 37° 26.3'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Gently sloping remnants of an old plateau surface; highest part with 2-3% slope; elevation 2,100m amsl.

Soil parent material: Old mixed river alluvium or gracio-fluvium probably with some admixture of volcanic ash and ignimbrites.

Present land use/vegetation cover: Arable land used for rainfed cultivation of mainly gibito and nough; poor crop stand; partly bush/open wood grazing land, probably left under long fallow.

Present erosion status: Moderate sheet and rill erosion mainly along the sloping margins; few gullies developed along the livestock tracks.

Drainage conditions: Externally well, internally moderately well drained.

FAO soil classification: Umbri-Humic Alisols.

PROFILE DESCRIPTION:

AP 0-15cm Dark reddish brown (5YR 3/3) moist; clay loam; weak fine granular; sticky, plastic, very friable moist; few fine tubular pores; noncalcareous; EC(1:1) 0.2 dS/m; common medium, many fine roots; clear smooth boundary; pH(H_2O) 5.6 (Sample No. YCC1-1).

Bt1 15-80cm Dark reddish brown (2.5YR 3/3) moist, clay loam that approaches clay; weak medium sub-angular blocky; common earth worm casts and termite colonies, few krotovinas; sticky, plastic, friable moist; few medium and common fine tubular pores; thin very patchy clay cutans along ped faces; noncalcareous; EC(1:1) 0.1 dS/m; few medium and common fine roots; diffuse smooth boundary; pH(H_2O) 4.7 (Sample No. YCC1-2).

Bt2 80-125cm Dark reddish brown (2.5YR 3/4) moist; clay; weak medium subangular blocky; sticky, plastic, friable to firm moist; few medium and fine tubular pores; thin patchy clay cutans along ped faces; noncalcareous; EC(1:1) 0.1 dS/m; few fine roots; diffuse smooth boundary; pH(H_2O) 5.2 (Sample No. YCC1-3)

Bt3 125-190cm+ Dark reddish brown (2.5YR 3/5) moist; clay; very weak medium subangular blocky; sticky, plastic, firm moist; few fine tubular pores; thin very patchy clay cutans along ped faces; noncalcareous; EC(1:1) 0.1 dS/m; few fine roots; pH(H_2O) 4.9 (Sample No. YCC1-4).

LABORATORY ANALYTICAL DATA (PEDON 7)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1)	Exch. cations (meq/100g)						CEC (meq/100g	Base sat (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL	(dS/m)	Na	K	Ca	Mg	Al	H		
2601/90	YCC1-1	0-15	6	58	36	SiCL	5.62	4.50	0.15	0.87	1.40	12.93	3.21	nd	nd	44.88	41.02
2602/90	YCC1-2	15-80	0	34	66	C	4.65	3.58	0.08	1.21	1.00	7.51	3.09	nd	nd	46.24	27.70
2603/90	YCC1-3	80-125	1	27	72	C	5.20	3.88	0.06	0.90	0.51	9.66	0.07	nd	nd	40.88	27.25
2604/90	YCC1-4	125-190+	0	28	72	C	4.86	4.16	0.09	1.87	0.44	8.06	2.69	nd	nd	37.36	34.96

Lab No.	Sample No	Depth (cm)	Organ Matte (%)	Total N (%)	Avail P (ppm)	Avail K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/l)				Soluble anions (meq/l)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2601/90	YCC1-1	0-15	4.06	0.26	1.94	363.00	12.25	32.56	3.63	1.43	tr	tr	tr	tr	tr	tr	tr	tr
2602/90	YCC1-2	15-80	1.99	0.16	1.18	150.30	6.10	19.42	3.13	0.48	tr	tr	tr	tr	tr	tr	tr	tr
2603/90	YCC1-3	80-125	1.66	0.14	0.85	55.85	3.52	11.77	3.15	0.42	tr	tr	tr	tr	tr	tr	tr	tr
2604/90	YCC1-4	125-190+	0.88	0.08	1.31	44.48	3.11	2.95	3.11	0.24	tr	tr	tr	tr	tr	tr	tr	tr

Lab No.	Sample No	Depth (cm)	Bulk densi g/ccm	Water Content (%) 0.1 ba	0.33 bar (F.C.)	3 bar	15 bar (P.W.P	Avail Water Capaci
2601/90	YCC1-1	0-15	0.93	52.38	44.96	34.26	26.12	18.84
2602/90	YCC1-2	15-80	0.93	50.20	41.40	32.61	28.11	13.29
2603/90	YCC1-3	80-125	1.09	52.84	39.08	32.96	29.47	9.61
2604/90	YCC1-4	125-190+	nd	nd	nd	nd	nd	

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiCL = Silty Clay Loam
SiC = Silty Clay
C = Clay
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capability
EC = Electrical Conductivity

PEDON 8 (Site No. YCC2)

LOCATION: Location 2.5 km SE of Yechereka town (about 50m SW of the old Dembecha-Yechereka main road) in West Gojam Admn. Region, on a gently sloping cultivated terrace; approx. coordinates 10° 35.1'N and 37° 25.7'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Gently sloping old alluvial subterrace with 3-5% slope; elevation 2,050m amsl.

Soil parent material: Mixed river alluvium probably derived from older glacio-fluvial deposits with some admixture of volcanic ash and ignimbrites.

Present land use/vegetation cover: Arable land (ploughed) used for rainfed cultivation of mainly maize, teff and barley; <1% surface cover of stones; few patches of bushes/hedges along field boundaries.

Present erosion status: Slight to moderate sheet and rill erosion; few shallow gullies developed from traditional ditches.

Drainage conditions: Externally well, internally moderately well drained.

FAO soil classification: Umbri-Humic Alisols.

PROFILE DESCRIPTION:

AP 0-15cm Dark reddish brown (2.5YR 3/3) moist; clay loam; massive to weak fine granular; sticky, plastic, firm moist; few fine tubular pores; noncalcareous; EC(1:1) 0.2 dS/m; few medium and coarse, common fine roots; clear smooth boundary; pH(H_2O) 5.1 (Sample No. YCC2-1)

Bt1 15-60cm Variegated, brownish black (10YR 3/1) and dull reddish brown (2.5YR 4/3) moist, dark reddish brown (2.5YR 3/3) moist when crushed; clay loam that approaches clay; moderate medium and fine angular blocky; sticky, plastic, firm moist; few coarse and medium, common fine tubular pores; thin, nearly continuous Mn coatings on ped faces; common to many soft and hard Mn concretions; noncalcareous; EC(1:1) 0.2 dS/m; common fine roots; gradual smooth boundary; pH(H_2O) 5.3 (Sample No. YCC2-2).

Bt2 60-125cm Very dark reddish brown (2.5YR 2/4) moist; clay loam that approaches clay; weak medium subangular blocky; very sticky, plastic, firm moist; few coarse, medium and common fine tubular pores; thin very patchy clay cutans on ped faces; few fine Mn concretions; few krotovinas; noncalcareous; EC(1:1) 0.2 dS/m; few fine roots; diffuse smooth boundary; pH(H_2O) 4.6 (Sample No. YCC2-3).

Bt3 125-170cm+ Dark reddish brown (2.5YR 3/4) moist; clay loam that approaches clay; weak, medium anf fine subangular blocky; sticky, plastic, friable to firm moist; few fine tubular pores; thin potchy clay cutans on ped faces; noncalcareous; EC(1:1) 0.2 dS/m; very few fine roots; pH(H_2O) 4.8 (Sample No. YCC2-4).

LABORATORY ANALYTICAL DATA (PEDON 8)

Lab No.	Sample No	Depth (cm)	TEXTURE Sand (%)	Silt (%)	Clay (%)	Class	pH(1:1) H2O	pH(1:1) KCL	EC(1:1) (dS/m)	Exch. cations (meq/100g) Na	K	Ca	Mg	Al	H	CEC (meq/100g	Base sat (%)
2605/90	YCC2-1	0-15	4	54	42	SiC	5.07	4.19	0.17	0.85	1.50	9.98	3.42	nd	nd	39.70	39.67
2606/90	YCC2-2	15-60	2	64	34	SiCL	5.25	4.29	0.16	0.84	1.25	10.53	3.85	nd	nd	27.71	59.44
2607/90	YCC2-3	60-125	2	36	62	C	4.58	3.70	0.15	0.80	0.8	6.87	2.82	nd	nd	44.51	25.37
2608/90	YCC2-4	125-170+	1	27	72	C	4.77	4.15	0.15	1.03	0.70	8.19	3.25	nd	nd	35.43	37.17

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail P (ppm)	Avail K kg/ha	Extractable micro-nutrients (ppm) Fe	Mn	Zn	Cu	Soluble cations (meq/1) Na	K	Ca	Mg	Soluble anions (meq/1) CO3	HCO3	Cl	SO4
2605/90	YCC2-1	0-15	4.62	0.23	2.3	323.70	11.84	31.29	0.41	1.23	tr	tr	tr	tr	tr	tr	tr	tr
2606/90	YCC2-2	15-60	3.45	0.23	1.30	344.30	12.47	29.42	0.40	1.46	tr	tr	tr	tr	tr	tr	tr	tr
2607/90	YCC2-3	60-125	2.64	0.16	1.26	120.00	7.02	29.67	0.19	0.74	tr	tr	tr	tr	tr	tr	tr	tr
2608/90	YCC2-4	125-170+	1.27	0.09	tr	94.69	3.23	5.99	0.08	0.51	tr	tr	tr	tr	tr	tr	tr	tr

Lab No.	Sample No	Depth (cm)	Bulk densi g/ccm	Water Content (%) 0.1 ba	0.33 bar (F.C.)	3 bar	15 bar (P.W.P	Avail Water Capaci
2605/90	YCC2-1	0-15	0.77	47.44	41.12	31.67	24.94	16.18
2606/90	YCC2-2	15-60	1.02	46.03	37.39	33.07	26.38	11.01
2607/90	YCC2-3	60-125	0.92	53.38	39.26	32.60	26.71	12.55
2608/90	YCC2-4	125-170+	nd	nd	nd	nd	nd	

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiCL = Silty Clay Loam
SiC = Silty Clay
C = Clay
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capability
EC = Electrical Conductivity

PEDON 9 (Site No. ATC3)

LOCATION: About 5km NW of Agut village (about 750m west of Tilili-Agut main track) in West Gojam Admn. Region, on the top of a high ridge; approx. coordinates 10° 51.7'N and 37° 07.4'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Gently sloping (5-6% slope) eroded part of an old plateau remnant; elevation about 2,570m amsl.

Soil parent material: Old mixed river alluvium/glacio-fluvial deposits originated probably from weathered basalt.

Present land use/vegetation cover: Arable land (harvested barley field) used for rainfed cultivation of mainly teff and barly; about 5% surface cover of stones and about 5-10% area with bare (weathered) rock surface.

Present erosion status: Moderate to servere sheet, rill and gully erosion.

Drainage conditions: Externally well, internally moderately well drained.

FAO soil classification: Humic Alisols, rudic phase.

PROFILE DESCRIPTION:

A 0-18/28cm Very dark reddish brown (5YR 2/3) moist; loam; massive to very weak granular; slightly sticky, slightly plastic, friable moist; noncalcareous; EC(1:1) 0.1 dS/m; common medium, many fine and very fine roots; clear smooth boundary; pH(H_2O) 5.2 (Sample No. ATC3-1).

Bt 18/28-50cm Variegated, dark reddish brown (2.5YR 3/6) and very dark reddish brown (5YR 2/3) moist; few fine distinct black mottles; clay; weak medium and fine angular blocky; sticky, very plastic, firm moist; very few very fine Mn concretions; noncalcareous; EC(1:1) 0.1 dS/m; few medium and common fine roots; pH(H_2O) 5.4 (Sample No. ATC3-2).

Btg 50-120cm+ Dark reddish brown (2.5YR 3/6) moist, common fine and medium prominent black mottles; clay; few stones/boulders; few fine Mn concretions; noncalcareous; EC(1:1) 0.1 dS/m; few medium and common fine roots; pH(H_2O) 5.3 (Sample No. ATC3-3).

Remarks: The soil was described and sampled by excavating a pit to about 60cm depth and augering below; could not be augered below 120cm due to presence of stones/bedrock .

LABORATORY ANALYTICAL DATA (PEDON 9)

Lab No.	Sample No	Depth (cm)	TEXTURE Sand (%)	Silt (%)	Clay (%)	Class	pH(1:1) H2O	pH(1:1) KCL	EC(1:1) (dS/m)	Exch. cations (meq/100g) Na	K	Ca	Mg	Al	H	CEC (meq/100g	Base sat (%)
2643/90	ATC3-1	0-18/28	17	56	27	SiL	5.17	4.29	0.10	0.70	0.38	11.79	3.40	nd	nd	36.23	44.91
2644/90	ATC3-2	18/28-50	6	35	59	C	5.35	4.37	0.08	0.65	0.16	10.48	3.14	nd	nd	33.33	43.29
2645/90	ATC3-3	50-120+	4	43	53	SiC	5.29	4.34	0.10	0.73	0.14	10.40	2.74	nd	nd	36.83	38.04

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail P (ppm)	Avail K kg/ha	Extractable micro-nutrients (ppm) Fe	Mn	Zn	Cu	Soluble cations (meq/l) Na	K	Ca	Mg	Soluble anions (meq/l) CO3	HCO3	Cl	SO4
2643/90	ATC3-1	0-18/28	3.70	0.28	7.38	69.68	32.80	8.57	0.68	1.20	tr	tr	tr	tr	tr	tr	tr	tr
2644/90	ATC3-2	18/28-50	1.74	0.15	5.76	26.88	11.30	8.53	1.05	0.70	tr	tr	tr	tr	tr	tr	tr	tr
2645/90	ATC3-3	50-120+	1.74	0.08	45.16	27.40	8.94	41.64	0.78	0.78	tr	tr	tr	tr	tr	tr	tr	tr

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiC = Silty Clay
SiL = Silt loam
C = Clay
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electricl Conductivity

PEDON 9a (Site No. ATC4)

LOCATION: About 4.8 km NW of Agut village (about 600m West of Tilili-Agut main track) in West Gojam Admn. Region, on the steep slope of a high ridge; approx. coordinates 10° 51.8'N and 37° 07.5'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Moderately steep (15-20% slopes) colluvial slope below an old plateau remnant; elevation 2,560m amsl.

Soil parent material: Mainly mixed colluvium derived from the glacio-fluvial deposits of the old plateau.

Present land use/vegetation cover: Mainly grass land probably under long fallow after cultivation; 50-70% surface cover of grass; 5-10% area covered by bare rock surface and stones.

Present erosion status: Very severe sheet, rill and gully erosion; 15-20% area occupied by deep (3-4m) gullies.

Drainage conditions: Externally well, internally moderately well drained.

FAO soil classification: Rudi-Rhodi Haplic Alisols, sloping phase.

