PROGRESS REPORT ON ASPECTS OF RAINFOED AGRICULTURE IN THE AWASH VALLEY.
A. HIGHLAND DEGRADED LAND PILOT FARMS
B. DRY FARMING THEORETICS
Development of the Awash Valley Ethiopia - Phase III

Progress Report on Aspects of Rainfed Agriculture in the Awash Valley.

A. Highland Degraded Land Pilot Farms
B. Dry Farming Theoretics.

Report prepared by
R.J. PATTISON
Technical Officer Livestock

On behalf of
The State Rivers & Water Supply Commission,
Victoria, Australia.

For the Executing Agency
Food & Agriculture Organisation of the United Nations
Disclaimer

This technical report is one of a series of reports prepared during the course of the UNDP/FAC project identified on the title page.

The conclusions and recommendations given in the report are those considered to be appropriate at the time of its preparation. They may be modified in the light of further knowledge gained at subsequent stages of the project.
A - PROGRESS REPORT ON HIGHLAND DEGRADED LAND PASTURE

PILOT FARMS

by R.J. Pattison,
Project Livestock Officer

Two pilot farms were established in 1973 to demonstrate restoration of degraded and eroded land.

At Chef a Donsa very promising results have been obtained with lucerne and high stock carrying capacities are possible.

At Mojo a number of soil conservation methods have been adopted. These and other measures will be employed to check the very severe erosion problem on the pilot farm.

ACKNOWLEDGEMENT

No discussion of this work would be appropriate without due acknowledgement of my counterpart, Ato Belette Dessalegne, who provided invaluable assistance in organising the field work and in making suggestions on methods to be adopted and ideas to be tried.

The field supervisors Ato Makonnen Bekele and Ato Kassaye Tegenne also carried out their tasks creditably.
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</table>
1. Introduction

In an agricultural country the soil is a primary resource. Any practices which lead to loss of soil or the reduction in the fertility of the soil strike at the heart of the national economy.

In Ethiopia loss of soil by erosion and lowering of fertility by overcropping are common place. The Awash River catchment area and river basin are no exceptions. If anything, soil erosion and soil degradation are proceeding at an accelerating rate within the river valley.

The results are easy to see:

(i) Severe gully erosion and/or sheet erosion.
(ii) Low crop yields. A number of factors contribute to low yields but a lowering of soil fertility and the actual loss of soil are primary reasons.
(iii) Siltation of Koka Dam.
(iv) High silt burdens carried by the Awash River.

Soil erosion and soil degradation can be prevented by sound agricultural practices and in many cases where erosion has not proceeded too far the damages can be made good.

Remedies and preventive measures very often require considerable changes in agricultural practices. In a sophisticated farming country soil conservation measures are not always readily adopted by farmers because of the costs involved and/or short term loss of income resulting from the changes.

In underdeveloped countries, particularly where there is considerable pressure on land by subsistence farmers, positive government action, including financial incentives, is likely to be needed to get farmers to adopt soil conservation measures. Not only must they be shown that these measures are necessary and desirable. The means must be made available by which the subsistence farmers can survive while the changes are being made.

2. Extent of Soil Erosion in the Awash Valley

The seriousness of soil erosion in the Awash Valley has been described by Mitchell (Ref. 1).

This erosion pattern is shown on Map 1.

Dole (Ref. 2) quoted the estimated annual degradation rate and sediment load for the Awash River (Table 1).
<table>
<thead>
<tr>
<th>Location</th>
<th>Sub Catchment Area (km²)</th>
<th>Estimated Annual Degradation Rate (ton/km²)</th>
<th>Total Sediment Load Annual (million tons)</th>
<th>Estimated Catchment Runoff (hm³)</th>
<th>Estimated Percentage Silt in Runoff (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Basin (to Koka Dam)</td>
<td>11250</td>
<td>1000</td>
<td>11.25</td>
<td>1750</td>
<td>0.65</td>
</tr>
<tr>
<td>Upper Valley (to Gotu Falls)</td>
<td>6000</td>
<td>150</td>
<td>0.9</td>
<td>1300</td>
<td>0.07</td>
</tr>
<tr>
<td>Middle Valley (to Lake Geder-bassa)</td>
<td>16650</td>
<td>150</td>
<td>2.5</td>
<td>1700</td>
<td>0.15</td>
</tr>
<tr>
<td>Lower Valley</td>
<td>30000</td>
<td>650</td>
<td>19.5</td>
<td>1915</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>63900</td>
<td>34.15</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1.

Lawry (Ref. 3) has quoted a figure of $135.7 \times 10^6$ cubic metres of soil as having been deposited in Koka Dam and Lake Galilea.

3. Farming Methods in Relation to Soil Conservation

In the highlands in the vicinity of Addis Ababa, and taking in the Upper Basin and Upper Valley areas of the Awash River Valley, there are few farmers employing even minimal soil conservation methods. Rather they are actively engaged in soil destruction.

Such poor conservation practices are not necessarily in use throughout Ethiopia. In some areas peasant farmers employ terraced agricultural practices on steep slopes with the end result being a minimum of erosion. Examples of this can be seen on the highland road to Dire Dawa and Harar on the S-E edge of the Awash Valley.

It is interesting to contemplate on the reasons for the differences in skills and techniques of the farmers in the different parts of Ethiopia. Farmers working on steep slopes may have quickly developed the techniques of contour cultivation as a matter of necessity to conserve soil, or cultivation on the contour may have happened as it was the easiest path for the bullock to tread as the ground was being ploughed.
On the much less sloping land nearer to Addis Ababa there was initially no need to work on the contour and the land could be easily ploughed in any direction. Now even when destruction of the land has progressed to an alarming degree the farmers seem unable to change their age old practices and adopt sensible cultivation techniques. Analogies of similar types could be drawn from observations of farming methods in many sophisticated farming countries.

Many of the soils in the Upper Basin are relatively heavy clays and clay loams. Under the very high intensity rainfall which occurs during the wet season the soil is unable to quickly absorb the water and ponding on the surface results. Much soil erosion results from the farmer's desire to remove this water as rapidly as possible.

Plough furrows frequently run directly up and down the slope. At best they run at a slope of 1 in 100; quite a sufficient slope to produce some erosion along the furrow itself. Greater erosion then occurs when the water from these furrows is discharged into already existing channels instead of onto stabilised grassed waterways.

It is necessary to remove much of the surplus water from the crop areas to prevent excessive waterlogging of the soil during the main wet season. However it must be done in such a fashion as not to cause any erosion. This can only be done by slowing down the velocity of the water to a non-erodable level and by discharging the water onto a stable surface, ideally a grassed waterway.

Over very extensive areas of relatively flat or undulating land, erosion has progressed to such an extent that it is difficult to design good, cheap grassed waterway systems to dispose of runoff.

In these cases, the runoff has to be discharged into

(i) existing erosion created waterways, after having first constructed gully checks to prevent further erosion.

(ii) grassed waterways, formed after a gully is battered in and shaped. Formation of such grassed waterways is expensive.

It is not the function of this paper to describe in detail all soil conservation methods which could be employed. Rather the methods actually used in the two pilot farms are described in the discussion on the progress of these farms.
4. Erosion by Wind

Water is the major eroding factor throughout the Awash Valley and causes the most spectacular damage. The erosive force of the wind is often neglected when soil erosion is being discussed. However it causes definite loss of soil, particularly in the Lower Valley where the land is dry and bare for the greater part of the year.

Wind erosion, as with erosion by water, is aggravated by:

(i) overstocking, leading to soil surfaces being laid bare for several months, or longer, during the year

and

(ii) the daily trekking of stock to water. The continued use of the same paths and the holding of stock for long periods around community watering points produce vast areas of completely bare soil which quickly turns to powder, ready to blow away whenever even a gentle breeze occurs.

The lighter soil types are the most prone to wind erosion, but even clay soils can be affected if they are sufficiently maltreated; and this maltreatment does occur.

5. Storage of Water in Small Ponds

The practice of trekking stock to water has been mentioned as a factor leading to accelerated erosion, both by water and wind.

The loss, in terms of kilograms of meat, as a result of this walking must be very considerable because of:

(i) large use of energy involved in walking and

(ii) loss of grazing time

The losses of soil and animal produce resulting from trekking to water could be minimised by the intelligent use of small water storages.

The provision of additional water supplies, whether by bores or by the retention of runoff water, has to be planned to fit in with overall land use and at times additional water supplies may not be beneficial. This particularly applies in the drier areas, frequently inhabited by nomadic peoples, where stock drinking water often is the restricting factor on stock numbers. Provision of additional water may encourage stock numbers to rise to the level where the land is badly overstocked and prone to erosion. The second problem is then worse than the first.
In the Upper Basin region of the Awash Valley, increasing water supplies are not likely to lead to a large increase in stock numbers. However, in the Upper, Middle and Lower Valley areas, problems could arise from the indiscriminate increase in water supplies and caution would need to be taken when devising any plan.

