SOMALI DEMOCRATIC REPUBLIC

NORTH WEST REGION AGRICULTURAL DEVELOPMENT PROJECT

PILOT WATERSHED MANAGEMENT
FOR SOIL AND WATER CONSERVATION

AND

SMALL GARDEN DEVELOPMENT

FINAL REPORT

VOLUME I

BACKGROUND AND WATERSHED MANAGEMENT

OCTOBER 1986

TAMS
TIPPETTS-ABBETT-McCARTHY-STRATTON
ENGINEERS, ARCHITECTS AND PLANNERS
655 THIRD AVENUE, NEW YORK, N.Y. 10017

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NORTH WEST REGION AGRICULTURAL DEVELOPMENT PROJECT

CONSULTANCY SERVICES FOR THE PLANNING OF PILOT WATERSHED MANAGEMENT AND SOIL AND WATER CONSERVATION MEASURES AND SMALL GARDEN DEVELOPMENT

FINAL REPORT

Volume I

Background
and
Watershed Management

PREPARED BY

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ENGINEERS, ARCHITECTS AND PLANNERS

OCTOBER 1986

NEW YORK, U.S.A. HARGEYSA, SOMALI DEMOCRATIC REPUBLIC

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Executive Summary

Introduction

The present report is the final report on the contract, dated 20 February 1985, between the Government of Somalia (GOS), through the North West Region Agricultural Development Project (NWADEP), and the contractor, Tippetts-Abbett-McCarthy-Stratton (TAMS) of New York, U.S.A. The contractor was engaged to undertake a feasibility study on watershed management in selected sub-watersheds, and carry out planning and control design for the development of small irrigated horticultural gardens. These studies are to form a basis for activities under Phase II of the NWADEP.

In compliance with this contract, TAMS supplied a team of experts who undertook about three months' field work in appropriate areas of the North West Region, from a base in Hargeysa. Subsequently, data analysis, preparation of plans and designs, and report and map preparation were undertaken in the home office.

While in Somalia, an Inception Report was submitted to the NWADEP management. Shortly after termination of the field work, but before plans and designs were finalized, an Interim Report was submitted. A Draft Final Report was submitted in June 1986. The present, final report incorporates such comments as were made by the NWADEP management on that Draft Final Report. Specifically, this Final Report is presented in four volumes, with contents as follows:

Volume I: Part I - Background: background to the project, to NWADEP, and the geographic setting

Part II - Watershed Management: concepts; description of the study areas; selection of the pilot project areas (PPAs); and general watershed management strategies and evaluations

Volume II: Description of, and management plans for, the Booli Diido Pilot Project

Volume III: Description of, and management plans for, the Geed Abeeran Pilot Project

Volume IV: Description of, and management plans for, existing and new small irrigated gardens.

The work undertaken, and this report, essentially has three parts - an understanding of the environment of the area of intervention, and how this is reflected in the objectives of the NWADEP; an analysis of the watershed management component; and the small irrigated garden development.

Background

The North West Region is located at the extreme north west of Somalia, and at the eastern extremity of the semi-arid zone of Africa, known as the Sahel. Physically it may be divided into three zones - the coastal plain; a deeply disected zone of precipitous mountains and narrow valleys; and the inland, elevated plateau extending into Ethiopia. Climate and vegetation - and to a lesser degree soil resources - follow this same pattern, with conditions becoming more favorable inland and being best on the plateau. The plateau, therefore, is the most densely populated and intensively used area. However, even on the plateau, the climate is only marginal for cultivation, and is characterized by wide variations in rainfall from year to year, frequently exacerbated by uneven distribution throughout the growing season. At Hargeysa and Boorama - the two main towns on the plateau, there is only about a 45% chance of receiving an "average" rainfall.

The area has traditionally been used primarily for nomadic herding. A combination of pressures has led to an imbalance in the traditional land use -- environment equilibrium. In particular, war and other factors have restricted the traditional nomadic movements; and this, combined with drought and a decline in traditional social controls, has led to overexploitation of the environment, and a reduced capacity to support the livestock. In consequence, the population has been increasingly turning to semi-settled subsistence-level cultivation, as a supplement to their herding activities. Such cultivation is located almost exclusively within the plateau. Cultivation is almost exclusively of sorghum and maize. Yields are very low and generally do not even meet on-farm requirements. In the meantime, there is both a regional and national grain deficit, especially with respect to the growing urban population in centers such as Hargeysa. The low production levels have been viewed primarily as function of the marginal climate. Meanwhile, overexploitation of the resources has contributed towards a serious erosion problem, with both gully and sheet erosion eating at the best lands - for cultivation and grazing - in the region.

In response to this situation, the NWADEP was created, to develop and extend strategies of soil and water conservation, for increased security and volume of production, and erosion control. Phase I of this program has concentrated on an extensive program of bunding -- building earthen dikes to interrupt the overland flow of water, and to store water behind the bund long enough to permit infiltration. While some success may be perceived, both in improved production and in localized erosion control, it is recognized that the measures to date do not provide a complete solution;—a broader approach is required, integrating a variety of measures on a watershed basis.

The NWADEP has also been active in encouraging the use of irrigation, which offers the best opportunity to not only provide security of production, but to diversify production. Irrigation development has occurred in part spontaneously, but the NWADEP has tried to encourage expansion and improved practices. In particular, the NWADEP has been instrumental, under Phase I, in developing twenty such irrigated gardens and prepares to establish a further fifty under Phase II. These gardens are small, both in individual size and combined area, but they provide a nutritionally important dietary diversification and, in terms of economic impact in the region, they probably equal or exceed that of the dryland cultivation. These irrigated gardens require considerable off-farm input, including equipment, fuel, and labor, and generate other off-farm employment in distribution and marketing.

Watershed Management

The watershed management component of the TAMS consultancy involved proposing and analyzing an integrated watershed management pilot program, in response to the dryland cultivation problems, and the perceived limitations of the Phase I developments, as outlined above. The work started when TAMS provided advice on selection of a study area of some 60,000 ha, from an area of about 480,000 ha recently flown for aerial photographic coverage. A contiguous area was proposed by TAMS but this was subsequently split by the NWADEP management, into about 38,000 ha just west of Hargeysa - termed the Hargeysa study area; and about 22,000 ha in the Ruqi-Baki area - termed the Baki study area. These areas were subsequently mapped for topography, under a separate contract between the GOS and Geosurvey of Nairobi.

Upon the arrival of the TAMS team in Hargeysa, it was immediately perceived that resource data, at appropriate scale, necessary for the detail of planning and feasibility analysis desired, was not available. Therefore an extensive program of primary data collection was undertaken in the two study areas. This is described in Volume I of this report, and on accompanying maps. In brief, the mapping covered land use, physiography, soil depth and texture, and erosion. The resource characterization undertaken was the minimum necessary to select a suitable area, or areas, for the pilot program. Subsequent evaluation of the mapped resources in the two study areas, showed the Baki study area to be unsuitable for the pilot program. Specifically, the area was found to be unrepresentative in terms of the main dry-land farming area to which the "pilot" project experience is to be extended; the area is surrounded by mountains from which a large, but unknown, volume of water issues, which would require extensive and expensive control structures; necessary local data, especially on rainfall and togga flow rates, is largely unknown; further topographic mapping would be required to permit inclusion of headwater areas in the development plan, and even then much of the contributary flow, which starts as far back as the plateau, would be excluded from the analysis; access is very poor, infrastructure negligible, and the local population small; and the low agricultural potential (climate and land) and strongly nomadic tradition of the area did not appear favorable. Thus the cost-benefit ratio appeared to be very low, and much lower than the Hargeysa study area. The Hargeysa study area is moderately representative of the dryland farming area; does not have the adverse physical conditions requiring large and expensive control structures; and is accessible, with a moderate infrastucture, and a substantial population with at least some commitment to cultivation. Further analyses therefore centered upon the Hargeysa study area.

Within the Hargeysa study area, a comparison was made of all sub-watersheds completely contained within the study area. Evaluation was based upon size, an area of 1000 to 2000 ha being preferred, the former being considered the minimum required to permit representation of the major landscape components, and the latter being considered the maximum manageable with existing project resources; accessibility, both in terms of access to project facilities, and protection from itinerants; representaiveness of the study area and the dryland agricultural areas as a whole; and the sociological characteristics of the population. In this area, one sub-watershed was selected as most appropriate for pilot project activities - the Booli Diido PPA. Subsequent to this, the management of the NWADEP requested that pilot studies also be undertaken within the Geed Abeerah sub-watershed.

The two pilot project areas were then subjected to further analyses. The topographic data base was upgraded to a 1 m contour interval, permanent monuments were installed, a series of gully long and cross sections were made, selected bunds were analyzed, and maps of farm boundaries and farmer attribution prepared. Resource analysis included a field by field evaluation of land use, and a more intensive network of soil and erosion observations. Finally, a detailed social survey was undertaken. Armed with this data, detailed management plans were prepared. Details are presented in Volume II (Booli Diido) and Volume III (Geed Abeerah).

Development of the management plans was constrained by the existing situation, in particular the extensive existing soil and water conservation works, and the socio-economic characteristics of the population. The absence of necessary local data regarding climate, and crop, forest, grazing, and land management systems, was also a major constraint. In developing the plans, priority was given to erosion control, although this is normally compatible with moisture conservation for improved production. During the social survey, it became clear that livestock remains the primary economic activity, and the proposals respect this. Thus areas are set aside for grazing, with proposals presented for improved livestock and grazing management. Measures and locations for gully control are presented but, in the long term, gully control must be effected through measures in the rest of the sub-watershed which stop water arriving at the gully. Phased revegetation of upland areas is proposed, with priority areas indicated. In the cultivated area, proposals are presented for improvements in the design, layout and construction of bunds, and for improved agricultural and land management practices. Other recommendations cover research and extension, an upgrading of the data base, energy, and improvements in human and livestock water supplies.

Implementation of the proposals is seen as urgent but constrained by the inadequate data base and the existing socio-economic situation. A phased implementation is therefore proposed, starting with an extension of the data base, especially through development of the Aburriin experimental farm and a socio-economic survey of the plateau; an upgrading of NWADEP institutions; and a major extension effort in the PPAs, designed to gain the understanding and participation of the farmers. That participation is called upon in the second phase, where local labor and materials are stressed.

Economically, the project is seen as difficult to justify in traditional economic terms, which tend to have short time horizons and rely on tangible benefits such as increased yield. However, the pilot nature of the program should be recognized. Economic viability should not be expected of a pilot program; indeed, part of such a program should be the collection of necessary economic data, and this is recommended. If the pilot program is successful, the benefits must include returns from the extension of the experience to the whole dryland area, the lives saved, and the arrest of the irreversible loss of land through erosion. Economic viability is also substantially conditioned by the social acceptability of the proposals. This is critical to a feasibility analysis of the project. Technically, environmentally, and in terms of the NWADEP physical institutions, the program is deemed feasible. Certain doubts remain as to the social and economic feasibility.

Small Irrigated Garden Development

During the TAMS mission, reconnaissance investigations were undertaken in 50 existing gardens, in different locations within the North West Region. The gardens are located in the low alluvial terraces, along the toggas. They are typically very small, in the order of 1 to 3 ha; however, farmers also often farm adjacent dryland areas. The gardens are generally surface irrigated by ground water pumped from the togga alluvial aquifer. Cultivation is predominantly (80%) fruit trees.

Various problems were noted and recommendations made. Problems varied between locations and between farms but included open unlined wells; insufficient yield; inadequate well spacing; pump location relative to water level; uncertain fuel supplied for the pump; and conveyance and delivery problems including unlined and open delivery ditches, which result in an estimated conveyance/delivery efficiency of only 48%. Many wells were found to dry out during the dry season, with a serious negative impact upon the fruit trees, while water quality ranged from good to extremely poor.

Recommendations made include increasing well yield and recharge through deepening and a collection system; lining of wells; a minimum well spacing; the characteristics and location of the pump units; an improved delivery network through proper engineering design based upon a topographic survey, lining of conveyance ditches or use of pipe, and structures for water control; improved irrigation methods including careful land levelling, use of furrows for vegetables, and adoption of other irrigation methods especially when using lower quality water; use of wind breaks; crop selection with respect to water quality; improved roads and marketing assistance; and fuel supply. The conveyance and delivery and water application recommendations, if fully implemented, are believed to raise the potential irrigation efficiency to about 80% (i.e., almost double that of present efficiency).

An analysis was made of possible locations for the 50 new irrigated gardens proposed for Phase II of the NWADEP. A list of potential sites supplied by the NWADEP was analyzed, within the limitations of available data, with respect to potential water and land resources, and accessibility for inputs and outputs. Most existing irrigation areas were found to be nearly or fully exploiting apparent water supplies. The greatest potential was seen to be in the Waheen basin, between Hargeysa and Aw Barkhaadle, and in the Durdur Basin, between Ceel Bardaale and Abakor Cadawe. These two areas account for 39 of the 50 proposed sites; other possible sites for limited development (one or two gardens) are listed. Preliminary designs and cost estimates for alternate typical irrigation systems are presented. These include well-pump arrangements and well designs; improved surface irrigation systems with alternatives of lined ditches or pipes; and sprinkler and drip irrigation systems. The systems described are compared in terms of total annual costs (amortization, replacements, operation and maintenance, fuel). For surface irrigation, pipe systems are seen to be most economical, but sprinkler systems are the most economical of all, costing about 20% less than pipe surface systems.

Some analysis and recommendations are also presented regarding the proposed new horticultural experimental farm. Analysis of available water supplies suggest the Jaleelo area to have the greatest potential, but complete hydrological studies are required prior to site selection. Other recommendations cover collection of basic resources data, access, and facilities. Further to the SOGREAH Report, it is recommended that the Horticultural Extension and Training Department engage an experienced irrigation engineer, and access to draftsmen and topographic survey crews. A consulting hydrogeologist is recommended for short term assignments.

PART 1

BACKGROUND

1. GENERAL

1.1 Introduction

The present Final Report is prepared in compliance with the Contract dated the 20th day of February, 1985, entered into and between the Government of the Somali Democratic Republic through the North West Region Agricultural Development Project Phase II, hereinafter referred to as the "Employer" or NWADEP with principal offices in Hargeysa, Somali Democratic Republic, and Tippetts-Abbett-McCarthy-Stratton, hereinafter referred to as the "Consultant" or TAMS, with principal offices in New York City, New York, U.S.A.

In accordance with the above referred Contract, the Consultant was to carry out Consultancy Services for the Planning of Pilot Watershed Management and Soil and Water Conservation Measures and Small Irrigated Garden Development Design in the North West Region of Somalia on the terms and conditions agreed upon in said Contract.

The present Final Report presents the findings of the Consultant resulting from the field work carried out in Somalia, and more specifically in the NWADEP area, and other analyses and investigations carried out in the home office. This work was conducted by a group of TAMS specialists from the starting date on 15th September 1985 to date. The field work was executed out of the office facilities supplied by the NWADEP in Hargeysa with the participation of NWADEP assigned counterpart personnel. The work was closely coordinated with the management of the NWADEP.

This Final Report contains the following sections and sub-sections, organized into four volumes in accordance with the employer's instructions (telex of October [illegible], 1986).

Volume I: Background and Watershed Management

Executive Summary

Part 1. Background

1. General
   - 1.1 Introduction
   - 1.2 Consultant Services
   - 1.3 Consultant Activities
   - 1.4 Acknowledgment

2. NWADEP
   - 2.1 Historical Background
   - 2.2 Available Data Base
   - 2.3 Geographic Setting

Part 2. Watershed Management

3. Pilot Watershed Management and Soil and Water Conservation Measures
   - 3.1 Basic Concepts
   - 3.2 Definition of Study Areas
   - 3.3 Land Characterization
   - 3.4 Land Evaluation and Land Use Planning
   - 3.5 Selection of Pilot Watershed Management Project(s)
   - 3.6 Pilot Watershed Control Projects

Volume II: Booli Diido Pilot Project

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    1.1 Introduction
    1.2 Consultancy Services
    1.3 Consultant Activities
    1.4 Background

2. The Booli Diido Pilot Project Area
    2.1 Location
    2.2 Resource Description

3. Management Plan
    3.1 Introduction
    3.2 Management Proposals for the Booli Diido Sub-Watershed

4. Proposal Implementation and Monitoring

5. Evaluation
    5.1 Economic Analysis
    5.2 Feasibility Analysis

Volume III: Geed Abeerah Pilot Project

1. General
    1.1 Introduction
    1.2 Consultancy Services
    1.3 Consultant Activities
    1.4 Background

2. The Geed Abeerah Pilot Project Area
    2.1 Location
    2.2 Resource Description

4. New Small Irrigated Garden Development
   - 4.1 General
   - 4.2 Water Resources
   - 4.3 Land Resources
   - 4.4 Proposed Location of New Irrigated Gardens
   - 4.5 Adopted Cropping Pattern
   - 4.6 Water Requirements
   - 4.7 Proposed Irrigation Methods
   - 4.8 Preliminary Designs and Cost Estimates for Typical Irrigation Systems

5. The Horticultural Experimental Farm

6. Organization and Staffing

7. Feasibility Assessment

1.2 <u>Consultancy Services</u>

The services to be carried out by the Consultant are specifically described in the Scope of Work set forth in Appendix 1 of the Contract, as follows:

"- With the objective of providing a concrete proposal capable of viable implementation during the Phase II of the Employer's Project:

(i) Prepare a complete and detailed feasibility study on watershed control in selected catchments

(ii) Prepare a viable and cost effective plan and design for the development of small irrigated horticultural gardens

- Consider in detail the agronomical and socio-economic implications of the feasibility studies and design for them to be practical and viable

- Liaise with the contractors for aerial photography and topographic mapping for the selection of appropriate areas for the pilot watershed control."

The services were to be provided by TAMS during a six month period from the starting date of the Contract. A tentative schedule of work and personnel assignments is given in Appendix 2 of the Contract. According to that schedule, the work was to be executed initially in Somalia and specifically in the project area for all aspects related to field activities, inception and interim reports, whereas the remaining studies, draft and final reports, were to be carried out in the Consultant's home office.

Execution was contingent upon 1) undertakings of, and facilities provided by the Employer, as set forth in the Contract, and 2) delivery of 1:10,000 scale maps prepared by Geosurvey.

1.3 Consultant Activities

The Consultant's activities started in March 1985 with Dr. Buursink's mission to Nairobi to assist in the definition of a 60,000 ha area to be mapped by Geosurvey. As discussed in section 3.2, this was carried out in collaboration with Dr. Hassan Abdu Munye, General Manager of the NWADEP.

The commencement of field activities had to be delayed because of the cholera epidemics and quarantine declared in the project area.

The consultancy team commenced mobilization on 15 September 1985 when Mr. G. Sobrino, Team Leader and Watershed Management Specialist, and Mr. G. J. King, Land Use Planner, departed from the home office. They arrived in Mogadishu on 17 September 1985 and proceeded to Hargeysa on 24 September 1985 after holding meetings with the General Manager and the Financial Controller of NWADEP in Mogadishu and obtaining the necessary work permits. Mr. M. G. Zanaty, Irrigation Specialist, arrived in Mogadishu on 9 October 1985 and proceeded to Hargeysa on 15 October 1985. The above personnel carried out their field assignments mostly within the project area and to a lesser extent in TAMS' office in Mogadishu and returned to the Home office during the second week of December. (The Land Use Planner and the Irrigation Specialist returned on 9 December 1985, and the Team Leader/Watershed Management Specialist on 12 December 1985.)

Liaison with Geosurvey was maintained during several months until the delivery of the last 1:10,000 scale maps in the second half of November 1985. The production of maps by Geosurvey took longer than originally anticipated, and therefore the field studies were mostly done on the basis of aerial photo interpretation (photos taken by Geosurvey in February 1985) and field reconnaissance (information recorded on the aerial photographs was subsequently transferred to the 1/10,000 scale topogaphic base). Similarly, the actual delivery schedule of the topographic maps was a determining factor in the scheduling of the complementary topographic surveys.

Initially, a Senior Topographic Surveyor, Dr. A. Habib, spent two weeks in Somalia (from 26 October to 11 November 1985) and assisted the Team in the planning of the complementary surveys on the basis of the data base provided by Geosurvey. Mr. M. El Dook, Topographic Surveyor, arrived in Mogadishu on 12 November 1985 and proceeded to Hargeysa on 16 November 1985.

Initially, he conducted surveys of several representative small irrigated gardens and later on carried out complementary topographic surveys in the areas selected for Pilot Watershed Management Projects. His work was completed by the end of January 1986. Mr. El Dook departed Somalia on February 4, 1986. The data he compiled was used in the Feasibility studies and designs for the watershed pilot project as well as in the typical irrigated garden designs.

Mr. G. King returned to Hargeysa, in the company of Ms. P. Chesnais, Sociologist, staying from 10 February 1986 to 21 February 1986. Together they undertook social and other analyses within the pilot project areas. During final report preparation an economic appraisal was undertaken by Mr. F. Peacock, Economist.

The Consultants prepared an Inception Report within the time frame established in the Contract. Said report included the following sections:

I	Introduction
II	Background
III	Consultancy Services
IV	Conceptual Framework for Integrated Workshed Management
V	Existing Data Base
VI	Site Selection and Data
VII	Initial Assessment of the Project Areas
VIII	Proposed Work Plan
IX	Consultant's Activities to Date

This report was presented to the NWADEP General Manager and key staff on 20 October 1985. The presentation was followed by a discussion of the subjects dealt with in this report and of the recommendations thereof. This included an agreement on the Consultant's recommendations for the preselection of study areas for watershed management and on the study areas for the small irrigated gardens component. The proviso was made that the Consultant carry out further studies in the Baki study area to provide full documentation of the reasons for rejection of the Baki area for watershed management pilot studies.

The activities conducted after 20 October 1985 have generally followed the above-referred Inception Report and are described below.

As far as the watershed management component is concerned, the work included the completion of the analysis of available data; the land characterization (watershed delineation, study of land characteristics - land use, topography, soils, access, erosion, socio-economic considerations) as well as the land evaluation and general land use planning for the Hargeysa and Baki study areas covering a combined area of about 60,000 hectares (items 1, 2, 4, 5, 6 and 7 of the Work Plan). Extensive photo-interpretation, field reconnaissance and mapping were done for the two study areas.

The above work led to the preselection of suitable areas and to the selection of pilot project subwatershed(s) - items 3 and 8 of the Work Plan. The work confirmed the initial finding presented in Section VII of the Inception Report and permitted the selection of a highly favorable sub-watershed for Pilot Project Watershed Management. Extensive additional studies were undertaken in this sub-watershed.

Following presentations to NWADEP Acting General Manager and Acting Team Leader, held on 20 and 28 November 1985, a field visit with same officers on 2 December 1985, and a meeting in the

Acting General Manager's office on 3 December 1985, the Employer decided that it was necessary to prepare a second Pilot Project within a sub-watershed selected by the Employer. This decision was acceded to by the Consultant.

The field work was therefore adjusted to comply with the Employer's decision. This adjustment involved the extension of the complementary topographic surveys to the second pilot project area, and additional reconnaissance work which was undertaken in February 1986.

Regarding the Small Irrigated Garden Development component, items 1 through 5 of the Work Plan were completed. This involved extensive field reconnaissance and data analysis as well as photo interpretation for areas included within the 1985 photo coverage. In addition, water and soils were assessed in the field, and topographic surveys were executed in several representative gardens. The locations for further development were selected on the basis of a list agreed to with the Employer, available data and field studies.

The findings of the Small Irrigated Garden Development field studies were presented to the NWADEP Acting General Manager and Acting Team Leader during a meeting in the NWADEP General Manager's office held on 24 November 1985. These findings were well received by these project officers.

Other activities conducted during the field phase of the studies included gathering of data on costs and other related ongoing projects in the North West Region and interviews with other related government agencies.

At the completion of the field assignment, an Interim Report was prepared presenting the team's findings to date. This report, which was submitted to the client in February 1986, included the following sections:

1. General

   1.1 Introduction
   1.2 Consultancy Services
   1.3 Activities to Date

2. The North West Region Agricultural Development Project

   2.1 Historical Background
   2.2 Available Data Base
   2.3 Geographic Setting

3. Pilot Watershed Management and Soil and Water Conservative Measures

   3.1 Basic Concepts
   3.2 Definition of Study Areas
   3.3 Land Characterization
   3.4 Selection of Pilot Watershed Control Areas

4. Small Irrigated Garden Development

   4.1 Definition of the Study Areas
   4.2 Present Irrigated Garden Development
   4.3 Recommended Improvements of Irrigation Techniques and Rehabilitation
   4.4 New Irrigated Garden Development (Partial)

Subsequent to submission of this report, preparation of a final draft report was undertaken in the home office. This included final map preparation and drafting; extensive analyses of field, map, and other data; preparation of management plans and designs for the pilot sub-watersheds; preparation of irrigated garden development plan and typical designs, and report writing and printing. The content of the draft final report, submitted to the employer in June 1986, was substantially the same as the present final report. Approval of the report by the employer was confirmed by telex dated 02 October 1986; however that same telex requested that the presentation be reorganized into four volumes. This has been completed within the present document, the Final Report.

As stated above, all work conducted in the NWADEP project area was carried out in close collaboration with the NWADEP management and with the assistance of the designated NWADEP counterpart personnel.

1.4 Acknowledgment

TAMS wishes to acknowledge all collaboration and assistance on the part of the NWADEP management and counterpart personnel assigned for the execution of this study. This acknowledgment is also extended to all other officials of the various government and collaborating agencies contacted during TAMS' in-country assignment as well as to the World Bank representatives in both Mogadishu and Nairobi.

2. THE NORTH WEST REGION AGRICULTURAL DEVELOPMENT PROJECT

2.1 Historical Background

Several attempts to develop dryland agriculture and to introduce soil and water conservation measures have been carried out in the North West Region of Somalia.

In the late 1940's a number of Yemeni farms were built for the Department of Yemeni Arabs. Such a farm diverted water from nearby streams into fairly level fields completely diked with strong earth banks. The system could not be adopted generally due to difficulties in controlling floods without masonry construction, as well as considerable flood risks and high sediment loads of the water.