PROFILE DESCRIPTION:

Ap	0-10cm	Dark reddish brown (2.5YR 3/5) moist and dull reddish brown (5YR 4/4) dry; clay loam; very weak granular; slightly sticky, plastic, friable moist, hard dry; noncalcareous; EC(1:1) 0.1 dS/m; few medium, common fine roots; gradual smooth boundary; pH(H_2O) 5.3 (Sample No. ATC4-1)
Bt1	10-25cm	Dark reddish brown (2.5YR 3/5) moist; clay loam approaching clay: moderate medium angular blocky; sticky, plastic, firm moist, very hard dry; few krotovinas; thin patchy clay cutans on ped faces; many fine Fe-Mn concretions; noncalcareous; EC(1:1) 0.1 dS/m; few fine and medium roots; gradual smooth boundary; pH(H_2O) 5.3 (Sample No. ATC4-2).
BT2	25-100cm+	Dull reddish brown (2.5YR 4/5) moist; clay; moderate medium and fine angular blocky; very sticky, very plastic, very firm moist, common fine Fe-Mn concretions; noncalcareous; EC(1:1) 0.1 dS/m; few fine roots; pH(H_2O) 5.5 (Sample No. ATC4-3).

Remarks: The soil was described and sampled by exposing fresh profile from the side of a gully.

LABORATORY ANALYTICAL DATA (PEDON 9a)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1)	Exch. cations (meq/100g)						CEC (meq/100g	Base sat (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL	(dS/m)	Na	K	Ca	Mg	Al	H		
2646/90	ATC4-1	0-10	4	37	59	C	5.27	4.35	0.09	0.53	0.30	10.86	6.31	nd	nd	42.00	42.86
2647/90	ATC4-2	10-25	6	23	71	C	4.58	5.32	0.07	0.50	0.21	9.10	2.68	nd	nd	40.91	30.53
2648/90	ATC4-3	25-100+	1	30	69	C	5.08	5.54	0.06	0.61	0.15	9.27	2.23	nd	nd	33.88	36.19

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/l)				Soluble anions (meq/l)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2646/90	ATC4-1	0-10	3.43	0.22	2.93	49.23	8.50	11.59	0.30	0.80	tr	tr	tr	tr	tr	tr	tr	tr
2647/90	ATC4-2	10-25	1.85	0.11	3.32	32.13	7.32	6.42	0.32	0.40	tr	tr	tr	tr	tr	tr	tr	tr
2648/90	ATC4-3	25-100+	0.78	0.05	1.18	21.44	2.63	7.82	0.21	0.25	tr	tr	tr	tr	tr	tr	tr	tr

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
C = Clay
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre
(equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electrical Conductivity

PEDON 10 (Site No. ATC1)

LOCATION: About 2.5km NW of Agut village (about 80m SW of Tilili-Agut main track) in West Gojam Admn. Region, on a very gently sloping cultivated tract of land; approx. coordinates 10° 51.3'N and 37° 08.5'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Very gently sloping (2-3% slope) old alluvial terrace, about 200m away from the terrace margin; elevation 2,485m amsl.

Soil parent material: Mixed river alluvium probably with some admixture of volcanic ash.

Present land use/vegetation cover: Arable land cultivated for mainly maize, barley and horse beans; common hedgerows along field boundaries and tracks.

Present erosion status: Slight sheet/rill erosion; few rills and shallow gullies formed from tracks.

Drainage conditions: Externally well, internally moderately well drained.

FAO soil classification: Umbri-Humic Alisols.

PROFILE DESCRIPTION:

Ap 0-13cm Dark brown (7.5YR 3/3) moist; loam; weak fine granular; slightly sticky, slightly plastic, very friable moist; very few fine tubular pores; noncalcareous; EC(1:1) 0.1 dS/m; common medium and many fine roots; clear smooth boundary; pH(H_2O) 5.0 (Sample No. ATC-1)

AB 13-50cm Brownish black (7.5YR 2/2) and black (7.5YR 2/1) moist; clay loam that approaches clay; weak medium subangular blocky breaking into fine granular; sticky, plastic, very friable moist; few fine and few medium tubular pores; noncalcareous; EC(1:1) 0.1 dS/m; few medium and common fine roots; gradual smooth boundary; pH(H_2O) 4.8 (Sample No. ATC1-2).

BA 50-70cm Very dark brown (7.5YR 2/3) and dark reddish brown (5YR 3/3) moist; clay loam that approaches clay; weak medium subangular blocky breaking into fine granular; sticky, plastic, friable moist; few fine and few medium tubular pores; few intillings of reddish brown and black material; noncalcareous; EC(1:1) 0.1 dS/m; few fine roots; diffuse smooth boundary; pH(H_2O) 4.9 (Sample No. ATC1-3).

Bt1 70-85cm Dark reddish brown (5YR 3/4) moist; clay; weak medium subangular blocky; very sticky, very plastic, firm moist; few medium and common fine tubular pores; few krotovinas; few infillings of reddish brown and black material, noncalcareous; EC(1:1) 0.1 dS/m; few fine roots; diffuse smooth boundary; pH(H_2O) 5.0 (Sample No. ATC1-4).

Bt2 85-200cm+ Dark reddish brown (5YR 3/6) moist, common medium very fine faint reddish brown mottles below 150cm; clay; moderate medium and fine subangular blocky; very sticky, very plastic, firm moist; few fine tubular pores; very thin patchy clay cutans on ped faces; many fine and medium Mn concretions; noncalcareous; EC(1:1) 0.1 dS/m; very few very fine roots; pH(H_2O) 5.2 (Sample No. ATC1-5).

LABORATORY ANALYTICAL DATA (PEDON 10)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1)	Exch. cations (meq/100g)						CEC (meq/100g	Base sat (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL	(dS/m)	Na	K	Ca	Mg	Al	H		
2635/90	ATC1-1	0-13	9	66	25	SiL	4.95	4.12	0.08	0.81	1.05	10.54	1.97	nd	nd	36.77	39.08
2636/90	ATC1-2	13-50	3	46	51	SiC	4.81	3.94	0.08	1.20	0.80	12.11	4.24	nd	nd	14.05	130.60
2637/90	ATC1-3	50-70	2	39	59	C	4.89	4.12	0.07	0.72	0.94	10.18	2.95	nd	nd	37.27	39.68
2638/90	ATC1-4	70-85	2	35	63	C	5.03	4.09	0.10	0.73	1.00	9.93	2.64	nd	nd	35.27	40.54
2639/90	ATC1-5	85-200+	1	26	73	C	5.22	4.56	0.09	0.80	0.64	11.66	2.49	nd	nd	38.09	40.93

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/l)				Soluble anions (meq/l)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2635/90	ATC1-1	0-13	5.23	0.32	8.91	140.50	34.80	16.77	0.55	1.16	tr	tr	tr	tr	tr	tr	tr	tr
2636/90	ATC1-2	13-50	4.70	0.27	4.25	117.80	25.22	6.74	0.23	0.51	tr	tr	tr	tr	tr	tr	tr	tr
2637/90	ATC1-3	50-70	2.40	0.16	6.15	153.10	17.10	4.88	0.23	0.96	tr	tr	tr	tr	tr	tr	tr	tr
2638/90	ATC1-4	70-85	1.42	0.13	4.26	174.20	12.80	3.71	0.23	1.01	tr	tr	tr	tr	tr	tr	tr	tr
2639/90	ATC1-5	85-200	1.10	0.11	3.05	90.95	6.67	7.83	0.12	0.36	tr	tr	tr	tr	tr	tr	tr	tr

Lab No.	Sample No	Depth (cm)	Bulk densi g/ccm	Water Content (%)				
				0.1 ba	0.33 bar (F.C.)	3 bar	15 bar (P.W.P)	Avail Water Capaci
2635/90	ATC1-1	0-13	0.91	57.56	42.62	34.73	23.70	18.92
2636/90	ATC1-2	13-50	0.46	61.10	40.53	33.87	28.06	12.47
2637/90	ATC1-3	50-70	0.49	55.14	36.63	30.60	27.47	9.16
2638/90	ATC1-4	70-85	nd	nd	nd	nd	nd	
2639/90	ATC1-5	85-200	nd	nd	nd	nd	nd	

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiL = Silt Loam
C = Clay
SiC = Silty Clay
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electrical Conductivity

PEDON 10a (Sample No. ATC2)

LOCATION: About 3.2 km NW of Agut village (about 50m SW of Tilili-Agut main track) in West Gojam Admn. Region, on a sloping side of the river; approx. coordinates 10° 51.4'N and 37° 08.1'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Sloping to moderately steep, upper parts of a terrace escarpment/margin with 5-15% slope; elevation 2,500m amsl.

Soil parent material: Mixed river alluvium probably with some admixture of volcanic ash.

Present land use/vegetation cover: Mainly grassland, part long fallowed after cultivation; >90% surface cover of grass; 5-10% area covered by stones/boulders.

Present erosion status: Severe sheet, rill and gully erosion on the exposed parts, mainly along the cattle tracks.

Drainage conditions: Externally well, internally moderately well drained.

FAO soil classification: Umbri-Humic Alisols, sloping phase.

PROFILE DESCRIPTION:

Ah 0-35/45cm Dark brown (7.5YR 3/3) moist; clay loam; weak coarse subangular blocky breaking into fine granular; sticky, plastic, friable moist; few medium and few fine tubular pores; noncalcareous; EC(1:1) 0.1 dS/m; many fine roots; clear wavy boundary; pH(H_2O) 5.0 (Sample No. ATC2-1).

Bt 35/45-90cm Dark reddish brown (5YR 3/4) moist; clay; moderate medium and fine subangular blocky; few fine tubular pores; thin patchy clay cutans; common medium and fine Fe-Mn concretions; few pebbles (of basalt) at lower depth; noncalcareous; EC(1:1) 0.1 dS/m; few fine roots; clear smooth boundary; pH(H_2O) 5.5 (Sample No. ATC2-2).

Btg 90-200cm+ Dark reddish brown (5YR 3/4) moist, many distinct reddish brown and prominent black mottles; clay; moderate fine subangular blocky; few fine tubular pores; thin discontinuous clay cutans; many medium and fine Fe-Mn concretions; many partially weathered stones and pebbles; noncalcareous; EC(1:1) 0.1 dS/m; no roots; pH(H_2O) 5.7 (Sample No. ATC2-3).

LABORATORY ANALYTICAL DATA (PEDON 10a)

Lab No.	Sample No	Depth (cm)	TEXTURE Sand (%)	Silt (%)	Clay (%)	Class	pH(1:1) H2O	pH(1:1) KCL	EC(1:1) (dS/m)	Exch. cations (meq/100g) Na	K	Ca	Mg	Al	H	CEC (meq/100g	Base sat (%)
2640/90	ATC2-1	0-35/45	9	58	33	SiCL	4.95	4.04	0.10	0.77	0.90	9.52	2.38	nd	nd	34.49	39.34
2641/90	ATC2-2	35/45-90	1	28	71	C	5.52	5.20	0.08	0.78	0.23	9.86	2.67	nd	nd	36.46	37.14
2642/90	ATC2-3	90-200+	5	44	51	SiC	5.73	5.35	0.05	0.91	0.42	10.27	2.54	nd	nd	16.64	84.98

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm) Fe	Mn	Zn	Cu	Soluble cations (meq/l) Na	K	Ca	Mg	Soluble anions (meq/l) CO3	HCO3	Cl	SO4
2640/90	ATC2-1	0-35/45	5.48	0.29	4.15	158.70	23.80	14.17	0.40	0.74	tr	tr	tr	tr	tr	tr	tr	tr
2641/90	ATC2-2	35/45-90	0.96	0.08	1.51	31.98	2.60	7.67	0.21	0.34	tr	tr	tr	tr	tr	tr	tr	tr
2642/90	ATC2-3	90-200+	0.55	0.03	0.94	79.03	1.98	7.36	0.40	0.45	tr	tr	tr	tr	tr	tr	tr	tr

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiCL = Silty Clay Loam
SiC = Silty Clay
C = Clay
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre
(equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electrical Conductivity

PEDON 11 (Site No. JGC1)

LOCATION: About 3 km WSW of Jiga town (along a NW-SE track originating near the Finote Selam-Jiga main road bridge of Leza river) in West Gojam Admn. Region, on a flat cultivated tract of land; approx. coordinates 10° 39.9'N and 37° 21'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Flat, highest terrace within the alluvial plains with <1% slope; elevation 1,880m amsl.

Soil parent material: Mixed river alluvium probably with some admixture of volcanic material (ignimbrites).

Present land use/vegetation cover: Arable land used for cultivation of mainly maize and teff; no stones at surface.

Present erosion status: No or slight sheet/rill erosion; no rills or gullies evidenced.

Drainage conditions: Externally and internally well drained.

FAO soil classification: Molli-Humic Alisols.

PROFILE DESCRIPTION:

AP 0-25cm Dark reddish brown (2.5YR 3/2) moist,brown (7.5YR 4/6) dry; clay loam; weak fine granular; sticky, plastic, very friable moist, hard dry; few fine tubular pores; noncalcareous; EC(1:1) 0.2 dS/m; common medium and many fine roots; clear smooth boundary; pH(H_2O) 5.8 (Sample No. JGC1-1).

Bt1 25-55cm Dark reddish brown (2.5YR 3/4) moist; clay loam that approaches clay; moderate medium and coarse subangular blocky; very sticky, very plastic, firm moist; common krotovinas; few fine and medium tubular pores; thin patchy clay cutans on ped faces; noncalcareous; EC(1:1) 0.1 dS/m; common fine roots; gradual smooth boundary; pH(H_2O) 5.6 (Sample No. JGC1-2).

Bt2 55-93cm Dull reddish brown (2.5YR 4/4) moist; clay loam that approaches clay; weak coarse angular blocky; few krotovinas; very sticky, very plastic, friable moist; few fine and medium tubular pores; thin patchy clay cutans on ped faces; noncalcareous; EC(1:1) 0.1 dS/m; few fine roots; diffuse smooth boundary; pH(H_2O) 5.0 (Sample No. JGC1-3).

Bt3 93-140cm Dull reddish brown (2.5YR 4/5) moist; clay loam that approaches clay; weak coarse angular blocky; few insect casts; very sticky, very plastic, friable moist; few fine tubular pores; thin very patchy clay cutans on ped faces; noncalcareous; EC(1:1) 0.1 dS/m; few fine roots; diffuse smooth boundary; pH(H_2O) 5.1 (Sample No. JGC1-4).

Bt4 140-200cm+ Dull reddish brown (2.5YR 4/4) moist; clay loam; weak coarse angular blocky; few krotovinas; sticky, plastic, friable moist; thin very patchy clay cutans on ped faces; few fine Fe-Mn concretions increasing with depth; noncalcareous; EC(1:1) 0.1 dS/m; few fine roots; pH(H_2O) 5.3 (Sample No. JGC1-5).