The Upper Basin offers great scope for small storages, and because of the generally sloping nature of the land, high ratios of water stored to soil removed can be obtained resulting in low costs per unit volume of water stored.

Because of the high rate of evaporation occurring during the dry months of the year, even in the highlands, all water storage ponds need to be dug to a depth of 5 meters, or greater, if the water is to last from the end of one wet season to the onset of the next.

These small storages would still have to be shared among a number of farmers and stockowners, just as at present the main watering points are community facilities. However the distances travelled, time taken and erosion hazards created by watering stock would be greatly reduced.

6. The Concern of A.V.A. in Soil Conservation

The Awash Valley Authority is concerned about the high rate of soil erosion occurring in the valley because of:

(i) the great loss of agricultural production which is resulting from this erosion.

(ii) the direct damage being caused to the irrigation systems of the Valley. The siltation of Koka Dam is the most serious problem being created by erosion, but the high silt load carried by the river also increases the cost of irrigation and the cost of structures being built on the river.

In 1973 two demonstrations were commenced to show techniques by which degraded and/or eroded soils could be restored. Both sites are in the Mojo River catchment area, the Mojo River being one of the main tributaries of the Awash River, feeding into Lake Galilea above Koka Dam.

The Mojo River catchment area is one of the most highly eroded catchments in the overall Awash River Basin (Mitchell Ref. 1). The Soil and Water Conservation Division of the Ministry of Agriculture have selected the Mojo River catchment as the area in which to carry out soil erosion control demonstrations, coupled with extension to the farmers, in an effort to rectify the rapidly deteriorating erosion situation. The A.V.A. demonstrations fit in with the proposed Soil and Water Conservation Division scheme.
The demonstrations, or pilot farms, were established at:

1. Chefa Donsa
2. Mojo

The two sites are separated by only 40 kilometers but differed in many important features, particularly soil type and degree of soil degradation.

7. Chefa Donsa Highland Degraded Land Pasture Pilot Farm.

Chefa Donsa is 45 kms. east of Addis Ababa. It is reached by vehicle after driving 37 kms. north-east on the Asmara Road from Addis Ababa, and then 24 kms. across the paddocks on a barely defined track. This "track" is impassable by vehicle during the wet season. Access then is on foot or horseback.

The village, typical of many in the highlands of Ethiopia, shows signs of better days. Decline in the fertility of the land has led to a lowered prosperity of the village and area in general. This is shown by deserted houses in the town and empty tukuls in the farming area.

7.1 Physical Description of Site

7.1.1 Elevation: 2,300 meters above sea level.

7.1.2 Rainfall: Rainfall pattern is typical of the central Ethiopian highlands with two main rainy periods during the year.

(i) Short rainy season, likely to occur between February and April. Reliability of these rains is not great, and only in 50% of years are they likely to contribute effective rainfall.

This situation is further complicated by the heavy clay soil at Chefa Donsa which requires a considerable quantity of rain to wet the soil sufficiently to allow active growth to take place.

(ii) Long rainy season, most likely to occur from mid-June to the middle of September. Rainfall during this period, particularly during July and August, is very reliable.

Average annual rainfall is 938 mm. per annum. Monthly distribution is shown in Table 2.
Table 2

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>10 Year Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>15.8 mm.</td>
<td>0 mm. - 99.5 mm.</td>
</tr>
<tr>
<td>February</td>
<td>26.5 mm.</td>
<td>0 mm. - 83.6 mm.</td>
</tr>
<tr>
<td>March</td>
<td>36.5 mm.</td>
<td>0 mm. - 130.0 mm.</td>
</tr>
<tr>
<td>April</td>
<td>65.9 mm.</td>
<td>22.0 mm. - 122.0 mm.</td>
</tr>
<tr>
<td>May</td>
<td>43.1 mm.</td>
<td>0 mm. - 111.7 mm.</td>
</tr>
<tr>
<td>June</td>
<td>86.7 mm.</td>
<td>6.8 mm. - 161.6 mm.</td>
</tr>
<tr>
<td>July</td>
<td>231.8 mm.</td>
<td>205.6 mm. - 314.2 mm.</td>
</tr>
<tr>
<td>August</td>
<td>260.6 mm.</td>
<td>164.4 mm. - 466.5 mm.</td>
</tr>
<tr>
<td>September</td>
<td>104.8 mm.</td>
<td>64.0 mm. - 208.6 mm.</td>
</tr>
<tr>
<td>October</td>
<td>14.9 mm.</td>
<td>0 mm. - 61.9 mm.</td>
</tr>
<tr>
<td>November</td>
<td>11.3 mm.</td>
<td>0 mm. - 78.4 mm.</td>
</tr>
<tr>
<td>December</td>
<td>7.2 mm.</td>
<td>0 mm. - 37.4 mm.</td>
</tr>
</tbody>
</table>

7.1.3 Temperatures

No data on temperatures is available for Chefa Donsa. However, temperatures are likely to be similar to those recorded at the Institute of Agricultural Research Station, Holetta, as elevations are similar.

It is only during October, November and December that minimum temperatures drop to such levels as would severely affect growth.

Maximum and minimum temperatures of a five-month period in 1973/74 were:

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 1973</td>
<td>8.2°C</td>
<td>19.7°C</td>
</tr>
<tr>
<td>October</td>
<td>4.6</td>
<td>21.4</td>
</tr>
<tr>
<td>November</td>
<td>1.2</td>
<td>22.1</td>
</tr>
<tr>
<td>December</td>
<td>1.5</td>
<td>22.3</td>
</tr>
<tr>
<td>January 1974</td>
<td>7.5</td>
<td>21.5</td>
</tr>
</tbody>
</table>

7.1.4 Soil Type

The dominant soil type was a friable black clay with free calcium carbonate being present throughout the profile except for the top ten centimeters of soil in non-eroded areas.

A typical profile, which in fact was a profile developed after the removal of ten or more centimeters of top soil, was:
0 - 50 cm. Friable, self mulching black clay; calcium carbonate concretions present throughout the profile, but particularly concentrated in the top two centimeters.

50 - 150 cm. Black clay, slightly heavier and less friable than 0 - 50 cm. layer.

150 - 200 cm. Brown clay.

pH in the top 0 - 50 cm. was 7.5.

The eroded soils, when seen from the air, have a white appearance because of the layer of calcium carbonate concretions on the surface.

The soils crack deeply when dry. This cracking increases the erosion hazard as blocks of soils along gullies are prone to falling in if pushed by passing stock, by sudden rainfall or just by gravity.

7.1.5 Vegetation

At the time the demonstration commenced, the major vegetation was made up of scattered clumps of Hyperrenia and Pennisetum. These clumps varied in size up to 20 cm. diameter, averaging 15 cm. diameter. The clumps were often separated by 20 to 30 cm. of bare soil.

Small numbers of legumes also occurred; the main species being Scorpiodes sp. Small isolated plants of Medicago lupilinus and Trifolium ruepellianum also occurred.

It is interesting to note that after sowing there was a considerably increased germination of legume species, particularly Scorpiodes sp. This germination was apparently caused by the cultivation as the neighbouring uncultivated area showed no such germination even when rainfall was very ample during the wet season. The phosphate fertiliser used on the demonstration area increased the growth of the volunteer legumes, but is unlikely to have actually stimulated germination.

The banks of the watercourse in the south-west corner of the demonstration area were almost completely denuded of cover.

7.1.6 Soil Erosion and Soil Degradation

A major drainage line crossed the area in an E-W direction, cutting the pilot farm into two blocks. The slope of each block was towards the drainage line.
Because of these factors, the pasture was not given the correct grazing management and this did affect the general pattern of growth and behaviour of the pasture.

9.1 Seed bed preparation

Cultivation commenced on 17 June and was completed on 28 June. Cultivation was carried out by:

(i) Oxen plough and/or
(ii) Offset disc plough - using a MF 135 tractor.

26 hectares were ploughed once only with offset disc.
4 hectares were ploughed once only with oxen plough.
4 hectares were ploughed once with oxen plough and once with offset disc.
3 hectares were ploughed twice with offset disc.
3 hectares were not cultivated.

From an extension point of view it may have been desirable to plough the whole of the area with oxen ploughs. However, as the start of the wet season was imminent, the tractor-drawn offset disc was used over much of the area so that the cultivating could be done as quickly as possible.

The same reasoning, i.e., critical shortage of time, dictated that only one cultivation be given to most of the area. Because of the nature of the soil and the limited number of weeds present on the land, the one cultivation was sufficient to produce a seed bed which was:

(i) of good tilth for the establishment of small seeds and
(ii) weed free

Some germination of weeds did occur subsequently, but these were not significant competitors with the pasture. Also, to have achieved a complete weed kill would have required cultivating through till the end of August. This was clearly impractical because of the severe adverse effect on the establishment of the pasture which would have resulted from the late sowing, even assuming that it would have been possible to cultivate the very wet soil at that stage.

Time involved in cultivation:

Tractor and plough - 49 hours.
Oxen plough - 45 working days - varying from 5 to 8 hours.