From the Second World War to 1953, many techniques which had been developed in other countries were tried. These included grass strips, broad based terraces, lines of stones or contour walls and a simple basin lister drawn by a pair of oxen. These systems generally held the soil but they did not hold enough water to make any substantial difference in crop yield. Reportedly, these measures were not popular with the local population and each had technical weaknesses.

Later a system was developed which consisted essentially of a series of low earth banks designed to collect and hold as much water as possible while allowing large storms to pass with least possible damage. Banks were up to 120 yards long and 3 feet high before settling. There were 3 to 4 banks to a 5-acre farm with no complete boxing effect.

With many small farms being established in areas where erosion was a problem, in 1954 a bunding hire service was set up with 20 pairs of oxen. This service constructed bunds with scrape boards. In the following year this program was enhanced when the government offered bunding teams free of charge providing they were matched by a similar number of teams operated by the farmer. Scrape boards were produced by the government and sold at cost. The scheme proved very popular and some farmers took great pride in their work.

Difficulties were encountered in subsequent attempts to carry out a large bunding program using oxen. When a new bund construction program was undertaken by USAID in 1963 in the Gebiley District, it was therefore decided to carry out the work with small tractors in place of ox power.

The USAID project was designed to demonstrate the effectiveness of soil and water conservation measures when applied on a watershed basis. Reportedly, bunds were built at a much faster rate than in the past, using 75 hp crawler tractors (300 m/day with tractor vs. 20 m/day with ox) and the use of oxen was abandoned. The project bunded 3,500 ha. This area was increased to 5,100 ha (with assistance from ONAT) after termination of the USAID work.

The North West Region Agricultural Development Project was initiated in 1977 by agreement between the Government of the Somali Democratic Republic and the International Development Association. The project is centered in Hargeysa with sub-centers in Gebiley, Boorama, and two in the Hargeysa area. The project was initiated in response to the general need to settle the nomadic population whose lifestyle and economy were devastated by drought and other factors during the 1970's. At the same time, an influx of refugees had placed greater pressure on the land resources of the North West.

Phase I of the project, lasting from 1977 to 1985, emphasized soil and moisture conservation for improved agricultural yields and erosion control, largely through extensive bunding. Project documents show that over 32,000 ha of existing cultivated land was so protected during this period. An average crop yield increase of 64% has been reported on bunded areas over unbunded areas. Twenty 1-ha irrigated gardens were also established as an example and an impetus to similar private investment.

During Phase I, experimental farms were also developed to carry out research on dryland and irrigated crop types, varieties and farming methods. However, only the existing (since 1953) farm at Aburriin is presently operational, although a new experimental irrigated farm will be established in the near future. An extension service was also established to provide such services to both dryland and irrigated farms. Finally, water points were constructed to extend both the quantity and quality of water available for human and livestock consumption.

While Phase I of the Project is assessed as very successful [1], it has been recognized that soil moisture conservation works such as bunding form only a partial solution. Pressures on the grazing land caused by, among other factors, the drought and increasing demands for fuelwood have resulted in a general degradation of the environment. This has been particularly brought home by the rapid and devastating environmental impact of the refugee camps. Also, throughout the region, erosion has continued largely unchecked and now seriously threatens much of the existing cultivated land. Bunding provides only partial and localized

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1 World Bank Staff Appraisal Report, 1984

control of erosion and water losses by runoff. It is recognized that soil and water conservation measures need to be implemented on a watershed basis for maximum control.

Phase II of the project, while extending present soil and water conservation measures, also envisages the development of integrated watershed management procedures. This responds to the conditions outlined above. The present Consultancy is designed to provide initial guidelines for the fulfillment of this objective.

2.2 Available Data Base

2.2.1 General

The paucity of data available in the North West Region is, and will remain, a hindrance to any developmental planning, design or implementation in the region. The design and feasibility assessment of projects, such as that demanded of this mission - soil and water conservation measures, integrated on a watershed basis, for increased agricultural production and erosion control - requires a minimum level of information pertinent to the existing condition of the resource to be managed (soil, vegetation, land use, climate), the potential of that resource (soil fertility, range carrying capacity, etc.), and the suitability and management of specific resources (soil; crop, range and forest species; etc.). This data needs to be available at a level of detail appropriate to the detail of planning desired (national, regional, semi-detailed, detailed, etc.). In terms of the present mission, these conditions did not exist nor could they be entirely compensated for during the course of the mission.

The problem in the North West Region is not always a lack of research. The region has been much studied and reported upon and the SOGREAH reports (see section 2.2.3) present extensive bibliographies. However, availability of this data within Somalia, and in particular in Hargeysa, is extremely limited. There is an urgent need to collect all available data in one place, as a prelude to new studies and programs. The NWADEP would appear to offer a suitable vehicle for such an undertaking, which would benefit the many projects now being undertaken in the region by different agencies.

Should all existing information be available, there would remain, however, large gaps in the data base, particularly of data at a level of detail appropriate to detailed planning and implementation. For example, the climatological network is very sparse and station records are frequently incomplete. In consequence, for large areas of the North West, there is no reliable (actual or projected) climatological information. Similarly, streamflow data are almost entirely absent; both river control and water use require information on the amount, velocity, and variability of flow. The cyclical nature of the climate makes such long term records imperative as observation of a short span of years provides insufficient information. The dynamics of the environment impact in other ways. Any existing natural resource (soil, vegetation, land use) data, even if available, would now be questionable due to the apparent recent and rapid environmental changes. Were such information available, however, it would provide a base level from which to assess the environmental degradation. A major problem in evaluating, and planning for, this region is the absence of quantitative assessments of changes that have taken place in the environment over the least two or three decades.

If information on the environment is limited, then socioeconomic information is even more so. The settlement of the nomadic population, the influx of refugees, and natural population increase have combined to see a dramatic increase in the "settled" population of the North West over the last two decades. However, no reliable up-to-date data exists on the population to be served, and therefore the demand being made on the natural resource base. Similarly, and perhaps more critically, animal numbers and types are almost totally unknown. Further, there is a lack of basic economic data on the local economy (agriculture, pastoralism, agro-pastoralism), the social framework, and how the population might respond, or be persuaded to respond, to given measures. The development of rational land use (grazing, cultivation, and forestry) and social policies (provision of health, education, etc. services) is dependent upon this data.

Designing any agricultural or environmental program for the region requires information on plant and crop suitability and cultivation. While a certain amount of information may be extrapolated from research in "similar" environments, in the final analysis local trials are required. Despite being in operation for some 33 years, no original research results from the Aburriin experimental farm could be found locally (some result summaries are available). Information on range and forest species - their propagation and growth - was similarly absent. Obtaining such information was clearly beyond the scope of the present mission and its absence justifies the "pilot study" approach proposed for Phase II of the NWADEP. Trial programs may be included within such a pilot study.

Overall, therefore, it must be said that most projects in the North West are constrained by the available data base. A systematic resource inventory of the North West, at appropriate scale, is needed and could be accommodated within the framework of the NWADEP. Certainly this mission was severely handicapped by lack of existing resource data. While the mission was asked to carry out a feasibility analysis, most of the effort went into collecting necessary original data, but the time and facilities provided for in the contract permitted only a cursory investigation and the acquired data is necessarily limited by the nature of its collection. Similarly, feasibility design and analysis was limited by the amount and quality of data, and by the time required to collect a minimal level of information. This re-emphasizes the points already made - a primary need in the North West is for a documentation centre containing all available data, followed by a systematic resource analysis at appropriate scale.

2.2.2 Aerial Photography and Topographic Maps

Aerial photography covering all, or part of the North West, exists for three dates - 1952 (RAF), 1973, and 1985. Topographic maps of 1:100,000 exist for the whole region. Together these provide an excellent base for analyzing the region's resources. However, the availability of this data is very limited. The following summarizes the known present status of this data base.

- 1952 Aerial photography. Flown by RAF in 1952 and 1953. Black and White. Nominal scale approximately 1:29,000, but somewhat variable. One set belongs to NWADEP and has recently been arranged by Transcentury/BCI Geonetics, Inc. The photo index is available from the Ordnance Survey in Great Britain (Directorate of Colonial Surveys 1952-59. Index Maps of Somaliland Protectorate Series DC5 39 (DOS 539, 125000) Ordnance Survey, Southampton, UK.) The photo negatives are kept by Hunting Surveys of Great Britain.

- 1973 Aerial photography. Its existence is reported in a number of documents but neither the photos, nor any information about them, are available.

- 1985 Aerial photography. Flown by Geosurvey International in February 1985. Black and White. Scale approximately 1:25,000. The approximate area of coverage, some 480,000 ha, is shown in Drawing 101. Six complete sets, with index maps, are available at the NWADEP. Further information may be obtained from Geosurvey, Nairobi.

- 1:100,000 topographic maps, updated in the mid-1970s. Unfortunately, only blueprints and those in only one copy, were available at the NWADEP. Further availability is restricted for security reasons. However, they remain a basic data source and the NWADEP would be advised to seek more copies.

- 1:10,000 topographic maps, produced in 1985 by Geosurvey from aerial photography and field work carried out that same year. The mapping covers 60,000 ha, divided between two areas as approximately shown in Drawing 101. These areas were the study areas for the present mission. This mapping was undertaken under contract to the Government of Somalia/World Bank. While intended as base maps for this mission, the contract was entirely separate from that covering this mission. Specifications for, and quality control of, the map production was the responsibility of the GOS/World Bank, and not of TAMS. Twenty complete sets were delivered to NWADEP.

The aforementioned need for a resource inventory becomes urgent in light of the combination of existing data base and apparent environmental degradation. The 1985 photography may quickly become outdated if environmental change is as rapid as it appears to be. The 1952 photography may provide an excellent baseline for assessing environmental change.

2.2.3 Feasibility Studies Conducted by SOGREAH

As part of the activities carried out under Phase I of the NWADEP, the firm Sogreah Consulting Engineers of Grenoble, France (hereinafter referred to as SOGREAH), was engaged to undertake studies of the entire North West region. The studies, carried out between 1980 and 1983, involved inventory and feasibility assessment at a regional scale. Inventory was undertaken of the physical resources (climate, soils, range, land use, geology, hydrology), social and economic characteristics, infrastructure, agronomy, and institutions. The mapping base was satellite (Landsat) imagery and the 1952 aerial photography. Data was presented primarily at a scale of 1:500,0000. Feasibility assessments were made for both rainfed and irrigated agriculture. The information collected was summarized in a series of reports and maps (see Table 1.1).

The work undertaken by SOGREAH is the only available complete and systematic analysis of the region. A complete set of the reports (one copy) was provided to this mission by project personnel. It formed the primary existing data source for this mission and is frequently cited, as the primary and only data base, by other missions working in the North West. However, the study was, as was intended in its inception, a regional level study and detail of data collection and presentation was appropriate to that objective. The objective of the present mission required a considerably greater detail of data. By way of illustration, data presentation of maps by SOGREAH was primarily at a scale of 1:500,000; the present mission was provided with aerial photos at 1:25,000 and topographic maps of 1:10,000 - 20 to 50 times larger than the existing (SOGREAH) resource data base. Such scale transformations are not feasible and the SOGREAH data was clearly inadequate to the task in hand. Hence the requirement

Table 1.1: SOGREAH Reports

A. Inventory Reports

			Date Published	Maps	
R0	Inventory stage	Interim report	March 1982		
R1	Technical report	#1 - Geomorphology	Dec. 1980	Geomorphology	1:500,000
R2		#2 - Climatology	Aug. 1981	Rainfall + meteorological network Total rainfall 1980	1:500,000 1:500,000
R3		#3 - Hydrology	Aug. 1981	Hydrological network	1:500,000
R4		#4 - Hydrogeology	(draft only)		
R5		#5 - Soil survey	May 1981	Soils Land classification Land classification (part of area only)	1:500,000 1:500,000 1:100,000
R6		#6 - Range and livestock survey	June 1982	Ecological map Range productivity	1:500,000 1:500,000
R7		#7 - Agronomical survey	Dec. 1980	Present land use: Rainfed cultivation Present land use: Irrigation area Present land use: Rainfed cultivation (plateau area)	1:500,000 1:500,000 1:100,000 (2 sheets)
R8		#8 - Soil and water conservation	March 1982	Present bunding: Hargeysa + Gebiley districts Present bunding: Boorama district Erosion map	1:100,000 1:100,000 1:500,000
R9		#9 - Population, demography and organization of agriculture	June 1981	Settled population map	1:500,000
R10		#10 - Economic survey	Nov. 1982	-	-
R11		#11 - Research and extension	Nov. 1982	-	-
R12		#12 - Road survey	Oct. 1981	Road network and current traffic flow Traffic flow map	1:500,000 1:500,000
R13		#13 - Electricity survey	Nov. 1982	-	-
R16		#16 - Hydrogeology	May 1983	Geological map Waterpoint location	1:500,000 1:500,000

B. Feasibility Study Reports

RI4 Agricultural Development Program: A. Rainfed Agriculture - June 1982

Vol. 1 - Agricultural development	Present land use: Arabsiyo-Gebiley Area Present land use: Xaraf area Present land use: Boorama area Main possible improvements: Arabsiyo-Gebiley area Main possible improvements: Xaraf area Main possible improvements: Boorama area Main possible improvements: Rainfed area	1:22,500 1:25,000 1:22,000 1:22,500 1:25,000 1:22,000 1:250,000
Vol. 2 - Soil and water conservation works	Gebiley-Arabsiyo pilot area Soil and water conservation measures in the rainfed cultivation area	1:22,500 1:250,000
Vol. 3 - Sociological and organizational aspects		
Vol. 4 - Economic analyses		

R17 Agricultural Development Program: B. Irrigated Agriculture - Nov. 1983

R18 Final Report - Nov. 1983

for a minimal level of original data collection; this also re-emphasizes the need for the resource analyses at appropriate scales (e.g., 1:200,000 and 1:50,000).

2.2.4 <u>Other Data</u>

A complete list of data sources consulted is contained in the Appendix Al.1: Bibliography. As may be seen, little data beyond the SOGREAH reports was available to the mission. A major study covering the North West Region (1) was only available for consultation on Mogadishu. Valuable data was obtained from the "Report on Geoexploration in the N W Region - Chinese Well - Drilling Team 1983." Personal contact was established with a number of government, local, and expatriate agencies working in the area, from which valuable information was acquired, especially concerning costs. However, in the final analysis much of the data required for successful completion of the present mission was simply unavailable. Part of this information was obtained by primary data collection (see section 3); much of the information remains to be determined within the framework of the pilot program.

2.3 <u>Geographic Setting</u>

2.3.1 <u>Location</u>

The North West Region is located in the extreme north west of Somalia between about 10 and 12 degrees N latitude. It is bordered to the north east by the Gulf of Aden, to the north west by Djibouti, and to the west and south west by Ethiopia (see

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1 Northern Rangelands Survey - Resource Management and Research, UK. 1984

Drawing 100). The Region lies at the eastern extremity of that sub-Saharan semi-arid zone commonly referred to as the Sahel, which traverses the continent from Senegal to Somalia. Soils, vegetation, climate, and the predominantly livestock economy all show characteristics in common with the rest of the Sahel. The main town is Hargeysa which, at between 300,000 and 500,000 population, is the second largest town in Somalia. The second town of the region is Berbera, containing large port facilities. It is a somewhat remote area, at the eastern extremity of Africa, and isolated from the rest of Somalia by the intrusion of the Ogaden region of Ethiopia, and by a simmering border conflict.

The NWADEP is located within the North West Region. The dryland farming component of the project is concentrated in an elongated area which hugs the Ethiopian border (see Drawing 100). Here soil, topography and climate show the most favorable combination for agriculture within the Region. However, this represents only a small proportion of the N W Region. The Hargeysa study area falls within the main dryland farming area, but the Baki study area is located further north (see Drawing 101). The irrigated areas, while very small in area, are more widely distributed throughout the Region (see Drawing 401, Volume 4).

2.3.2 Geomorphology

SOGREAH (Report No. 1; Geomorphology) reports that the N.W. Region can be broadly divided into three zones, running approximately NW to SE.

i) The Plateau: Inland there is a gently undulating plateau, extending into Somalia from Ethiopia. Elevation varies between approximately 1400 and 1600 m ASL, broken occasionally by upstanding crystalline hills. The northward limit of the plateau may be approximated by a line Boorama-Gebiley-Arabsiyo-Hargeysa. With n this plateau area, SOGREAH recognizes several different erosion surfaces. It is on this plateau area that the main agricultural land is to be found, especially on what SOGREAH refers to as the end-tertiary surface. The plateau also contains most of the population of the N W Region. The Hargeysa study area is located on this plateau.

ii) The Mountains: The plateau extends northwards to a fault zone which forms a narrow, rocky, mountainous belt. SOGREAH describes this zone as follows:

"This consists of sharp ridges and steep precipitous valleys, with a flat river bed choked by coarse alluvium. This is surely the poorest part of the (N W Region) and there is no opportunity for the development of any agricultural potentiality. Except on limestones, the runoff coefficient appears to be as high as 50%."

Part of this zone is also described as gently sloping pediments "thinly and discontinuously veneered with sand and stony waste, and usually cut out of the same rock materials as the adjacent mountains themselves...Only shallow soils develop on pediments."

The rocks of the area are primarily metamorphic (granites, granitic schists and gneisses) and limestone. It is within this zone that the Baki study area may be found, consisting primarily of the units as described above. The study area also contains a narrow valley area (peripedement and river terraces) forming part of what SOGREAH calls the Quatemary surface, and lying at about 1000 m. ASL.

iii) The Coastal Plain: The mountains end abruptly at a north facing escarpment, about 1000 m high, from the base of which the coastal plain slopes gently to the Gulf of Aden.

2.3.3 Climate

Existing data on the climate of the N W Region have been collected by SOGREAH and are presented in their report No. 2, Climatology. Observations on the climate of the N W Region are hampered by the very sparse network of recording stations. Long-term records are only available for Hargeysa and Boorama, on the plateau, and for Berbera on the coastal plain; however, their use is limited by gaps in the records and, in some areas, by questions as to the reliability of the records (see SOGREAH report R2). Stations at Gacan Libaax (weather station), Gebiley (rain gauge), Ged Deeble (rain gauge), Aburriin (weather station), and Arabsiyo (rain gauge) provide shorter periods of data but, again, are subject to gaps and inaccuracies in the records. A number of stations were installed or rehabilitated by SOGREAH during their work (see Table 1.2 and Drawing 100). However, it is known that a number of these were removed subsequent to SOGREAH's departure, reportedly due to problems of accessibility for reading and servicing the instruments.

Based on available data, SOGREAH presents extrapolated isohyets for mean annual rainfall. Due to the low density of the recording network and the shortness and unreliability of many of the records, the isohyets represent, in the main, an educated guess. The same is true for any other generalized observations on the climate of the region. This must be borne in mind in any discussion, as below, of climate. It also points to the urgency of installing an adequate meteorological network. Given the problems of accessibility, consideration should be given to the automatic recording and data transmission devices now available.

Table 1.2 Climatological Stations

Climatological stations existing before Phase I for which long-term rainfall and other records are available	Climatological stations installed in Phase I	Rainfall gauging stations installed or rehabilitated during Phase I	Old abandoned rainfall gauging stations
Berbera	Gerd Deeble	Ged Deeble	Saylae
Hargeysa	Qabri Baxar	Gebiley	Silil now Ceel Gaal
Boorama	Ceel Gaal	Aburriin	Cabdi Gaadir
	Bown	Ceel Gaal	Bown
		Cabdi Gaadir	Tug Wajale
		Bown	Mandheera
		Lafaruuq	Lafaruuq
		Illinta Dhexe	
		Horahaadley	
		Agabar	
		Qabri Baxar	
		Waraqadhigta	
		Ceel Bardaale (Caarino)	
		Xariirad	

Source: SOGREAH Technical Report No. 2, Climatology, August 1981

The N W Region shows considerable climatic variation, with a general trend from hot and dry on the coast to cooler and more humid in the interior. Coastal areas have a mean annual rainfall of less than 100 mm and temperatures which rise to the low 40s (°C). Evapotranspiration is consequently very high. Two seasons can be distinguished, with a "wet" season concentrated from March until May and a dry season from June to February. Rainfall increases and temperatures decrease inland (see Drawing 100) approximately paralleling the topographic rise of the land. On the high plateau, annual rainfall averages between 400 and 500 mm, and mean and maximum temperatures are much lower than on the coast (see Table 1.3). Here winter nights may be quite cool, but not enough to prove a limiting factor to any crop (dryland or irrigated). (Local people talk of occasional frosts, although the records show no temperatures approaching the freezing point -one example of the inadequacy and unreliability of the data.) Again, two seasons can be distinguished, the rainy season lasting from March to September.

Based on these average annual figures, SOGREAH classifies the North West Region as semi-arid. (Report RO: Interim report) A study on the Soil Moisture Regions of Africa (Van Wambeke) classifies Berbera as Extreme Aridic, Hyperthemic and Hargeysa as Typic Aridic, Isohyperthemic. These are defined in Table 1.4. As may be seen, by this latter definition, neither the climate at Berbera or Hargeysa is sufficient to support agriculture. This is partially supported by SOGREAH's findings as reported in Report No. 7: Agronomical Survey. They calculate theoretical water requirements for rainfed sorghum and maize, to obtain maximum grain yields, and show an annual moisture deficit, for Hargeysa, of about 350 mm, for both crops. The moisture deficits do not make cultivation impossible, but limit yields. Together, the two studies referred to lead to the inescapable conclusion that, even in the relatively favorable plateau area, cultivation of sorghum and maize is a highly marginal activity in an average year.

Mean figures for climate may be misleading to the degree that they hide the wide variations, especially in rainfall, common to the N W Region. Table 1.5 presents a frequency analysis of annual rainfall (see also Figs. 1.1 and 1.2). As may be seen, for both Hargeysa and Boorama, there is only about a 45 percent chance of receiving the mean rainfall. Probabilities of 70 or 75% are commonly used in assessing the feasibility of agricultural projects; the 75% probability level is much lower

Table 1.3 Climatic Characteristics

	Annual Rainfall mm Mean	High	Low	TEMPERATURE °C Mean Annual	Highest Monthly (June) Mean	Max.	Min.	Lowest Monthly (Dec/Jan) Mean	Max.	Min.
Coastal Plain										
Berbera	59	178	0	30.0	35.0	40.4	30.3	25.5	28.8	21.3
High Plateau										
Hargeysa	424[1]	810	156	23.0	25.0	30.8	18.9	19.8	24.0	13.7
Boorama	518[1]	864	311[2]							
Gebiley	441	-	-							

(1) Record updated to 1985 from records held at Hargeysa airport. Mean based on a 61 year record for Hargeysa and 49 years for Boorama.

(2) Records located at Hargeysa airport show a minimum of 129 mm in 1980.

SOURCE: SOGREAH Technical Report No. 2
Climatology, August 1981 except as indicated

Table 1.4 Soil Regimes

A. Soil Temperature Regimes

Hyperthermic - The mean annual soil temperature is 22° C or higher, and the difference between mean summer and mean winter soil temperature is more than 5° C (at a depth of 50 cm).

Isohyperthermic - The mean annual soil temperature is 22° C or higher, and the difference between mean summer and mean winter soil temperature is less than 5° C at a depth of 50 cm.

B. Soil Moisture Regimes

Aridic - The soil moisture control section in most years is:

i) dry in all parts more than half the time (cumulative) that the soil temperature at a depth of 50 cm is above 5° C.

ii) never moist in some or all parts as long as 90 consecutive days when the soil temperature at a depth of 50 cm is above 8° C.

Extreme Aridic - The soil moisture control section is always completely dry. No cultivation is possible without irrigation.

Typic Aridic - The soil moisture control section is moist in some or all parts at same time in the year for 45 consecutive days or less when the soil temperature at 50 cm depth is more than 8° C. Cultivation is not possible without irrigation.

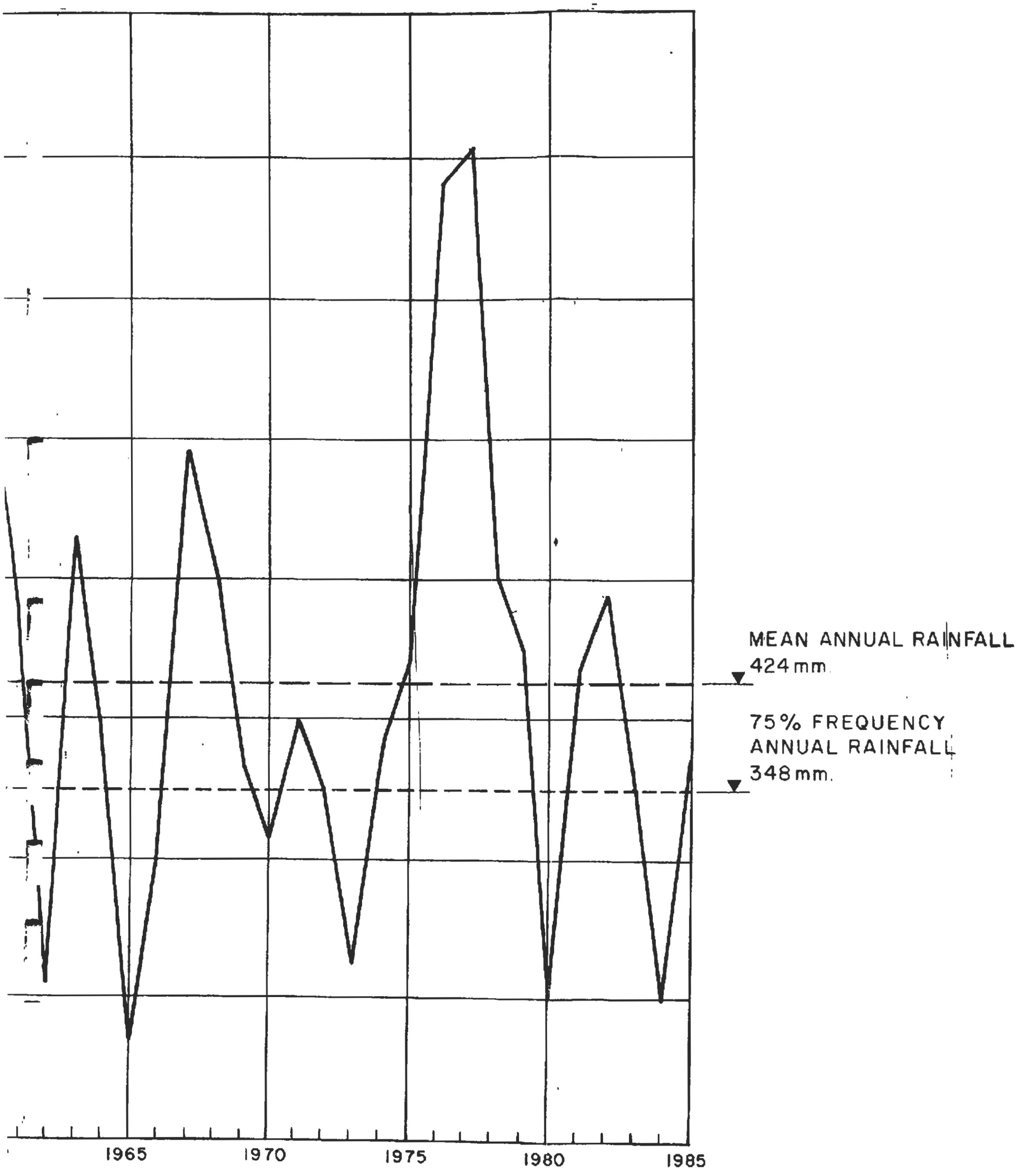
SOURCE: Van Wambeke, A. Soil Moisture and Temperature Regimes of Africa. SSMS Technical Monograph #2, 1982.