LABORATORY ANALYTICAL DATA (PEDON 11)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1)	Exch. cations (meq/100g)						CEC (meq/ 100g	Base sat (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL	(dS/m)	Na	K	Ca	Mg	Al	H		
2625/90	JGC1-1	0-25	4	64	32	SiCL	5.81	4.68	0.18	0.92	0.20	14.51	5.33	nd	nd	38.77	54.06
2626/90	JGC1-2	25-55	1	19	80	C	5.64	4.53	0.11	0.97	1.25	8.00	4.17	nd	nd	40.26	35.74
2627/90	JGC1-3	55-93	1	19	80	C	5.02	4.63	0.11	0.80	1.25	8.83	4.42	nd	nd	35.52	43.07
2628/90	JGC1-4	93-140	0	28	72	C	5.14	4.91	0.11	0.90	1.43	8.20	4.05	nd	nd	34.61	42.13
2629/90	JGC1-5	140-200+	0	22	78	C	5.33	5.07	0.09	0.84	1.54	8.14	4.46	nd	nd	72.26	20.73

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/l)				Soluble anions (meq/l)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2625/90	JGC1-1	0-25	4.14	0.24	2.04	530.70	29.20	37.03	1.06	2.57	tr	tr	tr	tr	tr	tr	tr	tr
2626/90	JGC1-2	25-55	1.54	0.13	tr	265.30	8.72	9.79	0.23	1.00	tr	tr	tr	tr	tr	tr	tr	tr
2627/90	JGC1-3	55-93	0.89	0.10	0.73	297.80	6.49	4.98	0.21	0.60	tr	tr	tr	tr	tr	tr	tr	tr
2628/90	JGC1-4	93-140	0.39	0.06	0.02	299.70	4.56	8.73	0.70	0.42	tr	tr	tr	tr	tr	tr	tr	tr
2629/90	JGC1-5	140-200+	0.62	0.06	0.02	501.80	3.36	7.13	0.91	0.40	tr	tr	tr	tr	tr	tr	tr	tr

Lab No.	Sample No	Depth (cm)	Bulk densi g/ccm	Water Content (%)				
				0.1 bar	0.33 bar (F.C.)	3 bar	15 bar (P.W.P)	Avail Water Capac.
2625/90	JGC1-1	0-25	0.77	61.00	38.82	31.89	24.60	14.22
2626/90	JGC1-2	25-55	1.11	61.08	41.63	35.14	30.78	10.85
2627/90	JGC1-3	55-93	0.92	49.43	38.68	32.56	28.96	9.72
2628/90	JGC1-4	93-140	nd	nd	nd	nd	nd	
2629/90	JGC1-5	140-200+	nd	nd	nd	nd	nd	

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiCL = Silty Clay Loam
C = Clay
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g = milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electrical Conductivity

PEDON 12 (Site No. JGC2)

LOCATION: About 3.5 km WSW of Jiga town (along a NW-SE track originating near the Finote Selam-Jiga main road bridge of Leza river) in West Gojam Admn. Region, on an almost flat tract of grass land; approx. coordinates 10° 40.2'N and 37° 20.6'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Almost flat basin within the alluvial plain; few microbasins in some parts (gilgai microrelief); 1-1.5% slope; elevation about 1,880m amsl.

Soil parent material: Clayey river alluvium probably mixed with volcanic ash.

Present land use/vegetation cover: Mainly grass land with >90% surface cover of vegetation; no bushes; no stones; a few low hummocks associated with microbasins.

Present erosion status: No erosion evident at the site due to thick grass cover but few shallow gullies seen towards the lower parts.

Drainage conditions: Moderately well to imperfectly drained.

FAO soil classification: Mazi-Pelli Eutric Vertisols.

PROFILE DESCRIPTION:

Ah 0-15cm — Grey (5Y 4/1) moist, many medium and fine prominent reddish brown mottles; clay; massive; very sticky, very plastic, very firm moist; few fine tubular pores; noncalcareous; EC(1:1) 0.3 dS/m; common fine roots; clear smooth boundary; pH(H_2O) 5.3 (Sample No. JGC2-1).

Bwg1 15-40cm — Yellowish grey (2.5Y 4/1) moist; common fine distinct yellowish brown and many medium distinct black mottles; clay; moderate medium and coarse angular blocky; few earth worm casts; very sticky, very plastic, very firm moist; few fine tubular pores; many pressure faces/silkensides; noncalcareous; EC(1:1) 0.3 dS/m; few infillings of topsoil material; common fine roots; gradual smooth boundary; pH(H_2O) 5.4 (Sample No. JGC2-2)

Bwg2 40-75cm — Yellowish grey (2.5Y 4/1) moist, many medium distinct reddish brown and black mottles; clay; moderate medium angular blocky; few earth worm casts; very sticky, very plastic, very firm moist; no tubular pores; many pressure faces/silkensides; few fine soft Mn concretions; noncalcareous; EC(1:1) 0.3 dS/m; few infillings of topsoil material; few fine roots; gradual smooth boundary; pH(H_2O) 5.4 (Sample No. JGC2-3).

Bwg3 75-110/130cm — Olive black (10Y 3/2) moist, many medium and fine distinct reddish brown and common coarse faint grey and medium distinct black mottles; clay; moderate coarse and medium angular blocky; very sticky, very plastic, extremely firm moist; no tubular pores; many prominent intersecting silkensides; noncalcareous; EC(1:1) 0.4 dS/m; few fine roots; gradual smooth boundary; pH(H_2O) 5.3 (Sample No. JGC2-4).

Bwg4 110/130-145cm — Dark greyish yellow (2.5Y 5/2) moist; clay; massive; very sticky, very plastic, extremely firm moist; no tubular pores; noncalcareous; no roots, abrupt/broken boundary (not Sampled).

Bwg5 145-175cm+ — Grey (5Y 5/1) moist, many fine and medium black mottles; clay; massive; very sticky, very plastic, extremely firm moist; no tubular pores; common fine soft Mn concretions; noncalcareous; EC(1:1) 0.4 dS/m; no roots; pH(H_2O) 5.4 (Sample No. JGC2-6).

Remarks: The soil was too moist to show cracks at surface or within the profile. During dry season, the soil surface exhibits wide cracks and the vegetation cover reduces to <70%.

LABORATORY ANALYTICAL DATA (PEDON 12)

Lab No.	Sample No	Depth (cm)	TEXTURE Sand (%)	Silt (%)	Clay (%)	Class	pH(1:1) H2O	pH(1:1) KCL	EC(1:1) (dS/m)	Exch. cations (meq/100g) Na	K	Ca	Mg	Al	H	CEC (meq/100g	Base sat (%)
2630/90	JGC2-1	0-15	1	29	70	C	5.27	4.01	0.34	1.12	0.95	35.80	35.40	nd	nd	74.78	97.98
2631/90	JGC2-2	15-40	1	27	72	C	5.35	4.00	0.30	1.25	0.90	36.50	7.53	nd	nd	74.84	61.70
2632/90	JGC2-3	40-75	2	24	74	C	5.38	4.13	0.33	0.95	0.12	41.60	13.73	nd	nd	65.60	85.98
2633/90	JGC2-4	75-110/130	2	21	77	C	5.34	4.07	0.43	1.51	0.94	35.94	36.08	nd	nd	81.68	91.17
2634/90	JGC2-6	145-175+	1	20	72	C	5.41	3.88	0.43	1.60	0.85	45.96	35.12	nd	nd	43.56	191.76

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm) Fe	Mn	Zn	Cu	Soluble cations (meq/l) Na	K	Ca	Mg	Soluble anions (meq/l) CO3	HCO3	Cl	SO4
2630/90	JGC2-1	0-15	3.63	0.15	4.33	132.80	14.00	12.91	0.43	1.92	tr	tr	tr	tr	tr	tr	tr	tr
2631/90	JGC2-2	15-40	1.48	0.07	1.56	112.90	13.83	9.24	0.46	1.84	tr	tr	tr	tr	tr	tr	tr	tr
2632/90	JGC2-3	40-75	1.60	0.08	6.72	101.20	13.93	8.58	0.36	1.91	tr	tr	tr	tr	tr	tr	tr	tr
2633/90	JGC2-4	75-110/130	0.46	0.08	2.35	105.40	13.86	10.12	0.51	2.22	tr	tr	tr	tr	tr	tr	tr	tr
2634/90	JGC2-6	145-175+	0.85	0.03	2.45	64.50	14.50	13.67	0.67	3.44	tr	tr	tr	tr	tr	tr	tr	tr

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
C = Clay
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre
(equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electrical Conductivity

PEDON 13 (Site No. TLC1)

LOCATION: About 10.5 km NE of Tilili town (about 300m SE of the Tilili-Gish Abay main road) in West Gojam Admn. Region, on a flat cultivated tract of land within a basin; approx. coordinates 10° 55.3'N and 37° 0.5'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Almost flat (1-2% slope) remnant of the old alluvial terrace within a broad basin; elevation 2,560m amsl.

Soil parent material: Mixed alluvium probably with some admixture of volcanic ash.

Present land use/vegetation cover: Grass land (fallowed) with >90% surface cover of grass; many hedgerows along the field boundaries.

Present erosion status: No or slight sheet/rill erosion.

Drainage conditions: Externally moderately well, internally imperfectly drained.

FAO soil classification: Umbri-Humic Alisols.

PROFILE DESCRIPTION:

Ap 0-12cm — Brownish black (7.5YR 2/2) moist; loam; weak fine granular; slightly sticky, plastic, very friable moist; few fine tubular pores; noncalcareous; EC(1:1) 0.4 dS/m; pH(H_2O) 4.4 (Sample No. TLC1-1).

Bw 12-52cm — Brownish black (7.5YR 2/2) moist, common fine distinct reddish brown mottles in lower part; loam; weak coarse subangular blocky breaking into fine granular; few krotovinas; slightly sticky, plastic, very friable moist; few medium and common fine tubular pores; noncalcareous; EC(1:1) 0.03 dS/m; common fine roots; gradual smooth boundary; pH(H_2O) 4.2 (Sample No. TLC1-2).

Abg 52-76cm — Dark brown (7.5YR 3/4) and bright brown (7.5YR 5/6) moist, many fine faint reddish brown and common medium distinct brownish black mottles; silty clay loam; weak medium and coarse subangular blocky; sticky, plastic, friable moist; few medium and many fine tubular pores; many tongues of material from the upper horizon; noncalcareous; EC(1:1) 0.02 dS/m; very few, very fine roots; abrupt smooth boundary; pH(H_2O) 4.4 (Sample No. TLC1-3).

Btbcs1 76-87cm — Yellowish brown (10YR 5/6) and bright reddish brown (2.5YR 5/6) moist, profusely mottled; silty clay loam; massive; weakly cemented; sticky, plastic, very firm moist; few fine tubular pores; many (about 60%) medium and coarse Fe-Mn concretions; noncalcareous; EC(1:1) 0.02 dS/m; no roots; clear smooth boundary; pH(H_2O) 4.6 (Sample No. TLC1-4).

Btbcs2 87-110cm — Yellowish brown (10YR 5/6) moist, profusely mottled; silty clay loam; moderate medium angular blocky; sticky, plastic, firm moist; few fine tubular pores; thin patchy clay cutans on bed faces; many (about 20%) medium and fine Fe-Mn concretions; noncalcareous; Ec(1:1) 0.04 dS/m; no roots; clear smooth boundary; pH(H_2O) 4.7 (Sample No. TLC1-5).

Btbg1 110-135cm — Bright reddish brown (2.5Y 5/6) and greyish yellow (2.5YR 6/2) moist, profusely mottled; silty clay; moderate coarse angular blocky; sticky, plastic, firm moist; no pores; thin patchy clay cutans; few fine Fe-Mn concretions; noncalcareous; EC(1:1) 0.05 dS/m; no roots; clear smooth boundary; pH(H_2O) 4.8 (Sample No. TLC1-6).

Btbg2 135-150cm — Variegated, bright reddish brown (5Y 5/6), greyish yellow (2.5Y 6/2) and brownish black (10YR 3/2) moist, profusely mottled; silty clay; moderate medium and coarse angular blocky; sticky, plastic, very firm moist; no pores; common fine Fe-Mn concretions; noncalcareous; EC(1:1) 0.06 dS/m; no roots; clear smooth boundary; pH(H_2O) 5.0 (Sample No. TLC1-7).

Btbg3 150-200cm+ — Dull reddish brown (5YR 4/4) moist, profusely mottled; clay; weak coarse angular blocky; very sticky, very plastic, extremely firm moist; few fine tubular pores; moderately thick Mn coatings on ped faces; common fine and medium Fe-Mn concretions; noncalcareous; EC(1:1) 0.1 dS/m; no roots; pH(H_2O) 5.5 (Sample No. TLC1-8).

LABORATORY ANALYTICAL DATA (PEDON 13)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1)	Exch. cations (meq/100g)						CEC (meq/100g	Base sat (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL	(dS/m)	Na	K	Ca	Mg	Al	H		
2649/90	TLC1-1	0-12	2	83	15	SiL	4.35	3.80	0.04	0.61	0.45	1.25	0.54	nd	nd	43.96	6.48
2650/90	TLC1-2	12-52	2	75	23	SiL	4.24	3.77	0.03	0.56	0.31	0.49	0.27	nd	nd	37.94	4.30
2651/90	TLC1-3	52-76	6	49	45	SiC	4.44	3.60	0.02	0.50	0.16	1.18	0.27	nd	nd	30.33	6.96
2652/90	TLC1-4	76-87	33	26	41	C	4.64	3.62	0.02	0.55	0.20	3.80	1.00	nd	nd	29.20	19.01
2653/90	TLC1-5	87-110	5	26	69	C	4.72	3.64	0.04	0.60	0.30	10.39	3.74	nd	nd	43.32	34.70
2654/90	TLC1-6	110-135	2	33	65	C	4.78	4.58	0.05	0.57	0.37	12.58	5.15	nd	nd	46.39	40.25
2655/90	TLC1-7	135-150	2	49	49	SiC	4.96	4.16	0.06	0.61	0.30	12.51	5.26	nd	nd	37.43	49.91
2656/90	TLC1-8	150-200+	3	24	73	C	5.45	5.45	0.12	0.61	0.44	11.32	5.51	nd	nd	34.50	51.83

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/l)				Soluble anions (meq/l)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2649/90	TLC1-1	0-12	13.89	0.74	21.76	70.40	16.40	5.41	0.15	0.06	tr	tr	tr	tr	tr	tr	tr	tr
2650/90	TLC1-2	12-52	6.17	0.37	25.12	48.51	13.36	0.88	0.19	0.04	tr	tr	tr	tr	tr	tr	tr	tr
2651/90	TLC1-3	52-76	1.32	0.08	9.08	21.36	3.35	4.69	0.06	0.02	tr	tr	tr	tr	tr	tr	tr	tr
2652/90	TLC1-4	76-87	2.82	0.06	6.51	27.13	5.83	7.59	0.16	0.04	tr	tr	tr	tr	tr	tr	tr	tr
2653/90	TLC1-5	87-110	0.26	0.04	0.55	38.29	1.44	3.61	0.56	0.15	tr	tr	tr	tr	tr	tr	tr	tr
2654/90	TLC1-6	110-135	0.30	0.02	0.76	49.23	1.96	0.43	1.09	0.24	tr	tr	tr	tr	tr	tr	tr	tr
2655/90	TLC1-7	135-150	0.45	0.03	1.20	43.52	4.24	3.60	0.36	0.23	tr	tr	tr	tr	tr	tr	tr	tr
2656/90	TLC1-8	150-200+	0.50	0.05	14.43	70.53	6.85	6.72	0.65	0.75	tr	tr	tr	tr	tr	tr	tr	tr

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiC = Silty Clay
C = Clay
SiL = Silt Loam
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre
(equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre

PEDON 14 (Site No. TLC5)

LOCATION: About 12 km NE of Tilili town (about 400m SE of the Tilili-Gish Abay main road) in West Gojam Admn. Region, on a flat grass land; approx. coordinates 10° 55.8'N and 37° 0.5'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Flat to slightly concave middle part of a broad basin with <1% slope; elevation 2,530m amsl.