9.1.1 Cost of seed bed preparation

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tractor, plough @ $11.71 per hour including labour*</td>
<td>$574.00</td>
</tr>
<tr>
<td>Oxen plough - actual payment</td>
<td>$80.00</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td>$654.00</td>
</tr>
</tbody>
</table>

* (Boyd - Ref.4)
9.2 **Sowing**

Seed and fertiliser were mixed together and sown by hand. Rates used were:

- **Seed** - 7 kg./ha Hairy Peruvian Lucerne (Medicago sativa)
- **Fertiliser** - 40 kg./ha Diammonium phosphate.

Sowing commenced on 19 June and was completed on 3 July.

After sowing the seed was covered by spike harrows (tractor drawn). These buried the seed to a depth of 0.5 to 1.0 cm.

Harrowing to cover the seed was not possible on the steeper, more eroded areas. Actually on the worst slopes no cultivation was carried out - the seed and fertiliser merely being dropped on the surface of the soil.

Harrowing did improve the germination and establishment of the lucerne, and also produced a smoother surface than the un-harrowed area. This latter effect could be an advantage in the future if mechanised hay-making or silage-making are carried out.

Even where harrowing was not possible, establishment was quite satisfactory. In fact, establishment on the unploughed area was reasonable, although subsequent growth was not as good as on the ploughed area.

The ease of establishment of the lucerne following such a programme of minimum cultivation is largely a function of the self mulching nature of the soil and the ideal pattern of rainfall which occurred after sowing.

The demonstration of this technique of minimum cultivation has implications for much of the severely eroded land in the general vicinity of Chefa Donsa and similar areas in the highlands.

9.2.1 **Inoculation**

The first 3 hectares were sown with seed which had not been treated with the specific Rhizobium inoculum. On the remainder of the area the recommended Rhizobium inoculum, in peat form, was used.

No benefit could be seen from the use of the inoculum and indeed all plants nodulated satisfactorily.

The method of use of the Rhizobium inoculum is open to some criticism. The seed was weighed out in the required quantities and then treated with the dry inoculum. The seed was then mixed with the corresponding quantity of fertiliser and sown immediately. No seed was in contact with fertiliser for longer than 15 minutes. The granular nature of the fertiliser also would have reduced the contact between inoculum and fertiliser particles.
From the obvious satisfactory nodulation of the lucerne, it would seem that inoculation of lucerne of these soils is not required. This is not surprising in view of the high pH (7.5) and the likelihood that the land had grown Medicago species at some time in the past.

### 9.2.2 Rainfall

Rainfall following sowing was ideal to produce a good germination. Indeed seed germinated within 3 days of sowing - as defined by the emergence of the radicle. Even seeds lying on the surface of the uncultivated soil received sufficient timely rainfall to prevent dessication and were able to quickly get their root down through the top 3 to 5 mm. of soil which is prone to quick drying out and cracking.

Daily rainfall immediately following sowing was measured on the mornings of:

- 18 June - 0 mm.
- 19 June - 9.6 mm.
- 20 June - 7.7 mm.
- 21 June - 5.4 mm.
- 22 June - 43.9 mm.
- 23 June - 1.7 mm.
- 24 June - 2.6 mm.
- 25 June - 0 mm.
- 26 June - 3.7 mm.
- 27 June - 5.9 mm.
- 28 June - 5.5 mm.
- 29 June - 3.8 mm.
- 30 June - 11.6 mm.

Time involved in sowing operation:

| Tractor harrowing | 31 hours |
| Manual sowing     | 162 man hours |
| Other manual operations | 100 man hours |

### 9.2.3 Cost of sowing operation

<table>
<thead>
<tr>
<th>Operations</th>
<th>Tractors and harrows @ $9.17 per hour</th>
<th>$284.27</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sowing</td>
<td>actual payment</td>
<td>$48.00</td>
</tr>
<tr>
<td>Other manual operations</td>
<td>$30.00</td>
<td></td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td></td>
<td>$362.27</td>
</tr>
<tr>
<td>Materials</td>
<td>Fertiliser @ $0.40 per kg.</td>
<td>$592.00</td>
</tr>
<tr>
<td>Seed</td>
<td>@ $4.00 per kg.</td>
<td>$1036.00</td>
</tr>
<tr>
<td>Inoculum</td>
<td></td>
<td>$50.00</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td></td>
<td>$1678.00</td>
</tr>
<tr>
<td><strong>Total Cost of Sowing</strong></td>
<td></td>
<td>$2040.27</td>
</tr>
</tbody>
</table>
12. **Water Supply**

Demonstration area was adjacent to a creek fed by a permanent spring. Because of this it was not necessary to provide a separate water supply.

13. **Housing**

A stone house 8 metres x 4 metres (outside dimensions) was erected.

Other buildings erected were a guard's hut, galvanised iron shed and kitchen.

Total cost of these buildings was $2,650.00.

As these buildings were not a typical cost of land development, their cost is not included when a cost per hectare is calculated.

14. **Summary of Costs**

Total Cost of establishing the demonstration area, including one follow up topdressing (considered as a capital cost).

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cultivation</td>
<td>$ 654.00</td>
</tr>
<tr>
<td>2. Sowing</td>
<td>$ 362.00</td>
</tr>
<tr>
<td>3. Seed and inoculum</td>
<td>$ 1086.00</td>
</tr>
<tr>
<td>4. Fertiliser - at sowing</td>
<td>$ 592.00</td>
</tr>
<tr>
<td>(including application)</td>
<td></td>
</tr>
<tr>
<td>5. Fertiliser - follow up dressing</td>
<td>$ 975.00</td>
</tr>
<tr>
<td>(including application)</td>
<td></td>
</tr>
<tr>
<td>6. Fencing</td>
<td>$ 4287.00</td>
</tr>
<tr>
<td>7. Yards</td>
<td>$ 900.00</td>
</tr>
<tr>
<td>8. Housing and Shed</td>
<td>$ 2650.00</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td>$11506.00</td>
</tr>
</tbody>
</table>

Cost per hectare (excluding item 8) = $ 221.40

This cost would be applicable to a general property development. If a small area, not by present Ethiopian farming standards, but small by standards which may develop if actual land owners start to take a more active part in farming, of say 10 hectares of pasture are established it would be possible to eliminate much of the fencing, relying on shepherding and to reduce the cost of yards.

Costs for a 10 hectare development could be:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cultivation</td>
<td>$ 163.50</td>
</tr>
<tr>
<td>2. Sowing</td>
<td>$ 90.50</td>
</tr>
<tr>
<td>3. Seed and inoculum</td>
<td>$ 271.50</td>
</tr>
<tr>
<td>4. Fertiliser - at sowing</td>
<td>$ 148.00</td>
</tr>
<tr>
<td>5. Fertiliser - follow up dressing</td>
<td>$ 243.75</td>
</tr>
<tr>
<td>6. Fencing</td>
<td>$ 400.00</td>
</tr>
<tr>
<td>7. Yards</td>
<td>$ 50.00</td>
</tr>
<tr>
<td><strong>Total cost per hectare</strong></td>
<td>$1367.25</td>
</tr>
</tbody>
</table>
This is the cost per hectare used when arriving at an internal rate of return.

15. Establishment and Growth of Pasture

Rainfall received since the start of sowing of the pasture has been.

<table>
<thead>
<tr>
<th>Date</th>
<th>Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 - 30 June 1973</td>
<td>101.4</td>
</tr>
<tr>
<td>July</td>
<td>334.1</td>
</tr>
<tr>
<td>August</td>
<td>275.7</td>
</tr>
<tr>
<td>September</td>
<td>145.3</td>
</tr>
<tr>
<td>October</td>
<td>0.0</td>
</tr>
<tr>
<td>November</td>
<td>0.0</td>
</tr>
<tr>
<td>December</td>
<td>2.3</td>
</tr>
<tr>
<td>January 1974</td>
<td>0.0</td>
</tr>
<tr>
<td>February</td>
<td>0.0</td>
</tr>
<tr>
<td>March</td>
<td>130.0</td>
</tr>
<tr>
<td>April</td>
<td>0.0</td>
</tr>
</tbody>
</table>

This rainfall pattern was typical of anticipated rainfall for the period June to February. However March rainfall was approx. four times average for that month and in fact was the highest received during the last ten years.

Establishment was satisfactory in all except a few small areas which apparently were not seeded at the normal rate. Considering the method of seeding used some missed, or lightly sown, areas are not to be unexpected.

Growth was rapid from the time of germination until limited by lack of moisture.

As it was not possible to graze or mow the lucerne, as desired, at a height of fifteen centimeters the growth during September was tall and stemmy with a lower leaf to stem ratio than would normally have been expected. Also tillering was not as prolific as expected.

At the 30 September plants were twenty five to thirty centimetres tall and obviously quite healthy. However overall density was not sufficient to allow a cut of hay to be made from the pasture.