Table 1.5 Frequency Analysis of Annual Rainfall at Hargeysa Airport and Boorama

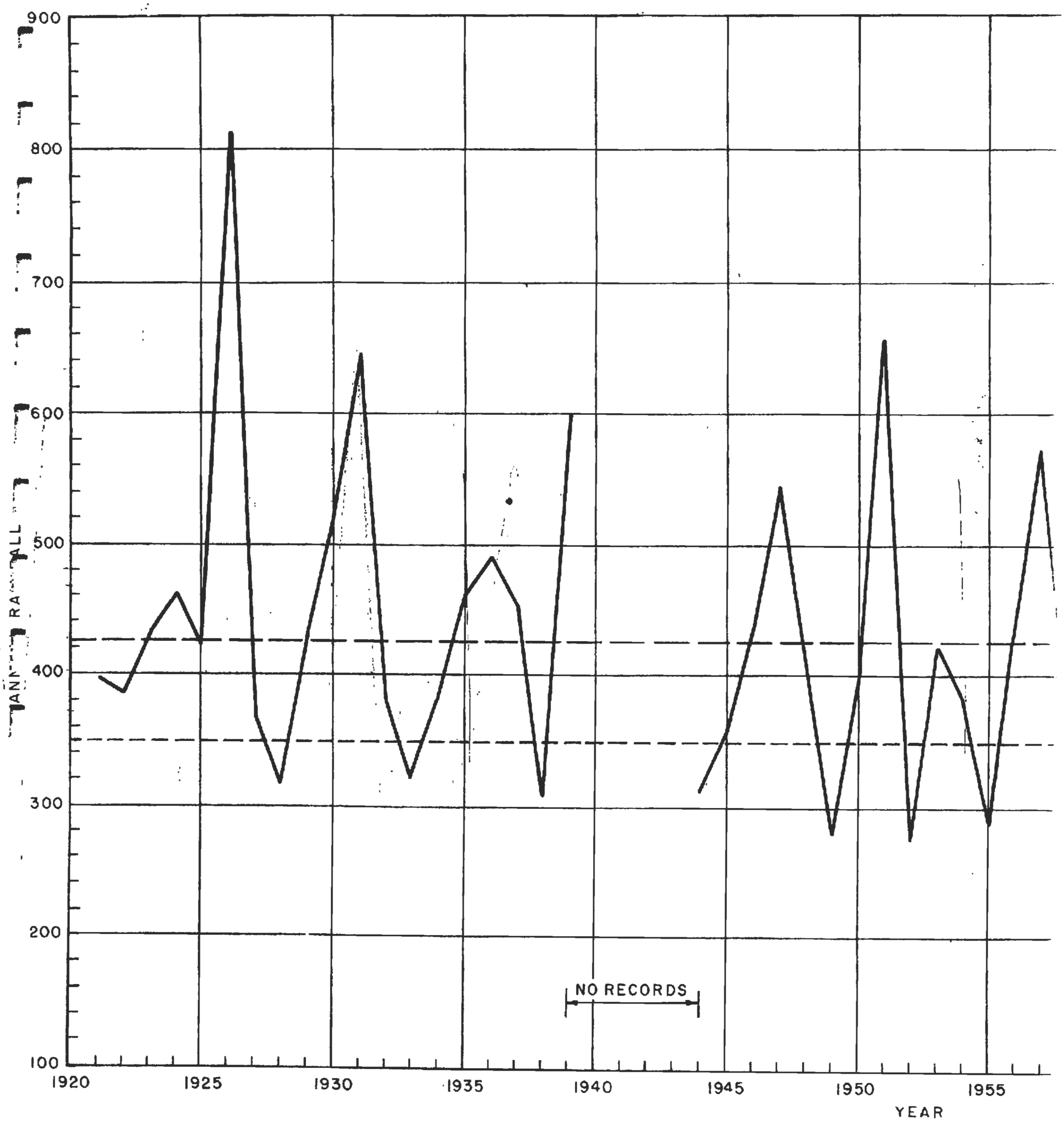
Frequency	Annual Rainfall (mm)	
	Hargeysa Airport (mean 424)	Boorama (mean 518)
25	488	600
45	424	518
50	399	508
75	348	412
90	259	364

than the mean annual rainfall. Average annual rainfall at Hargeysa has varied from 156 to 810 mm (see Table 1.3); the respective figures for Boorama are 311 and 864 mm. Analysis of existing data does not indicate that this variation follows any cyclical pattern, as has been suggested for other regions of Africa. Year to year variations may be quite extreme and trends apparent at one station are often not reflected at another station. Considerable attention has been given to the recent and ongoing drought in this part of Africa. However, analysis of available figures (see Figs. 1.1 and 1.2) does not indicate either that recent minimums are exceptionally low or any increase in frequency of low precipitation years. A downward trend is marginally discernible but is insufficiently defined to justify conclusions on increasing aridity. The problems, agricultural and human, encountered in the region may not therefore be blamed entirely on climate. Another variability component, characteristic of semi-arid areas, is that rainfall in any one year may be quite variable over space. Different areas may show quite different trends, relative to the average, in the same year, and this is supported by the trend differences between stations, previously noted. For example, rain gauges in two locations, 5 km apart, at Hargeysa, are reported as giving very different results. Further illustration of this point was obtained during interviews conducted within the pilot project areas (see Volumes II and III). These areas, while close to Hargeysa and to each other, reported considerable climatic differences from each other and from the Hargeysa record.

Rainfall distribution is an extremely important characteristic in agriculturally marginal areas such as the N W region. Many times the difference between crop growth in adjacent fields can be explained simply by correlating seeding date with respect to a particular rain. Crop failures or yield losses may also result in years of average or better than average rainfall where

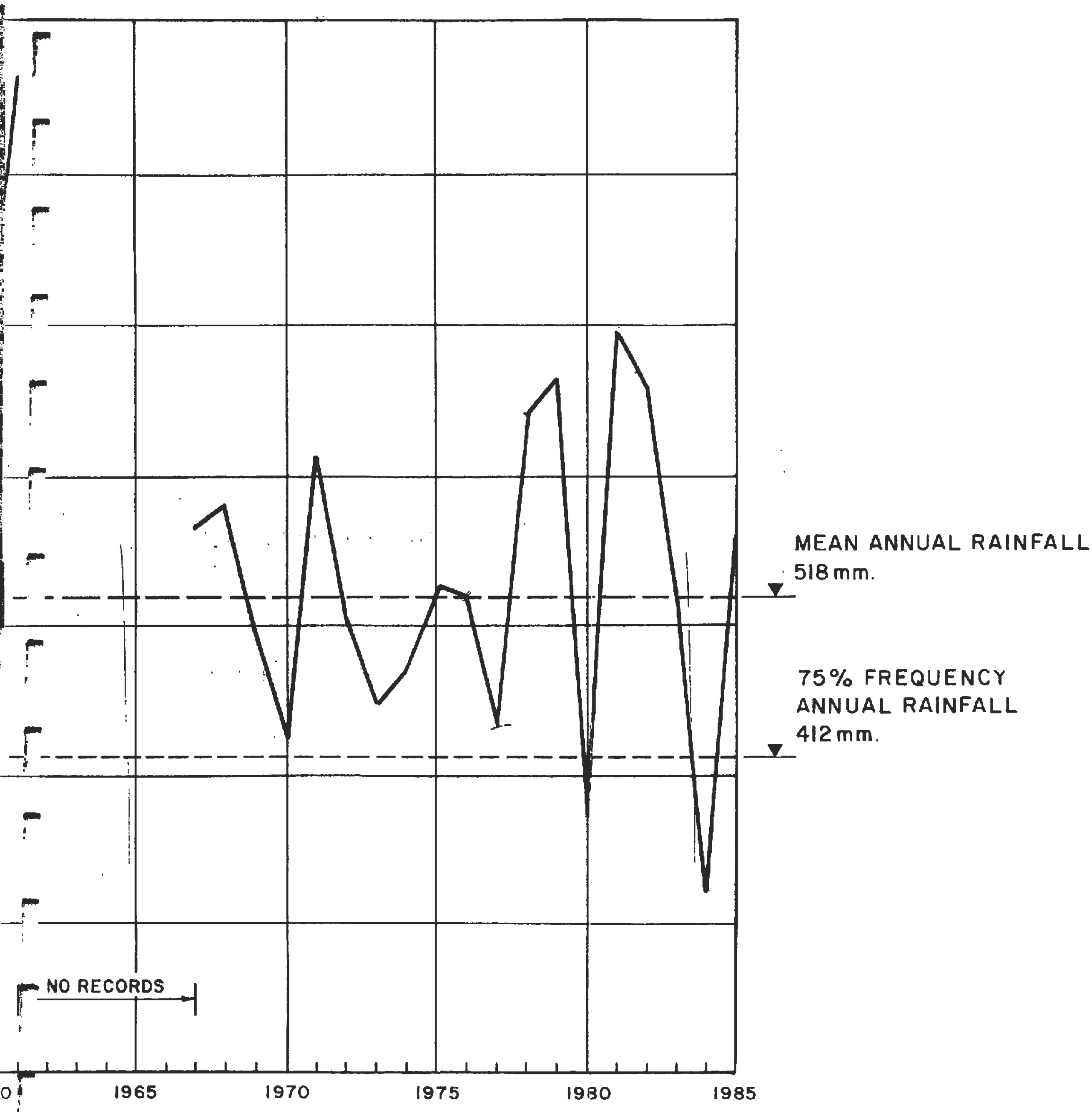


ANNUAL RAINFALL RECORDS – HARGEYSA AIRPORT
FIGURE 1.1

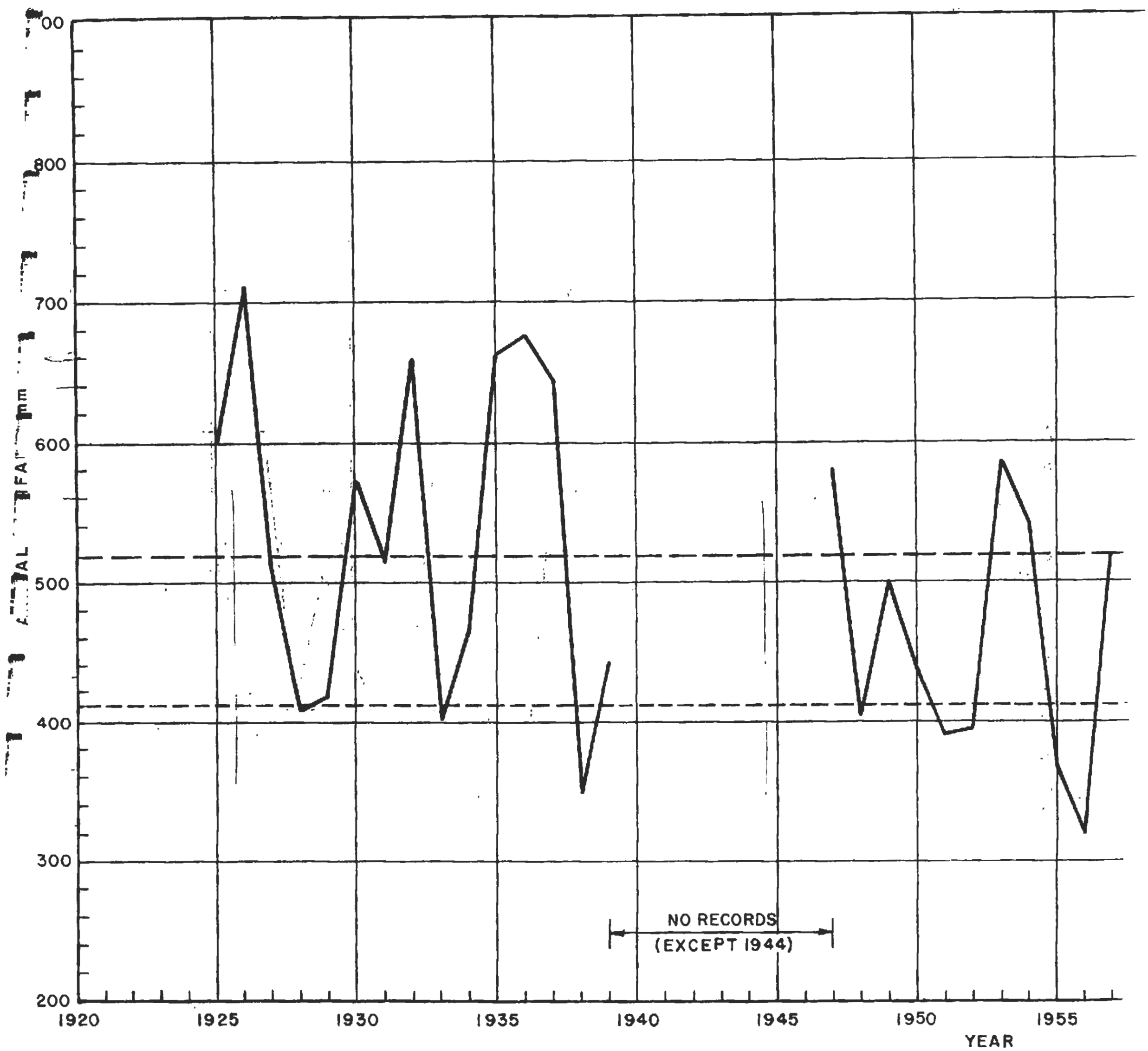


SOURCES:

1. SOGREAH REPORT NO. 3, 1921 TO 1980
2. HARGEYSA AIRPORT, 1981 TO 1985.



ANNUAL RAINFALL RECORDS – BOORAMA
FIGURE 1.2



SOURCES:

1. SOGREAH REPORT NO. 3, 1925 TO 1980.
2. HARGEYSA AIRPORT, 1981 TO 1985.

rainfall distribution through the growing season is severely skewed or sharply bimodal (see Table 1.6 and below). When this is taken into account, the probabi ity of a successful crop decreases. SOGREAH's theoretical analysis shows a deficit in most months of the growing season but unfortunately there is no analysis of the frequency with which the deficit becomes critical.

Table 1.6 completes the climatic records, to 1985 for Hargeysa and Boorama, presented in the SOGREAH Climate Report. It also serves to illustrate the problems of rainfall distribution through the growing season. For example, for Hargeysa 1981 was a better than normal year in terms of total rainfall, but only 6 mm of rain were recorded in mid-season, in June. The same problem occurs in the more critical, sub-normal year of 1983. 1985, a marginally sub-normal year, might well have had a better harvest than the higher rainfall 1981 year due to better distribution. Similar problems may be seen for Boorama in 1981 and 1985 (low rainfall in mid-season, June) and 1983 (no rainfall in September when heads are filling). Table 1.6 also presents some data for Galsahar (Ged Deeble), close to the junction of the plateau and the mountain zone. Both the annual and seasonal variations are seen to be more extreme here. Finally, the problems of data reliability are illustrated. The number of readings with whole rather than fractional numbers, especially for Hargeysa and Galsahar, is suspicious. Further, discrepancies with other data records are noted.

In addition to rainfall amounts and distribution, it is necessary to consider rainfall effectiveness. This is partly related to temperature which determines evapotranspiration. However, other factors are also important, such as the intensity and duration of rainfall. Rains of low intensity and long duration are more effective in infiltrating the soil than are rains of short duration and/or high intensity. High intensity rains tend

Table 1.6 Rainfall Distribution In mm, 1980 - 1985

HARGEYSA	1980	1981	1982	1983	1984	1985
Jan	-	-	-	-	-	-
Feb	-	-	-	42.0	-	-
Mar	-	183.5	8.0	-	-	13.0
April	13.0	45.0	46.7	24.0	6.4	71.0
May	41.0	56.6	109.4	89.0	70.5	138.0
June	16.0	6.0	68.3	-	-	43.1
July	23.3	25.0	25.0	42.5	23.0	37.0
Aug	6.0	69.5	36.6	109.7	11.0	36.0
Sept	65.0	48.5	36.0	44.7	83.0	35.6
Oct	24.7	2.0	149.0	-	-	15.5
Nov	1.8	-	8.5	-	-	-
Dec	-	-	-	-	12.0	-
TOTAL	190.8	436.1	487.5	351.9	205.9	389.2

BOORAMA	1980	1981	1982	1983	1984	1985
Jan	1.0	-	-	-	-	-
Feb	-	7.0	-	-	-	-
Mar	-	115.5	152.0	-	-	55.8
April	-	104.9	81.8	142.8	29.4	197.3
May	26.0	48.7	59.0	138.2	128.5	77.8
June	10.0	15.0	54.0	28.6	9.2	1.4
July	-	74.0	-	44.7	20.3	42.8
Aug	-	183.2	130.2	94.1	8.0	105.3
Sept	65.0	143.0	129.3	-	49.7	83.6
Oct	19.0	-	35.7	59.9	-	8.0
Nov	8.0	-	7.0	-	-	-
Dec	-	-	4.0	-	71.8	-
TOTAL	129.0	691.3	653.0	508.3	316.9	572.0

Table 1.6 Rainfall Distribution In mm, 1980 - 1985

Cont'd page 2

GALSAHAR	1980	1981	1982	1983	1984	1985
Jan	-	-	-	-	-	-
Feb	-	-	-	-	-	-
Mar	-	644.0	96.0	-	-	-
April	-	71.0	229.0	289.0	-	308.5
May	-	56.0	124.7	-	86.4	228.0
June	-	33.0	84.0	-	125.0	80.0
July	33.0	-	20.0	-	-	73.0
Aug	204.0	68.0	65.0	-	-	1.0
Sept	155.0	96.0	-	-	211.0	3.0
Oct	-	-	-	-	-	-
Nov	-	-	36.6	-	-	-
Dec	-	-	-	-	37.0	-
TOTAL	392.0	968.0	655.3	289.0	459.4	693.5

Source: Hargeysa Airport.

Note: Figures obtained for Hargeysa 1985 do not accord with those reported by the project (1985 4th Quarterly Report). Similarly, the figures for 1980 for both Hargeysa and Boorama do not accord with those given in the SOGREAH Climate Report: the monthly and daily sections of that report show 188.6 and 193.4 mm, respectively, for Hargeysa, and 369.5 mm for Boorama.

to seal the soil surface, especially in early season when the soil is substantially bare, with the result that most of the rain runs off. Data from SOGREAH suggests that most rains in the N W Region are of high intensity and short duration.

Obviously, land mismanagement, such as overgrazing and burning or removing crop stubble, which reduces ground cover over a longer than natural period, will tend to exacerbate this problem. The tendency of the soil to crust, observed in the N W Region, is a common problem in the Sahel. The effect is not only a reduction in infiltration, and thus of crop available moisture, but of producing a severe erosion hazard where runoff is uncontrolled. Erosion, in its turn, exposes a generally denser subsurface soil, thus further reducing infiltration and increasing runoff. This erosion problem is well illustrated in the N W Region. The objectives of soil and water conservation are interrelated. Measures which conserve water on the land also serve to reduce erosion from runoff; conversely, erosion control measures designed to reduce runoff from the land serve to promote infiltration and water conservation.

One other climatic characteristic worthy of note is wind. Data on winds in the N W Region is fragmentary. However, that data which exists suggests that there is sufficient wind, for at least part of the day, throughout the year, to support small wind powered generation and pumping.

The analysis of climate indicates that even the more favorable parts of the N W Region are marginal for sorghum and maize production and measures designed to conserve moisture would appear essential to minimize the probability of crop failure, and to generally enhance yields. Investigations conducted by the NWADEP during Phase I indicate an overall increase in yields, as a function of bunding, of about 60%. However, the climatic characteristics of the region suggest that these results should be treated cautiously. Until recently, no attempt was made to correlate the results to climatic variability, annually and spatially; date of seeding; soil characteristics; slope; etc., and many of the factors discussed are still not being considered. Another question which should be considered is the suitability of both crop types and varieties grown. The present choice, of sorghum and maize, appears to be more a question of tradition and cultural preferences than of crop suitability. Analysis of the climate suggests that the most drought tolerant crop types and varieties should be assessed and encouraged before more is spent in remodelling the environment in what is likely a vain attempt to adapt it to the chosen crop and variety.

The approximate locations of the two dryland study areas, analyzed during this mission, are shown in Drawing 101. As may be seen, the Hargeysa study area is located in an area of just under 400 mm average annual rainfall, which is slightly drier than the major part of the dryland project area. In other climatic characteristics it is similar to the rest of the dryland project area. The Baki study area, however, falls between the 300 and 350 mm isohyets and, being at lower elevation than the plateau, is subject to higher temperatures and higher evapotranspiration losses. The effective climate, therefore, is significantly drier than the main dryland project area.

2.3.4 Geology

The Geology of the North West region has been mapped in the past at 1:125,000 scale. The existing geologic mapping has been used and presented in the recent Feasibility Studies by SOGREAH (Report No. 16) and in the Geoexploration Report by the Chinese Well Drilling Team, both dated 1983. The geologic maps presented in said reports show some discrepancies but are essentially very similar.

The North West Region is located in the African Continental Platform. The regional bed rocks are mainly metamorphic rocks of the Pre-sinian with intrusive masses of igneous (granitic) rocks. Reportedly, there is no major folding; however, the area is severely faulted and fractured.

According to available information, metamorphic rocks are overlain by Jurassic limestones, Cretaceous Nubian sandstone, thick massive limestone (Auradu series) of the Lower Eocene, gypsum anhydrite of the Lower to Middle Eocene, and bio-limestone (Duban series) of the Miocene. The Quaternary formations include Pleistocene basalt (Aden volcanic rock), and Holocene (recent) alluvial materials, eolian sand dunes and others.

The areas where TAMS' studies were conducted include:

a. The plateau immediately west of Hargeysa where Nubian sandstone is the predominant formation

b) The Ruqi lowlands whose sub-surface is mainly formed by Jurassic limestones

c) Togga areas where alluvial materials predominate

d) The valleys north of Hargeysa whose sub-surface is mainly composed of the granitic/metamorphic rocks, and above mentioned Quaternary formation

2.3.5 Water Resources

There exist both surface and ground water resources in the Northwest Regions. However, available information is limited, the main source of information being the Feasibility Report conducted by SOGREAH during Phase I (Reports No. 3, Hydrology, and No. 16, Hydrogeology).

The major drainage system as shown in Drawing 100 is formed, from East to West, by toggas Baba, Waheen, Biji, Durdur and Silil with a combined drainage area in the order of 15,000 square kilometers.

The togga Baba is formed by several small mountain tributaries, then a stretch formed by sandy bed and rocky exposures and finally a sandy coastal section.

The Waheen basin covers an area of 3,000 sq. km. of which 2,760 sq. km. are upstream of the gorges and the remainder in the desertic coastal plain. This river is formed by two major tributaries; the eastern tributary originates in the Gacan Libuax Mountains and the western one (Maroodijex) drains part of the Hargeysa plateau.

The Biji basin covers an area of 3,560 sq. km. Its upper section with an area of about 2,000 sq km. is formed by a largely developed (population, agriculture, etc.) plateau in the Gebiley-Arabsiyo-Ged Deeble area drained by several toggas converging near Agabar to form the togga Biji. Downstream, the river runs through a 30 km long section of narrow gorges and finally traverses the wide, sandy, and coastal plain before reaching the sea.

The Durdur basin drains an area of 3,850 sq. km. Most of the basin upstream of the gorged area at Qabri Baxar (3,660 sq. km.) drains rough terrain formed by several tributaries, whereas the downstream portion is in the coastal plain. Upstream of Abarkor Cadawe, the headwater is partly in the Boorama plateau and partly in rough mountainous terrain and then abruptly plunges into the Ruqi plain. The difference in elevation between the headwater section and the Ruqi plain is in the order of 400 to 500 m. The alluvial plain at Ruqi is blocked by rocky outcrops with small permanent flow surfaces. Further downstream at Qabri Baxar the valley is dammed and the underflow surfaces once more.

The Silil basin is composed of two main toggas, the Jidhi and the Silil and two smaller tributaries in the lower part of the basin, the Gaargaara and the Laanley. Its total drainage area is in the order of 2,890 sq. km.

Data on runoff is very limited. Twelve gauging stations, whose locations are shown on Drawing 100, were installed during Phase I and SOGREAH conducted flood flow measurements during 1980. Apparently, the flow measurement program carried out at that time was not systematic as flow records are not available. It appears that the flow measurements were primarily aimed at obtaining information on total runoff/infiltration in large watersheds and in some small representative catchment areas.