Soil parent material: Mixed river alluvium probably with some admixture of volcanic ash.

Present land use/vegetation cover: Mainly grass land with >90% surface cover of vegetation; no trees/bushes; peripheral parts of the basin rainfed cultivated for mainly teff and barley.

Present erosion status: Slight sheet/rill erosion; an old gully runs through the middle part of the basin.

Drainage conditions: Imperfectely (seasonally poorly) drained; ground water table at 105cm depth.

FAO soil classification: Humi-Umbric Gleysols.

PROFILE DESCRIPTION:

Ah1 0-8cm — Brownish black (7.5YR 2/2) moist, common medium and fine distinct reddish brown and black mottles; loam; massive to weak fine granular; slightly sticky, plastic, friable moist; few fine tubular pores; noncalcareous; EC(1:1) 0.04 dS/m; common medium and many fine roots; clear smooth boundary pH(H_2O) 4.6 (Sample No. TLC5-1).

Ah2 8-55cm — Light grey (10YR 7/1) moist, loam; moderate fine granualr; slightly sticky, plastic, very friable moist; common coarse and medium, few fine tubular pores; noncalcareous; EC(1:1) 0.04 dS/m; common fine roots; gradual smooth boundary; pH(H_2O) 4.6 (Sample No. TLC5-2).

Ab 55-75cm — Brownish black (7.5YR 2/2) moist, common fine and medium distinct yellowish brown mottles; silt loam that approaches silty clay loam; moderate medium and fine subangular blocky; sticky, plastic, friable moist; common medium and fine tubular pores; noncalcareous; EC(1:1) 0.1 dS/m; few very fine roots; gradual smooth boundary; pH(H_2O) 5.0 (Sample No. TLC5-3).

Btbh1 75-180cm+ — Variegated, brown (7.5YR 4/3) moist when crushed, profusely mottled with yellowish brown, reddish brown and black; silty clay loam changing to clay below 130 cm; moderate fine subangular blocky; few coarse, common medium and many fine tubular pores; noncalcareous; many fine soft Mn concretions below 130 cm; EC(1:1) 0.1 dS/m; no roots; pH(H_2O) 5.1 (Sample No. TLC5-4).

LABORATORY ANALYTICAL DATA (PEDON 14)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1)	Exch. cations (meq/100g)						CEC (meq/ 100g	Base sat. (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL	(dS/m)	Na	K	Ca	Mg	Al	H		
2657/90	TLC5-1	0-8	0	79	21	SiL	4.55	3.87	0.04	0.75	0.52	5.40	1.36	nd	nd	45.17	17.78
2658/90	TLC5-2	8-55	2	73	25	SiL	4.63	3.93	0.04	0.72	0.33	1.39	0.47	nd	nd	55.25	5.27
2659/90	TLC5-3	55-75	1	44	55	SiC	4.99	3.75	0.10	1.34	0.29	7.07	2.69	nd	nd	37.63	30.27
2660/90	TLC5-4	75-130+	3	40	57	SiC	5.06	3.90	0.08	1.07	0.27	7.07	4.55	nd	nd	35.91	36.09

Lab No.	Sample No	Depth (cm)	Organ. Matter (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/l)				Soluble anions (meq/l)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2657/90	TLC5-1	0-8	6.21	0.48	24.77	92.74	44.00	13.09	0.30	0.26	tr	tr	tr	tr	tr	tr	tr	tr
2658/90	TLC5-2	8-55	6.63	0.45	70.15	44.40	12.21	7.99	0.19	0.17	tr	tr	tr	tr	tr	tr	tr	tr
2659/90	TLC5-3	55-75	2.41	0.20	41.43	42.62	10.60	3.10	0.34	0.30	tr	tr	tr	tr	tr	tr	tr	tr
2660/90	TLC5-4	75-130+	1.64	0.11	7.33	51.15	20.40	0.71	0.37	0.34	tr	tr	tr	tr	tr	tr	tr	tr

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiC = Silty Clay
SiL = Silty Loam
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electrical Conductivity

PEDON 15 (Site No. FTC1)

LOCATION: About 4 km NW of Fagta village (along Addis Kidane - Fagta main track, about 1.2 km ESE of Sigle Yohannes church) in West Gojam Admn. Region, on the sloping side of a ridge; approx. coordinates 11° 05.4'N and 37° 0.6'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic Position: Old alluvial subterrace slope with 10-12% gradient; elevation 2,410m amsl.

Soil parent material: Mixed alluvium with some colluvium mainly originated from the glacio-fluvial deposits of the upper old plateau surface.

Present landuse/vegetation cover: Mainly grass land (probably fallowed after long cultivation); about 5% surface cover of stones/gravels; 60-70% grass cover.

Present erosion status: Severe sheet, rill and gully erosion; common patches of exposed soil surface; gullies mainly developed from traditional criss-cross drainage ditches.

Drainage conditions: Externally well, internally moderately well drained.

FAO soil classification: Rhodi-Humic Alisols, part rudic phase.

PROFILE DESCRIPTION:

AP 0-12cm — Very drak reddish brown (5YR 2/3) moist, greyish brown (5YR 4/2) dry; clay loam; massive to weak fine granular; few fine and medium tubular pores; noncalcareous; EC(1:1) 0.10 dS/m; common medium and many fine roots; clear smooth boundary; pH(H_2O) 5.5 (Sample No. FTC1-1).

BA 12-40/54cm — Very dark reddish brown (5YR 2/3) and dark reddish brown (5YR 3/3) moist; common medium and coarse faint brownish black mottles; clay loam that approaches clay; weak medium subangular blocky breaking into fine granular; few krotovinas infilled with black, fine granular clay material; few coarse, common medium and many fine tubular pores; few fine Fe-Mn concretions; noncalsareous; EC(1:1) 0.09 dS/m; few medium and common fine roots; clear wavy boundry; pH(H_2O) 5.8 (Sample No. FTC1-2).

Bt2 62-200cm+ — Dark reddish brown (5YR 3/4) moist, common medium and coarse faint reddish yellow and brownish black mottles; clay; moderate medium and fine angular to subangular blocky; few coarse, common medium and many fine tubular pores; thin nearly continuous clay cutans on ped faces; many fine and medium Fe-Mn concretions; noncalcareous; EC(1:1) 0.05 dS/m; few to common fine roots; pH(H_2O) 5.4 (Sample No. FTC1-4).

LABORATORY ANALYTICAL DATA (PEDON 15)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)			Exch. cations (meq/100g)						CEC (meq/100g	Base sat (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL	EC(1:1) (dS/m)	Na	K	Ca	Mg	Al	H		
2661/90	FTC1-1	0-12	3	66	31	SiCL	5.53	4.17	0.10	0.65	0.93	11.35	2.97	nd	nd	41.29	38.51
2662/90	FTC1-2	12-40/54	3	46	51	SiC	5.84	4.37	0.09	0.63	0.89	9.26	4.37	nd	nd	42.80	35.40
2663/90	FTC1-3	62-200+	2	47	51	SiC	5.40	4.09	0.05	0.60	0.72	5.82	2.47	nd	nd	23.98	40.08

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail P (ppm)	Avail K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/l)				Soluble anions (meq/l)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2661/90	FTC1-1	0-12	5.74	0.30	3.13	151.30	24.20	70.35	0.32	0.69	tr	tr	tr	tr	tr	tr	tr	tr
2662/90	FTC1-2	12-40/54	3.73	0.20	5.36	155.30	15.63	1.09	0.23	0.89	tr	tr	tr	tr	tr	tr	tr	tr
2663/90	FTC1-3	62-200+	0.69	0.09	1.90	132.20	10.62	5.81	0.27	0.59	tr	tr	tr	tr	tr	tr	tr	tr

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiCL = Silty Clay Loam
SiC = Silty Clay
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre
(equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capability
EC = Electrical Conductivity

PEDON 16 (Site No. FTC2)

LOCATION: About 4.5km NW of Fagta village (along Addis Kidane - Fagta main track, about 1 km ESE of Sigle Yohannes Church) in West Gojam Admn. Region, on a gently sloping cultivated terrace; approx. coordinates 11° 05.5 N and 37° 0.5'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Gently sloping old alluvial terrace/terracette with 3-4% slope; elevation 2,395m amsl.

Soil parent material: Mixed river alluvium probably with some admixture of volcanic ash.

Present land use/vegetation cover: Aable land used for rainfed cultivation of mainly maize and teff; 2-5% surface cover of stones.

Present erosion status: Moderate sheet and rill erosion; few gullies in the adjoining parts.

Drainage conditions: Externally well, internally moderately well drained.

FAO Soil Classification: Humic Alisols, rudic phase.

PROFILE DESCRIPTION:

AP 0-15cm — Dark brown (5YR 3/3) moist, dull brown (5YR 5/3) dry; clay loam; weak fine granular; few krotovinas; sticky, plastic, very friable moist, slightly hard dry; few medium tubular pores; noncalcareous; EC(1:1) 0.13 dS/m; few medium and many fine roots; clear smooth boundary; pH(H_2O) 5.3 (Sample No. FTC2-1).

AB 15-50cm — Brownish black (7.5YR 3/2) moist; clay loam; moderate medium and fine subangular blocky; few krotovinas; sticky, plastic, friable moist; few medium and common fine tubular pores; noncalcareous; EC(1:1) 0.09 dS/m; common to many fine roots; diffuse smooth boundary; pH(H_2O) 5.5 (Sample No. FTC2-2).

Bt1 50-92cm — Brownish black (7.5YR 2/2) moist; clay loam that approaches clay;; moderate medium subangular blocky; few krotovinas; sticky, plastic, friable moist; common medium and many fine tubular pores; noncalcareous; EC(1:1) 0.08 dS/m; common fine roots; gradual smooth boundary; pH(H_2O) 5.3 (Sample No. FTC2-3).

Bt2 90-150cm — Dark brown (7.5YR 3/4) moist, common fine and medium faint yellowish brown mottles; clay; moderate fine and medium subangular blocky; few pockets of brownish black loamy material; very sticky, very plastic, firm moist; few coarse, few medium and common fine tubular pores; thin patchy clay cutans on ped faces; noncalcareous; EC(1:1) 0.06 dS/m; few very fine roots; pH(H_2O) 5.4 (Sample No. FTC2-4).

Btg 150-200cm+ — Same as Bt2 except having many medium and fine prominent black mottles.

LABORATORY ANALYTICAL DATA (PEDON 16)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1)	Exch. cations (meq/100g)						CEC (meq/100g	Base sat (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H20	KCL	(dS/m)	Na	K	Ca	Mg	Al	H		
2664/90	FTC2-1	0-15	5	66	29	SiCL	5.30	4.17	0.13	0.60	0.50	12.73	2.25	nd	nd	48.09	33.44
2665/90	FTC2-2	15-50	3	60	37	SiCL	5.49	4.06	0.09	1.12	0.34	12.35	2.45	nd	nd	25.68	63.32
2666/90	FTC2-3	50-92	4	53	43	SiC	5.28	3.84	0.08	0.72	0.32	9.49	2.36	nd	nd	54.90	23.48
2667/90	FTC2-3	92-200+	5	42	53	SiC	5.43	3.88	0.06	0.62	0.27	9.27	2.48	nd	nd	39.62	31.90

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail P (ppm)	Avail K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/1)				Soluble anions (meq/1)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2664/90	FTC2-1	0-15	6.66	0.40	1.31	60.12	23.60	7.43	0.37	0.65	tr	tr	tr	tr	tr	tr	tr	tr
2665/90	FTC2-2	15-50	6.12	0.33	1.52	48.96	19.30	2.65	0.28	0.52	tr	tr	tr	tr	tr	tr	tr	tr
2666/90	FTC2-3	50-92	4.75	0.25	11.72	43.40	15.40	1.42	0.21	0.41	tr	tr	tr	tr	tr	tr	tr	tr
2667/90	FTC2-4	92-200+	1.69	0.10	3.83	37.28	11.70	1.32	0.08	1.06	tr	tr	tr	tr	tr	tr	tr	tr

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiCL = Silty Clay Loam
SiC = Silty Clay
ppm = parts per million
meq/l = milliequivalents per litre
dS/m = deci Siemens per metre
(equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capability
EC = Electrical Conductivity

PEDON 17 (Site No. FTC7)

LOCATION: About 5 Km NW of Fagta village (about 750m E of Sigle Yohannes Church) in West Gojam Admn. Region, on a steeep cultivated tract of land alongside the Fagtit river; approx. coordinates 11° 05.6' N and 37° 0.4'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Moderately steep, lower part of a colluvial slope/escarpment; 15-20% slope; elevation 2,370m amsl.

Soil parent material: Mixed river alluvium with some culluvium derived from the glacio-fluvial deposits of the old plateau surface and the upper alluvial terraces.

Present land use/vegetation cover: Arable land used for rainfed cultivation of mainly maize and finger millet; 5-10 percent surface cover of stones.

Present erosion status: Severe sheet, rill and gully erosion; about 30% area occupied by exposed rock; common deep gullies evident.

Drainage conditions: Externally well, internally moderately well drained.

FAO Soil Classification: Rhodi-Haplic Alisols, sloping phase.

PROFILE DESCRIPTION:

AP 0-10 cm — Dark reddish brown (2.5YR 3/6) moist, reddish brown (2.5YR 4/6) dry; clay loam; massive; sticky, plastic, friable moist, very hard dry; noncalcareous; EC (1:1) 0.07 dS/m; few medium and fine roots; pH(H_2O) 5.3 (Sample No. FTC7-1).

Bt 10-100cm+ — Dull reddish brown (1YR 3/6) moist, reddish brown (1YR 4/6) dry; clay; very sticky, very plastic, firm moist, extremely hard dry; noncalcareous; EC(1:1) 0.06 dS/m; pH(H_2O) 5.3 (Sample No. FTC7-2).

Remarks: The soil was described and sampled by augering right from the surface.

LABORATORY ANALYTICAL DATA (PEDON 17)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1)	Exch. cations (meq/100g)						CEC (meq/100g	Base sat (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL	(dS/m)	Na	K	Ca	Mg	Al	H		
2668/90	FTC7-1	0-10	2	33	65	C	5.25	3.95	0.07	0.67	0.37	6.33	2.23	nd	nd	36.48	26.32
2669/90	FTC7-2	10-100+	2	33	65	C	6.05	5.27	0.06	0.64	0.24	8.66	2.74	nd	nd	32.28	38.04

Lab No.	Sample No	Depth (cm)	Orga. Matt. (%)	Total N (%)	Avail P (ppm)	Avail K kg/ha	Extratcable micro-nutrients (ppm)				Soluble cations (meq/1)				Soluble anions (meq/1)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2668/90	FTC7-1	0-10	1.63	0.13	2.04	53.65	5.40	7.51	0.30	0.32	tr	tr	tr	tr	tr	tr	tr	tr
2669/90	FTC7-2	10-100+	0.54	0.06	0.85	42.48	3.12	3.16	0.21	0.16	tr	tr	tr	tr	tr	tr	tr	tr

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
C = Clay
ppm = parts per million
meq/1 = milliequivalents per litre
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g = milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capability
EC = Electrical Conductivity

PEDON 20 (Site No. ATI7)

LOCATION: About 2.5km NE of Agut village (about 200 metres east of the main foot track crossing of Yingri river) in West Gojam Admn. Region, on a flat cultivated tract of land; approx. coordinates 10°40.3'N and 37°11.4'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Almost flat middle part of a levee in recent floodplain; 1 to 1.5 percent slope; elevation about 2,340m amsl

Soil parent material: Mixed river alluvium probably with some admixture of volcanic ash/ignimbrite.