The indigenous species made moderate growth. However they provided very little in the way of competition to the lucerne. Nor were they sufficient to really give a balanced pasture. The small native legume, Scorpiodes, which responded well to cultivation and fertiliser was greatly favoured by the sheep who actively sought it out.

During October the older leaves of the lucerne started to change colour and gradually became yellow and fell off. This caused severe loss of feed available to grazing animals. At the same time the younger tillers of lucerne remained quite dark green and healthy.
A similar case of leaf drop also occurred with lucerne at the Holetta station of the Institute of Agricultural Research during October 1973. It had not been recorded in any of the previous three years.

The effects of management of this leaf drop and suggestion on possible causes are discussed in Section 19.2.

Sheep were introduced to the pasture in December and remained there until the end of March. Details of sheep grazing days obtained are listed in Section 17.

During February and March the pasture was severely overgrazed, even though sheep did apparently maintain their condition. During this period of overgrazing the topsoil became very powdery and sheep were able to dig around the roots of the lucerne and to bite the root off below the crown, thus killing the plant. It is estimated that 5% of the lucerne plants were killed in this way.

The above average rain in March greatly stimulated lucerne growth. Growth was rapid until the end of April when lack of moisture caused growth to almost cease.

When inspected in mid-May lucerne was 25 cm. high, with a large number of small tillers being available to carry on rapid growth as soon as the moisture situation improved. At this stage the older leaves were again starting to show signs of colour change which could possibly have led to leaf fall if drying out continued further. Young tillers were of a very healthy green colour.

The natural species showed virtually no response to the March rain. Annual species did not germinate and perennial grasses showed only a slight change in colour but no real growth. These species may have such a built in survival mechanism that they are unable to take advantage of any unseasonable rain and are really only geared to grow during the main wet season. If this is generally true it further indicates the need for introduced species to fill the main role in any pasture improvement programme in the Highlands.

Sheep purchasing commenced in May and the aim will be to keep the pasture stocked near capacity from May till December when growth will slow down and carrying capacity will decline.

16. Method of Grazing

Area was subdivided into seven paddocks as mentioned. Six paddocks were expected to have approximately equal carrying capacities, paddock 5 being the exception having a lower carrying capacity.
Grazing management, when stocked to capacity, will be to have all stock in one group and to graze the lucerne on a rotational basis. Some alteration in grazing days per paddock may come with experience but the initial plan is to graze each paddock for one week before moving stock onto the next paddock.

Rotational grazing will prove essential if the lucerne is to last its scheduled five years. Set stocking could kill out most of the lucerne in two years.

Many examples of the advantage of rotational grazing of lucerne are available from Australia e.g. C.S.I.R.O. Ginninderra, Dept. of Agriculture Trangie. At Trangie a four fold increase in carrying capacity was achieved with rotational grazing when compared with set stocking.

Satisfactory results can be obtained with a four paddock rotational system when grazing lucerne. However a six to eight paddock system leads to better utilisation and higher production from the lucerne. A sufficiently long rest period is necessary to allow the lucerne to perform at its optimum rate. This is achieved with a six to eight paddock system.

At Chefa Donsa the paddock subdivision will allow for a six weeks rest between grazings.

17. Stocking

A few sheep were purchased during early December but real stocking did not commence until the 28 December when a mixed flock of ewes and lambs totalling 168, were placed on the pasture. The numbers were then further increased to 335 on the 16 January and this number was maintained until the 20 March when 200 sheep were removed. A further 100 were transferred on the 12 April leaving 25 sheep on the pasture. These have been carried through to the end of May, together with new purchases.

Sheep grazing days obtained from 1 Dec. to 31 April were

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Days</th>
<th>Sheep</th>
<th>Grazing Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Dec. - 28 Dec.</td>
<td>25</td>
<td>16</td>
<td>400</td>
</tr>
<tr>
<td>28 Dec. - 16 Jan.</td>
<td>19</td>
<td>168</td>
<td>3,192</td>
</tr>
<tr>
<td>16 Jan. - 20 Mar.</td>
<td>63</td>
<td>335</td>
<td>21,105</td>
</tr>
<tr>
<td>20 Mar. - 12 Apr.</td>
<td>23</td>
<td>110</td>
<td>2,530</td>
</tr>
<tr>
<td>12 Apr. - 30 Apr.</td>
<td>18</td>
<td>25</td>
<td>450</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>27,677</td>
</tr>
</tbody>
</table>

Sheep Grazing Days/hectare = 692

This figure however in no way gives an indication of the potential carrying capacity of the pasture, as it measured carrying capacity during the time of the year when pasture growth rates are at their lowest.
18. Carrying Capacity – Calculated from Experimental Results

The I.A.R. station at Holetta has obtained yields averaging about 50,000 kg. green matter per hectare from lucerne (Ref. 6).

This production would give a theoretical carrying capacity of
\[
\frac{50,000 \times 11 \times 0.65}{184.8} \text{ d.s.e/year} = 19.35 \text{ d.s.e./hectare}
\]

where 50,000 kg. is total fodder production

11\% is starch equivalent content of pasture

0.65 is pasture utilisation

184.8 is total S.E. requirement per year per d.s.e.

The carrying capacity would be reasonably well in line with carrying capacities obtained in Australia from lucerne pasture often grown in less favourable environments.

Whilst these results are obtained experimentally, farmers generally opt for a lower stocking rate to give a built in reserve to carry the stock over unseasonally bad periods, mistakes in managements etc.

On this basis, the likely carrying capacity of a lucerne pasture under average management ability is likely to be in the vicinity of 12 to 14 dry sheep equivalents per hectare.

Because of the small blocks of pastures likely to be sown in Ethiopia, coupled with the considerable reliability of the wet season rains, it is possible that the carrying capacity in the highlands may actually approach closer to the theoretical level. This can only be shown after a number of years of practical experience.

One of the main factors against achieving the theoretical carrying capacity lies in the great seasonality of production with three-quarters of total production likely to occur during the period mid-June to the end of November. Fodder conservation could be used to spread the feed supply but this must be restrained to an economic level.

These questions can only be answered over a number of years of grazing experience. However, some points on management can be made at this stage.

19. Stock and Pasture Management

19.1 Stock Policy

Because of the seasonal nature of production, the aim should be to have the maximum stock numbers, or stock feed demand, corresponding with the period of maximum feed production.
This can be easily achieved if a fattening enterprise is carried out but is difficult when breeding stock are run.

In the case of a fattening enterprise the time of purchasing of stock can be made to correspond with the time of feed availability. No such options exist with breeding sheep or cattle. With a one time of year lambing there is a marked fluctuation in feed demand, the high demand period corresponding with the immediate pre and post - lambing stages. In cattle herds this fluctuation in feed demand is not so marked.

The sheep situation in the Highlands is further complicated by the ewes ability to lamb twice a year which has the result of evening out to a large extent the monthly feed requirement. As the aim should be to produce the maximum number of lambs per year this dual lambing ability is to be encouraged even though it does complicate matters. Therefore with breeding flocks it seems impossible to juggle feed demand to match feed supply by any means other than the conserving of surplus feed grown in the wet season so that it can be fed back in the dry season when growth is at its slowest.

In areas of seasonal production fodder conservation and feeding back always seems to be a very logical system to adopt. However it does not always produce the economically desired result. When a conservation system is compared with a non conservation system often the monetary return from the apparently inefficient non conservation is greater than from the so called efficient scheme in which fodder is conserved. This can come about because of three main factors.

(i) The cost of making hay or silage is very high per unit of feed conserved.

(ii) Stock have considerable ability to act as their own fodder conservation scheme i.e. in times of plentiful feed supply they store feed, by way of fat, to be used in times of stress.

(iii) Immediately stock are given supplementary feed they cease to be efficient grazers. The feed given e.g. hay, becomes not a complement to the diet but a substitute.

This is not to say that fodder conservation will not be applicable at Chefa Donsa or at other places in the Highlands. It almost certainly will be but the economic level must be ascertained.

Factors which will make some fodder conservation profitable in this environment are:

(i) Seasonal nature of production.

(ii) High quality hay which should be produceable from lucerne in the area.

(iii) Necessity to avoid the dangers of leaf shedding if this proves to be a consistent happening (Sections 15, & 19.2).
19.2 Leaf Shedding

As mentioned, Section 15, most mature leaves on the lucerne developed chlorosis i.e. change in colour to yellow, during October 1973 and then dropped off the plant. A similar happening also took place at the I.A.R. station at Holetta (Bekele Ref. 5).

The reason for the development of chlorotic symptoms is not known for certain. However the most likely explanation is that the drying out of the soil after the cessation of the wet season tends to raise the pH of the soil. This rise in pH in turn alters the availability of the heavy metal elements, e.g. Fe, Cu, in the soil, producing as symptoms marked yellow chlorosis. The leaves then die and fall.

This argument is further supported by the appearance of some chlorosis in the older leaves of the lucerne in mid-May 1974. This time corresponded with a drying out of the soil following a period of active plant growth resulting from the March rains. At the time of writing this report it has not been possible to inspect the lucerne to see if the heavy rains, which started on the 26 May, have delayed the further development of chlorotic symptoms.