Also during Phase I, synthetic data for a theoretical 10-year period was developed for the main river basins. Mean annual volumes were thus determined for (1) potential runoff; (2) infiltration upstream of the gorges; (3) runoff passing through the gorges; and (4) infiltration on the coastal plain. The runoff occurs in the form of floods meaning that only a small portion of the runoff can be considered usable. On the other hand, the infiltration figures estimated by SOGREAH can be taken as an indication of the total theoretical volume of groundwater in the toggas. After deducting estimated losses, these estimates can be considered as the maximum volume of water that may be theoretically abstracted from the surface aquifers (see Table 1.7).

The handling of runoff in the pilot project areas is dealt with in the study of selected watershed management pilot projects in Volumes II and III of this report.

Table 1.7 Estimated Mean Annual Volumes of Runoff and Infiltration per Basin

	Biji	Waheen	Durdur	Silil & Jidhi
Catchment area (km2)	3 560	3 000	3 850	960 + 1930
Potential Upstream Runoff	100	130	160	31 + 58
Infiltration upstream of the gorges	56	90	120	85
Water passing the gorges	44 + 7	40	40	4
Infiltration on the coastal plain	51	40	40	4

Source: SOGREAH Interim Report, March 1982

The water bearing formation offering the best potential for good quality groundwater is the recent alluvium located primarily along the toggas. Other water bearing formations of varying potential in terms of quality and quantity are the cretaceous Nubian sandstones (low quantity and quality) and possibly the Jurassic limestones currently being investigated in the Ruqi area with USAID funding.

Most of the groundwater potential requires pumping for its utilization. Nevertheless, some of these resources rise to the surface in springs or at natural rock barriers across the toggas. Such resources can be utilized in many instances by means of simple intakes and gravity diversions.

A systematic inventory of potential groundwater resources is not available. Approximate volumes of exploitable groundwater primarily from shallow togga aquifers have been estimated for the purpose of planning new small garden developments. These estimates are indicated in Volume 4 of this report.

Water quality data is scarce. Some measurements were taken by SOGREAH and are appendixed to their Report No. 16. Water quality is further discussed in Volume 4 of this report.

2.3.6 Land Resources

Soils: The soil resources of the N W Region were examined by SOGREAH (Report No. 5: Soil Survey). Their classification of the soil follows Soil Taxonomy (USDA/USCS 1975). It is not possible here to discuss this system beyond some general comments on the soils recognized by SOGREAH. Soil Toxonomy recognizes ten primary soil divisions (Orders) of which four were recognized by SOGREAH in the N W Region. Non-soil areas of rock, gravel and cobble were classed as "rockland."

i) Entisols were the primary soil order recognized. These are very weakly developed soils, with little profile development. Where the parent material is riverine, these are termed Fluvents. Non-riverine deposits may be sandy (Psamments) or non-sandy (Orthents). At the Great Group level they are divided on the basis of soil moisture regime - Aridic (Torri-) or Ustic (Usti-). Shallow soils over rock are recognized at the Sub-Group level (Lithic).

ii) Mollisols are soils rich in organic matter. However, in the tropics, organic matter degrades very rapidly and accumulates only under special conditions. Neither field observations during the present mission, nor the field and laboratory data presented by SOGREAH, support this classification. Based on limited field experience in "Mollisol areas," it seems most probable that these soils are Inceptisols - soils showing limited profile development, greater than that of Entisols but with insufficient translocation of minerals within the profile to satisfy the requirements of other orders. They are commonly referred to as "young" soils.

iii) Vertisols are heavy textured (high clay content) soils which crack deeply when dry, and swell and seal when wet. In consequence, they have low infiltration and permeability, and are very difficult to work, especially where modern equipment is not available. The vertisol area was not visited during this mission and so no further comment can be offered.

iv) Aridisols are soils, other than Entisols, developed under an aridic climate (see section 2.3.3). Only small areas along the coast are so classified. However, as previously noted, Van Wambeke (1982) classifies Hargeysa as having an aridic moisture regime; if true, then almost all the soils of the N W Region (except Entisols) would be classified as Aridisols.

The pattern of soil distribution closely follows the geomorphology of the region. On the high plateau SOGREAH has mapped the soils as predominantly deep and heavy textured, classed as Mollisols and Vertisols. Soils observed here during the current mission were considered, based on hand texturing in the field, to be more medium textured in the subsurface (at 50 cm) (1). The surface was generally sandy (loamy sand or sandy loam) and showed a distinct tendency to crust. As may be seen from Table 1.8, these soils, which are the primary soils for dryland agriculture, occupy only 7-8% of the area of the N W Region. Upstanding hills are rocky or covered with shallow soils, generally a thin, sandy layer over rock or gravels. A major problem in the plateau, especially towards its northern edge, is the susceptibility of the deep soils to erosion. Severe sheet and gully erosion are both common, with the gullies cutting deeply (several meters) into the soil. Between Arabsiyo and Gebiley, gully erosion may be considered to be the primary characteristic of the landscape.

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[1]The apparent discrepancy may be explained by the aggregation of the clays into silt and sand sized aggregates. This is referred to by Ahn (FAO Soils Bulletin No. 24) as the "natural" texture and is similar to the texture observed in the field by hand texturing. In laboratory analyses these aggregates are often dispersed by a chemical dispersing agent, giving a "true" texture which may have a much higher clay content that the "natural" texture. However, the "natural" texture reflects more accurately the way soils behave under field conditions. SOGREAH presents data on five "Mollisols." Four have laboratory contents showing high clay contents; the fifth has only field textures which are consistent with those observed during this mission.

Table 1.d Soil Occurrence

SOIL CLASSIFICATION

Order	Subgroup	Surface ha	%	General Characteristics
ARIDSOLS	Typic Salorthids	65 000	1.9	Saline, non arable, camel rangeland
	Typic Torrifluvents	164 000	4.9	Flood spreading areas, uncultivable, rangeland
	Ustic Torrifluvents	2 500	0.1	Alluvial plain, togga terrace, irrigable pastures
	Typic Ustifluvents	175 000	5.2	Togga terraces, flat valleys, cultivable under irrigation
	Typic Torripsamments	656 000	19.6	Coastal plain, cultivable under irrigation, rangeland
ENTISOLS	Ustic Torriorthents	24 000	0.7	Plateau, sheet and wind erosion, rangeland
	Lithic Torriorthents	101 000	3.0	Eroded colluvial glacis, gullies unsuitable
	Lithic Ustorthents	309 000	9.2	Eroded hillsides, uncultivable, poor rangeland
	Sub-total	1 432 000	42.8	
MOLLISOLS	Typic Argiustolls	219 000	6.5	Plateau, rainfed cultivation
VERTISOLS	Typic Chromusterts	44 000	1.3	Marginal for rainfed cultivation, rangeland
ROCK LAND		1 590 000	47.4	Unsuitable for cultivation, poor rangeland
TOTAL		3 350 000	100.0	

Source: SOGREAH, Interim Report, March 1982

The mountainous zone is mapped as consisting primarily of rock, gravel, and shallow, weakly developed soils (Lithic Ustorthents; Lithic Torriorthents). Deeper soils occur along, and adjacent to the main toggas (Fluvents, Ustic Torriorthents). Observations made during the present mission would support these general conclusions although much of the "rockland," especially on the limestone, contains pockets of deeper soil wherever the products of erosion have had a chance to accumulate. Many of these areas, often very isolated, show evidence of cultivation, but these areas are now frequently being destroyed by erosion.

The coastal plain is dominated by deep, sandy soils (Psamments; sandy Torrifluvents; coastal sand dunes). Occasional outcrops of rock are also mapped. Only on the eroded pediments, at the junction of the mountain zone and coastal plain, are heavier textured soils encountered.

SOGREAH also presents an interpretation of the soils in terms of soil capability for agriculture (dryland and irrigated) and for rangeland. Many factors enter into a determination of soil capability but in an area, such as the N W region where climate is such a severe constraint, soil moisture holding capacity may be considered to be the primary consideration after climate. Shallow and sandy soils both have low moisture holding capacities; such soils dominate the N W Region and offer no amelioration of the harsh climate. The steep slopes in the mountains further facilitate the loss of moisture, through runoff, while the deep sands of the coastal plain are nutrient deficient. In consequence, the SOGREAH land classification shows the bulk of these two zones - and, indeed, the bulk of the N W Region - as unsuitable for agriculture (dryland or irrigated) and poor to unsuitable for rangeland. Only on the plateau are the soils found suitable, for both agriculture and range. As seen in

Table 1.9, only 11.7% of the N W Region is considered suitable for rainfed cultivation, and 13% for range. However, the SOGREAH analysis take no account of soil erodibility which, as already indicated, is very high for the highest potential soils. About 0.2% is considered suitable for irrigation. Soil suitability for irrigation involves a delicate balance between moisture holding capacity and drainage. A medium textured soil is preferred for fruit and vegetable crops. The soils of most of the togga terraces seen during this mission appeared suitable for irrigation.

The Hargeysa study area is shown by SOGREAH as an area of Mollisols mixed with rockland and shallow soils. Most of the deep soil areas are classed as class 1 soils for rainfed cultivation. This is somewhat misleading as, while these soils may be the best in the region, they are still severely limited by climate. However, the study area appears to be representative of the rest of the plateau/dryland project area, most of which is classed as class 1 or 2. Only the Vertisol area is classed as class 3, due to problems of infiltration and workability.

The Baki study area is shown to consist primarily of rockland, with smaller areas of shallow soils over rock and with deep soils along the toggas. The land classification classes the whole area as unsuitable for dryland agriculture, and poor to unsuitable for rangeland. However, a high potential for irrigation is recognized, subject, of course, to water availability.

Vegetation: The vegetation of the N W Region is perhaps the most studied characteristic of the region. Two comprehensive studies have been undertaken - by SOGREAH (Report No. 6: Range and Livestock Survey) and by Resource Management and Reasearch (Northern Rangeland Survey). As indicated by their titles, both focus on the range resources for the livestock industry. The Northern Rangelands Survey is a multi-volume document which was

Table 1.9 Soil Capability

Classification for	Land Class	Suitability		Land Distribution	
		Rainfed Cultivation	Rangeland	Ha	% (rounded figures)
Rainfed Cultivation	1	Good	Good	99,000	3.0
	2	Medium	Good	292,000	8.7
	3	Poor	Medium to Poor	44,000	1.3
	4	Unsuitable	Low to unsuitable	2,915,000	87.0
Total 1 to 4				3,350,000	100.0

Classification for	Land Class	Class irrigability	Land Distribution	
			Ha	% (rounded figures)
Irrigated Cultivation	I	Good	3,500	0.1
	IV	Restricted to good for special crop	2,500	0.1
	V	Under conditions	1,091,000	32.6
	VI	Non irrigable	2,253,000	67.2
TOTAL I to VI			3,350,000	100.0

SOURCE: SOGREAH, Interim Report, March 1982 available for consultation only in Mogadishu. The present summary description is adapted from SOGREAH's analysis.

Five bioclimatic zones were recognized by SOGREAH, with various subdivisions within each. In general, both vegetation type and density can be related to geomorphology and climate, a low density of grasses and bushes dominating near the coast, with both vegetation density and the importance of tree species increasing inland.

The plateau area, and extending into the mountain zone, with 350-550 mm of annual rainfall, is termed the Acacia etbaica bioclimatic zone. This is an area of semi-open woodland. The tree layer is dominated by Acacia etbaica with a ground cover of about 10 to 50%. Tree height is typically 3-4 m, and rarely exceeds 6 m. The herbaceous layer shows the effects of grazing, both in its low ground cover and by the increasing dominance of unpalatable species such as Aloe. The impact of man is also important, with extensive clearing for cultivation and cutting of fuelwood.

Most of the rest of the high mountains, between 900 and 1250 m altitude, fall into the Acacia bussei zone. Annual rainfall for this zone in the N W Region is between 250 and 350 mm. This is an open woodland in which the tree layer is dominated by Acaccia bussei, with a tree and shrub cover of 10 - 25%. SOGREAH reports that this is the most degraded zone in Northern Somalia, with the almost total loss of the herbaceous layer. This loss has reduced rainfall infiltration and promoted soil erosion, and the trees are now beginning to die back.

The coastal plain is dominated by the Coastal Plain Bioclimatic Zone, dominated by grasses, herbs, and low bushes.

Salt-tolerant plants occupy salt-affected sites. Total ground cover is very low (5-20%).

A transition zone, termed the Subcoastal Zone, occupies the inner coastal plain and lower mountain slopes intermediate between the Coastal Plain and the Acacia zone. A wider range of flora is found than in the coastal zone and trees and shrubs are more important. However, ground cover is still very low, generally less than 20%.

A fifth bioclimatic zone, the Evergreen Zone, was also recognized, occurring above 1400 m altitude in areas of higher rainfall. This is a relic forest but is otherwise insignificant occupying only 2.2% of the N W Region.

The capacity to support livestock is of greater interest than the details of the vegetation. Different livestock obviously have different grazing requirements and so carrying capacity is commonly expressed in terms of livestock units (LU) defined as 250 kg live weight, consuming 6.25 kg of dry matter a day (see Table 1.10). SOGREAH calculated carrying capacity for each of the bioclimatic zones (see Table 1.11). Total carrying capacity is far below estimated livestock numbers in the region, resulting in chronic overgrazing. The Acacia etbaica zone, which coincides with the plateau, has the greatest grazing potential; however, this is also the area of greatest agricultural potential and human activity.

Grazing not only affects the herbaceous layer, but also the tree layer as it is common to cut down branches from palatable species for animal fodder. However, man also cuts trees for other activities, notably for fuelwood. Wood and charcoal

Table 1.11 Carrying Capacity of the Bioclimatic Zones

Bioclimatic zone	Total area (ha)	% of the studied area	Total Carrying Capacity (LU/year)	Carrying Capacity (Ha/LU/year)
Coastal	932 120	27.8	60 530	15.4
Sub coastal	876 630	26.1	24 560	35.7
Acacia bussei	717 760	21.4	92 700	7.7
Acacia etbaica	729 520	21.8	152 930	4.8
Evergreen	72 520	2.2	5 780	12.5
Cultivated area	23 650	0.7	16 900	1.4
Total area	3 352 200	100.0	353 400	9.5

Source: SOGREAH Technical Report No. 6
Range and Livestock Survey, June 1982

Table 1.10 Relationship Between Livestock Unit (LU) and Animal Type

MEAN LIVE WEIGHT (IN KG) AND CORRELATION WITH LU

	Mean live weight (kg)	LU
Sheep	20	0.08
Goats	20	0.08
Camels	325	1.30
Cattle	175	0.70
Donkeys	100	0.40

Source: SOGREAH Technical Report No. 6
Range and Livestock Survey, June 1982

are about the only fuels used in the region. Deforestation is very severe around the major population centres, notably Hargeysa and the major refugee camps. This, and overgrazing, expose the soil with resultant erosion and loss of productive potential. The N W Region would appear to be caught in a vicious cycle whereby the pressure of man and animals is causing environmental degradation which in turn increases the pressure on the remaining resources.

The Hargeysa study area falls entirely within the Acacia etbaica zone, as does all the plateau and the dryland cultivation project area. The Baki study area falls primarily in the Acacia bussei zone.

Land Use: This will be discussed in more detail in section 2.3.7: Agriculture, as agriculture is the primary land use of the N W Region. Nomadic livestock herding is the traditional activity, but recent pressures have led to an increasingly settled population and greater cultivation. Forestry and range are handled by the same government ministry and there would appear to be no attempt, in the N W Region, at the separation of forest and range, or at forest development, protection, or management. This undoubtedly reflects the traditional pre-eminence given to livestock. However, this free-range approach to livestock production is increasingly coming into conflict with other demands on the land - cultivation, fuelwood, and the need for soil conservation. The problem is both a social and a political one, but until it is addressed, no program of land management can ever be effective.

Erosion: The question of erosion must be addressed in any discussion of resources in the N W Region. It is a prominent feature of the N W Region, especially on the plateau where it would appear to threaten the future viability of the most productive area of the N W Region. The degree and rate of erosion have not been adequately studied, and it is recommended that this be done using existing aerial photography (see section 3.4.3). However, it appears that much of the erosion is recent, severe, and rapid and if allowed to continue unchecked will destroy the resource base of the plateau. As such, it would appear to be the most critical concern for the region. Therefore, soil conservation and erosion control should take precedence over moisture conservation as a NWADEP objective.

2.3.7 Agriculture

Agriculture is the primary activity of the N W Region. The area is traditionally one of nomadic herding but during the last twenty or so years, government policy, war in the dry season grazing lands of the Ogaden, and diminished resources have led to an increasingly settled population and an increase in cultivation. The resource problems are commonly attributed to drought; however, as discussed in section 2.3.3, no downward trend in precipitation can be positively identified from available data and it seems probable that the diminishing resource base can be substantially correlated to land mismanagement due to a host of social and political reasons. A similar situation has been identified in other parts of the Sahel. Contributing factors include government policies to restrict nomadic movements; increased population; introduction of common wells and other factors - including legal restrictions - which interrupt the traditional grazing order and the grazing controls contained therein; and a northward drift of cultivation which has reduced grazing lands. A relationship between land mismanagement and drought has also frequently been suggested, with devegetation precipitating the onset of drought. Unfortunately, drought often leads to a shift away from cattle to sheep and goats which are more drought hardy but which are also more destructive of the environment. The goat represents the eternal paradox of the Sahelian region of Africa; when all else fails, the goat will give both milk and meat, but it may well be a principal cause of all else failing.

SOGREAH found there to be no complete or reliable data on livestock numbers. By combining and analyzing all available data, they arrived at an estimate for 1979-1980 (see Table 1.12).

Table 1.12 Probable Livestock Popoulation In North West Region In 1979-1980

	Number of heads	Head/km2
Cattle	120,000 to 145,000	2.7 to 3.3
Camels	160,000 to 180,000	3.6 to 4.3
Sheep and goats	2,200,000 to 2,500,000	49.0 to 57.7

Source: SOGREAH Technical Report No. 6
Range and Livestock Survey, June 1982

Their figures translate into 8.8 ha/LU/year compared to a carrying capacity of 9.5 ha/LU/year (1) (see section 2.3.6). This represents a significant deficit in range resources, especially as, due to factors of accessibility or availability of water, not

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1 A requirement of 9.5 hectares per livestock unit per year while present usage allows only 8.8 hectares.

all the range can be evenly pastured, resulting in greater pressure on other areas. In consequence, SOGREAH concludes that "the region is 'chronically' overgrazed in the zones with higher livestock density."

The other characteristic of note, from Table 1.12, is the emphasis on sheep and goats. As noted previously, it is these animals which are most destructive of the environment. SOGREAH also analyzed the distribution of livestock, and found that about 80% were concentrated in the two Acacia zones, which also contain the cultivable land and most of the population. For further analysis of the livestock industry, the reader is referred to in the SOGREAH Report No. 6; Range and Livestock Survey.

Extensive cultivation, occurring essentially on the plateau, is a relatively recent phenomenon. The nomads, their life-style threatened, as described, and under pressure from governments, have increasingly turned to cultivation as a means of sustaining their families. However, only about 2% of the region is presently cultivated. In the N W Region, cultivation is, at best, a marginal activity and the choice of crop - almost exclusively sorghum and maize - seems to be dictated by tradition rather than its climatic suitability. These were the grains purchased in Ethiopia, where they were likely grown under different climatic conditions. The nomadic tradition of the new cultivators poses a number of problems. This fragile environment has been opened to cultivation not by farmers schooled for generations in land management, but by novices with no tradition of sustained occupancy and use of the land. Further, the commitment of these newcomers to cultivation and sustained agriculture remains questionable; cultivation appears to be often regarded as a marginal supplemental activity, and it seems likely that many would return to the nomadic life if suitable conditions were to return. Livestock retains a paramount importance in their farming activity. One noticeable characteristic is the use of traditional, long season crop varieties; this is partly a function of lack of research and extension but these varieties are also adapted well to a system in which the farmer migrates with his herd during the 4 to 5 months between seeding and harvest. Further, "cultivators" will often retain as many animals as possible. However, being settled for most of the year, these animals cause a concentrated destruction within the farming area. The result is rapid erosion and we were approached by many farmers concerned with the erosion of their fields. The necessary changes must come through education. The proposed pilot program offers an excellent opportunity to develop and demonstrate strategies of livestock and land management although it may take generations before the people are weaned from their traditional attachment to animals. Extension of the pilot experience, on a broader scale, will require not only an economic investment, but a major investment of political will.

SOGREAH (Report No. 7) provides some basic data on farm characteristics. For rainfed cultivation, essentially confined to the plateau, there are about 7,700 farms with a total area of about 64,000 ha. Farms are small - 56% less than 5 ha, and only 17% greater than 16 ha. However, less than half of this land is cultivated, cultivated area ranging from 28 to 44% of farm area. The reasons for this are unclear. When enquiries were made, we were usually told "lack of labor," but this seems an improbable reason. In part, it may reflect the traditional rotation, with crop followed by a long period of fallow, although in most areas there was no evidence of previous cultivation. In bunded areas it may sometimes be a conscious effort to maintain a catchment area to the bunds, although other evidence suggests that this is not normally the case. Most likely is the imperative of retaining grazing land for livestock, which takes priority over producing grain surpluses for sale. As noted previously, sorghum and maize are overwhelmingly the main crops grown (see Table 1.13). Most of the agricultural work is done manually, although both animals and tractors are used for ploughing. Ploughing commonly takes place after seeding. The seed is usually broadcast, which is neither efficient for production nor does it contribute to soil and moisture conservation. Seed is obtained from a variety of sources and is usually untreated. There is little maintenance of the crop during the growing season such that much of the precious soil moisture goes to weed growth. Until its recent banning by the government, qat was also commonly grown and many qat fields -now abandoned with the plants removed - may still be seen in the region. The careful husbandry applied to the qat fields provides an interesting contrast to the cultivation of cereal grains (note also contast with irrigated gardens, below).

Much stress has been laid on climate as the limiting factor to agricultural production in the N W Region. In response, the NWADEP has been established with a primary aim of introducing moisture conservation measures. However, the above overview of the current situation (see SOGREAH Report No. 7 for more detail) suggests that significant improvement could be made if greater attention were paid to crop type, variety, and cultivation method. Also, development projects have to be adapted to the socio-economic environment of the region (see USAID Project Impact Evaluation Report No. 62, 1985).

Irrigated land only occupies 0.06% of the N W Region, but generates the majority of the surplus crop value. Farm size is very small, mostly less than 2 ha. These irrigated lands are found on low togga terraces, wherever groundwater reserves provide sufficient water for all or most of the year. The effort put into cultivating this land contrasts sharply with most of the

Table 1.13 Estimated Agricultural Areas, 1980

a) By irrigation (pumping and flood spreading)

Gross area		(0.06% of the total study area - N.W.R.)	1 965 ha
Farm area			1 965 ha
Fallow land		(59.6% of the gross area)	1 171 ha
Cultivated area		(40.4% of the gross area)	794 ha
Total cropped area		(a land use rate of about 101.4%)	806 ha

The crops cultivated are as follows:

Citrus fruits		(35.2%)	283.5 ha
Other fruits		(14.6%)	118.1 ha
Vegetables		(9.2%)	74.3 ha
Cereals	maize	(22.5%)	181.0 ha
	sorghum	(1.3%)	11.0 ha
Qat		(10.8%)	86.6 ha
Date palms		(5.9%)	47.5 ha
Coffee		(0.4%)	3.5 ha
Tobacco			0.5 ha

b) By rainfed crops

Gross area		(2.04% of the total study area)	68 700 ha
Farm area		(92.8% of the gross area)	63 750 ha
Infrastructure (villages, roads)		(7.2% of the gross area)	4 950 ha
Fallow land		(62.9% of the farm area)	40 100 ha
Cultivated area		(37.1% of the farm area)	23 650 ha
	Sorghum*	(60.8% of the cultivated area) .	14 370 ha
Cropped	Maize	(39.0% of the cultivated area) .	9 230 ha
areas	Wheat/barley	(0.1% of the cultivated area) .	25 ha
	Qat	(0.1% of the cultivated area) .	25 ha

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* Including 650 ha of millet.

Source: SOGREAH, Report No. 7, December 1980 rainfed areas. A full analysis is undertaken in Volume IV of this report.

2.3.8 Population

The Feasibility Report by SOGREAH, 1983 (see SOGREAH's Report No. 9) contains an analysis of the population pattern prevailing in 1980.

The population of the area can be broken down into three major categories: nomads, semi-sedentary and sedentary. At that time the population of the North West Region was estimated to be in the order of 444,000 broken down as follows:

	Population	%
Nomads	42,000	9.5
Semi-sedentary	103,000	23.0
Sedentary	299,000	67.5
Totals	444,000	100.0

(Source: SOGREAH Technical Report No. 9
Population, demography and organization of agriculture, June 1981)

Reportedly, nomadic stock breeding which used to be the predominant life style a generation ago, has considerably declined due to the overgrazing in the area and more recently to the difficulty of grazing in areas under Ethiopian administration. Drought conditions in 1979-1980 have also contributed to the reduction in this type of activity. Part of the population has found complementary activities in rainfed agriculture and become semi-settled; part of the family involved in dryland farming is also involved in parallel stock breeding with some of the members travelling with the herd during part of the year. The increase in small irrigation has also contributed to the sedentarization process although only a minority of the population are engaged in this activity.

Those that have been unable to find a viable activity in agriculture or mixed agriculture-stock breeding, have moved into towns and villages thus contributing to an increasing urbanization in the area.

The main population centers and the estimated population in 1980 were as follows:

Hargeysa	300,000
Berbera	30,000
Gebiley	10,000
Boorama	10,000

(Source: SOGREAH Technical Report No. 9
Population, demography and organization of agriculture, June 1981

Undoubtedly Hargeysa is the urban center that has experienced the fastest growth from about 20,000 in the 1960's to probably over 450,000 at present with resulting increased demand for jobs and services. The annual population growth rate of Hargeysa has been estimated to be in the order of 11%. Its main activities are administrative and commercial. Hargeysa is a major livestock trading center and the seat of regional administration.