Present land use/vegetation cover: Arable land used for rainfed cultivation of mainly maize, teff and barley with some potatoes, supplemented with irrigation by diverted canal.

Drainage conditions: Moderately well drained; casually receiving light, short-lived sheet flooding from Yingri river; groundwater table between 150 and 200 cm.

FAO soil classification: Rhodi-Umbric Fluvisols, phreatic phase

PROFILE DESCRIPTION:

Ap 0-12cm Dark reddish brown (5YR 3/3) moist; clay loam; massive; slightly sticky, plastic, friable moist; few fine tubular pores; few krotovinas; noncalcareous; EC(1:1) 0.23dS/m; common medium and fine roots; clear smooth boundary; pH(H2O) 5.4 (Sample No. ATI7-1).

Bw 12-42cm Dark reddish brown (5YR 3/3) moist, many fine faint reddish brown, few fine distinct black mottles; loam and clay loam, mixed; very weak coarse subangular blocky with about 30% remnant of original rock structure; slightly sticky, slightly plastic, friable moist; few fine tubular pores; noncalcareous; EC(1:1) 0.12dS/m; few medium and common fine roots; clear smooth boundary; pH(H2O) 5.8 (Sample No. ATI7-2).

Bwg1 42-76cm Very dark reddish brown (5YR 2/3) moist, common medium and fine distinct black and few medium distinct reddish brown mottles; loam; weak coarse subangular blocky with about 30% remnant of original rock structure; slightly sticky, plastic, friable moist; few fine tubular pores; noncalcareous; EC(1:1) 0.11dS/m; few fine roots; clear smooth boundary; pH(H2O) 5.7 (Sample No. ATI7-3).

Bwg2 76-98cm Dark reddish brown (5YR 3/2) moist, many fine distinct reddish brown and common fine and medium distinct black mottles; loam; very weak coarse subangular blocky, part stratified; slightly sticky, slightly plastic, firm moist; few fine tubular pores; noncalcareous; EC(1:1) 0.11dS/m; no roots; clear smooth boundary; pH(H2O) 5.3 (Sample No. ATI7-4).

Abg 98-115cm Brownish black (7.5YR 2/2) moist, many fine and medium black mottles; clay loam; moderate medium and fine subangular blocky breaking to fine granular; sticky, plastic, very friable moist; few fine tubular pores; few fine Fe-Mn concretions; noncalcareous; EC(1:1) 0.03dS/m; no roots; clear smooth boundary; pH(H2O) 5.3 (Sample No. ATI7-5).

Bbg 115-150cm+ Very dark brown (7.5YR 2/3) moist, few fine distinct black and reddish brown mottles, many prominent yellowish brown and reddish brown below 160cm; clay; moderate medium and fine subangular blocky breaking to fine granular; very sticky, very plastic, very firm moist; few fine tubular pores; common fine Fe-Mn concretions; noncalcareous; EC(1:1) 0.14dS/m; no roots; pH(H2O) 5.9 (Sample No. ATI7-6).

LABORATORY ANALYTICAL DATA (PEDON 20)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1) (dS/m)	Exch. cations (meq/100g)						CEC (meq/ 100g	Base sat. (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL		Na	K	Ca	Mg	Al	H		
2692/90	ATI7-1	0-15	6	52	42	SiC	5.43	4.58	0.232	0.69	0.72	11.82	5.23	nd	nd	39.62	46.59
2693/90	ATI7-2	15-42	6	58	36	SiCL	5.83	4.53	0.121	0.70	0.42	20.69	17.86	nd	nd	41.80	94.90
2694/90	ATI7-3	42-76	5	59	36	SiCL	5.66	4.51	0.112	0.70	0.46	12.31	4.37	nd	nd	38.00	46.95
2695/90	ATI7-4	76-98	0	76	24	SiL	5.34	4.28	0.113	0.64	0.36	12.77	4.37	nd	nd	27.90	65.02
2696/90	ATI7-5	98-115	1	77	22	SiL	5.32	4.41	0.033	0.70	0.33	21.88	8.96	nd	nd	36.98	86.18
2697/90	ATI7-6	115-150+	3	69	28	SiCL	5.91	4.77	0.136	0.64	0.30	16.29	7.61	nd	nd	42.14	58.95

Lab No.	Sample No	Depth (cm)	Organic Matter (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/1)				Soluble anions (meq/1)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2692/90	ATI7-1	0-15	4.483	0.216	5.80	133.10	21.30	16.18	0.34	0.95	tr	tr	tr	tr	tr	tr	tr	tr
2693/90	ATI7-2	15-42	1.744	0.089	4.71	58.96	16.50	15.43	0.25	0.81	tr	tr	tr	tr	tr	tr	tr	tr
2694/90	ATI7-3	42-76	5.284	0.209	6.36	74.97	19.27	17.99	0.33	0.91	tr	tr	tr	tr	tr	tr	tr	tr
2695/90	ATI7-4	76-98	4.479	0.263	5.67	48.28	23.69	13.94	0.36	1.24	tr	tr	tr	tr	tr	tr	tr	tr
2696/90	ATI7-5	98-115	3.708	0.263	3.58	43.00	32.03	9.46	0.45	1.39	tr	tr	tr	tr	tr	tr	tr	tr
2697/90	ATI7-6	115-150+	4.079	0.233	2.62	32.25	35.26	7.33	0.32	1.39	tr	tr	tr	tr	tr	tr	tr	tr

Lab No.	Sample No	Depth (cm)	Bulk dens. g/ccm	Water Content (%)				
				0.1 bar	0.33 bar (F.C.)	3 bar	15 bar (P.W.P)	Avail. Water Capac.
2692/90	ATI7-1	0-15	0.37	45.57	41.42	31.09	25.03	16.39
2693/90	ATI7-2	15-42	0.78	59.44	50.59	32.97	29.12	21.47
2694/90	ATI7-3	42-76	0.64	41.75	40.08	31.47	28.03	12.05
2695/90	ATI7-4	76-98	0.61	44.41	44.35	31.62	28.44	15.91
2696/90	ATI7-5	98-115	nd	nd	nd	nd	nd	
2697/90	ATI7-6	115-150+	0.56	36.72	35.42	28.79	28.10	7.32

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiCL = Silty Clay Loam
SiC = Silty Clay
ppm = parts per million
meq/1 = milliequivalents per litre
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electrical Conductivity
SiL = Silt loam

AGUT 'A' AREA (Irrigation Site No. 38a)

LABORATORY ANALYTICAL DATA OF WATER SAMPLE
(Yingri River water, sampled in Nov., 1990)

pH	= 7.89
EC (mmho/cm)	= 0.172
TDS (mg/l)	= 120

Cations (meq/l):

Calcium (Ca)	= 0.82
Magnesium (Mg)	= 0.82
Potassium (K)	= 0.036
Sodium (Na)	= 0.218
Boron (B)	= 0.003

Anions (meq/l):

Carbonates (CO3)	= Nil
Bicarbonates (HCO3)	= 1.199
Chlorides (Cl)	= 0.176
Sulphates (SO4)	= 0.003
Nitrates (NO3)	= Nil

SAR (Sodium Adsorption Ratio)	= 0.24
Adjusted SAR	= 0.29
RSC (Residual Sodium Carbonate)	= Nil

Water quality assessment: Highly suitable for irrigation

PEDON 21 (Site No. ATI1)

LOCATION: About 2km NNE of Agut village (about 300 metres SW of the Lah river) in West Gojam Admn. Region, on a gently sloping, terraced, cultivated tract of land; approx. coordinates 10°40.3'N and 37°11.4'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Gently sloping, lower parts of old alluvial terrace; 3 to 6% slope; elevation about 2,360m amsl

Soil parent material: Mixed river alluvium probably with some admixture of volcanic ash/ignimbrite.

Present land use/vegetation cover: Arable land used for rainfed cultivation of mainly maize, teff and barley with scanty supplemental irrigation from diverted canal.

Drainage conditions: Externally well, internally moderately well drained.

FAO soil classification: Rhodi-Haplic Alisols

PROFILE DESCRIPTION:

Ap 0-12cm Dark reddish brown (5YR 3/3) moist, dull reddish brown (5YR 5/4) dry; clay loam; massive; sticky, plastic, friable moist, hard dry; few fine tubular pores; noncalcareous; EC(1:1) 0.13dS/m; few medium and common fine roots; clear smooth boundary; pH(H2O) 5.8 (Sample No. ATI1-1)

Btg1 12-45cm Dark reddish brown (5YR 3/3 and 3/6) moist, common medium and coarse distinct black mottles; clay; weak medium and coarse subangular blocky; sticky, plastic, firm moist; few infillings of topsoil material; few medium and fine tubular pores; few fine Fe-Mn concretions; noncalcareous; EC(1:1) 0.12dS/m; few fine roots; clear smooth boundary; pH(H2O) 5.9 (Sample No. ATI1-2)

Btg2 45-75cm Reddish brown (5YR 4/6) moist, common medium and coarse prominent black mottles; clay; moderate medium and coarse angular blocky; sticky, plastic, firm moist; few infillings of topsoil material; very thin patchy clay cutans on ped faces; few fine tubular pores; common medium and fine Fe-Mn concretions; noncalcareous; EC(1:1) 0.13dS/m; few very fine roots; gradual smooth boundary; pH(H2O) 5.9 (Sample No. ATI1-3).

Btg3 75-150cm+ Dull reddish brown (2.5YR 3/4) moist, common medium and coarse prominent black mottles; clay; moderate to strong fine angular blocky; very sticky, very plastic, very firm moist; thin nearly continuous clay cutans on ped faces; few fine, few medium and few coarse tubular pores; many medium and fine Fe-Mn concretions; noncalcareous; EC(1:1) 0.13dS/m; very few very fine roots; pH(H2O) 5.6 (Sample No. ATI1-4)

LABORATORY ANALYTICAL DATA (PEDON 21)

Lab No.	Sample No	Depth (cm)	TEXTURE Sand (%)	Silt (%)	Clay (%)	Class	pH(1:1) H2O	pH(1:1) KCL	EC(1:1) (dS/m)	Exch. cations (meq/100g) Na	K	Ca	Mg	Al	H	CEC (meq/100g	Base sat. (%)
88/90	ATI1-1	0-12	5	51	44	SiC	5.8	4.6	0.131	0.71	0.85	10.14	3.82	nd	nd	38.20	40.63
89/90	ATI1-2	12-45	3	25	72	C	5.9	4.5	0.117	0.71	0.49	9.63	3.56	nd	nd	40.02	35.96
90/90	ATI1-3	45-75	4	22	74	C	5.9	4.5	0.130	0.71	0.40	12.92	4.02	nd	nd	39.24	46.00
91/90	ATI1-4	75-150+	4	22	74	C	5.6	4.3	0.130	0.70	0.37	11.77	3.75	nd	nd	40.66	40.80

Lab No.	Sample No	Depth (cm)	Organic Matter (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm) Fe	Mn	Zn	Cu	Soluble cations (meq/1) Na	K	Ca	Mg	Soluble anions (meq/1) CO3	HCO3	Cl	SO4
688/90	ATI1-1	0-12	4.012	0.231	1.81	154.70	19.41	17.07	0.36	1.30	tr	tr	tr	tr	tr	tr	tr	tr
689/90	ATI1-2	12-45	0.920	0.098	2.35	64.20	7.81	5.45	0.21	0.57	tr	tr	tr	tr	tr	tr	tr	tr
690/90	ATI1-3	45-75	0.332	0.083	2.78	42.88	3.79	4.80	0.08	0.21	tr	tr	tr	tr	tr	tr	tr	tr
691/90	ATI1-4	75-150+	0.589	0.090	1.99	37.45	2.37	6.78	0.10	0.25	tr	tr	tr	tr	tr	tr	tr	tr

Lab No.	Sample No	Depth (cm)	Bulk dens. g/ccm	Water Content (%) 0.1 bar	0.33 bar (F.C.)	3 bar	15 bar (P.W.P)	Avail. Water Capac.
2688/90	ATI1-1	0-12	0.51	39.25	36.00	31.08	21.58	14.42
2689/90	ATI1-2	12-45	0.65	39.02	37.53	28.29	24.49	13.04
2690/90	ATI1-3	45-75	0.94	44.45	41.49	29.09	25.79	15.70
2691/90	ATI1-4	75-150+	0.68	41.39	39.54	32.16	26.94	12.60

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiC = Silty Clay
ppm = parts per million
meq/1 = milliequivalents per litre
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electrical Conductivity
C = Clay

PEDON 21 (ATI1)

WATER INFILTRATION CURVE

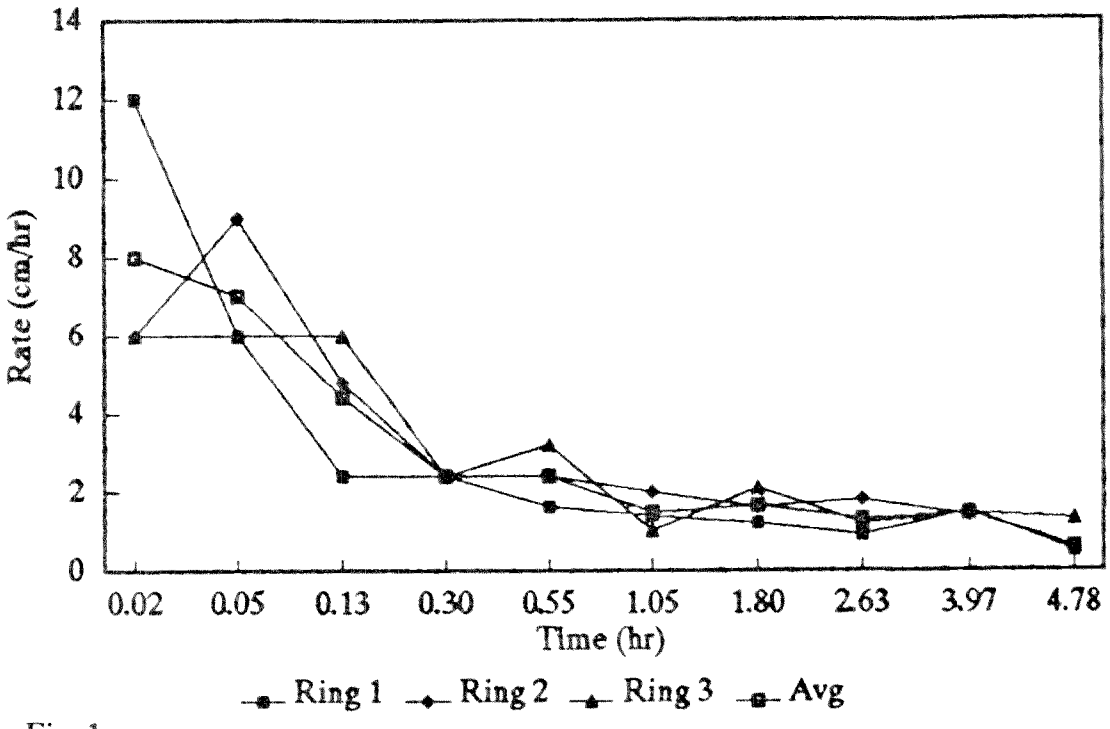


Fig. 1

Basic Infiltration Rate (cm/hr): Replicate 1 = 1.2

Replicate 2 = 1.4

Replicate 3 = 1.4

Average = 1.3

AGUT 'B' AREA (Irrigation Site No. 42)