This shedding of the leaves produced a great loss of feed in 1973 and if it occurred annually to the same extent would necessitate definite management practices to overcome the problem. At Holetta leaf loss has occurred one year in the last four years, which is of sufficient frequency to be a definite constraint. However if in practice it was shown that severe leaf shedding only occurred once in ten years little significance would have to be attached to the problem.

The lucerne in 1973, because it had not been grazed, was no doubt in a more susceptible stage of growth to receive this setback than if it had been rotationally grazed, as is intended in the future. Under a grazing system only two paddocks out of the seven at Chefa Donsa would be at such an advanced stage of growth at any one time. Young lucerne did not seem affected to any marked degree by this leaf loss and grazed lucerne may fit into this category.

There is also the strong possibility that lucerne stands of two years age or older may not be as effected by the problem as a new stand. This could result from the much greater depth of root penetration and lateral root development of an older stand which would mean that the plant can tap a larger volume of soil, a soil which at depth would take longer to dry out after the rains finish and may even have a different pH or mineral make up than the soil in the top 100 cm, the approximate limit of major root penetration achieved during the first four months of growth i.e. to mid October.
If it is found over a period of years that leaf shedding occurs frequently it will be necessary to adapt management to avoid the problem. The most obvious management solution would be to cut the lucerne for hay before the chlorotic symptoms developed. Because the chlorosis starts a month, or longer, after the finish of the wet season it should be possible to consistently make good quality hay out of the surplus growth, feeding the hay back as required during the dry part of the year.

20. **Susceptibility of Lucerne to Grazing**

Dryland stands of lucerne, if well managed, can last for ten years or more even when stocked to capacity. Poor management on the other hand can kill a lucerne stand in one year. The key to success lies in the management.

The lucerne plant is killed if the crown is grazed too closely resulting in the developing buds being destroyed. This susceptibility of lucerne to crown damage has led to the attempts to develop "creeping lucernes" which have the ability to develop new crowns along the root at a distance from the original crown. However to date no creeping lucerne can match the conventional varieties in production.

Under a rotational grazing system as proposed at Chefa Donsa lucerne should last for many years as the plant is protected from crown damage and is given ample time to rebuild root reserves.

However at Chefa Donsa the very friable nature of the soil brings in another problem. When the surface soil is dry it powders up under foot pressure. It is then quite easy for sheep to dig around the root of the plant and to bite the root below the crown. The plant is then killed as the roots seldom develop new crowns. This biting of the root could occur even when a sufficient growth of top leaves are still available. Loss occurred during February 1974 due to this habit being developed by some sheep. Again full importance will only be seen after grazing has been carried out for a number of years.

Reducing stock numbers to low levels during the dry months would be the most effective way of avoiding this problem but is only possible if a fattening enterprise is conducted. Breeding systems are not sufficiently flexible.

One means of minimising the problem would be to include other species in the pasture mix, in particular species which give a good ground cover. Phalaris tuberosa would seem the best species to try in this regard.
Sheep Costs

Purchase 20 kg at 60 c/kg $12.00 per head
Buying Costs
$1.50 "  "
Husbandry drench
$0.50 "  "

$14.00 "  "

Sales

Sheep gain 0.125 kg/day i.e. 22.5 kg over 180 days.
Proceeds if 5% deaths and sale price 62c/kg
0.95 x 42.5 x 0.62 = $25.03
Profit Margin per animal = $11.03
Margin per hectare = $242.66
Over 10 hectares Trading profit = $2427.00

This income would apply in the second to fifth years of each pasture phase.

In the first year a lower turnoff would be obtained. Assumption made that turnoff is one third of full year's production. Therefore would equal $809.

Crop Income

Yield 15 quintals of wheat per hectare selling at $24.00 per quintal.

Crop Income from 10 hectares $3600

22.2 Costs

Pasture Costs

<table>
<thead>
<tr>
<th>Year</th>
<th>Pasture Establishment 10 hectares</th>
<th>Labour Charge</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$1367.00</td>
<td>$600.00</td>
<td>$1967.00</td>
</tr>
<tr>
<td>Years 2 to 5</td>
<td>$250.00</td>
<td>$200.00</td>
<td>$1200.00</td>
</tr>
<tr>
<td></td>
<td>$1850.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Cropping Costs (Boyd Ref. 4)

Years 1 and 2 of each cropping phase
Costs/hectare sowing, cultivation (oxen) - $ 7.50
Seed - $ 20.00
Fertiliser - $ 30.00
Bags - $ 7.80
Labour - hand labour - $ 101.20
Maintenance, improvements - $ 6.00
Total $ 172.50

Years 3 to 5 of each cropping phase
Costs/hectare sowing, cultivation (oxen) - $ 7.50
Seed - $ 20.00
Fertiliser - $ 70.00
Bags - $ 7.80
Labour - $ 101.20
Maintenance, improvements - $ 6.00
Total $ 212.50

23. Internal Rate of Return

TABLE 3.

From the graph the Internal Rate of Return is 57% - hence a very profitable venture.

This I.R.R. is boosted very considerably by the high income received from the cropping phase. However if the figures are dissected out it will be seen that the I.R.R. for the pasture sowing over the first five years is 34%. If the pasture lasted for six years the I.R.R. would exceed 40%.

These internal rates of return do not take into account the residual value of fixed assets, i.e. fences, yards. By the end of the twenty year period, these assets would have little value and could be ignored. However they would have a real value at the end of the first five or six year grazing phase. If included at their written down value, then the returns would be even more attractive.

The land selected at Chefa Donsa was not an isolated block. There are many thousands of hectares of land in the Ethiopian highlands at a similar stage of degradation. If given proper treatment the return to the individual and to the nation would be very great.

The economics here are based on sheep fattening. Relatively similar results could also be obtained with cattle fattening. However breeding flocks would give a much less attractive return.
At this point in time, fattening sheep or cattle on small areas of pasture in the highlands is a very practical exercise possessed of few of the difficulties of supply or sale of fattening stock which would face a person considering fattening stock on irrigated pastures in the Awash Valley.
<table>
<thead>
<tr>
<th>Year</th>
<th>Benefits</th>
<th>Costs</th>
<th>Nett Benefits</th>
<th>@ 30% Factor Value</th>
<th>@ 40% Factor Value</th>
<th>@ 50% Factor Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>809</td>
<td>1967</td>
<td>- 1158</td>
<td>0.7692</td>
<td>0.7143</td>
<td>0.667</td>
</tr>
<tr>
<td>2</td>
<td>2427</td>
<td>1850</td>
<td>577</td>
<td>0.5917</td>
<td>0.5104</td>
<td>0.444</td>
</tr>
<tr>
<td>3</td>
<td>2427</td>
<td>2850</td>
<td>577</td>
<td>0.4552</td>
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</tr>
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<td>4</td>
<td>2427</td>
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<td>1850</td>
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<td>0.0174</td>
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<td>1850</td>
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<td>16</td>
<td>3600</td>
<td>1725</td>
<td>1875</td>
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<td>0.0046</td>
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<td>0.0023</td>
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</tr>
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<td>20</td>
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<td>1475</td>
<td>0.0053</td>
<td>0.0012</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Nett Benefits Discounted

Year 1 | Benefits | Costs | Nett Benefits | @ 30% Factor Value | @ 40% Factor Value | @ 50% Factor Value |
|--------|----------|-------|---------------|--------------------|--------------------|--------------------|

| Year | Benefits | Costs | Nett Benefits | 1267 | 602 | 243 |

DEGRADED HIGHLAND PASTURE FARM
INTERNAL RATE OF RETURN
HIGHLAND PASTURE FARM

24.1 Physical Description of Site

24.1.1 Elevation: 1870 metres above sea level.

24.1.2 Rainfall: Rainfall pattern is similar to that described for Chefa Donsa.

Average annual rainfall, on A.V.A. records, is 945 mm. i.e. similar to Chefa Donsa. However, Mojo always appears to be a drier area than Chefa Donsa, certainly on the hill area where the pilot farm is situated. A rain gauge has now been installed but the data gathered to date would be of no value at present in ascertaining an average rainfall for the area.

Distribution of rainfall at Mojo, from A.V.A. records, is shown in the table below.