In addition, as a result of the Ogaden conflict and war with neighboring Ethiopia, a large influx of refugees has been displaced to Somalia. A large portion of this population has been placed in several camps in the North West region. There is no reliable information concerning the size of the refugee population; however, it is known to be substantial. UNHCR and several international agencies, as well as volunteer and charitable organizations assisting the Government of Somalia, are operating out of Hargeysa.

2.3.9 Infrastructure

Transport and Communications

The North West Region is accessible through overland route from Mogadishu, by air transport to the airports at Hargeysa, Berbera, and nearby Djibouti and by sea via the Berbera port and nearby Djibouti.

The overland route from Mogadishu serves primarily for transporting supplies from the southern part of the country through a long (approximately 1600 km) road link.

As far as the air transport is concerned, the better equipped airport at Berbera handles jet routes to Mogadishu, Saudi Arabia and other gulf destinations. Hargeysa is not equipped for heavy traffic. From this airport, there are several weekly flights to Mogadishu and Djibouti in light aircraft.

Berbera is the main port in the North West region and has recently been expanded and improved. It is equipped with handling and storage facilities. Oil imports and animal exports are handled through this port.

The communications network is extremely poor and constitutes a major stumbling block for development in the region. Telephone and telex with Mogadishu and elsewhere in the country and abroad is almost impossible. Telegraph system and radio are practically the only way to communicate with areas outside the North West. Local telephone system in Hargeysa and telephone to other localities is also poor.

The road system was evaluated by SOGREAH in its Feasibility Report (see Report No. 12). It is generally insufficient and needs considerable rehabilitation and improvement. Total main network shown on Drawing 100 includes some 2,600 km of roads including about 500 km of main roads (some 250 km paved roads and the remaining essentially dirt roads), as well as some 400 km of secondary roads and the remainder in feeder roads/tracks. At present the main paved road linking Hargeysa with Berbera, Arabsiyo, Gebiley and Kalabaydh is being extended to Boorama and there are plans to extend the paved (asphalt) section to Djibouti.

Power and Water Supplies

Both power and water supplies are insufficient (see SOGREAH Reports No. 13 and 16).

The National Power Utility (ENEE) operates diesel power generation and distribution facilities in Hargeysa and Berbera where electric power is available during 8 to 10 hours from about 6 p.m. Municipalities operate small oil fired systems in Gebiley, Arabsiyo, Boorama, and other small towns. Some large private consumers have their own means of production. The distribution network of electric power needs to be improved.

Water pumps in the small irrigated farms are generally powered by diesel or gasoline engines.

Lack of fuel for power and pumping (and for agricultural machines) is seriously hampering the economic development.

The main water supply system in the N W is that of Hargeysa. Other smaller systems exist in Berbera, Boorama, Gebiley and Arabsiyo. These systems are insufficient to meet the needs in these urban centers. All supplies tap from aquifers.

Hargeysa is supplied from deep tube wells in the Ged Deeble area. SOGREAH reported that the volume of water pumped from these wells at the time of the Feasibility Study was 1.62 million cubic meters per year. Plans to increase the supply by 1.46 million cubic meters per year are also reported. The water demand of Hargeysa at that time, assuming an average daily requirement of 100 liters per capita and a population of 300,000 would be 30,000 m^3 per day or 11 million m^3 per year. This depicts the enormous water supply deficit in Hargeysa. The distribution system also needs considerable expansion.

The rural water supply system has been improved by the Project under Phase I by construction of numerous human and animal water points. Further expansion of these facilities will take place during Phase II.

PART 2

WATERSHED MANAGEMENT

3. PILOT WATERSHED MANAGEMENT AND SOIL AND WATER CONSERVATION MEASURES

3.1 Basic Concepts

3.1.1 Watersheds

The terms "watershed" and "watershed management" are terms which are commonly used but which lack precise definitions. In our discussions with people interested in watershed management, both within and external to the project, we noted wide variation in the use and understanding of these terms. Before proceeding with any discussion of work plans, it is essential to understand clearly the meaning of the terms under discussion.

"Watershed" is, literally, the area which sheds water to the river. It includes all the land, from the watershed divide (see Figure 1.3) to the river, from which runoff water flows toward the river. Unfortunately, the terminology is not established in terms of scale, or size, and the term "watershed" is sometimes used interchangeably with other terms such as river basin and catchment. It is proposed to use here the following terms and definitions for river systems and sub-divisions (see Figure 1.3):

<u>River basin</u> - all the land contributing water to a river system, from the headwaters to the river mouth.

<u>Watershed</u> - that land contributing water to a main branch of the river system. Thus the river basin may consist of several watersheds (1, 2, 3, 4 on Fig. 1.3).

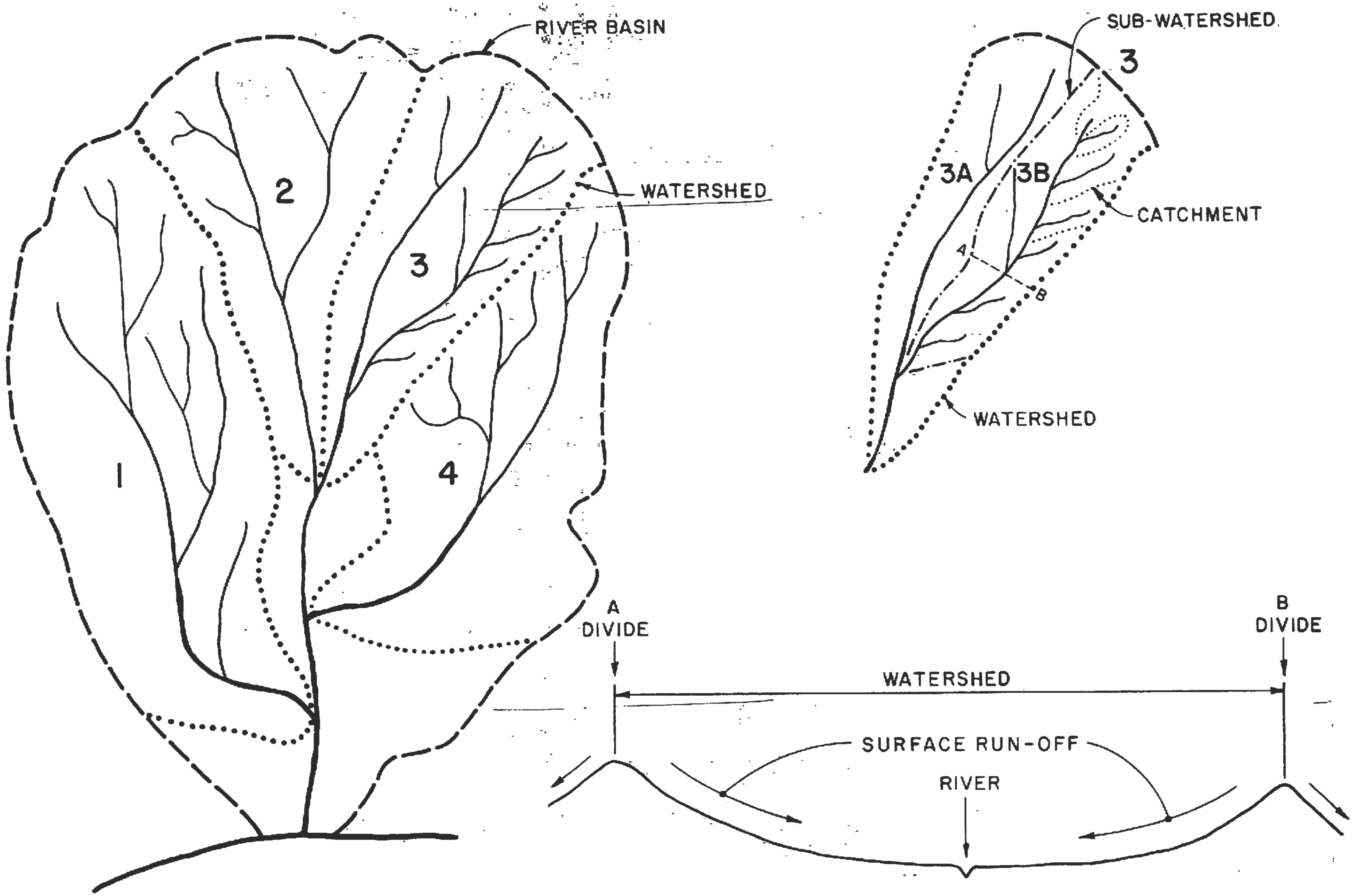


FIGURE 1.3
SCHEMATIC REPRESENTATION OF A RIVER SYSTEM AND SUBDIVISIONS

Sub-watershed - that land contributing water to a subordinate tributary. Thus each watershed may contain several sub-watersheds (3A, 3B,....., on Fig. 1.3)

Catchment - a small area contributing water to a specific drainage line or to a specific feature, e.g., a water point.

In this study we believe that the sub-watershed probably provides a manageable unit for a pilot study on watershed management, while retaining sufficient areal variation to confront a variety of problems and try alternate solutions.

3.1.2 Integrated Watershed Management

The resources of the watershed - water, land, vegetation, livestock - may be managed by individual or by integrated strategies. In the N W Region it is normal for individual land owners to make independent management decisions without any necessary consideration of surrounding land parcels. This approach may be successful where all the land of the watershed is managed by land owners with common objectives and methods; however, this is not the situation in the N W Region. Large parts of the watershed remain essentially unmanaged, left for uncontrolled communal grazing and wood cutting. The effect is often a serious degradation of these areas, and the resulting uncontrolled run-off adversely affects the downslope lands, no matter how good their individual management. A gully may be fed primarily by waters from an unmanaged area of the watershed, but the resulting gully advance may eat back into the well managed lands. The management of land in the N W Region, especially the bunding of individual fields, tends to direct excess water into drainage lines between bunds; as no one is responsible for managing the drainage, in terms of channel construction and maintenance, a gully is frequently the result.

The farm by farm approach so far practiced in the N W Region has, by and large, helped slow the erosion process. However, in the long term, the only rational approach is to integrate land management decisions on a watershed basis. The NWADEP has recognized the requirement for a more integrated approach, and has proposed a pilot study as part of Phase II of the project. However, the integrated management concept involves more than simply integrating on-farm measures. It must also include the non-farm areas, which will involve grazing management, forest management (afforestation and controlled cutting), water management (human and livestock water supply, and drainage), and gully control measures. No part of the watershed can be left untouched by this integrated strategy.

In summary, integrated watershed management is an all-encompassing concept, covering the physical, socio-political and economic characteristics of managing the entire watershed area, in a coordinated and integrated manner. It recognizes that individual land parcels are affected by the management of the surrounding lands and cannot be managed in isolation. This concept formed the basis of the appraisal and management proposals presented in the present document.

3.1.3 Pilot Watershed Management Project

The contract between the GOS and TAMS specifically refers to developing a "pilot" project in watershed control. The term "pilot" is understood to mean a project which defines appropriate actions and leads to the extension of these actions into areas which are environmentally s milar.

This pilot approach is thought to be most appropriate when applied to watershed control in the N W Region. As already described (section 2.2), the available data base is very limited and insufficient to define the many components of a watershed control program in very precise terms. Many aspects will need to be defined, by experimentation and trial, within the framework of the pilot project. Further, neither the NWADEP staff, nor the local population have any experience in implementing or managing such an integrated program. A pilot program, established within a limited area, will facilitate the development of that expertise. Both these characteristics of developing expertise suggest that the pilot area, while needing to be large enough to incorporate the principal elements of the environment, should otherwise be limited in area as far as possible. Similarly, the study suggests that the socio-economic situation may prove a major constraint to project implementation; a concentrated effort in a small defined area has a greater chance of developing local attitudes than does a similar level of effort dispersed over the whole plateau. Finally, the pilot area need be representative of as large an area as possible, such that the expertise developed can be extended to the largest possible area. These considerations formed the primary criteria for pilot study area selection during this mission.

3.1.4 Soil and Water Conservation

3.1.4.1 Introduction

A thorough review of the principles and practices of soil and water conservation is beyond the scope of the present document. However, an understanding of basic concepts is essential to comprehension of the various management alternatives. The review presented here is maintained at a basic level, which necessarily involves some oversimplification of this complex subject; for further detail and analysis, the reader is referred to the extensive existing literature on the subject. Unfortunately, much of the existing documentation has limited applicability to the physical, technological, and sociological environment of North West Somalia.

Soil and water conservation deals with the wise use of these important resources (Troeh, Hobbs, and Donahue). Soil and water conservation practices seek not only to preserve the resources but aim at their sustained utilization. In the case of soils, there are two related considerations - actual soil loss through removal by erosion, and soil degradation through the breakdown of soil structure, loss of fertility, etc. Soil conservation, therefore, seeks not only to keep the soil in place but to maintain its productive capacity. Water conservation involves maximizing the productive use of limited water. This may involve collection and/or retention of water, and reduction of losses (evaporation, use by non-productive users, etc.). It is fundamental to the practice of dryland farming.

In practice, soil and water conservation are almost inseparable, as measures designed for one almost inevitably aid, simultaneously, the other. For example, a vegetative cover protects the soil from raindrop splash and helps limit erosion; the vegetation also improves soil permeability and, by reducing runoff velocities and protecting the soil from puddling and crusting by raindrop impact, increases infiltration (water conservation).

The principles of soil and water conservation are discussed below. In terms of soil erosion, emphasis is placed on water erosion, as this reflects the emphasis of the various management measures proposed in this report. Water erosion is believed to be the most serious and urgent erosion problem in the North West Region. Wind erosion, while serious, is more difficult to assess and more difficult to control, especially in an environment (physical, social, economic) like North West Somalia where wind breaks are, by and large, not a realistic proposition.

3.1.4.2 Soil Erosion

Erosion is generally a smoothing or levelling process - nature's way of reducing everything to the same level. It is commonly divided into geologic and accelerated erosion. Geologic erosion is a natural phenomenon, which takes place without human influence. It is the natural process of surface levelling over geologic time by which mountain ranges have been reduced, and basins filled, to a common level. While catastrophic natural events, such as landslides, gain national and international attention, most geologic erosion is a slow, continuous process. In general, soil loss to geologic erosion is equalled or exceeded by soil development. The environment may be said to be in an equilibrium, with losses equalled by gains. The erosion in North West Somalia is, to a degree, geologic, as nature is trying to redress a balance interrupted by geologically recent uplifting in the area (See SOGREAH Report No. 8). However, there is little doubt that nature is being actively aided by man's activities.

Accelerated erosion involves a disequilibrium in the environmnent, where soil losses exceed soil development. This is generally a product of man's activities, especially those that result in increased soil exposure. Such activities include forest cutting, overgrazing, tillage, and heavy traffic.

Soil erosion by water and by wind are generally considered separately. This practice will be followed here, although both may be active in the same area.

Soil Erosion by Water

Soil erosion by water occurs when raindrops impact upon bare soil or when water moves over the surface creating a shearing force. Movement of soil by water occurs in three steps - soil detachment, transportation, and deposition. It involves an interaction between the water and the soil, and is determined by the properties of each. The important properties of water include volume, velocity, depth, and turbulence; these define the erosivity of the water, or potential of the water to cause erosion. These, in turn, are influenced by land characteristics, such as gradient and length of slope, surface roughness, and land management. Soil properties, especially texture and structure, define the erodibility of the soil, or its susceptibility (vulnerability) to erosion. The most important characteristics of water and soil, relevant to erosion, will be reviewed separately.

A. <u>Water</u>: Two major agents are active in water erosion - falling raindrops and running water.

i) Raindrops: Raindrop impact is being increasingly recognized as a major - perhaps the major - contributor to water erosion. This is because, in general, raindrops have much higher energy levels per unit of water than does runoff; runoff in its turn is, generally, merely that portion of raindrops that cannot be absorbed by the soil. Raindrops impact upon the soil in many ways.

- o soil detachment. Raindrop impact can dislodge particles or aggregates of soil.

- o soil transportation. On a flat surface, rainfall splash containing dislodged particles may be considered uniform in all directions, involving no net soil loss. On a slope, however, there is greater splash downslope than upslope, resulting in a net movement downslope.

- o structural breakdown. Raindrop impact breaks soil aggregates into smaller aggregates, which are easier to transport, and which may clog soil pores.

- o surface puddling and sealing, by direct impact and by clogging of the pores by the easier-transported finer particles and aggregates. Sealing decreases infiltration and therefore increases runoff and consequent soil transportation.

In general, raindrop energy (and therefore erosivity) and raindrop size are directly related, as are raindrop size and storm intensity. Thus, the greater the storm intensity, the larger the raindrop size, and the greater the energy and consequent erosion. Many storms in North West Somalia involve high intensity rains. The impact of raindrops on soil erosion can be lessened by intercepting the rainfall through maintaining a vegetation or mulch cover on the soil. Much of the intercepted rainfall will still reach the soil, but with reduced velocity and energy levels. The climate of North West Somalia results in a naturally thin surface cover of vegetation which provides but limited protection from raindrop erosion. This is exacerbated by practices of tillage and overgrazing which leave the soil bare for large parts of the year.

i) Running Water: The most common cause of runoff is rain falling at a rate faster than the soil can absorb it. The erosiveness of running water is influenced by its depth, velocity, turbulence, and transported material which acts as an abrasive. Velocity generally increases with depth, and turbulence increases with increases in the depth and velocity of flow. The capacity of water to detach soil increases in proportion to the square of the speed of flow; thus detachment capacity is quadrupled when the speed is doubled. Likewise, the transportive power of runoff varies with the speed of runoff to the power of 5; thus the transportive power is increased by 32 times when velocity is doubled. (SOGREAH Report No. 14)

A number of land parameters also influence the characteristics, and therefore the erosivity, of running water:

- slope gradient. Velocity of water flow is directly proportional to slop gradient. Thus, the steeper the gradient the greater the flow velocity and consequent erosivity.

- slope length. The longer the slope, the greater the volume of water accumulating upon it, and thus the greater the velocity, turbulence, sediment load, and erosivity. Thus, in general, there is more erosion per unit area on longer slopes.

- shape. Most slopes are either convex or concave (or a mixture of both). The effect of shape depends on the location of the steepest portions along the slope. Erosion is greatest where the steep slopes occur at the end of a slope (as in a simple convex situation) where the maximum runoff has accumulated.

- surface condition. A smooth, bare surface offers the least frictional resistance to the passage of water; a soil covered with dense vegetation presents the greatest resistance. Thus velocity of water flow is inversely proportional to surface roughness. Micro-topographical depressions, vegetation, or dead vegetation naturally increase surface roughness; tillage and cultivation techniques can also be used to increase surface roughness.

Erosion by surface flow is generally classified as follows:

i) <u>Sheet/rill erosion</u>: Sheet erosion is the removal of thin layers of soil by water acting over the whole soil surface. Sheet flow rarely achieves velocities necessary for soil detachment; this is almost invariably accomplished by raindrop impact, and this may even be more important in transportation than is sheet flow. In fact, water rarely acts over the whole surface evenly; runoff is rarely in flat sheets but in small channels or rills. Rills are erosion channels small enough to be obliterated by normal tillage operations. In the analysis presented in this report, sheet and rill erosion have not been separated.

ii) Gully erosion: Gullies are defined as erosion channels that are too large to be erased by ordinary tillage operations. The concentration of water into these channels gives greater depth and therefore greater velocity and turbulence of flow, while the sediment contained in the contributing runoff provides an abrasive action.

iii) Streambank erosion: This is erosion associated with perennial streams. It affects, in particular, the more productive lowland soils and frequently damages structures such as bridges. While apparent in the main toggas of the area, this is not something which occurs in the pilot project areas, and will not be discussed further here.

B. Soil: Soil erodibility is its susceptibility to erosion. It is a function of its detachability and transportability. The most important soil characteristics influencing erodibility are as follows:

- soil texture: Soil texture refers to the proportion of small (clay), medium (silt) and large (sand) particles that make up the soil. Sand particles are easily detached from the soil mass, but difficult to transport due to their size. The inverse is true of clay particles. Silt particles are susceptible to both detachment and transportation. Coarse textured soils also have greater permeability and infiltration due to the larger pores. In heavy soils, the reverse is true, resulting in greater runoff from heavy rains. However, total porosity of heavy textured soils is greater than for coarse textured soils, giving a greater total absorptive and retention capacity, and less losses from leaching.

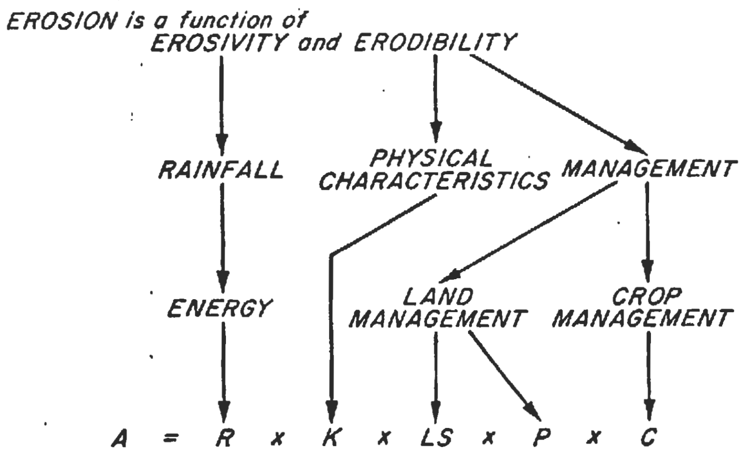
- soil structure: Structure refers to the arrangement of individual soil particles in the soil into separate aggregates. Size and stability of these aggregates are very important. Large stable aggregates are difficult to detach and transport, and they increase soil permeability. Soil structure is related to texture, organic matter content, the ions on the cation exchange complex, clay mineral type, other cementing agents (especially, in the tropics, iron and aluminum oxides), land management, and cropping history. Organic matter is of particular importance but is generally lacking in North West Somalia soils which, in general, are poorly structured. Good management practices will aim to improve organic matter content, soil tilth, and soil structure, thereby decreasing soil erodibility.

C. Erosion damage: Erosion involves both soil loss and soil degradation. It is usually noticed when soil loss occurs as water flow creates an extensive and dramatic gully system. Erosion may go unnoticed on a smooth soil surface where raindrops and sheet/rill flow are working over a large surface. While less dramatic, such erosion is often more damaging, over the long term, than gully erosion.

Equally, or even more damaging, but far more insidious, is soil degradation. This may involve nutrient loss and reduced soil fertility. The manner of this varies for different elements. Phosphorous, for example, is mainly lost as part of soil removal, along with colloidal (very small) particles on whose surface it is absorbed; conversely, nitrogen, in the nitrite or nitrate forms, is soluble in water and so can be lost in solution, without physical soil movement. Physical soil movement most frequently involves a net loss of the finer particles, with resultant textural changes, especially in the coarser soils. Soil structure disintegrates, due to raindrop impact and loss of binding agents (especially organic matter). Surface compaction and clogging of surface pores, resulting in decreased permeability and infiltration, have already been discussed. (A similar effect may result from the physical removal of the topsoil and exposure of less friable and less permeable sub-surface soils.)

In summary, erosion results in a physical loss of soil, especially the more fertile top soil; degradation of the soil leading to decreased fertility, decreased crop available moisture (from reduced infiltration), and increased problems of tillage; exposure of more compact subsoils which also increases tillage problems and decreases infiltration; and dissection of the fields for decreased efficiency of farming. Overall, soil productivity, and its capacity to support both man and animals, is reduced.

D. Erosion and erosion control: Hudson (1973) provides the following summary of the process of soil erosion by water:



The final equation has been termed the Universal Soil Loss Equation and was first put forward by Wischmeier and Smith in 1965. The major factors contributing to soil erosion by water are summarized in this equation. As may be seen, some items contributing to erosion are out of the effective control of man. Apart from difficult and expensive techniques such as cloud seeding, rainfall (R) may be taken as given, both as regards quantity and characteristics. The soil physical properties (K) are also essentially fixed, although structure may be improved by effective management. Likewise, slope gradient (S) is fixed without major earth reshaping, as in terracing. This leaves slope length (L) and the two management practices, conservation (P) and crop management (C), as the elements most open to manipulation for the control of erosion.

Most soil (and water) conservation practices are aimed at reducing the erosivity and transport capacity of water (raindrop and runoff), and increasing the soils resistance to detachment. From the analysis, above, of the Universal Soil Loss Equation, it is apparent that the possibilities of intervention may be grouped under two general headings:

a) practices which protect the soil from raindrop splash. This includes land use management which provides a soil cover over as long a period as possible. Such management may include controlled grazing, continuous cropping, intercropping, mulching, minimum tillage or tillage operations which leave the crop residue on the soil surface and produces few soil particles that are easily detached and transported. Also included here are management practices which build the soil, such as rotations, incorporation of organic matter, and manuring; such practices help increase soil resistance to detachment, increase infiltration, and reduce runoff.

b) practices which seek to reduce slope length and, to a lesser degree to lessen slope gradient. These impact upon flow velocity and erosivity, as previously explained. Such practices may involve land and crop management, or techniques of mechanical protection (land reshaping).

i) Land and crop management practices designed to reduce slope length include contour ploughing, row seeding, contour hedging, and strip cropping. Strip cropping is particularly effective where a permanent (fodder) crop is maintained periodically within the strip pattern.

ii) Mechanical protection practices can be grouped:

- diversion type channels (diversions, storm channels). These protect the lower lying land from erosion by intercepting the runoff and assuring its safe disposal.

- Terraces (channel terraces, bench terraces, irrigation terraces, contour bunds) divide the slope up into shorter segments and, in some cases, segments of lower gradient. They also intercept and arrest runoff, thus encouraging infiltration.

- drainage and waterways dispose of surplus water from diversions and terraces.

- gully control structures. These generally take the form of small dams constructed of rock, masonry, brush, or wood. They reduce water flow velocity down the gully, and dissipate its energy. In a sense, however, they are misnamed as control of the gully can only be totally effective through the implementation of upslope measures; once these upslope measures are in place, gully control structures are no longer required, exce t to control the exceptional flow.