LABORATORY ANALYTICAL DATA OF WATER SAMPLE
(Lah River water, sampled in Nov., 1990)

pH	= 7.55
EC (mmho/cm)	= 0.131
TDS (mg/l)	= 124

Cations (meq/l):

Calcium (Ca)	= 0.62
Magnesium (Mg)	= 0.74
Potassium (K)	= 0.041
Sodium (Na)	= 0.174
Boron (B)	= 0.004

Anions (meq/l):

Carbonates (CO3)	= Nil
Bicarbonates (HCO3)	= 1.149
Chlorides (Cl)	= 0.099
Sulphates (SO4)	= 0.023
Nitrates (NO3)	= Nil

SAR (Sodium Adsorption Ratio)	= 0.21
Adjusted SAR	= 0.25
RSC (Residual Sodium Carbonate)	= Nil

Water quality assessment: Highly suitable for irrigation

PEDON 12 (Site No. MKII)

LOCATION: About 3.5km SE of Mankusa town, about 300 metres west of the Debohila river, in West Gojam Admn. Region, on a gently sloping cultivated tract of land; approx. coordinates 10°40.3'N and 37°11.4'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Gently sloping, lower parts of old alluvial terrace; 4 to 5% slope; elevation 1,920m amsl

Soil parent material: Mixed river alluvium probably with some admixture of volcanic ash/ignimbrite.

Present land use/vegetation cover: Arable land used for growing of maize, coffee, teff, pepper, sugarcane and banana with supplemental canal irrigation; many trees and bushes commonly found in the fields.

Drainage conditions: Well drained

FAO soil classification: Rhodi-Chromic Luvisols

PROFILE DESCRIPTION:

Ap 0-27cm Dark reddish brown (5YR 3/3) moist, dull reddish brown (5YR 4/4) dry; clay loam; massive to weak coarse subangular blocky; sticky, plastic, friable moist, very hard dry; few medium and many fine tubular pores; noncalcareous; EC(1:1) 0.07dS/m; few coarse, common medium and many fine roots; clear smooth boundary; pH(H2O)6.0 (Sample No. MKI-1)

Bt1 27-102cm Dark reddish brown (2.5YR 3/4) moist, dull reddish brown (2.5YR 4/4) dry; clay; moderate medium and coarse angular blocky; very sticky, very plastic, very firm moist, extremely hard dry; few krotovinas; thin patchy clay cutans on ped faces; few fine tubular pores; few fine Fe-Mn concretins; few subrounded stones and boulders with moderately thick coatings of Fe2O3; noncalcareous; EC(1:1) 0.06dS/m; few coarse and medium, common fine roots; diffuse smooth boundary; pH(H2O) 6.1.(Sample No. MKII-2)

Bt2 102-185cm+ Dark reddish brown (2.5YR 3/5) moist; clay; weak medium subangular blocky; very sticky, very plastic, very firm moist; very thin patchy clay cutans on ped faces; few fine tubular pores; few fine Fe-Mn concretions; few subrounded stones and boulders with moderately thick coatings of Fe2O3, boulders increasing with depth; noncalcareous; EC(1:1) 0.07dS/m; few medium and common fine roots; pH(H2O) 6.2. (Sample No. MKII-3)

Remarks: The soil exceptionally has stones/boulders and relatively low porosity in the subsoil; the normal soils rarely have stones and are quite porous. The site was selected because all other fields under different crops.

LABORATORY ANALYTICAL DATA (PEDON 22)

) No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1) (dS/m)	Exch. cations (meq/100g)						CEC (meq/ 100g	Base sat. (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL		Na	K	Ca	Mg	Al	H		
35/90	MKI1-1	0-27	5	57	38	SiCL	5.95	4.48	0.066	0.90	1.34	25.56	8.88	nd	nd	39.28	93.38
36/90	MKI1-2	27-102	3	15	82	C	6.06	4.81	0.055	0.78	1.07	11.08	8.35	nd	nd	33.34	63.83
37/90	MKI1-3	102-185+	2	22	76	C	6.20	4.87	0.069	1.02	0.37	7.60	5.44	nd	nd	28.70	50.28

b No.	Sample No	Depth (cm)	Organic Matter (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/1)				Soluble anions (meq/1)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
85/90	MKI1-1	0-27	4.190	0.288	21.33	237.60	16.05	65.44	1.92	4.03	tr	tr	tr	tr	tr	tr	tr	tr
86/90	MKI1-2	27-102	1.488	0.126	1.16	211.00	3.27	8.22	0.14	1.18	tr	tr	tr	tr	tr	tr	tr	tr
87/90	MKI1-3	102-185+	0.692	0.052	0.11	63.30	1.43	3.48	0.12	0.40	tr	tr	tr	tr	tr	tr	tr	tr

ab No.	Sample No	Depth (cm)	Bulk dens. g/ccm	Water Content (%)				
				0.1 bar	0.33 bar (F.C.)	3 bar	15 bar (P.W.P)	Avail. Water Capac.
685/90	MKI1-1	0-27	0.78	39.68	35.55	30.00	25.64	9.91
686/90	MKI1-2	27-102	0.75	39.29	38.45	30.89	29.60	8.85
687/90	MKI1-3	102-185+	0.85	40.46	37.88	32.23	30.62	7.26

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiCL = Silty Clay Loam
ppm = parts per million
meq/1 = milliequivalents per litre 100 grams of soil
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electrical Conductivity
C = Clay

PEDON 22 (MKI1)

WATER INFILTRATION CURVE

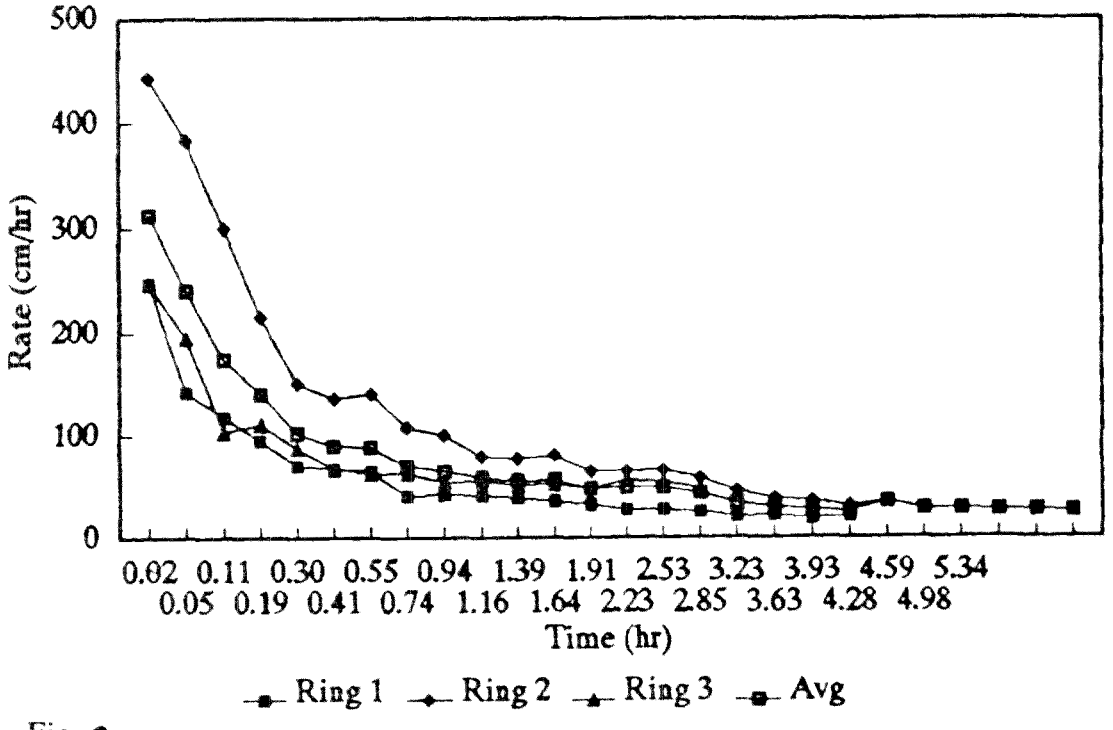


Fig. 2

Basic Infiltration Rate (cm/hr): Replicate 1 = 20.5

Replicate 2 = 34.3

Replicate 3 = 27.3

Average = 27.4

Remarks: The high infiltration rate was obtained probably due to the presence of krotovinas in the soil; the normal rate should be between 1 and 5 cm/hr as estimated from the soil porosity and structure of this and other representative pedons.

MANKUSA AREA (Irrigation Site No. 15)

LABORATORY ANALYTICAL DATA OF WATER SAMPLE
(Debohila River water, sampled in Nov., 1990)

pH	= 7.29
EC (mmho/cm)	= 0.289
TDS (mg/l)	= 224

Cations (meq/l):

Calcium (Ca)	= 1.24
Magnesium (Mg)	= 1.64
Potassium (K)	= 0.049
Sodium (Na)	= 0.296
Boron (B)	= 0.003

Anions (meq/l):

Carbonates (CO3)	= Nil
Bicarbonates (HCO3)	= 2.248
Chlorides (Cl)	= 0.162
Sulphates (SO4)	= 0.011
Nitrates (NO3)	= Nil

SAR (Sodium Adsorption Ratio)	= 0.25
Adjusted SAR	= 0.43
RSC (Residual Sodium Carbonate)	= Nil

Water quality assessment: Highly suitable for irrigation

PEDON 23 (Site No. YCI6)

LOCATION: About 350 metres south of the Finote Selam-Dembecha main road bridge of Yechereka river (600m SE of Yechereka town) in West Gojam Admn. Region, in a flat cultivated strip of land along the river; approx. coordinates 10°35.5'N and 37°25.4'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Almost flat middle part of a levee in recent floodplain of Yechereka river; 1.5 to 2 percent slope; elevation about 2,000m amsl

Soil parent material: Mixed river alluvium probably with some admixture of volcanic ash.

Present land use/vegetation cover: Arable land used for rainfed/flood-watered cultivation of mainly maize and teff; fallow parts with 70-80% grass cover; no trees.

Drainage conditions: Moderately well drained; casually receiving light, short-lived sheet flooding from Yechereka river; groundwater table between 150 and 200 cm.

FAO soil classification: Gleyic Cambisols, phreatic phase

PROFILE DESCRIPTION:

Ap 0-15cm Dark brown (7.5YR 3/3) moist, dull brown (7.5YR 5/4) dry; clay loam; massive; sticky, plastic, firm moist, very hard dry; few fine tubular pores; noncalcareous; EC(1:1) 0.30dS/m; few medium and many fine roots; clear smooth boundary; pH(H2O) 6.3 (Sample No. YCI6-1)

Bw 15-35cm Very dark rown (7.5YR 2/3) moist; clay loam; weak medium and coarse subangular blocky few krotovinas; sticky, plastic, very firm moist; few medium and fine tubular pores; noncalcareous; EC(1:1) 0.37dS/m; few medium and common fine roots; clear smooth boundary; pH(H2O) 5.9 (Sample No. YCI6-2)

Bwg1 35-85cm Dark reddish brown (5YR 3/3) moist, common fine prominent black and many medium faint reddish brown mottles; clay loam; weak medium and coarse subangular blocky; sticky, plastic, firm moist; few medium and coarse, common fine tubular pores; very thin very patchy clay cutans on ped faces; common fine Fe-Mn concretions; noncalcareous; EC(1:1) 0.32dS/m; few fine roots; diffuse smooth boundary; pH(H2O) 6.5 (Sample No. YCI6-3).

Bwg2 85-160cm+ Dark brown (7.5YR 3/4) moist, common fine prominent black and many medium and coarse faint reddish brown mottles; clay loam; very weak coarse subangular blocky; few pockets of silty infillings; sticky, plastic, firm moist; few medium and common fine tubular pores; common medium and fine Fe-Mn concretions; noncalcareous; EC(1:1) 0.28 dS/m; few very fine roots; pH(H2O) 7.1 (Sample No. YCI6-4).

Remarks: The soil was saturated with water below 160cm depth; the groundwater table was at 180 cm depth.