<table>
<thead>
<tr>
<th>Month</th>
<th>Average for Month</th>
<th>10 Year Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>12.05 mm.</td>
<td>0 - 71.8 mm.</td>
</tr>
<tr>
<td>February</td>
<td>35.6 mm.</td>
<td>0 - 112.5 mm.</td>
</tr>
<tr>
<td>March</td>
<td>29.6 mm.</td>
<td>0 - 63.6 mm.</td>
</tr>
<tr>
<td>April</td>
<td>68.3 mm.</td>
<td>32.7 - 119.0 mm.</td>
</tr>
<tr>
<td>May</td>
<td>44.4 mm.</td>
<td>1.4 - 111.1 mm.</td>
</tr>
<tr>
<td>June</td>
<td>90.1 mm.</td>
<td>13.9 - 165.7 mm.</td>
</tr>
<tr>
<td>July</td>
<td>242.2 mm.</td>
<td>128.4 - 400.5 mm.</td>
</tr>
<tr>
<td>August</td>
<td>232.7 mm.</td>
<td>141.8 - 332.7 mm.</td>
</tr>
<tr>
<td>September</td>
<td>117.9 mm.</td>
<td>35.2 - 137.9 mm.</td>
</tr>
<tr>
<td>October</td>
<td>18.5 mm.</td>
<td>0 - 45.3 mm.</td>
</tr>
<tr>
<td>November</td>
<td>18.9 mm.</td>
<td>0 - 135.7 mm.</td>
</tr>
<tr>
<td>December</td>
<td>6.0 mm.</td>
<td>0 - 28.2 mm.</td>
</tr>
</tbody>
</table>

24.1.3 Soil Types

(i) Alluvial Soils.

A small area of alluvial soil was situated at the lower part of the farm. The extent of this soil type would have been no more than 1 hectare.

This soil would have been laid down by the creek bordering the farm at some former time before the creek cut down to its present level.
There was little variation in this soil throughout the profile to a depth of two metres. Even below this level there was only a gradual change in colour. Total depth of soil was up to 4 metres.

Soil was a grey sandy loam.

(ii) Soils Developed in Situ

The major surface soil type on the farm before severe erosion took place was a yellow brown sandy loam.

The original soil profile was:

- 0 - 25 cm. - yellow brown sandy loam (Analysis A)
- 25 - 60 cm. - dark grey silty loam (Analysis B)
- 60 - 100 cm. - dark grey sandy clay
- 100 - 300 cm. - dark brown clay - friable clay (Analysis C) Small amounts of calcium carbonate concretions appear at 100 to 110 cm. and then again at 250 to 300 cm., these become more numerous at depth.

For details of analysis see following table (Section 24.1.4).

(iii) Erosion Produced Soils

(a) At different parts of the area erosion has removed varying amounts of the land surface, leaving as the top soil any one of the lower soils mentioned in (ii). Fortunately all these soil types when exposed to the surface would be expected to develop into quite reasonable soils, capable of supporting good plant growth, provided run off can be prevented and any fertiliser deficiencies rectified.

(b) One area, of several hectares, has been produced as a result of soil washed off the higher land being deposited on a gradual sloping piece of land.

This soil type, a brown sandy clay loam, makes up the bulk of the strip cropped area. (Analysis D).

24.1.4 Soil Analysis

Soil analyses carried out by the Ministry of Agriculture showed all soils to be alkaline. pHs ranged from 7.30 to 7.90.

Nitrogen levels are low and phosphorous levels medium to low. However all soils are well supplied with potassium.
The table below gives details for four soils referred to above.

<table>
<thead>
<tr>
<th>Soil</th>
<th>pH</th>
<th>Organic Matter</th>
<th>N total</th>
<th>Avail P</th>
<th>Avail K</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7.3</td>
<td>0.69%</td>
<td>0.098%</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>B</td>
<td>7.6</td>
<td>1.31%</td>
<td>0.070%</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>C</td>
<td>7.3</td>
<td>0.59%</td>
<td>0.070%</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>D</td>
<td>7.9</td>
<td>0.62%</td>
<td>0.084%</td>
<td>Medium</td>
<td>High</td>
</tr>
</tbody>
</table>

24.1.5 Extent of Erosion

The area of the pilot farm is typical of many of the worst eroded areas in the Upper Basin of the Awash River.

The slope of the land as it is at present can be ascertained from the contour map (Map 2).

The steepest land was not the most severely eroded. Actually it was difficult to know how much soil had been removed from the two high knobs of land within the pilot farm, but the soil loss does not appear to have been great, despite the steep slope.

The most severe sheet erosion has occurred in a belt running across the middle of the farm. The reason for this manner of loss is not at present apparent, but is likely to have been tied up with past cropping patterns. Possibly the worst eroded land, which initially contained some of the deepest soil, was exhaustively cropped until erosion prevented further cropping. Only then was the higher land, with its much shallower soil, considered for cropping. Because of the slope of the high knobs, cultivation would have had to have been on the contour, hence a minimum of soil loss.

Sheet erosion has removed up to 2 metres of topsoil in the worst eroded belt of land. Even after the removal of this great quantity of soil there is still sufficient depth of soil remaining to provide reasonable conditions for plant growth.

Cutting through the sheet eroded areas are a number of gully systems of varying sizes. One very extensive gully system formed the boundary of the pilot farm, whilst another, up to 30 metres wide in places, ran through the area. Maximum depth of this gully would have been 5 metres below the original ground surface.
Many of the gullies however were less than 4 metres wide. The erodability of the subsoil is well illustrated by the development of gullies of 3 metres depth but being only 50 to 100 centimetres wide at the top.

25. Soil Conservation Methods

The soil conservations measured planned for the pilot farm were drawn up under the guidance of Mr. R. Harburg, of the British Overseas Development Agency, working in the I.E.G. Soil and Water Division of the Ministry of Agriculture.

The task of constructing the necessary structures to gain full control of the run off water will be spread over two to three years, such is the magnitude of the erosion on the farm.

The various structures and methods used are described.

25.1 Contour map

On scale 1 in 200 with contour intervals of 2 metres. This was drawn up as the initial step in planning. A reduced scale map is included (Map 2).

25.2 Water reservoir

A water reservoir was made by constructing a bank across a major gully system. The dam was sited high up in the catchment area and has little direct catchment of its own. The main flow into the dam will come from the hill area above and to the sides of the reservoir being directed into the dam by watergathering bunds. The situation of this reservoir is shown in Map 2.

The reservoir has the dual function of:

(i) Stock water reservoir
(ii) Preventing further run off into the gully system below the dam bank by removing and storing much of the run off which would otherwise run down the slope.

The dam is estimated to hold 1500 cubic metres of water when filled to its maximum depth of approximately 5 metres.

A two inch internal diameter pipe with a stop cock fitted was placed in the bank of the reservoir to enable water to be drawn from the reservoir for stock watering purposes.

The reservoir was dug entirely with hand labour at a cost of $1985. Cost per volume of water was therefore $1.30 per cubic metre of stored water.
The reservoir site was chosen to gain the maximum advantage from the ground slope, i.e. to give the greatest volume of water stored per volume of soil removed.

25.3 Grassed Waterway

The major grassed waterway is to serve as the entrance into the water reservoir. Water will be discharged onto this waterway from the watergathering bunds.

Area of waterway to be graded and then covered with a thick sward of grass. Perennial grasses are much preferred to annuals because they can give year round protection. Annual swards give little protection against storms at the start of the wet season, or out of season rains. Time is taken for germination to take place and a sward to develop. In this time much damage can be done.

Grassed waterway to be fenced so that proper grazing management can be exercised. Area will be grazed but always with the idea of keeping a good grass cover.

Other smaller grassed waterways will be constructed as necessary.

25.4 Water gathering bunds

To gather and discharge water into the reservoir. This will in itself act as the first stage in preventing erosion by being able to remove a large percentage of the water falling on the farm.

Bunds surveyed on slope of 1 in 400
Base cross section 1 metre
Settled height 0.50 metre

25.5 Contour banks

Similar in dimensions to water gathering bunds.

Surveyed on the contour. To act in slowing down velocity of water in various parts of the farm.

25.6 Cut off drain

Built above the cropped area to protect this land. Cropped land was cut by several gullies and water had to be removed from the parts of the gullies running through the cultivated land or severe erosion would have occurred.

Slope of drain 1 in 400
Base cross section 1.5 metres
Settled height 0.70 metres
25.7 **Gully checks**

Built in the gullies to store water and thereby reduce velocity of the water rushing down the gully.

A variety of designs used, the most common being built of stone and soil. On the uphill side, stone and soil are mixed, but on the downhill side only stone is used. Slope on downhill side 1:1.

Checks built to a height of two-thirds of the gully depth. This leaves ample freeboard for water to flow over the check but still remain in the gully itself.

An exception to this height is where the check is in line with a bund or drain. Here the check is built to the full height of the gully so that water can be taken out of the gully and run off where intended.

Checks are positioned along a gully so that there is a difference in elevation from the top of the lower check to the base of the higher check of 5 to 10 centimetres. This means that when the gully system is filled with water, the water flowing over a check drops into water on the lower side, thus preventing further erosion of the gully floor.

In places of extreme water volume and velocity, stone to be wrapped in wire mesh to give greater cohesion to the structure.

Gully checks shown in Diagram II.

25.8 **Contour Strip Cropping**

Strip cropped area protected initially by a cut off drain. Diag. III shows the layout of contour strips for cropping.

The starting points of each contour on the boundary are positioned fifty metres apart. Contours are then pegged as normal and cultivation commenced. Cultivation then carried out parallel to the contour until the plough line meets the next contour. Cultivation then stops.