Choice of soil conservation method must be dictated by the local situation, especially slope gradient. The FAO (Soils Bulletin No. 44 - Watershed Development) makes the distinction between "lowlands" with slopes of less than 2%, and "uplands" with higher slopes. The authors state:

> "The main soil and water conservation priorities on lowlands are concerned with maintaining and improving soil fertility by good farm management....Under dryland farming the main objective should be good soil, water and farm management."

This reflects a common viewpoint, in the literature, that the areas of lower slope can normally be managed, for erosion control, by good land and crop management. On higher slopes mechanical protection devices may be required. However, in all areas:

> "Mechanical protection works are to supplement good agronomic or cultural practices and should not be viewed as a substitute for them." (FAO Soils Bulletin No. 30: Soil Conservation for Developing Countries)."

Similarly:

> "Soil conservation has a wide scope, much beyond the generally accepted standards of physical works for erosion control. It is in fact a comprehensive approach to soil and farm management in which all so-called soil conservation practices contribute only a part to the overall target of maintaining and improving soil fertility, to the improved relationship between soil water and plant and to higher

sustained yields. It is the most important segment of re-establishing and maintaining the ecological balance between man and nature.

"Mechanical means for erosion control should be considered as supplementary measures for soil conservation on arable land and should be applied only if and when the physical conditions - slope, soil texture, rain distribution, intensity, etc. - are such that good farm management alone is insufficient to prevent erosion. But, even under these conditions, soil fertility, maintained or established by good farm management should always be considered as the first stage in soil conservation on arable land. There is a tendency in most countries to divorce soil conservation and farm - (soil) - management from conservation practices. Consequently, expensive physical works are carried out without any regard to the integrated approach which could save large investments and in all cases will produce the highest benefit to the farmer."

(Gill, in FAO Soils Bulletin No. 33: Soil Conservation and Management in Developing Countries)

These are two examples of a viewpoint common to the available literature. Another common viewpoint is also expressed by Gill:

"A very close and interdependent relationship exists between all phases of comprehensive watershed development. Soil conservation activities on agricultural lands alone can only be partly effective.... Without the complementary works in other sections of the watershed development plan, it may sometimes give only temporary relief."

In summary, therefore, soil conservation for agricultural development, requires action throughout the watershed. It starts with good land and land use (forest, grazing, crop) management. Mechanical measures should be used only where management alone is insufficient. However, it should also be remembered that land reshaping is an expensive proposition and should only be considered when there are strong economic or social reasons; other times it may be more economically efficient to change the land use.

Soil Erosion by Wind

Wind erosion is a serious problem in dryland regions and may cause serious soil detachment. As with water erosion, the process involves detachment, transportation, and deposition. The detaching capacity of the wind is related to its friction velocity, or sheer stress, and to the size of the erodible grain. The capacity of wind to transport soil material is related mainly to wind velocity and seems not to vary with size of soil grains. (Troeh et al)

Wind velocity is generally referred to as the velocity at 10 cm above the ground. The friction velocity evaluates the erosive power of wind. Friction velocity over a bare soil surface increases in direct proportion to wind velocity until the drag on the soil surface (surface shear stress) begins to cause erosion. For a given friction velocity, the shear force is greater over rougher surfaces which would, in consequence, be more erodible than smoother areas if the surface grains are erodible. However, rougher surfaces usually result from non-erodible clods or surface plant material; therefore, a rough surface generally helps soil resistance to the erosive power of wind. Air turbulence is a major factor in keeping soil grains in suspension. Wind strong enough to cause erosion is always turbulent, with eddies moving in all directions at a variety of velocities. The frequency and velocity of the eddies are related to the wind velocity and to the roughness and temperature differences of the surface over which the wind moves. Turbulence increases in proportion to increases in friction velocity, is greater over a rough surface than over a smooth one, and is more pronounced where changes in surface temperature are great. (Troeh et al). Table 1.14 shows a classification of wind velocities and the resulting wind erosion hazard.

Table 1.14 The Beaufort scale of wind velocities (measured at a height of 10 m) and their effects on wind erosion

Beaufort number	*Descriptive word*	*Velocity (km/hr)*	*Specifications for estimating velocities*	*Wind erosion hazard*
0	Calm	<1.5	Smoke rises vertically	None
1	Light air	1.5-5	Smoke drifts in direction of wind	
2	Light breeze	5-12	Wind felt on face; leaves rustle;	
3	Gentle breeze	12-20	Leaves and small twigs in constant motion	Begins in muck
4	Moderate breeze	20-30	Raises dust and loose paper; small branches are moved	Slight on mineral soil
5	Fresh breeze	30-40	Small trees in leaf begin to sway	
6	Strong breeze	40-50	Large branches in motion; whistling heard in telegraph wires	Considerable
7	Moderate gale	50-62	Whole trees in motion; inconvenient to walk against the wind	
8	Fresh gale	62-75	Breaks twigs off trees; generally impedes progress	
9	Strong gale	75-88	Slight structural damage occurs	Severe
10	Whole gale	88-100	Trees uprooted; considerable structural damage occurs	
11	Storm	100-120	Rarely experienced; accompanied by widespread damage	
12	Hurricane	>120	Devastation	

Source: Troeh, Hobbs, and Donahue, 1980

Soil is moved by wind in one of three ways. Soil particles and aggregates less than 0.05 mm (50 um - silts and clays) are moved in suspension. This is the most spectacular form of wind erosion, giving rise to the dust storms common in many dryland areas, including North West Somalia. However, suspension may account for only a small part of total soil movement. Conversely it is responsible for the movement of the smaller and most productive soil particles.

Intermediate sized gains, 0.05 to 0.5 mm (50 - 500 um) are moved by saltation, whereby individual particles lift off the surface and fly short distances. This movement accounts for the bulk of soil transportation (50-80% according to Dregne and Willis). Saltating grains are usually stopped at fences or other barriers, and result in the soil heaps common on the downwind field boundary. Large grains, to 1 mm, may be set in motion by saltating particles; however, these grains do not leave the surface, and this movement is referred to as soil creep.

Wind erosion affects, in particular, the finer grains. The effect of wind erosion, therefore, may be changes in soil texture and a decline in fertility status and productivity. From the above analysis, protective measures become evident. Management practices which improve soil structure increase effective grain size and increase resistance to erosion. These large grains not only resist movement, they also protect and stabilize erodible grains in their wind shadow. Similarly, tillage techniques which leave clods or increase surface roughness (e.g., surface ridges) reduce erosion. The length of exposed area is also important, soil drifting increasing with distance. Strip cropping, at right angles to the wind, reduces the length of exposed area, as do physical barriers. However, the most effective way to reduce the erosiveness of wind is to cover the soil with a protective mantle of growing plants or with a thick mulch. Retaining stubble and trash on the field also is effective. Unfortunately, wind erosion may be most active during the dry season, or early in the wet season, when ground cover is at its minimum.

Water Conservation

Water conservation is of paramount importance for plant and animal production in dryland agriculture. Seldom is sufficient, adequately distributed rainfall received during the growing season, such that a crop can produce to its potential. Therefore it is imperative to store water (from winter rains and high rainfall years) in the soil, or increase the water supply by diverting water from non-cropped areas. Even more important is preservation of water received, by promoting infiltration, stopping runoff losses, and reducing evaporation. Losses by evaporation alone may exceed 50% of the annual rainfall in dryland areas (Troeh et al). Equally important is that the crops be adapted to the area, with crop type and variety selected for minimum water requirement and a growing season adapted to the prevailing rainfall.

Water conservation may be effected largely by the same techniques discussed under soil erosion by water. Management techniques which conserve and build the soil promote infiltration. Runoff can be reduced or stopped by the methods described - contour cultivation, vegetation covers, mechanical devices, etc. Any of these which slow runoff also promote infiltration. A vegetative cover is the best way to reduce evaporation, but minimum tillage and mulches are also important practices.

The measures described under soil erosion, can all be used for moisture conservation. It may also be desired to channel and concentrate runoff in prepared sites fields). However, the collected water must be dispersed in a non-erosive fashion, and provision must be made for drainage for those storms where run-in exceeds the storage capacity. A negative aspect of such systems is that the amount of cultivable land is reduced by the amount of land required as a catchment. This is the principle behind the bunding program of the NWADEP, with the bunding providing for water retention to promote infiltration. In principle, if the climate is deficient in terms of crop production, then production on all slopes may be improved by increasing the effective moisture. The arguments against bunding on slopes of lower gradient are based on the notion that such slopes are generally in moisture reception situations (which is not necessarily true) and that on such low gradient slopes, water flow velocity is low and runoff control and infiltration can be effected by crop and land management, without water retention structures. This is probably true, but it does not obviate the need to provide for sufficient inflow from upslope or from catchment areas.

The final comment to be made is the same as that made under soil erosion by water. The first practice of water conservation is good land, soil and crop management. Mechanical measures such as bunds should be supplemental to good management, and not be seen as a replacement for good management.

3.1.5 Assumptions

The direction of the watershed management component of the work was influenced by certain assumptions based on the contract and various project and World Bank documents. TAMS was contracted to conduct a feasibility and design study, with design to be "practical and viable." This study forms part of a multi-million dollar dryland project, with about $10 million already invested by the World Bank and another $15 million (approximate) committed for the dryland component of Phase II. A project appraisal (World Bank 1984) provided a highly positive assessment of the project. The present mission proceeded on the following assumptions:

a) the dryland farming objectives of the NWADEP are i) to improve grain yields within the project area, for improved self-sufficiency and security, and to contribute to a reduction in the national grain deficit, and ii) to combat erosion. The emphasis is on improved grain yield, as evidenced by the World Bank appraisal (1984) which justified existing and future funding in terms of economic return on investment based on improved grain yields.

b) improvements in rainfed agricultural yields, within the study area are possible, given the application of appropriate technology, within the physical, economic and social environment of the region. This aspect was assumed to have been fully evaluated prior to project implementation, and is embodied in the concept of the NWADEP.

c) the present study was primarily designed to define that appropriate technology, and not to review the project as a whole. In this regard, the terms of reference for the contract called for a team of engineers; no sociologist, economist, or agronomist were called for.

d) the commitment of funds is firm. Thus it is better to design the most practical scheme possible, to make the best use of these funds, then to simply arrive at negative conclusions as to project feasibility, which we were not asked to assess. In fact, as will be described, the conclusions of the team raise severe doubts about the feasibility of a project designed to improve grain yields and reduce grain deficits. The study reflects this, as far as possible, by selecting an area where designs may use low-technology methods.

These assumptions seem reasonable, and the work was undertaken in good faith, guided by these assumptions. TAMS accepts no responsibility for limitations and deficiencies resulting from errors in the above assumptions. In particular, TAMS has proceeded on the assumption that the NWADEP dryland component is fundamentally sound in principle; if this is not the case, then the present study will also be unsound, for which TAMS cannot accept any responsibility.

3.2 Definition of Study Areas

Under the terms of the Project Preparation Facility of Phase II of the NWADEP, aerial photography was obtained, in February 1985, of some 480,000 hectares of the N W Region. This photography at 1:25,000 scale and subsequent topographic mapping at 1:10,000 scale were obtained through a contract between the Government of Somalia (GOS) and Geosurvey International. That contract was independent of the contract between the GOS and TAMS. As part of the TAMS contract, TAMS was requested to:

> "Liaise with the contractor for aerial photography and topographic mapping for the selection of appropriate areas for the pilot watershed control."

These areas would then be mapped by Geosurvey for topography and form the study areas for the pilot watershed control study.

In compliance with this contract provision, a representative of TAMS visited Nairobi and, in collaboration with Dr. Hassan Abdo Munye, General Manager of the NWADEP, and representatives of Geosurvey, reviewed the aerial photography and existing topographic maps to identify approximately 60,000 ha for subsequent topo-mapping by Geosurvey and Feasibility Study by TAMS. During Phase I of the NWADEP, three possible pilot areas had been identified. However, one of these, in the Durdur drainage, had not been included in the 1985 aerial photographic coverage due to security reasons and was excluded from further study for this reason. The other two areas were included in the contiguous 60,000 ha study area finally selected by TAMS. This area covered the upstream portions of the Toggas Arabsiyo (Biji basin) and Maroodijex (Waheen basin). The limits of the study area were carefully drawn to conform to the pattern of watersheds, such that as many complete sub-watersheds as possible would be available for the subsequent watershed control study. Justification of the selection of one contiguous study area was provided by TAMS in June 1985. (See Appendix A.1.2.)

Subsequently the study area was changed. In June 1985 (telex of 26 June 1985) the World Bank raised the possibility of change to permit inclusion of a part of the Durdur basin, where rainfall is within the 400-500 mm isohyet. In July, the NWADEP informed Geosurvey of an intention to redefine the boundaries of the study areas to allow for inclusion of part of the Durdur basin. Thus the original contiguous 60,000 ha was reduced to about 38,000 ha, and 22,000 ha were assigned to the Ruqi-Baki area of the Durdur basin, an area receiving 300-350 mm of rainfall. These two study areas were mapped by Geosurvey and are now referred to, respectively, as the Hargeysa and Baki study areas. At no time did the NWADEP consult TAMS on this change, or request TAMS' concurrence, and TAMS is in no way responsible for the final selection, or for any considerations arising from that selection.

The basis for selecting the limits of the newly defined areas is not clear, but appears to have been arbitrary. The western limit of the Hargeysa study area has a stepped pattern (air photo limits) which does not follow any natural boundary. The effect here was to exclude, or partially exclude, almost all sub-watersheds within the Biji drainage, thus effectively eliminating this drainage from selection of the pilot watershed areas. Only two small sub-watersheds attached to this drainage remained completely in the study area. The rectangular Baki area was selected without consideration to natural boundaries. In consequence, the headwaters of almost all the associated sub-watersheds are excluded or partially excluded from the Baki study area, and were thus not topo-mapped. This was a major constraint in subsequent considerations of this area for pilot watershed studies.

3.3 Land Characterization

3.3.1 Introduction

Under the terms of its contract with the GOS, the consultant (TAMS) was asked to prepare pilot proposals for soil and water conservation on a watershed basis. As an initial step, this involved a selection of a pilot sub-watershed from all sub-watersheds contained within the study areas; a knowledge of the limits and resource characteristics of possible sub-watersheds was therefore necessary. Such information would also be necessary for the subsequent development of management proposals for the selected sub-watershed.

As indicated previously (section 2.2), the available resource data base for the N W Region was very limited, especially that available at a level of detail appropriate to the present mission. Therefore, most necessary data on the resource base had to be obtained by primary (original) data collection, and this became the principal task of the period of in-country assignment. Initially, the limits of included sub-watersheds were defined. Then the 60,000 ha study area was mapped, at an original scale of 1:25,000, for present land use, physiography (land form and slope), basic soil characteristics, erosion and stoniness.

3.3.2 Watershed Delineation

The first task was to define the limits of the sub-watersheds contained within the study areas. Due to the unavailability of the topographic maps, this was initially undertaken by stereoscopic analysis of the aerial photographs, with a map produced by creating an uncontrolled mosaic of these photographs. With the arrival of the topographic maps, the limits of the sub-watersheds were redefined through interpolation of the contour lines. However, the definition of the study areas (see section 3.2) left the headwaters of many of the sub-watersheds outside of the study (mapped) areas.

As previously discussed (section 3.1.1), the concept of a watershed or sub-watershed is not defined by any precise criteria on stream order, size, etc. The concept of sub-watershed used here suggested an area draining into a principal tributary. In the Hargeysa study area, the limited drainage network gave little choice in definition of sub-watersheds. However, in much of the Baki area the drainage network is very dense and some selection between drainages was necessary. This selection was largely subjective, with particular consideration given to size of the sub-watershed area. Stream order was not considered although in both areas it is thought that the selected sub-watersheds represent about fourth-order drainages.

The extreme topography of most of the Baki area made definition of the sub-watershed limits a relatively simple task. The divides between sub-watersheds were generally clearly apparent on both the topographic maps and the air photos. In the Hargeysa study area, however, the more subdued relief made definition of the limits far more difficult, especially in the flatter areas of the south-west of the study area. However, the air photo and topo map analyses, while carried out independently, showed close agreement in location of these divides and it is felt that the defined divides are very close to the actual divides.

The defined sub-watersheds are presented in Drawings 102 (Hargeysa study area) and 106 (Baki study area). The different sub-watersheds included completely, or mostly, within the study areas have been assigned numbers. A comparison of sub-watershed sizes, for both study areas, is given in section 3.5.

3.3.3 Methodology for Resource Characterization

Resource characterization was undertaken primarily by the stereoscopic analysis of the 1:25,000 aerial photography taken by Geosurvey in February 1985. Due to problems in obtaining vehicles and fuel for field work, the initial legend development and mapping were carried out almost entirely by air photo interpretation. During this period only one field day was possible in each of the two study areas. Subsequently, a three day field trip was undertaken in the Baki area, and about five days were spent in the Hargeysa area. This facilitated field checking and modification of the photo interpretations. Fortunately few modifications were required as field work largely confirmed the office interpretations. The field work also facilitated the collection of supplemental information, especially some minimal data relevant to the soil.

Observations were made on land use, physiography, soil, erosion, and stoniness. For land use, the primary separation was between cultivated and pasture/forest; in the study areas, no separation could be made between grazing land and forest. Cultivated areas were divided as to whether bunded or not, and pasture/forest areas according to apparent vegetation density and structure. These determinations were made primarily by air photo analysis. Physiography was also defined from the air photos, but slope was calculated from the topographic maps. Soil depth, and surface and sub-surface (at 50 cm) texture, was determined in the field at selected locations, and extrapolated to the complete areas by air photo analysis. Gully erosion was primarily defined by air photo analysis but sheet erosion and stoniness was extrapolated from field observations at selected locations. Water points and settlements were both described from the air photos. However, motorable tracks were defined by field experience as it was found that photo interpretation was misleading; clear tracks on the photos were by no means necessarily passable by vehicle due to erosion or other constraints.

Interpretations and observations were annotated directly onto the aerial photographs using a grease pencil. In the absence of the topographic maps, this data was assembled on uncontrolled photo mosaics of the study areas. Once the topographic maps were received, the original data was visually transferred to 1:25,000 scale reduced mosaics of the topographic maps, and this was further reduced to the 1:50,000 publication scale. Data presentation is in the form of line drawings. Drainage, water points, roads and settlements are shown by symbols. The other resource data is presented symbolically for defined map units. A complete description of the methodology is given in Appendix A1.3, and of the legends in Appendix A1.4.

3.3.4 Resource Maps: Hargeysa Study Area

The resource characterization carried out is presented as a series of four maps and cross sections. The first map (Drawing 102) shows the drainage network, defined sub-watersheds, and water points; the second (Drawing 102A) presents the settlements and the road network; the last (Drawing 104) presents information on land use, physiography, soils, erosion, and stoniness. Topographic information is presented by the cross sections in Drawing 103; the lines of the cross sections are shown on Drawing 102.

Each of the drawings is presented with a full legend; these legends are fully described in Appendices A1.3 and A1.4. The following presents a brief resume for each map, of included data and the nature of presentation.

Drawing 102: Drainage and water points

Drainage lines, watershed divides, livestock water points, and human water "pits" are presented by symbols. Wells are not included as these are not readily observable on the aerial photographs and there was no other realistic way of obtaining this information.

Drawing 102A: Roads and settlements

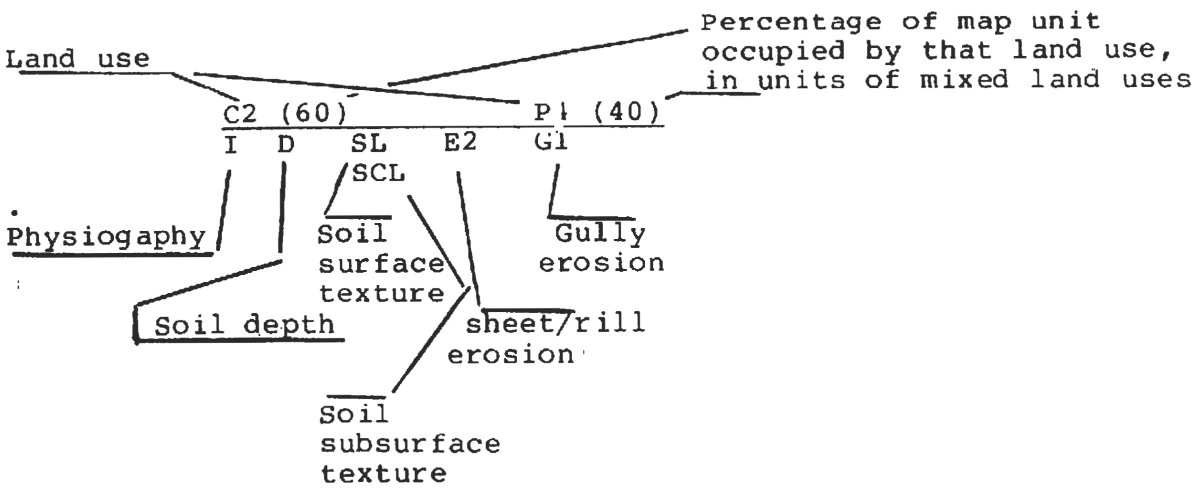
Only one paved road occurs in the study area. There are no other improved routes and so all other routes are classed as tracks. These have been classed on the basis of use (primary tracks) and known accessibility to motor vehicles (other motorable tracks). Foot paths are not shown. Settlements are divided according to size and permanency. Those containing masonry construction are assumed permanent, as are some settlements on main routes which appear to have local administrative or service functions (e.g., Aburriin, Xidhinta). Other settlements, off the main routes and consisting primarily of the oval, nomadic-type huts, provide no clue as to their permanence and are classified solely by size. Size was defined by the number of fenced enclosures which could be counted on the aerial photographs.

Drawing 104: Land Resources

The primary designation here is the land use. Fields cultivated for dryland agriculture are divided according to whether they are bunded or unbunded. Irrigated fields are also recognized. As the photography was not obtained during the season of standing crop, it was impossible to distinguish fallow land. Grazing and forest lands are grouped together as all such areas serve both functions. Divisions are based on plant density and structure (dominance of trees or bushes). Other land uses recognized include excavations, and the broad, bare, sandy togga bottoms.

Physiography was defined according to land form and slope. Interpolated soil depth, and surface and subsurface textures (hand textured) are also presented. Erosion is presented in two forms. Very severe gully erosion is included under physiography, as a gully landform. Shallow gullying and sheet erosion are presented as a separate characteristic, with an estimate of their severity. The presence and severity of surface stones and rocks were also recorded in the field; as these were found to vary very little within a physiographic unit, and in the interests of space on the map, this information is presented only in the descriptive legend accompanying the maps.

In order to present the spatial variation of the above parameters, the project area is divided into mapping units, each unit being an area of relative homogeneity in terms of the land characteristics described. The map unit concept is described in Appendix A1.3. The resource characteristics of each map unit are presented symbolically, according to the following general format:



Where the land characteristics below the line are essentially non-variable, as in the case of rocky hills, the format is shortened to present just the land use and the physiography. By reference to the legend accompanying the map, these symbols allow direct access to the primary land characteristics of each parcel of land. Further details are contained in Appendix A1.4.

3.3.5 Resource Maps: Baki Study Area

The resource characterization carried out is presented in two maps and one cross section. The first map (Drawing 106) shows the drainage network, defined sub-watersheds, roads, and settlements. This was presented on two maps for Hargeysa but in Baki, the absence of water points, and very limited network of roads and settlements permits the presentation of this data on one map. The second map (Drawing 108) presents information on land use, physiography, soils, erosion, and stoniness. Topographic information is presented in the cross sections in Drawing 107; the lines of the cross sections are shown in Drawing 106.

Each of the drawings is presented with a full legend; these legends are fully explained and described in Appendices A1.3 and A1.4. The following presents a brief resume, for the two maps, of included data and the nature of presentation.

Drawing 106: Drainage and Infrastructure

Drainage lines, watershed divides, motorable tracks, and settlements are shown by means of symbols. Water points are non-existent within the study area. The track between Ruqi and Baki, and the track from Ruqi to Boorama have been classed as principal tracks on the basis of their use. Other tracks have been marked where known to be accessible to 4-wheel drive vehicles. The only village of any size is Ruqi; Baki is now the main administrative centre and contains several masonry buildings, but is still very small. Other settlements, consisting primarily of the oval, nomadic-type huts, are few in number and small in size. Those associated with the religious community of Ceel Bardaale have been indicated.

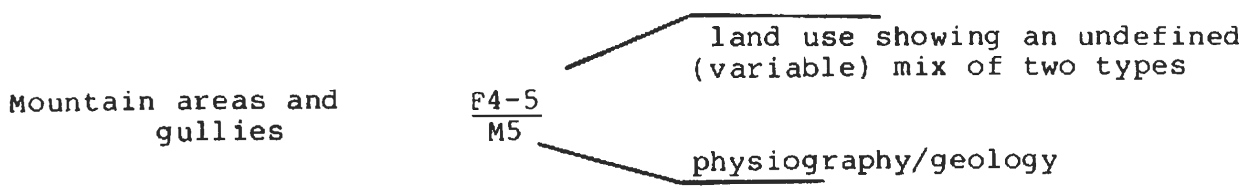
Drawing 108: Land Resources

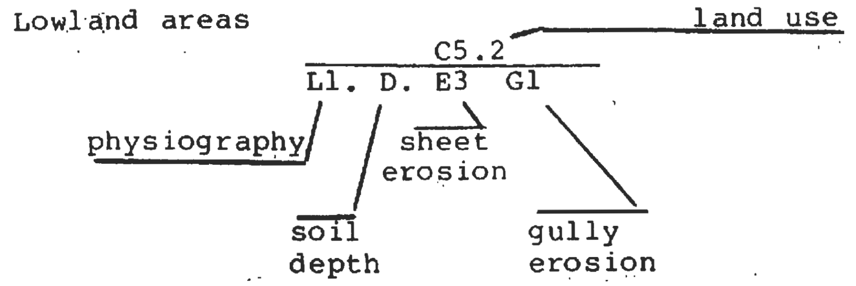
A primary distinction is made between the mountains and the lowlands. The mountains are simply classed by land use - forest/pasture, divided by density of tree cover - and a combination of physiography and geology. The mountains are dominantly areas of steep slope and shallow soil over rock, and the most obvious variations appear to be related to geology - type and angle of bedding - and to drainage density. A more detailed characterization was prevented by limited access.