LABORATORY ANALYTICAL DATA (PEDON 23)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1) (dS/m)	Exch. cations (meq/100g)						CEC (meq/ 100g	Base sat. (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL		Na	K	Ca	Mg	Al	H		
78/90	YCI6-1	0-15	5	61	34	C	6.3	4.88	0.304	0.63	0.92	21.76	9.00	nd	nd	51.84	62.33
79/90	YCI6-2	15-35	6	58	36	SiCL	5.9	4.64	0.366	0.76	0.77	18.05	9.36	nd	nd	48.21	60.03
80/90	YCI6-3	35-85	4	54	42	SiC	6.5	4.88	0.317	0.85	0.36	20.13	10.31	nd	nd	37.54	84.31
81/90	YCI6-4	85-160+	6	62	32	SiCL	7.1	5.96	0.280	0.83	0.27	21.20	10.69	nd	nd	45.87	71.92

Lab No.	Sample No	Depth (cm)	Organic Matter (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/1)				Soluble anions (meq/1)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2678/90	YCI6-1	0-15	4.062	0.234	9.50	145.80	35.80	30.24	1.20	1.87	tr	tr	tr	tr	tr	tr	tr	tr
2679/90	YCI6-2	15-35	2.647	0.166	3.78	124.30	24.46	26.80	0.88	1.66	tr	tr	tr	tr	tr	tr	tr	tr
2680/90	YCI6-3	35-85	1.172	0.099	3.47	54.25	16.90	21.48	0.64	1.23	tr	tr	tr	tr	tr	tr	tr	tr
2681/90	YCI6-4	85-160+	0.936	0.061	5.76	54.35	13.00	22.82	0.58	1.13	tr	tr	tr	tr	tr	tr	tr	tr

Lab No.	Sample No	Depth (cm)	Bulk dens. g/cm	Water Content (%)				
				0.1 bar	0.33 bar (F.C.)	3 bar	15 bar (P.W.P)	Avail. Water Capac.
2678/90	YCI6-1	0-15	0.70	67.47	43.33	39.80	25.53	17.80
2679/90	YCI6-2	15-35	0.67	44.54	40.60	31.75	27.85	12.75
2680/90	YCI6-3	35-85	0.40	48.33	47.81	32.65	31.52	16.29
2681/90	YCI6-4	85-160+	0.70	47.25	41.88	31.78	30.75	11.13

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiC = Silty Clay
ppm = parts per million
meq/1 = milliequivalents per litre
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per 100 grams of soil
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electrical Conductivity
C = Clay
SiCL = Silty Clay Loam

PEDON 23 (YCI6)

WATER INFILTRATION CURVE

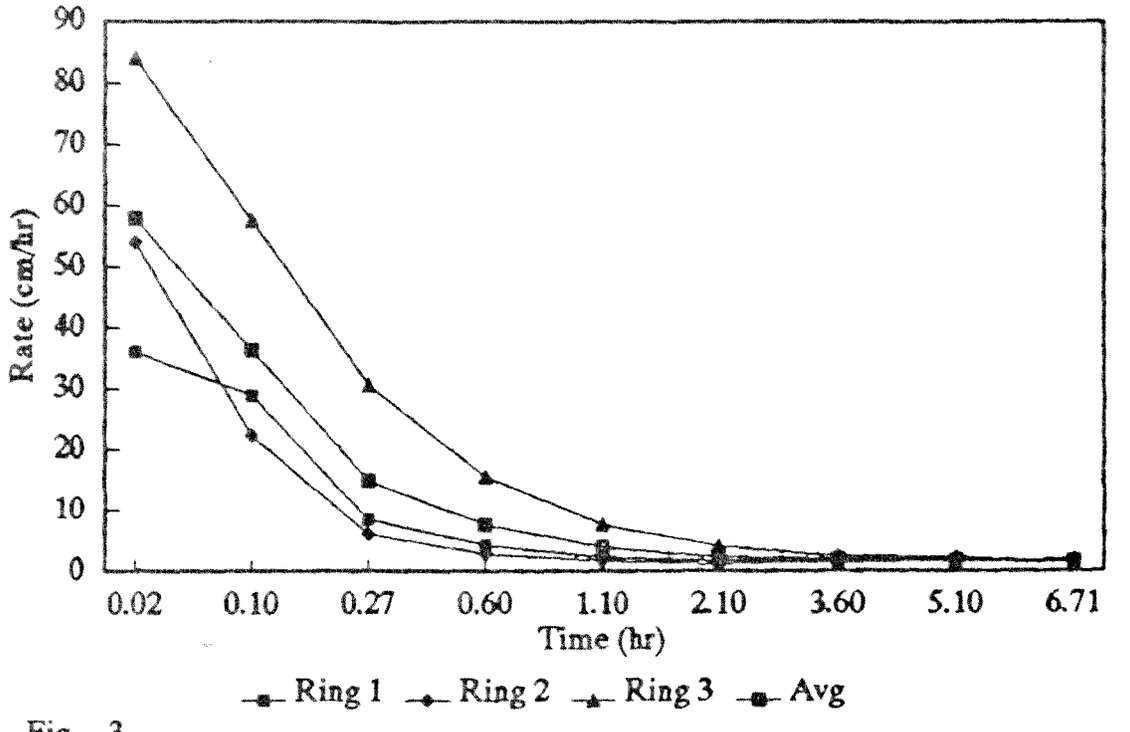


Fig. 3

Basic Infiltration Rate (cm/hr): Replicate 1 = 1.4

Replicate 2 = 1.7

Replicate 3 = 1.8

Average = 1.6

YECHEREKA AREA (Irrigation Site No. 14)

LABORATORY ANALYTICAL DATA OF WATER SAMPLE
(Yechereka River water, sampled in Nov., 1990)

pH	= 7.63
EC (mmho/cm)	= 0.094
TDS (mg/l)	= 106
Cations (meq/l):	
Calcium (Ca)	= 0.36
Magnesium (Mg)	= 0.60
Potassium (K)	= 0.031
Sodium (Na)	= 0.139
Boron (B)	= 0.002
Anions (meq/l):	
Carbonates (CO3)	= Nil
Bicarbonates (HCO3)	= 0.599
Chlorides (Cl)	= 0.134
Sulphates (SO4)	= 0.043
Nitrates (NO3)	= Nil
SAR (Sodium Adsorption Ratio)	= 0.20
Adjusted SAR	= 0.16
RSC (Residual Sodium Carbonate)	= Nil

Water quality assessment: Highly suitable for irrigation

PEDON 24 (Site No. YCI3)

LOCATION: About 1.4km south of the Finote Selam-Dembecha main road bridge of Yechereka river (about 2km SE of Yechereka town) in West Gojam Admn. Region, in a flat cultivated strip of land along the river; approx. coordinates 10°35.1'N and 37°25.2'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Almost flat lower part of a levee/basin in the recent floodplain of Yechereka river; 1 to 1.5 percent slope; elevation about 2,000m amsl

Soil parent material: Mainly clayey river alluvium probably with some admixture of volcanic ash.

Present land use/vegetation cover: Arable land used for rainfed/flood-watered cultivation of mainly teff; fallow parts with 70-80% grass cover; no trees.

Drainage conditions: Imperfectly (seasonally poorly) drained; annually receiving light, short-lived sheet flooding from Yechereka river; groundwater table within 100cm depth.

FAO soil classification: Eutric Gleysols, phreatic phase

PROFILE DESCRIPTION:

Ap 0-15cm Variegated, Dark brown (7.5YR 3/3) and olive black (5Y 2/2) moist, many medium and fine prominent reddish brown mottles; clay loam that approaches clay; massive; sticky, plastic, very firm moist; few fine tubular pores; noncalcareous; EC(1:1) 0.15dS/m; common medium and many fine roots; clear smooth boundary; pH(H2O) 6.3 (Sample No. YCI6-1).

Btg1 15-70cm Dark brown (7.5YR 3/3) moist, many medium and fine distinct black and faint reddish brown mottles; clay; moderate medium subangular blocky; very sticky, very plastic, very firm moist; few medium, common fine and many very fine tubular pores; very thin patchy clay cutans on ped faces; common fine Fe-Mn concretions; noncalcareous; EC(1:1) 0.14dS/m; few medium and common fine roots; pH(H2O) 6.7 (Sample No. YCI6-2).

Btg2 70-120cm+ Same as BTg1 except being saturated with water and no structure or porosity observable.

Remarks: The soil had groundwater table at 80 cm depth at the time of observation.

LABORATORY ANALYTICAL DATA (PEDON 24)

Lab No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1) (dS/m)	Exch. cations (meq/100g)						CEC (meq/ 100g	Base sat. (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL		Na	K	Ca	Mg	Al	H		
2676/90	YCI3-1	0-15	2	54	44	SiC	6.30	4.86	0.153	1.05	0.68	15.34	8.54	nd	nd	42.55	60.19
2677/90	YCI3-2	15-70+	4	56	40	SiC	6.70	5.09	0.142	0.94	0.25	18.23	10.28	nd	nd	49.12	60.46

Lab No.	Sample No	Depth (cm)	Organic Matter (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/1)				Soluble anions (meq/1)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
2676/90	YCI3-1	0-15	5.776	0.309	6.80	124.20	33.90	10.80	0.41	0.79	tr	tr	tr	tr	tr	tr	tr	tr
2677/90	YCI3-2	15-70+	1.190	0.106	3.25	37.87	19.60	16.01	0.56	1.32	tr	tr	tr	tr	tr	tr	tr	tr

Lab No.	Sample No	Depth (cm)	Bulk dens. g/ccm	Water Content (%)				
				0.1 bar	0.33 bar (F.C.)	3 bar	15 bar (P.W.P)	Avail. Water Capac.
2676/90	YCI3-1	0-15	0.67	6.55	56.05	33.53	33.18	22.87
2677/90	YCI3-2	15-70+	0.54	87.83	44.25	43.45	30.95	13.30

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiC = Silty Clay
ppm = parts per million
meq/1 = milliequivalents per litre 100 grams of soil
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electrical Conductivity

PEDON 25 (Site No. FSI1)

LOCATION: About 4.5km east of Finote Selam town (about 1.5km NW of the Finote Selam-Jiga main road bridge of Temim river, along its right bank) in West Gojam Admn. Region, in a flat cultivated strip of the river floodplain; approx. coordinates 10°41.5'N and 37°18'E.

LANDSCAPE CHARACTERISTICS:

Landform and physiographic position: Almost flat part of the recent floodplain of Temim river; 1-2% slope; elevation about 1,830m amsl

Soil parent material: Mixed river alluvium probably with some admixture of volcanic ash/ignimbrite.

Present land use/vegetation cover: Arable land used for rainfed/flood-watered cultivation of mainly maize, barley and rapeseed with some potatoes.

Drainage conditions: Moderately well to imperfectly (seasonally poorly) drained; annually receiving light, short-lived sheet flooding from the river; groundwater table at 150 to 200 cm depth.

FAO soil classification: Humi-Gleyic Luvisols, phreatic phase

PROFILE DESCRIPTION:

Ap 0-20cm Dark reddish brown (5YR 3/3) moist, dull reddish brown (5YR 5/3) dry; clay loam; massive; sticky, plastic, friable moist, hard dry; few fine tubular pores; noncalcareous; EC(1:1) 0.20dS/m; common medium and many fine roots; clear smooth boundary; pH(H2O) 7.1 (Sample No. FSI1-1).

BAg 20-65cm Brownis black (7.5YR 2/2) moist, many fine distinct reddish brown mottles; clay loam that approaches clay; moderate medium and fine subangular blocky breaking to fine granular; sticky, very plastic, friable moist; few coarse and medium, common fine tubular pores; few fine Fe-Mn concretions; noncalcareous; EC(1:1) 0.11dS/m; few medium and common fine roots; gradual smooth boundary; pH(H2O) 6.9 (Sample No. FSI1-2).

Btg 65-155cm+ Brownish black (7.5YR 2/2) moist, many fine distinct reddish brown mottles; clay; moderate medium angular blocky; very sticky, very plastic, firm moist; few fine tubular pores; thin, nearly continuous clay cutans on ped faces; few distinct slickensides in lower parts; non-calcareous; EC(1:1) 0.12dS/m; few medium and fine roots; pH(H2O) 5.6 (Sample No. FSI1-3).

Remarks: The soil was saturated below 135 cm depth; the groundwater table was at 155cm depth.

LABORATORY ANALYTICAL DATA (PEDON 25)

No.	Sample No	Depth (cm)	TEXTURE				pH(1:1)		EC(1:1) (dS/m)	Exch. cations (meq/100g)						CEC (meq/100g	Base sat. (%)
			Sand (%)	Silt (%)	Clay (%)	Class	H2O	KCL		Na	K	Ca	Mg	Al	H		
2/90	FSI1-1	0-20	3	61	36	SiCL	7.12	5.84	0.202	0.84	1.00	26.09	11.30	nd	nd	51.20	76.62
3/90	FSI1-2	20-65	2	54	44	SiC	6.89	5.90	0.107	0.89	0.33	31.80	14.28	nd	nd	63.04	75.03
4/90	FSI1-3	65-155+	3	41	56	SiC	5.60	4.26	0.116	1.20	0.35	25.92	17.27	nd	nd	59.12	75.68

b No.	Sample No	Depth (cm)	Organic Matter (%)	Total N (%)	Avail. P (ppm)	Avail. K kg/ha	Extractable micro-nutrients (ppm)				Soluble cations (meq/1)				Soluble anions (meq/1)			
							Fe	Mn	Zn	Cu	Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
82/90	FSI1-1	0-20	3.019	0.168	1.64	186.00	24.50	26.91	0.74	1.72	tr	tr	tr	tr	tr	tr	tr	tr
83/90	FSI1-2	20-65	3.243	0.232	2.21	49.77	28.97	13.71	0.86	2.45	tr	tr	tr	tr	tr	tr	tr	tr
84/90	FSI1-3	65-155+	1.902	0.139	0.77	55.15	25.36	7.94	0.52	1.89	tr	tr	tr	tr	tr	tr	tr	tr

ab No.	Sample No	Depth (cm)	Bulk dens. g/ccm	Water Content (%)			
				0.1 bar	0.33 bar (F.C.)	3 bar	15 bar (P.W.P)	Avail. Water Capac.
682/90	FSI1-1	0-20	0.90	65.61	52.49	36.27	28.54	23.95
683/90	FSI1-2	20-65	0.48	54.74	49.43	29.38	24.56	24.87
684/90	FSI1-3	65-155+	0.74	49.39	44.14	39.29	34.53	9.61

Abbreviations:

nd = not determined
tr = traces
F.C = Field Capacity
P.W.P = Permanent Wilting Point
SiCL = Silty Clay Loam
SiC = Silty Clay
ppm = parts per million
meq/1 = milliequivalents per litre 100 grams of soil
dS/m = deci Siemens per metre (equivalent to mmho/cm)
meq/100g= milliequivalents per
g/ccm = grams per cubic centimetre
Cm = Centimetre
Ha = Hectare
CEC = Cation Exchange Capacity
EC = Electrical Conductivity

FINOTE SELAM AREA (Irrigation Site No. 1)

LABORATORY ANALYTICAL DATA OF WATER SAMPLE
(Temim River water, sampled in Nov., 1990)

pH	= 7.62
EC (mmho/cm)	= 0.246
TDS (mg/l)	= 162

Cations (meq/l):

Calcium (Ca)	= 1.40
Magnesium (Mg)	= 0.76
Potassium (K)	= 0.064
Sodium (Na)	= 0.378
Boron (B)	= 0.004

Anions (meq/l):

Carbonates (CO3)	= Nil
Bicarbonates (HCO3)	= 1.698
Chlorides (Cl)	= 0.152
Sulphates (SO4)	= 0.001
Nitrates (NO3)	= Nil

SAR (Sodium Adsorption Ratio)	= 0.36
Adjusted SAR	= 0.50
RSC (Residual Sodium Carbonate)	= Nil