Irregular shaped uncultivated blocks therefore are left between the parallel sided cultivation strips.

25.9 **Water Conservation Terraces**

These are to be built on the contour in some of the roughest areas.
These are broad terraces with a level base of approximately 5 metres and a height of 1 metre above ground level at the lower side of the bank.

25.10 **Tree plantations**

Trees to be sown in the water conservation terraces. The additional water conserved here is aimed at promoting extra growth as well as preventing loss of soil.

Indigenous Acacia trees and Eucalyptus to be grown. Investigations still being made as to most suitable species of Eucalyptus to be used. Blue gum E. globulus is not a fully satisfactory tree to use in erosion control.

25.11 **Pasture Sowing**

Pastures are the essential link in restoring the land. Legume based pastures will be sown to restore nitrogen and organic matter levels.

A thick sward of pasture is the final means of protecting the soil from surface erosion.

The banks, terraces, reservoirs etc. are the means by which the ground conditions are altered so that the pastures can grow successfully.

Pastures on the farm will have a high fertiliser demand, particularly in the initial stages. Diammonium phosphate will be used to supply both nitrogen and phosphorous, the two major elements not present in adequate quantities. Phosphate will remain the major deficient element and annual topdressings will be needed to provide sufficient P for optimum growth.

Pasture species to be used include:-

Lucerne (Medicago sativa)
Barrel medic (Medicago sp)
Dolichos Lablab
Siratro (Macroptiiium atropurpureum)
Rhodes grass (Chloris gayanah)
Phalaris tuberosa
Cenchrus ciliaris (Buffel grass)
Cynodon dactylon - for grassed waterways
Eragrostis curvularia var. Malagassy
Ryegrasses, Lolium perennie and Lolium multiflorum.
Pasture work on eroded soils in the Mojo area is still in its infancy and other species may be added to the aforementioned list. Likewise some species mentioned may prove unsatisfactory.

26. **Ultimate Profitability**

At this stage it is not possible to put a realistic figure on the profitability of the pilot farm. However the restoration of this land must be done or the whole structure of farming in many areas of Ethiopia will collapse.

The block of land at Mojo had virtually no earning capacity at all apart from about four hectares in crop. The grazing land grew virtually nothing.

As it is confidently predicted that three-quarters of the land will return to an arable stage at the end of development, the gain in capital value will more than match the cost of restoration.

The annual return, naturally, will be increased many fold.
DIAGRAM II  GULLY CHECKS
Not to Scale

DIAGRAM III  CONTOUR STRIP CROPPING
Fencing

A fence of similar design was used at both Chefa Donsa and Mojo.

Some variation in post size did occur, because of supply difficulties on one occasion. Post type stated here is as used when available and is considered to be the most suited for general use.

Diagram IV

Posts:

Eucalyptus posts, pressure treated with copper chrome arsenate salts.

Line Posts: 2.00m long, 8-10 cm min. diameter at small end.

Placed at 20 metre intervals except where different spacings were dictated by ground surface, rocks etc.

Placed 0.75m in ground, 1.25m out of ground.

Holes dug using hand auger.
2.

Strainer Assemblies: As shown in diagram IV.

Posts 2.30m long 12 cm min. diameter at small end. 1.05m in ground, 1.25m out of ground.

Rails: 2.30m long, 10cm min. diameter.

Diagonal truss made from doubled strand 4mm diameter plain wire. Rail held in place by pieces of 10mm steel rod.

Cost of Posts: Cost of posts varies with the method of purchase.

1. If purchased from retail outlet (Vasken) posts cost in the vicinity of $4.00 to 5.00 per post, varying with size.

   Posts sold by Vasken are normally 2.50m long - longer than required for normal use.

2. Purchase of untreated post cut to size from local timber seller, followed by treatment by Ethiopian Electric Light & Power Authority (EELPA).

   Cost of untreated post - 2m, 8-10cm diam. $0.85
   2.30m, 12cm diam. $1.10

   Treatment - 45 cents for small posts, 55 cents for larger posts.

   Total cost of treated post - 2 metre - $1.30
   2.30 metre - $1.65

3. Purchase of untreated posts as above (2) followed by treatment by sap replacement method.

   EELPA will only treat posts for Government instrumentalities, but private individuals could produce their own posts at the same price as those treated by EELPA by using the sap replacement method of treatment.

   Green freshly felled timber is required.

   Details available from C.S.I.R.O. Australia.

   Then Cost of line posts - $1.30 each
   Cost of Strainer assembly inc. wire - $5.00

Wire: 5 strands of barb wire used.

Double strand barb wire, approx. 2.5mm wire (-12½g)
Spacing of wire from ground level.
This is shown in Diagram IV.
Cost of barb wire - 13 cents per metre.
Therefore cost of 5 strands - 65 cents per metre.
3.

**Droppers**

Untreated Eucalyptus stakes 4 to 5 cm diameter, 1.20 long, attached to wires by tie wire.

Two droppers used for 20 metre panel.

Cost of droppers - $0.25 each inc. tie wire.

**Staples**

Galvanised staples, 4 cm long used to attach wires to posts.

Cost of staples - $1.70 per kg

Cost per post - 0.5 cents

**Gates**

Simple wire gates used - Mallee gates. 5 strands barb wire, attached to strainer post at one end and wooden dropper at other end.

Wire then held tight across gate-way by wire catches fixed between dropper and next strainer post.

Cost of gate, including labour - $3.00.

**Labour Cost**

Rate of erection 500 metres per day using a 4 man team - including strainer assemblies placed at an average of 250 metres apart. This rate of erection was influenced by the presence of stone in some places which greatly showed the rate of digging of post holes.

Rate of pay for unskilled or semi-skilled labourer - $2.00/day

Rate of pay for skilled fencer - $4.00/day

Erection cost per kilometre = $20.00

**Erected Cost of Fencing per Kilometre**

- strainer assemblies excluded.

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity per Kilometre</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posts</td>
<td>50</td>
<td>$65.00</td>
</tr>
<tr>
<td>Wire</td>
<td>5 strands barb</td>
<td>$650.00</td>
</tr>
<tr>
<td>Droppers</td>
<td>100</td>
<td>$25.00</td>
</tr>
<tr>
<td>Staples</td>
<td></td>
<td>$2.50</td>
</tr>
</tbody>
</table>

Total Cost materials - $742.50

Labour  

$20.00

$762.50 per km.

Total Erected Cost  

0.76 per metre
Cost of Fencing on demonstration sites:

(i) **Chefa Donsa**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>5350 metres fencing</td>
<td>$4080.00</td>
</tr>
<tr>
<td>36 strainer assemblies</td>
<td>$180.00</td>
</tr>
<tr>
<td>9 gates</td>
<td>$27.00</td>
</tr>
<tr>
<td><strong>Total Cost of Fencing</strong></td>
<td><strong>$4287.00</strong></td>
</tr>
</tbody>
</table>

(ii) **Mojo (estimate)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>6100 metres fencing</td>
<td>$4636.00</td>
</tr>
<tr>
<td>60 strainer assemblies</td>
<td>$300.00</td>
</tr>
<tr>
<td>10 gates</td>
<td>$30.00</td>
</tr>
<tr>
<td><strong>Total Cost of Fencing</strong></td>
<td><strong>$4966.00</strong></td>
</tr>
</tbody>
</table>

**Footnote**

**Daily Wage**

Daily Wage quoted of $2.00 is above average for Ethiopia.

Wage structure at the time of writing was under review and it was considered better to err on the generous side.

Labour costs have little effect on overall cost of fence. Fencing wire makes up 90% of total cost.
Sheep Yards:

Sheep working yards, built as per plan, on both sites.

Posts - Eucalyptus posts treated. 2.30 metres long, 12cm diameter.
Rails - Sawn timber 10 cm. x 4 cm.
Wire - 8/32 Ringlock fabricated fencing.
Gates - Welded, ¼" internal diameter.

Costs:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posts</td>
<td>$ 76.00</td>
</tr>
<tr>
<td>Timber rails</td>
<td>$ 170.00</td>
</tr>
<tr>
<td>Wire</td>
<td>$ 44.00</td>
</tr>
<tr>
<td>Gates</td>
<td>$ 360.00</td>
</tr>
<tr>
<td>Misc. materials</td>
<td>$ 40.00</td>
</tr>
<tr>
<td>Labour</td>
<td>$ 60.00</td>
</tr>
</tbody>
</table>

$ 750.00
B - DRY FARMING THEORETICS

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2. Fallow Farming - Definition 1
3. Description of Area 1
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8. Pasture Species 4
Summary

Much greater crop productivity in marginal rainfall areas of Ethiopia could be achieved if different cropping techniques were adopted.

The use of a fallow i.e. a weed free, moisture conserving period, would greatly assist in stabilising and increasing crop yields.

This technique is standard practice in many countries of the world and has direct application to parts of the Awash Valley.
DRY FARMING THEORETICS

1. Introduction

Applications for finance to conduct a dryland farming project, based on a fallow farming technique, were submitted to the I.E.G. Planning Commission Office for the years 1966 and 1967 E.C. However in neither year was the project approved.