A more comprehensive categorization is presented for the lowlands. The primary designation is the land use. In broad terms, three different land uses were recognized - forest/pasture, areas with field pattern, and irrigated lands. Grazing and forest areas are grouped together as all such areas serve both functions. Divisions are based on plant density and structure (dominance of trees or bushes). Despite the extensive areas with a field pattern, very little active cultivation was seen. However, it was unclear as to whether the land was in fallow or abandoned, temporarily or permanently, and so the term fallow was not applied. Most such land is hedged, and mixed with grazing/ forest land (P3 or P4); a division was made on the basis of the percentage of the mapping unit showing a hedged field pattern. Some areas of bunded and of unbunded fields were also recognized, but again these were largely uncultivated. The only other land use recognized was the broad, bare, sandy togga bottoms.

Physiography of the lowlands is essentially that of a sloping plain, and divisions were based on slope angle. The only other physiographic type is the gully, which may also occur in mountain areas. Interpolated soil depth is presented, along with two expressions of erosion - sheet/rill erosion, and gully erosion, with an estimate of their severity. The presence and severity of surface stones is also recorded in the accompanying descriptive legend.

This data is presented for the study area within mapping units, each unit being an area of relative homogeneity in terms of the land characteristics described. The map unit concept is described in Appendix A1.3. The resource characteristics of each map unit are presented symbolically. Two formats are used, one for the mountain areas and gullies, and one for the lowlands as follows:





Further details are contained in Appendix A1.4.

3.3.6 Erosion Maps

During the resource analysis of the two project areas, it became apparent to the consultant that a primary problem in the study areas is erosion. Extensive areas have been lost to gullies while much of the rest of the land shows moderate to severe sheet and gully erosion. Much of this erosion appears to be of recent origin, presumably as a result of increased pressure on the land over the last fifty or so years. However, it was not possible to confirm this; no existing studies of erosion were available, nor were there any old resource studies which might provide a base year for comparison. The possibility exists of comparing visible erosion patterns for the years of available photographic coverage (1952, 1973, 1985); this was outside of the scope of the present study, but is recommended for future action.

The resource mapping showed erosion to be extensive and interviews with farmers indicated gully encroachment at a rate of up to 12-15 m per year. If this is true, then erosion would appear to present a far greater hazard to the long term agricultural viability of the area than questions of climate and plant available moisture. In order to highlight this problem, separate maps are presented showing current and projected severe erosion (Drawings 105 and 109). Projected erosion is shown for 150 m and 300 m of gully advance; at the aforementioned erosion rates, this would represent 10-15 and 20-25 year time horizons.

3.3.7 Topography

The topography of the study areas is shown by the topographic maps at 1:10,000 scale prepared, under a separate contract, by Geosurvey. Delivery of these maps to NWADEP was completed in November 1985. The topographic variation within the study areas is illustrated by cross sections taken from these maps, and presented in Drawings 103 (Hargeysa) and 107 (Baki). Further slope information was calculated from the topographic maps.

3.4 Land Evaluation and Land Use Planning

The two study areas were described for their land characteristics, as detailed in section 3.3 and Appendices A1.3 and A1.4 and in the corresponding drawings. This section seeks to describe and evaluate, in more detail, the major land characteristics of each study area, and to evaluate in general terms the various land management options for each of the described land types. The land use options presented here are necessarily general as they cover broad and areally extensive land types; more detail would be equivalent to the preliminary design for the pilot watershed areas, as presented in Volumes II and III, and would be beyond the scope of this project.

The two study areas of Hargeysa and Baki are very different in their environmental setting and land use potential, and this is brought out in their descriptions. These descriptions are compared throughout the text to those provided by the SOGREAH study, the only other resource evaluation of these areas. Finally, consideration is given to the question of erosion, which is evaluated as a primary concern in both study areas.

3.4.1 Hargeysa Study Area

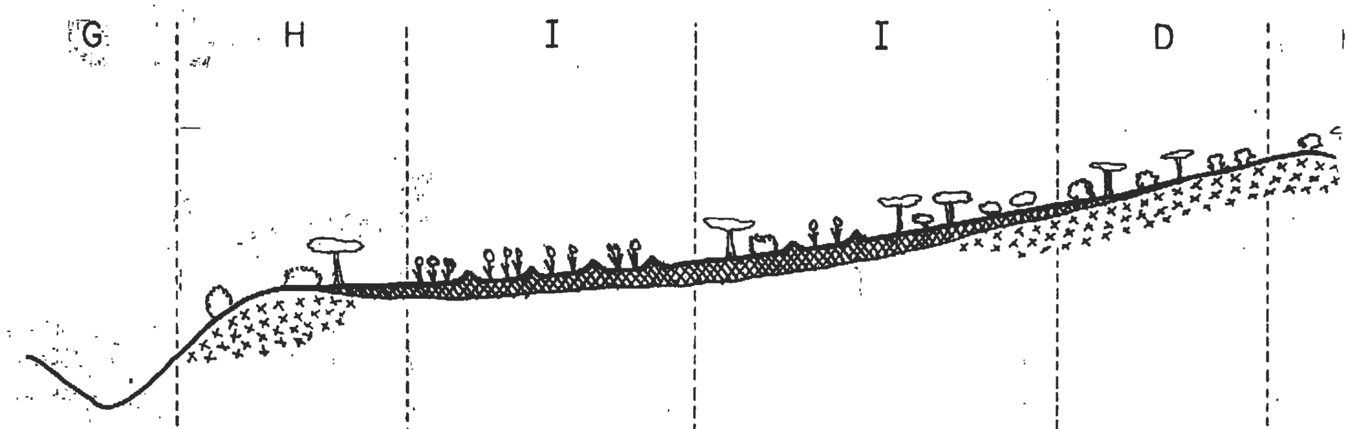
3.4.1.1 Overview

The Hargeysa study area is an irregular shaped area of some 38,000 ha, located just west of Hargeysa. The northern limit of the study area follows, approximately, the paved road from Hargeysa, to Abaarso to Arabsiyo; the southern limit is approximately defined by the track from Gadhyogol to Aburriin and Xidhinta. These boundaries follow the watershed divides, which explains the irregular shape. The eastern limit is the city of

Hargeysa, while the western limit is arbitrary. Most of the area is drained by the Togga Maroodijex, which drains north-eastwards, and its tributaries. As such, the area falls primarily into the headwaters area of the Waheen drainage. The far western portions of the study area, however, are drained by the Togga Arabsiyo, which is within the Biji drainage (see Drawings 101 and 102).

The study area is part of the plateau (see section 2.3.2); it is a very gently rolling elevated plain, broken by upstanding hills and cut by deep gullies. Within the study area, slopes on the plain rarely exceed 2 1/2%, stretching gently down to the intermittent streams or toggas. To the southwest the drainage becomes more subtle, with little visible pattern, and slopes decrease to less than 1%. Apart from these main drainage lines, there are also numerous gullies which cut deeply into the soils of the plain. The plain is sharply broken by a series of sandstone outcrops, upstanding by up to 100 meters and tilted southwards to form steep, north facing escarpments (see Figure 1.4 and Drawing 104). Two such escarpments define the south-eastern and northern boundaries of the study area. Within the study area, the plain is also punctured by a number of low, rounded, rocky hills.

The climate is semi-arid to arid, with an average of 424 mm recorded at Hargeysa. However, the SOGREAH analysis shows the 400 mm isobyet swinging south such that most of the study area is assessed as receiving just under 400 mm average annual rainfall. This is considered to be marginal for dryland farming. However, annual variations may be extreme, ranging from 156 to 810 mm at Hargeysa. Similarly, there is considerable areal



H: Very shallow soil over rock. Rock and stone surface with rock outcrops. Scattered bushes, occasional trees. P5 or P6. Soil may be deeper near boundaries. Slopes to 10%. Severe sheet erosion.
E 2-3
G 0-1

I: Deep loamy soil typically sandy loam or loam surface and heavy sandy loam or clay loam subsurface. Bunded fields C2. Slope 1.1 to 3%.
E 1-2
G 0-1

I: Moderately deep to deep soil. Loamy sand over sandy loam or sandy loam over heavy sandy loam to sandy clay loam. Dispersed trees, bushes P4 or P5. Mixed with some cultivation, bunded (C2). Slopes 1.1. to 3%.
E 2
G 1-2

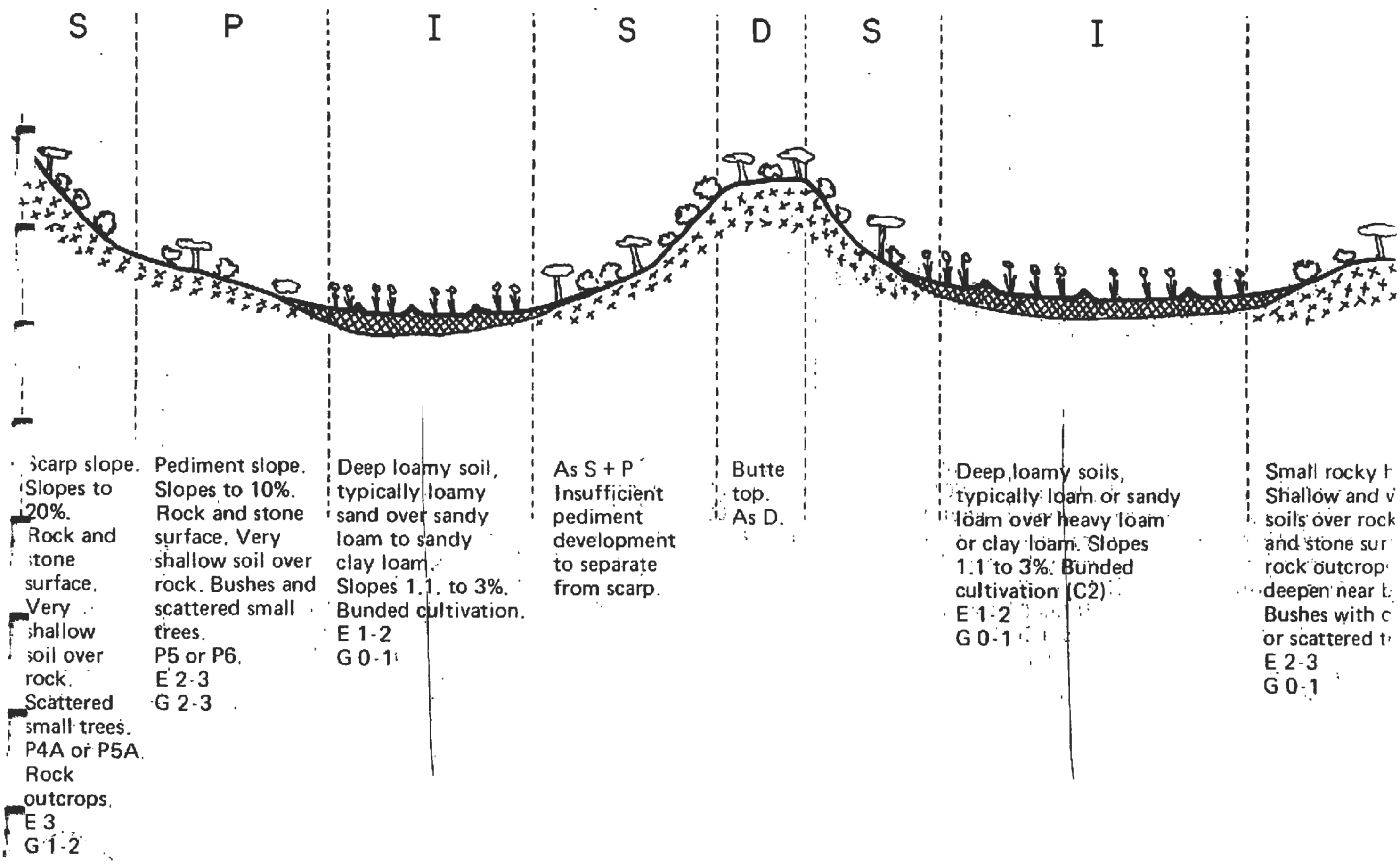
D: Very shallow to shallow soil, gravelly loam over rock. Maybe deeper patches supporting occasional cultivation. Dispersed trees, bushes. P4 Slopes 0-3%. Surface of rock and gravel.
E 1-2
G 0-1

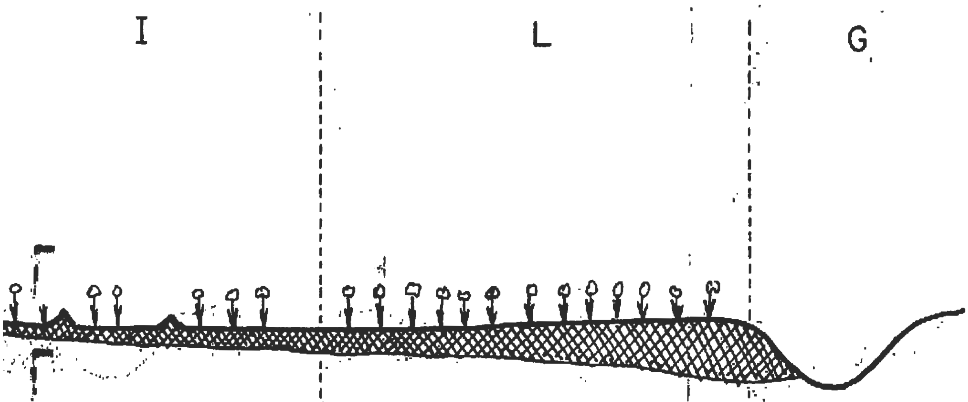
Crest [...] Very s[...] soil ov[...] with r[...] outcro[...] and st[...] surface[...] Bushes [...] occasi[...] trees. [...] P5.
E 2-3
G 0-1

LEGEND:

- xxxxxxx ROCK
- SOIL
- BUSH
- ▲ BUND
- TREE (PRIMARILY ACACIA BUSHES)
- DRYLAND CROP

NOT TO SCALE


S
P
I
S
D
S
I
Scarp slope. Slopes to 20%. Rock and stone surface. Very shallow soil over rock. Scattered small trees. P4A or P5A. Rock outcrops.
E 3
G 1-2
Pediment slope. Slopes to 10%. Rock and stone surface. Very shallow soil over rock. Bushes and scattered small trees.
P5 or P6.
E 2-3
G 2-3
Deep loamy soil, typically loamy sand over sandy loam to sandy clay loam. Slopes 1.1. to 3%. Bunded cultivation.
E 1-2
G 0-1
As S + P Insufficient pediment development to separate from scarp.
Butte top. As D.
Deep loamy soils, typically loam or sandy loam over heavy loam or clay loam. Slopes 1.1 to 3%. Bunded cultivation (C2)
E 1-2
G 0-1
Small rocky h
Shallow and v
soils over rock
and stone sur
rock outcrop
deepen near b
Bushes with c
or scattered t
E 2-3
G 0-1



eep loamy soils
pically loam or sandy
am over heavy loam or
ay am. Slopes 1.1-3%.
nd cultivation (C2).
1-2
0-2

Level area, slopes 0 to 1%.
Very deep loamy soils,
typically loam or silt loam
surface over heavy loam or
silty clay loam subsurface.
Non-bunded cultivation.
E 0-1
G 0-1

GULLY FORMATIONS:

G - 1 Main channel with minimal lateral development. Slope moderate, vegetation P4 or P5, with some cultivation on broader interfluves.

G - 2 Severe lateral gullying, steep slopes almost bare of vegetation, limited interfluve areas. Typically P3 or P4 in drainages and P6 or P7 on interfluves (mapped as compromise eg. P5)

G - 3 Extreme dissection, intense frequency of dissection, interfluve areas essentially bare.

HARGEYSA STUDY AREA HYPOTHETICAL CROSS SECTION
FIGURE [illegible]

variation; the two pilot project areas, while both close to Hargeysa and to each other, show (1) important variation from the rainfall pattern recorded at Hargeysa, and between the two PPAs.

Soils of the plain are deep and medium textured. They are used extensively for cultivation, almost exclusively sorghum and maize. Yields are low, partly because of the climate. However, many other factors intrude, including variety and seed selection, land and crop management (land preparation, seeding, weeding, etc.), pests and diseases, erosion, and cultural attitudes. Erosion is extremely severe throughout most of the study area, and is considered as the major threat to sustained agriculture.[1] The severity of gully erosion is highly visible. However, sheet erosion is also severe, and serves to rob the soil of its more fertile top soil, expose compact subsoils and seal the soil against water infiltration and seedling emergence. The climatic and erosion constraints have been the subject of soil and water conservation programs, primarily bunding, going back to the 1950's. Now most of the agricultural land, on slopes over 1%, is bunded.

The people are nomadic by culture, and settlement is quite recent, essentially within the last century. Settlement within the Biji drainage area appears to have been a little earlier than that of the Waheen drainage area. However, active cultivation, especially within the Waheen, seems to have developed only over the last 50 years or so. In the early 1950s, cultivation was already extensive in the Gebiley area and was considerable and rapidly extending in the study area (2). These people, therefore, do not have a long tradition of cultivation

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1 From interviews with farmers in the PPAs

2 Personal communication, Roy Green, ex-Agricultural Officer, Hargeysa, Somalia

and still attach great importance to livestock; many of the people are still semi-nomadic. The livestock are partially responsible for the severe loss of vegetation in the area; however, the study area is within the orbit of influence of Hargeysa, with the fuel requirements of 300,000 to 500,000 people. [However, vegetation was reportedly equally diminished in the 1950s, when Hargeysa was still a small town (1)]

Management of the land should have as priority the conservation of the soil resource - that is, protection against erosion -and secondly, moisture conservation for improved yields. These two objectives, however, are positively correlated. The needs for grazing and fuel also must be factored in. Ideally, land use proposals would suggest reforestation of the upland areas with grazing control; integrated measures of land management and drainage in the agricultural areas; vegetated buffer zones and drainage diversion around the gullies; and, for the gullies themselves, grading, revegetation, and check structures as necessary. Much of this would be dependent upon research results and be implemented by extension programs. However, existing soil and water conservation works (bunding) and the cultural traditions of the farmers - especially their fierce independence and opposition to integrated measures - impose severe constraints on what may be proposed.

The Land Evaluation and Land Use Planning described herein are a function of the land character mapping (see Drawings 102 to 105 and Figure 1.4), and subsequent analyses.

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Personal communication, Roy Green, ex-Agricultural Officer, Hargeysa, Somalia

3.4.1.2 Study of the Major Land Units

The major land elements, which repeat throughout the landscape, have been recognized, and are presented in schematic form in Figure 1.4 (hypothetical cross-section). These may be grouped into three general land types, which may then be considered in detail according to the component land units. The general land types are (1) Elevated Units, (2) Lowland Units, and (3) Gullies. Each general land type and component land units are evaluated, followed by a general Land Use Planning assessment and management recommendations.

(1) Elevated Units (S, D, P, H)

These are elevated, rocky areas, with very shallow soils over rock. Land use is almost invariably pasture/forest and the areas are all overexploited, both for grazing and for wood. These areas occupy about 25% of the land area of the Hargeysa project area (see Table 1.15) and are therefore a major factor in the watersheds, and normally form the headwater areas. They contain the steepest slopes, shallowest soils, and minimal vegetation cover, which together cause uncontrolled runoff of high velocity, and contribute to downslope erosion (sheet and gully) of the prime agricultural soils. These areas should be kept vegetated at all times, to help reduce both the volume and velocity of runoff. Ideally it might be proposed to reforest these areas, with controlled cutting for fuelwood and fodder, and prohibition of grazing. However, livestock rank so highly in the social and economic system that the ideal must be considered impracticable, and some modification proposed.

Table 1.15 Approximate Area of Major Land Types Within Hargeysa Study Area

	Area (ha)	% of Study Area
Towns	149.0	0.4
Togga Beds	189.5	0.5
Elevated Units	9901.0	25.0
Lowland Units	24737.5	62.4
Gullies	4627.0	11.7
Total	39604.0	100.0

The component land units are:

S1 - Scarp face, side slopes of buttes. This is a steep erosional slope, with slopes typically in the range of 10-20%, but with steeper sections. In the mapping, the footslopes (pediment slope) have been included in this unit where the pediment lacks sufficient dimension for independent cartography. The unit is always associated with very shallow soils (loamy sand or sandy loam matrix) over rock, with a stony and rocky surface and rock exposures. The unit is commonly occupied by a thin tree cover with Acacia spp. 3-5 m in height. The tree cover is frequently denser than in other upland units, probably due to the unit's comparative inaccessibility for tree cutting and grazing. The bush layer is very sparse. This has typically been mapped as land use P4A or P5A. Cultivation is never found in this unit. However, it is said to support a grass cover during the wet season, when it is used for grazing. However, due to the slope angles and surface conditions, this area is accessible primarily to goats. Sheet erosion may be assumed to be very severe (E3) but gully erosion is usually limited (G1). The surface is very stony and rocky (S4).

This unit has no potential for cultivation. It is a major watershed area and will shed almost all the water it receives, both that received directly and that received from any upslope catchment, although the watershed divide is frequently at or close to the top of this slope. The combination of slope, soil, and lack of vegetative ground cover allows the water to be shed in an almost uncontrolled fashion, both as sheet flood and concentrated in gullies. This is a headwater area for downslope gullies. A permanent vegetation cover is required to disperse the runoff and check runoff velocity. This unit should be revegetated (grass, trees) and protected from all grazing. Check dams should be built in the gullies to break the velocity of flow and disperse the water over the land. In some other countries, similar slopes have been successfully terraced and reforested, but this is probably too extensive an undertaking for the project. However, small dikes or bunds (10-30 cm) could be built, by hand, along the contour using available surface rock debris. Apart from helping to break flows and retain water, these will, over time, lead to a natural terracing and an improved medium for plant growth. Efforts at revegetation should be started behind these rock bunds, where greatest moisture availability may be expected, especially as soil builds up behind the bund. During the early years, these bunds may need considerable attention and repair.

Recommendations

1. Prohibition of, and protection from, all grazing.

2. Prohibition of, and protection from, all wood cutting. This measure may be considered temporary in that once an acceptable vegetation cover is achieved, controlled cutting may be permissible.

3. Limited revegetation, especially of fast growing bushes and grasses, starting behind the rock bunds. In its present eroded state, it is questionable whether the unit would support a denser forest cover; further, it is questionable whether the project is capable of undertaking a large scale reforestation program, and such proposals should be reserved for those areas of greatest need and/or greatest probability of success.

4. Contour diking, by hand, using the locally available rock and stone material and, as far as possible, local labor. These bunds must be maintained; being unconsolidated, damage from severe storms may be expected during the early years.

D - Dip slope or butte top. The High Plateau. A level to very gently sloping (0 - 3%) unit. Typically associated with very shallow or shallow soils (sandy loam matrix) over rock, with a stony surface (S3-4) and rock exposures. Downslope, in flatter areas, and in depressional pockets, the soil may be deeper and may even, on occasion, support a cultivated field. However, cultivation is excluded from the general concept of this unit which is typically occupied by a thin to dispersed tree cover of Acacia spp., and a sparse to moderate Acacia bush layer. This has typically been mapped as land use P4. In the rainy season the grass layer is probably well developed, but is rapidly grazed off.

The unit typically occupies the highest positions in the project area, sloping down from the watershed divides and forming part of the headwaters of the watersheds. Its shallow soil and rock subsurface have little absorptive capacity and most water will run off. However, slopes are gentle and this unit is typically the best vegetated and least disturbed of the "upland" units in the project area. Its continued vegetative cover is almost certainly a function of its restricted accessibility. It is elevated and fronted by steep slopes (Unit S). The unit contains almost no settlements, very few trails, and presents difficult access from the populated and cultivated areas. While it is grazed during the wet season, when grasses are plentiful, the lack of easily accessible water requires that the herds be moved to lower pastures once surface water supplies are depleted. This has undoubtedly helped protect the trees and bushes from the cutting for fodder typical of other grazed areas. (However, close to Hargeysa, similar units have been totally deforested, presumably for fuelwood.) As more accessible fuel sources are stripped, these relatively untouched areas will undoubtedly require attention. The first priority, therefore, for these areas is protection of the status quo. Because much of the water received will run off, surface erosion may be expected but does not normally appear to be very severe (E1-2) due to the relatively good vegetation cover. There is little gully erosion.

Except in the pockets of deeper soils, as mentioned, the unit has no potential for cultivation but a moderate to high potential for forestry and also for seasonal grazing. Occupying, as it does, a headwater position, this unit should ideally be reserved as forest. However, it is also imperative to respect the grazing needs of the people, and this unit does provide important seasonal grazing. Therefore, it is suggested that this unit be managed as a mixed forest and livestock feed unit. Initially, this should be approached on an experimental/trial basis, in one or two locations. One possible scenario is as follows. The forest, properly protected against grazing, should occupy the limits of this unit, thus providing some protection, to those land units occurring downslope, from runoff and erosion. Elsewhere, strips of forests should be preserved or developed along the contour, possibly combined with hand built bunds which will help minimize runoff, erosion, and downslope flow. The intervening areas should be maintained with a vegetation cover at all times and should therefore not be left to open grazing. Rather, it is suggested that these areas be managed for improved grazing or fodder production; with a proper rotation of animals, sufficient ground cover may be maintained to help in runoff control. This scenario would require preliminary research into suitable grazing and fodder species.

Recommendations

1. Prohibition of, and protection from, wood cutting, in order to maintain the status quo and prevent deforestation.

2. Research into possible fodder grasses which can be grown on these soils.

3. Hand bunding using locally available rocks and stones.

4. Selection and fencing of forest reserve strips, for protection from grazing.

5. Upgrading (reforestation, etc.) of forest reserve strips.

6. Once the research results (2) are obtained, fencing of areas to be used for grazing or fodder production, selection and fencing of stockyards, and provision of water (wells?) to the same.