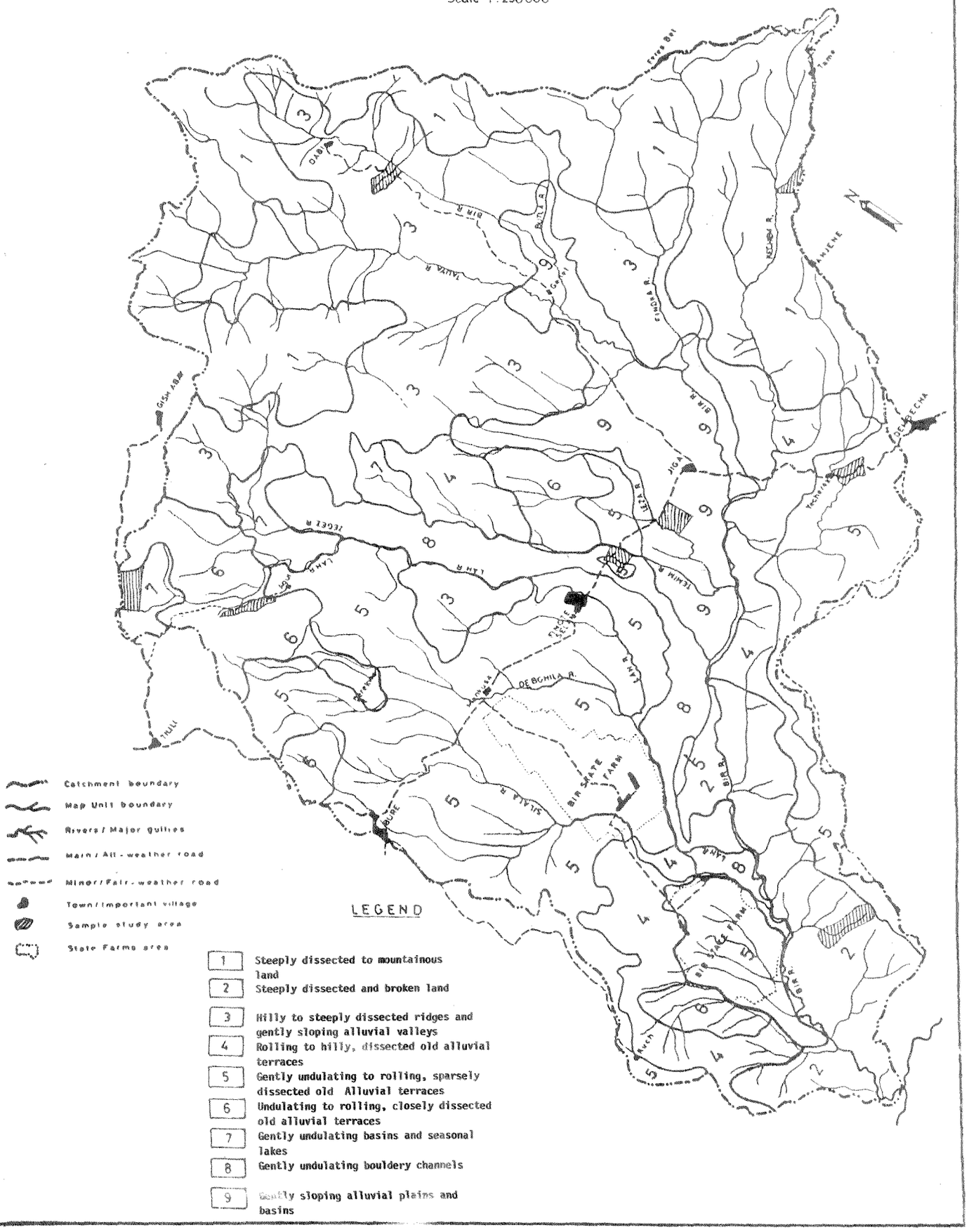
Water quality assessment: Highly suitable for irrigation

HSWCP-1

BIR WATERSHED

Major Landform Units

Scale 1:250000

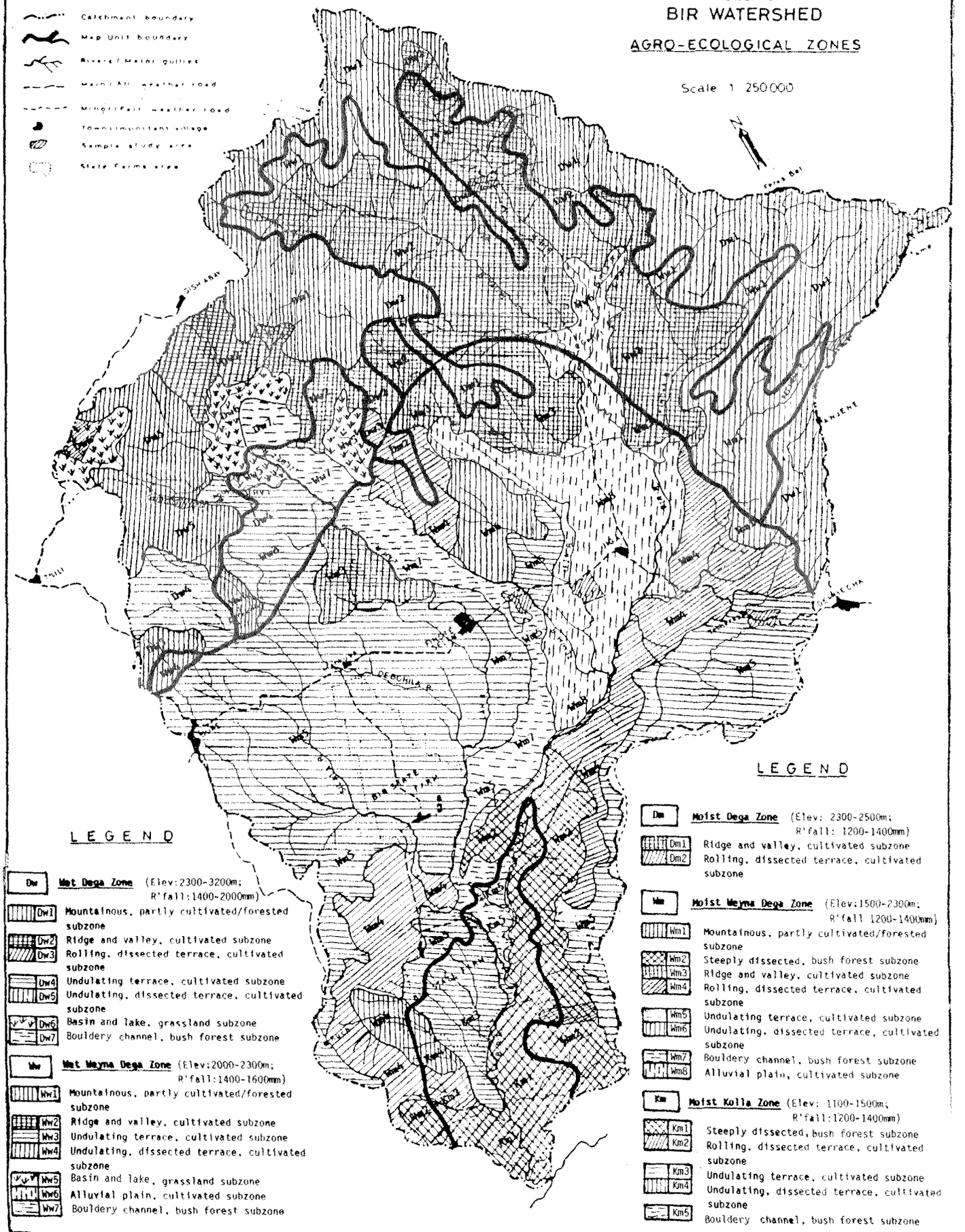


HSWCP-I

BIR WATERSHED

AGRO-ECOLOGICAL ZONES

Scale 1 250000

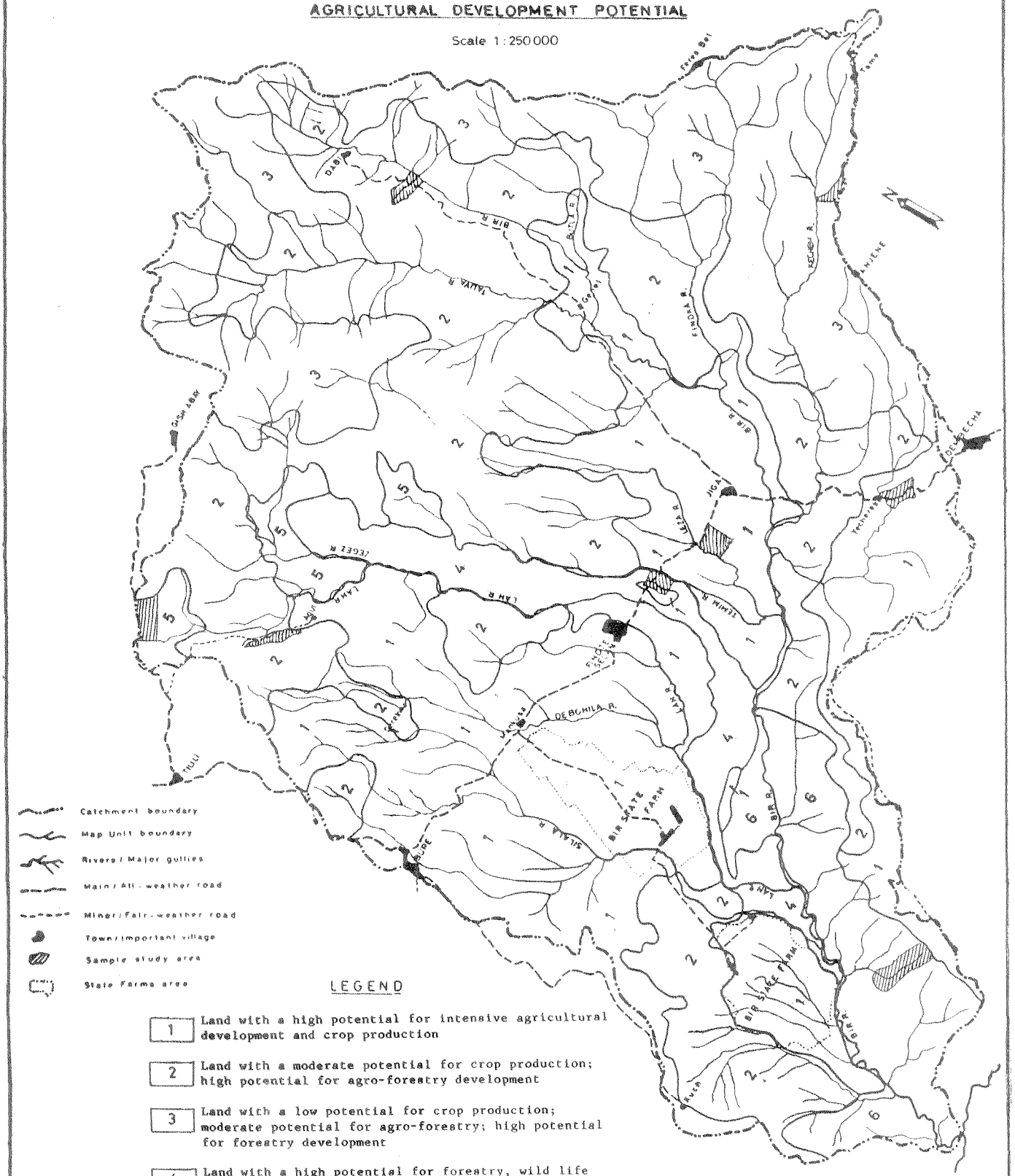


HSWCP-I

BIR WATERSHED

AGRICULTURAL DEVELOPMENT POTENTIAL

Scale 1:250000



LEGEND

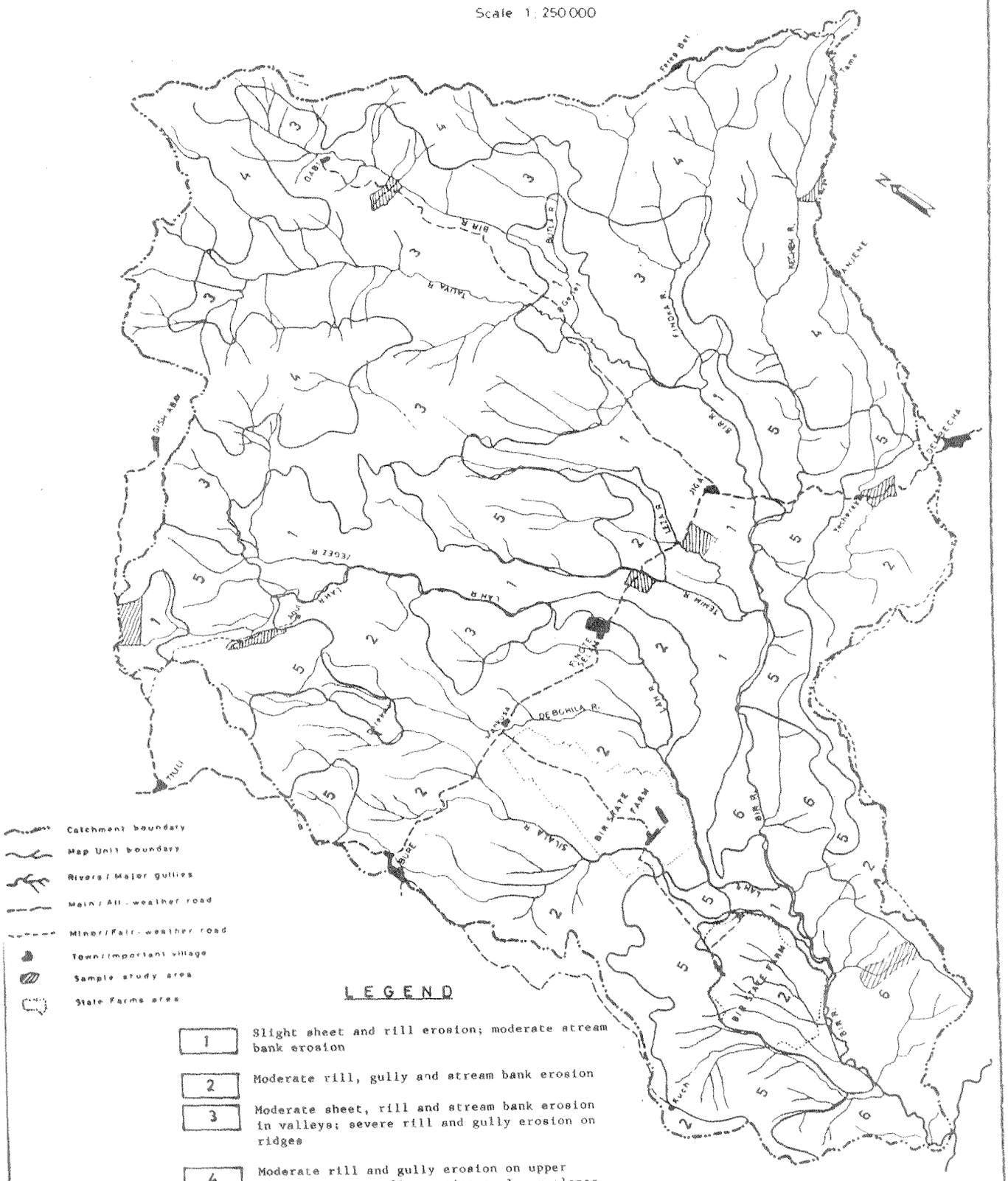
1	Land with a high potential for intensive agricultural development and crop production
2	Land with a moderate potential for crop production; high potential for agro-forestry development
3	Land with a low potential for crop production; moderate potential for agro-forestry; high potential for forestry development
4	Land with a high potential for forestry, wild life and range development; low potential for crop production
5	Land with a high potential for development as rangeland and recreational sites; very low potential for crop production
6	Land with a low potential for forestry development only

HSWCP-I

BIR WATERSHED

SOIL EROSION HAZARD

Scale 1: 250 000



LEGEND

1	Slight sheet and rill erosion; moderate stream bank erosion
2	Moderate rill, gully and stream bank erosion
3	Moderate sheet, rill and stream bank erosion in valleys; severe rill and gully erosion on ridges
4	Moderate rill and gully erosion on upper slopes; severe gully erosion on lower slopes
5	Severe rill and gully erosion
6	Very severe gully erosion in all parts