The suggestion of the trial followed observations of many abandoned cultivation areas in the Miesso Mullu area on the eastern boundary of the Awash Valley. Soils are certainly favourable for crop growth and average rainfall would also indicate the cropping should be profitable. Variation in rainfall leading to erratic yields, is one of the major problems associated with cropping in the area.

2. Fallow Farming - Definition

Fallow is a term often applied to idle land. Less frequently it is applied to any land not in crop and would then apply also to pasture land.

In this instance a much more specific meaning is intended and fallow farming here means:

"The growing of crops on land which has had a long period of preparatory cultivation aimed at conserving moisture which has fallen in one wet period so that it is available for the later crop.

The crop is then grown on the combined moisture of the two wet periods."

Moisture is conserved by maintaining the soil in (i) a weed free condition to prevent losses via plant tissue, and (ii) at such a tilth that moisture loss by evaporation is reduced to a minimum.

The fallow period also assists in the build up of soil nitrogen for use by the following crop.

3. Description of the Area

3.1 Locality

There are approximately 150,000 hectares of potentially arable land, generally adjacent to the Addis Ababa-Djibouti railway line, between Arba and Dire Dawa. The main focus of the proposed dryfarming project was the Miesso-Mullu-Afdem area.

3.2 Soils

The arable land is characterised by deep friable soils, the soils ranging from grey loams to black clay loams and cracking clays. Depth of soil is considerable and in many cases would exceed two metres.
Soils have a high moisture holding capacity.

3.3 Vegetation

Originally the whole area was covered by Acacia spp. trees. Some growth of indigenous grasses occurred in conjunction with these trees, e.g. Cenchrus, Panicum species.

Where cropping is intended trees have been cleared. This thinning out of trees would also have to be done in newly considered crop areas. Cactus, of a prickly pear type, is widespread in the area. In the cropping districts it is grown between the cropped fields and on the non arable ground. In the non cropped, or abandoned cropping land, it is one of the major plants growing in association with Acacia trees. Its presence effects the grazing potential of the area and eradication would be worthwhile, even if no attempt at cropping was made. Biological control with Cactoblastis cactorum beetles could be investigated.

3.4 Elevation

Medium elevations. Miesso 1310 metres above sea level.

3.5 Rainfall

Rainfall records are available for eight centres in the area. Rainfall varies from 700mm per annum at Arba to 1000mm at Miesso and Mullu, rising then to 1200 mm at Asbe Tefari as the elevation increases.

The area of arable land is bounded on each side by quite high mountain ranges. These ranges could effect the pattern of rainfall throughout the area and the rainfall records at scattered stations may very well not give the full picture of rainfall in the area.

4. Land Use - Present

At present there is an intensive farming area from a little west of Asebot to Miesso, and then to Asbe Tefari. Beyond Miesso towards Mullu there are only scattered patches of cultivation although there are signs of formerly cleared land having been abandoned. This has reverted to Acacia scrub, prickly pear and various other weeds.

The reasons for the pattern of cropping are not easily apparent as rainfall records put Asebot, Miesso and Mullu on an almost equal rainfall level. Two possible reasons for the more intensive cropping at Asebot are (i) more reliable rainfall or higher rainfall than indicated by the rainfall records - affected by nearly Asebot Mountain - and (ii) traditional land usage.
Using present cropping techniques and practices the Ministry of Agriculture's supervisor at Asebe Tefari considered the Miesso district to be an unreliable cropping area. This would agree with general observations and indicate that a trial based on fallowing to conserve moisture would be worthwhile.

In the more established crop zones crop yields are low, 6 quintals/hectare was quoted as an average yield. If this is true much which could be done here to improve crop yields including improved cropping techniques, use of fertiliser and better varieties of crop plants.

Even in the established cropping area there was little crop sown in 1973 because of a late start to the rainy season.

5. **Land Use - Potential**

Based on research and broad acre practical farming in other countries the area has potential for improved crop and pasture production.

The best supporting evidence for the potential of the Miesso, Mullu area comes from its similarity to the Katherine-Tipperary area in Australia. Total rainfall is similar but the pattern differs in that Katherine has only one rainy season compared to the two peaks in rainfall at Mullu. Temperatures and evaporation are similar at both localities.

The length of growing season at Katherine is quoted at 20 weeks for crop growth and 22 weeks for pasture.

At Mullu, using Prescott's formula i.e. Effective Rainfall occurs when Rainfall is greater than 0.70 x Evaporation, the months of effective rainfall are April, part May, July, August, and September - i.e. 18 weeks for crops. Conservation of moisture by a fallow period could ensure effective crop growth during April through to October without severe moisture checks.

Also at Katherine improved pastures have been maintained resulting in a considerable increase in stock carrying capacity and corresponding results at Mullu are possible although the alkaline native of the Mullu soil, compared with acid soils at Katherine, would necessitate looking for different species of legumes.

The aims of any demonstration at Mullu would include,

1. Demonstrate the advantages of a fallow farming system in increasing the yield of sorghum.
2. Ascertain the economic advantage to be obtained with fertilisers and improved varieties of crop.
3. Investigate improved pasture species.
6. **Crop Rotation**

A crop rotation of

Fallow - sorghum - fallow - sorghum - pasture - pasture

seems quite applicable.

Therefore one third of the area would be in crop each year.

This intensity of cropping would not cause any deterioration in soil structure.

The fallowing would commence in June, July of one year and then the crop would be planted in April to June of the following year, depending on moisture conditions.

7. **Crop Yields**

Under an efficient fallowing system crop yields show considerable stability.

Anticipated yields and, frequency of yields, would be of the order of:

<table>
<thead>
<tr>
<th>Year</th>
<th>Frequency</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>0.6</td>
<td>17 q/ha</td>
</tr>
<tr>
<td>Fair</td>
<td>Frequency</td>
<td>10 &quot;</td>
</tr>
<tr>
<td>Bad</td>
<td>0.1</td>
<td>4 &quot;</td>
</tr>
<tr>
<td>Failure</td>
<td>0.1</td>
<td>0 &quot;</td>
</tr>
</tbody>
</table>

Average yield over ten years = 12.6 q./ha.

8. **Pasture Species**

Pasture species which could be investigated include

- **Grasses**
  - Cenchrus setigerus - Birdwood grass
  - Cenchrus ciliaris - Buffel grass
  - Panicum maximum var trichoglume

- **Legumes**
  - Macroptilium atropurpureum (Siratro)
  - Macroptilium Cathroides

- **Browse Shrub**
  - Leucaena Cucucephala
Conclusion

Ethiopia is already under pressure to produce sufficient food for her own needs. This pressure is likely to increase.

By Ethiopian standards the 700 to 1200 mm rainfall areas at elevations of 1000 metres are regarded as marginal cropping areas and little attention has been paid to them. In other parts of the world similar areas have been successfully utilised to produce grain crops and to support improved productive pastures.

The use of a fallow period should be investigated as a means of storing moisture so that crop yields can be stabilised and increased.

Legume pastures would assist in increasing stock carrying capacity of the land and also by raising soil nitrogen levels would increase crop yields.

Fallow cultivation, involving a weed free, moisture storing period, is quite within the capability of the Ethiopian peasant farmer but would need the adoption of a tyned cultivator in place of the traditional plough for intermediate cultivations.
REFERENCES

Ref. 1  A. Mitchell
Soil Conservation
UNDP/FAO/ETH/72/006
Informal Technical Report No. 15  1973

Ref. 2  D. Dole
Engineering Investigations and Operations
UNDP/SF/ETH 25
Informal Technical Report No. 5  1972

Ref. 3  R. Lawry
Lake Galila Siltation Survey
UNDP/FAO/ETH 72/006  1973

Ref. 4  T.M. Boyd, Production Economist
The Economics of Crop Production in the
Awash Valley.
UNDP/SF/ETH 72/006
Informal Technical Report No. 22  1973

Ref. 5  Bekele Sissay
Institute of Agricultural Research, Holetta
Personal discussion  1974

Ref. 6  Ibrahim and Bekele Sissay
Institute of Agricultural Research, Holetta
Personal discussion.  1973/74
SEVERE HIGHLAND EROSION
ACCELERATING

WIND AS MAIN ERODING FACTOR

RELATIVELY STABLE AREA
GOOD GRASS COVER

ACCELERATING EROSION BECAUSE OF CLEARING OF TREES
FOR CHARCOAL PRODUCTION — LIGHT SOIL TYPE

EROSION ACCELERATING BECAUSE OF INCREASED OVERSTOCKING
AS MORE RIVER LAND TAKEN FOR IRRIGATION

AWASH RIVER BASIN
(Area Approx. 120,000 Sq. Km.)
April 1974
SURVEYED BY Getachew H. Gabriel

SCALE 1:4000 DATE 13-9-1974

ERODED LAND PILOT PASTURE FARM

"MODJO"