P - Pediment slope. The pediment slope, or footslope, is an erosional surface of intermediate slope (to 10%), characterized by very shallow to shallow soils over rock, and a rock and stony surface (S4) with rock outcrops. Downslope the pediment dips, sometimes quite sharply, below the overlying soils, as the pediment merges into the downslope units. Vegetation is typically sparse, with Acacia bushes and scattered Acacia trees. This has typically been mapped as land use P5 or P6. This is a water reception area (from Unit S), as well as a water shedding area. The lack of vegetation is probably anthropic, reflecting the improved accessibility of this unit for grazing and fuelwood cutting compared to Units S and D. Indeed, settlements are found in this unit, generally perched just above the deeper cultivable soils downslope.

The significant slope, shallow soil and rock subsoil, and minimum vegetation cover, permits almost unrestricted water flow over the pediment. Sheet erosion is very severe (E3) and where the water is concentrated, it bites deeply into the deep, loamy soils where it enters the downslope units.

This unit has no cultivation potential except at the margins downslope. These margins, however, should be kept vegetated to help reduce the volume and velocity of runoff flow from the pediment, thus providing some protection to the downslope agricultural units. It will always prove difficult to prevent runoff from the steep slopes upslope (Unit S) and so the pediment, with its lower slope angles, is particularly important in runoff flow control stratagems for protection of the downslope agricultural lands. Not only should grazing and forest cutting be immediately banned, but in this unit a serious attempt at reforestation should be made. Check structures should be built across the gullies, with the underlying rock providing good foundations. Other structural measures to contain, slow down and spread the flow should also be considered.

Recommendations

1. Immediate prohibition of and protection from all grazing and wood cutting.

2. Building by hand of bunds constructed from the locally available rock and stone, these to follow the contour and to provide a temporary measure of impedance to flow.

3. Construction of check structures across all gullies.

4. Revegetation and reforestation.

5. Implementation of other structural measures as recommended elsewhere in this report or as developed in the pilot watershed management project.

H - Hill areas. Originally this unit was identified as consisting of low to medium rock hills, with slopes typically in the range of 2 to 10%. However, analysis indicated similar soil-vegetation-land use situations occurred as exposures on the shoulders overlooking some gullies. The undulating rocky crest areas, sometimes occurring as narrow bands between scarp and dip slopes, were also grouped in here as they shared many characteristics and their limited extent did not warrant a separate unit. However, in any extension of this mapping, if this last situation is found to be extensive, it should be separated as an independent unit.

The unit typically shows at least some elevation above the surrounding terrain. It is characterized by very shallow to shallow soils (loamy sand to sandy loam matrix) over rock or calcrete. The surface is strewn with stones and rocks (S2-3) and rock exposures are common. The unit may provide the divide between sub-watersheds but also occurs within the sub-watersheds. Its moderate elevation and slope, and juxtaposition to the agricultural lands, has made it a prime location for human settlement. Most villages and settlements within the Hargeysa study area are located within this unit, and tracks and footpaths cling to this unit as far as possible. Further, many of the more extensive examples of this unit, where there is significant catchment area, are pitted by water points, sheer sided pits about 10x10 m, and 5 m deep. As a result of this human activity, this unit has been almost totally deforested and in many cases, particularly close to the villages, almost totally devegetated. Typically the unit has been mapped as land use P5 or P6. The annual grasses and few remaining bushes provide important grazing, especially for the sedentary herds attached to the villages. The shallow soils, rock subsurface, moderate slopes, and sparse vegetation combine to provide little or no control of runoff. Sheet erosion may be assumed to be severe (E3). However, by and large, the catchment areas within these hills are small and there is little evidence of severe gullying of the agricultural soils being initiated on these hills. However, as noted, this unit is often associated with gullies, occupying shoulder positions on the side slopes. Whether this association is causal or coincidental is unknown. However, it may be assumed that once gullying is initiated, the rock provides a natural sheer surface, and an erosional base for soils resting on the rock.

Management of these lands poses a special problem. They have no cultivation potential, except occasionally in pockets of deeper soil or at the margins with the agricultural lands. Reforestation is required but would be a major undertaking and is impractical given the proximity and impact of human settlement, and the importance of these lands for grazing. How much grazing they actually provide is unknown, as is the possibility of improving that grazing potential. Both range management, range improvement, and fodder production should be investigated for these areas. Limited and protected re-vegetation might be attempted at the fringes of the hills, to provide some impediment to run off, and thus downslope protection from erosion. Low (10-30 cm) rock bunds, along the contour, may be constructed by hand, using locally available materials. These will help to break flow velocity and provide an impediment to further loss of what little soil remains. As part of a range management program, the areas could be divided into parcels for controlled grazing purposes, in which case land parcelling could be designed to facilitate contour hedging for further runoff control. Overall, this unit, while extensive, is not usually priority for runoff control as the contribution to runoff and erosion, while significant, is secondary to the other "upland" areas discussed. At present, it is best to maintain this unit as a grazing and settlement area, and seek improvements in grazing management and fodder production. Other measures may be considered once control measures have been implemented, and their effectiveness and advantages demonstrated elsewhere in the watersheds. Only then might it be possible to persuade the people to accept control within their "back yards."

Recommendations

1. Revegetate and protect lower slope areas as a protection of downslope agricultural land.

2. Build check structures on any gully development coming from these hills.

3. Build low rock bunds along the contour.

4. Study the results of the experimental stratagems to be carried out within the pilot project area in examples of this and other upland units, and apply as appropriate.

5. Investigate improved grazing management procedures and provide extension services in the same.

(2) Lowland Units (I, L, T)

These units consist of level to gently sloping areas with deep soils. Geomorphologically, the units would be considered as comprising a level to gently sloping plain; narrow alluvial terraces are, however, also included here. These units occupy about 62% of the land area of the Hargeysa study area (See Table 1.15) and contain almost all the agricultural land. They are also the units which have received attention under Phase I of the NWADEP. Almost without exception, those cultivated areas (within the study area) with any slope (1 to 3%) are already substantially bunded. Unbunded areas are found primarily in level areas (0 to 1% slope), although bunding also extends into these level areas. The bunding program is quite literally changing the face of the landscape, and the bunds are one of the most noticeable features of the study area; Phase II of the NWADEP proposes to extend the bunding significantly. The bunding is of special importance not just in its physical presence, but also in the impact it has on planning for the use and management of the lowlands, and because of the importance of the program within the NWADEP. Therefore, it is discussed separately prior to the descriptions of the individual lowland units.

Not all of the land is cultivated or bunded. Most cultivated areas are, in fact, a mixture of cultivated and uncultivated land. The reason for this is not entirely clear but probably reflects a mixture of considerations, including demarcation/boundary areas between farms, grazing and fuelwood requirements, and perceived crop production needs. Very few areas, in the study area, are dominantly uncultivated.

Soil textures appear loamy, surface soils ranging from loamy sands, through sandy loams and silt loams, to loams. Subsurface textures are invariably heavier - heavy sandy and silty loams, fine sandy and silty clay loams, and clay loams. (These analyses are based on hand texturing in the field.) The investigations undertaken did not permit a thorough analysis of soil textural distribution, but the impression obtained was that soils are sandier close to the "upland" areas, especially the S, D, and P units, and become finer (very fine sands to silts) closer to the toggas, with loam soils falling somewhere in between.

These deep, medium textured soils have a high potential for agriculture, within the limitations imposed by climate, and if properly managed to prevent erosion and maintain productivity (structure, fertility, etc.) However, the climatic limitations are severe, particularly during dry years which occur frequently. Further, the devegetation and environmental degradation that is occurring is thought by many to promote drought; if this is so, then the climatic constraint will become increasingly severe. In the meantime, there is plenty of evidence that environmental degradation is promoting runoff, and decreasing rainfall effectiveness.

Even without such trends, SOGREAH claims that the average climate is marginal for the production of sorghum and maize, which are almost the only crops grown. Improved varieties, and more drought tolerant crops such as millet, might prove more productive, even without bunding. Other crops, such as groundnuts, cowpeas and green gram, which were successfully tried by the British, would also seem to have potential. However, this is a subject for research. Small grains (e.g., wheat) might also be more effective in providing a ground cover for erosion control. However, choice of crop and crop variety are primarily cultural phenomena. Crop choice is conditioned partly by dietary habits, which were formed when the nomadic population purchased grains in other locales, where environmental conditions were probably different from those pertaining today in the Hargeysa study area. To change such habits requires extension work, not only in cultivation techniques but, addressed to the women of the area, in techniques of preparation and use of these new grains. People interviewed frequently claimed ignorance of these crops and of their preparation into food. Choice of crop variety is also, in part, cultural; the traditional, local variety of sorghum (Elmi Jama) is a 6-month (to maturity) variety which fits in well with present farm management/semi-nomadic practices. After seeding, the crop may be left while the herd is grazed, for up to 6 months, in distant pastures. Harvesting is done upon, or just prior to, the herd's return. There is another detrimental impact to this management practice; absence of the farmer for all or much of the growing season means that there is generally little or no crop maintenance (e.g., weeding). The serious negative impact of weeds on crop yields is well documented. The importance attached to animals also impacts crop choice, millet straw being less palatable than that of sorghum and maize. Finally, the ready availability in the region of donated foods, especially vegetable oils, may be distorting the farming picture, and discouraging experimentation with such crops as groundnuts which are a major source of oil and protein in so many other parts of Africa.

Cultivation practices are discussed elsewhere in this report but it is pertinent to review them when discussing these agricultural units. The seed is untreated and is broadcast after the first rains. Cultivation frequently takes place after seeding. Crop maintenance is minimal. The use of fertilizers and of chemicals for pest and disease control is extremely limited; not even animal manure from animal pens is applied to the fields. Harvesting and threshing is by hand, and grain storage is primitive - in holes in the ground, sacks, or old oil drums. The use of kerosene or chemicals on stored grain, as a protection against pests, would seem to pose a health hazard.

In sum, therefore, the agricultural situation reflects a complex mix of climate, ignorance, cultural traits, and demand. Moisture deficits are only one aspect of this mix; however, as previously indicated, this aspect may be exacerbated by poor land and crop management (runoff, erosion, weeds, etc.). The possibilities for improvement in this situation appear to be considerable, although cultural tradition will always prove an obstacle. Bunding is only one possible measure, designed to relieve the moisture deficit problem. There appears to be plenty of room for research and extension in other moisture-related measures, and in the other aspects described. The full range of agricultural problems needs to be addressed if the potential of these units for sustained agricultural production is to be realized. The main possible improvements have been analyzed by SOGREAH (Report No. 14) and are summarized in Table 1.16.

Table 1.16 MAIN POSSIBLE IMPROVEMENTS

AGRONOMICAL AND AGRICULTURAL IMPROVEMENTS

In view of the present situation (Cf Agronomy Report No 7), the following actions to improve the traditional system and increase the production of foodstuffs in the North West Region can be recommend d unreserved y:

- The improvement of farming methods (deep ploughing, destruction of the plough pan, sowing density, sowing in lines, second dressing, weeding, etc.);
- The perfection of working methods; use of the plough or of the chisel plough: deeper working of the soil; use of the harrow: preparation of the seed bed; of the seed drill: sowing in lines to facilitate weeding and to obtain a uniform plant density;
- The phyto-sanitary treatment of seeds (fungicides + insecticides);
- The systematic destruction by fire of all the plants in fields attacked by insects (borers), or the phyto-sanitary treatment of the plants in the fields (insecticides);
- The use of various improved varieties, well adapted to the environment when these have been thoroughly tested on the experimental farm;
- The use of crop rotation;
- Ploughing of land which is then allowed to lie fallow;
- The sieving of the seeds to remove foreign matter (impurities, broken grains);
- The use of organic manures, this assumes a certain degree of pastoral farming development;
- The use of mineral fertilisers;
- The improvement of the hydrodynamic characteristics of the soils (porosity, permeability) and the physical-chemical characteristics (proportion of organic matter, fertilising elements N, P, K for example);
- The extension of the areas cultivated by reducing the extent of the existing areas of fallow land, by the development of certain pasture lands.

9.2.2 LAND DEVELOPMENT

Land development, which is related partly to the geomorphology (mainly the slope) and partly to the wide dispersion of the plots of land (farming) can be summarised as follows:

- Establishment of a system for dividing up the plots of farming land at the village or administrative division level;
- Establishment of a development plan after redistribution of the lands integrating the roads serving the villages, agricultural units and the improvement works (bunds where appropriate);
- Ploughing along the contours, depending on the slope;
- Level bands alternating with banked up beds cultivated or not on slightly sloping ground (ie. between 2 and 3 %);
- Retaining bunds between on slopes between 3 and 5 %.

Source: SOGREAH Report No. 14: Agricultural Development Programme A-Rainfed Agriculture. Volume I

Any development, agricultural or otherwise, of these lands must be designed to protect the land from erosion and preserve the soil resource for future generations. The deep, moderately textured soils are very prone to erosion, both sheet and gully erosion. The soils, when exposed, have a natural tendency to crust and seal, which promotes both erosion and runoff. General land mismanagement, especially devegetation of the uplands, has also promoted runoff and erosion. The result has been very severe erosion. Indeed, it is believed that the loss and degradation, by erosion, of the agricultural soils, poses a greater threat than soil moisture limitations to the future viability of the area for cultivation and settlement. The use of these lands for agriculture may be continued and, indeed, extended into the uncultivated areas, but this should only be done within the frame work of a comprehensive and integrated soil conservation and erosion control program. That program should be implemented on a sub-watershed basis, with recognition that protection of the agri cultural land starts in the upland, headwater areas. Nor should the program be side-tracked by the visible impact of gully erosion; soil loss and degradation by sheet erosion may well be as, or more, damaging than losses to gully erosion. Further, control of sheet erosion will both reduce gully erosion and promote soil conservation at the same time. In general, such a program calls for revegetation and grazing control on the uplands; integrated land management on the plain; controlled drainage from the plain; and protection around the gully heads through revegetation, grazing control, and drainage diversion. The problems of implementing such a program are formidable, particularly given the fierce independence of the population which militates against cooperation, even amongst family members. Unfortunately, the present bunding program may be serving to reinforce this attitude and, if successful in raising production to meet family requirements, may obviate any perceived need for other adaptive techniques.

The question of rural roads in relation to erosion needs to be considered. It is discussed here although it is equally applicable to the upland areas, especially the hill unit (H). As previously noted, the settlements are mostly located on rocky elevations, and the connecting tracks typically run straight down the hills, across the plain, and up the opposite hill to the next settlement. The tracks, becoming slightly depressional from use, provide a natural conduit for runoff waters, which in turn erode the track. The surface of most tracks is now well below that of the surrounding fields. This promotes erosion, as may be seen by the frequent deep gullying occupying previous track beds, and results in a loss of valuable moisture. A major program of track development is needed to retrace the routes, if possible, and to raise the beds of the principal tracks and channel water into the surrounding fields (see section 3.6 and Volumes II and III). Other tracks should be redirected so that they are oriented across the slope; the old tracks should either be infilled and incorporated into the surrounding fields, or closed with a series of earth and/or rock structures, which will interrupt runoff flow, promote siltation and infilling of the tracks, and provide a barrier against the future use of these tracks. Unfortunately, people have a tendency to believe firmly in the shortest route, regardless of ease of travel, which may make this program difficult.

Finally, reference has been made above to the need for research and extension. This is a necessary input into planning and implementing management strategies and therefore is of concern here. Further, the Aburriin experimental farm happens to fall within the study area, within the lowland units. No research records from this farm were available and no serious ongoing research effort was apparent. A major upgrading of this farm is required, as an input into the proposed management plans. This is discussed in more detail in section 3.4.1.3.

Properly managed, these lowland units have a moderately high potential for agriculture, within the constraints imposed by climate. Given the food deficits in the region and country, it is difficult to propose alternate uses; the recommendations presented are less land use proposals and more land management proposals. Many of those management aspects are already fully covered in the SOGREAH reports, and often are integrated, in principle, into proposals for Phase II of the NWADEP. Many constraints are presented. However, the degradation and loss of the soil resource may not permit the resolution of cultural problems through generational change. In the final analysis, the sustained agricultural use of these lands may depend upon an injection of political will, confronting such problems as land tenure, commodity prices, and livestock holdings and enforcing controls on grazing and woodcutting.

Existing soil and water conservation measures. The existing soil and water conservation measures in the project area consist essentially of bunds and water points. Such measures form part of the existing situation within which the watershed management program must be developed. Indeed, the bunding in the Hargeysa study area is a significant - even a dominant - feature of the landscape and, as such, cannot be ignored and poses a constraint on land use planning. That constraint is not only limited to the physical presence of the bunds but also related to the dominance of the bunding program in the actions and minds of the NWADEP. Further, land use planning for these lands cannot ignore the intended expansion of the bunding, under Phase II of the project. This program, however, was not the focus of the present mission and it was found impossible to evaluate the bunding using available existing data. Thus the soil and water conservation program is described, along with such observations, analyses and suggestions as were possible, and pertinent questions raised.

A. Bunding: Bunds are dikes or banks of earth built along the contour, designed both to interrupt surface flow as a measure against erosion, and to store water behind the bund to facilitate infiltration, thus increasing soil moisture and consequently plant growth and yield. Three major efforts have been undertaken, within the project area, to introduce bunding. In the 1950s, the British introduced a series of low bunds. Location was primarily on slopes of less than 3%, which were perceived to have the greatest agricultural potential. Participant farmers were selected on the basis of their interest and their capacity to carry out the work. Bund length was variable, being dependent on the catchment size. Bund spacing was typically 20-30 yards, depending on the slope. Bunds were about 3 feet high, on a broad base, giving gentle side slopes which were then grassed. Bund design included the retaining arm concept. The ends of the bunds were faced with stone or metal, as a protection against erosion, and spillways built with very low grade, to lead surplus water from one bund into the next. Diversion ditches were also constructed to feed the bunds. Design support was provided by the British, but construction was undertaken by the farmer himself using oxen and a scrapeboard. Further details are presented by Seager, Green and Lawrie (in Soil Erosion by Water, FAO Land and Water Development Series No. 7).

In the 1960s, a USAID funded project built bunds as part of an alleged watershed management program. Design details are provided by Londner (in USAID Project Evaluation Report No. 62).

> "Bunding under this project was started at the upper end of the watershed at the beginning of the uppermost gully, between the villages of Xidhinta and Taisa.
>
> The plan called for a series of bunds down both sides of every existing gully to serve as protection to the gullies' steep sides. On the gentle, gradual slopes leading to the valley bottom, bunds were to be installed in groups of three. Within each of these groups the lowest

bund was to be 180 meters long, the next 150 meters, and the uppermost 110 meters. This arrangement was intended to ensure that any surplus water escaping from one bund would be captured by the next. As construction would have progressed, the lower groups of three bunds would have been situated in such a way as to capture any water escaping from bunds above them, as well as to cover the gaps between the upper groups.

The bunds themselves were built by straight bulldozer action. Soil was obtained from the back (downhill) side of the bund.

The horizontal spacing of the bunds was determined by vertical intervals rather than by horizontal measurement. The desired vertical interval was 0.6 meters; thus, on slopes of 1 percent the bunds averaged 60 meters apart, on 2 percent slopes 30 meters apart, and so forth. In the course of the project some 2,800 bunds totaling 380 km in length were constructed."

From field observations, it is clear that these bunds have pronounced wings.

Since 1978, the NWADEP has been building bunds. These are described (1) as being triangular in vertical section, about 1 m high and 2 m broad at the base, and about 120 m in length. In principle they are built along the contour. However, they are also built in a gentle curve, and in series, the upper bunds becoming progressively shorter to allow water run-in from a catchment area (see Figure 1.5). Distance between bunds is 30 m, apparently regardless of slope, and the number of bunds in a series is determined by field size. Construction is by bulldozer, the bund being constructed by scraping the soil from downslope of the bund (see Figure 1.6). This has the effect of partially terracing the land, while subsequent erosion may be expected to complete the terracing over the next few years. The bunds are not compacted. By being built on the contour, in principle the long profile of the bunded area is level, which is

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1 Farooqi and Munye, 1985

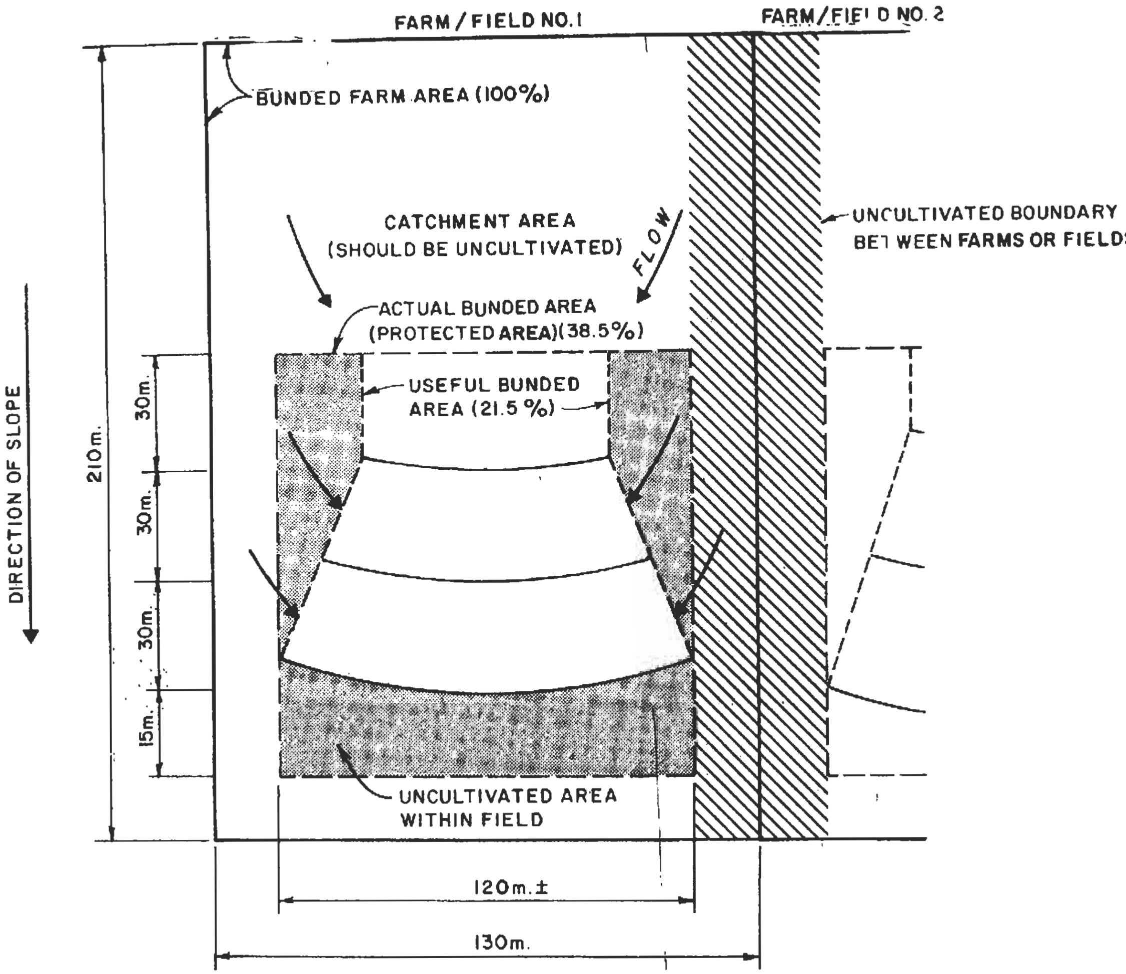

FIGURE 1.5
TYPICAL LAYOUT DESIGN OF NWADEP BUNDING
(MODIFIED FROM SOGREAH, FINAL REPORT)

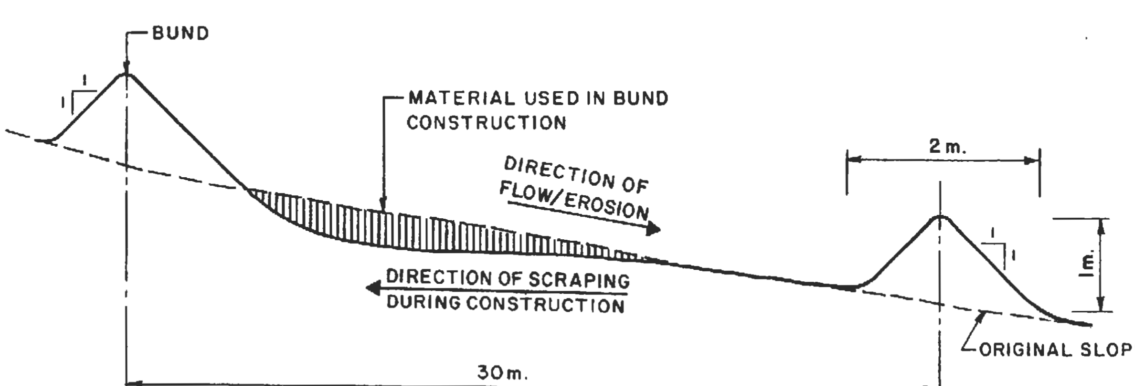

FIGURE 1.6
CONSTRUCTION OF NWADEP BUNDS

necessary for an even distribution of moisture and uniform crop response.

All bunding so far carried out by the project has been on a farm-by-farm basis (unit bunding). According to the layout design, within each set of bunds, bund length increases downslope, thus forming a pyramidal shape (see Figure 1.5). The upper corners are left unbunded and normally uncultivated, as are the boundary areas between farms and fields. The requirement to install bunding on a unit basis means that there are more sets of bunds, and therefore more unbunded/uncultivated land, than would be the case with integrated bunding or, possibly, with another management strategy (see Fig. 1.5). This layout also explains the difference between "bunded farm area," "actual bunded" or "protected area," and "useful bunded area," the first being the total farm area, the second the area under the influence of the bunds, and the last being the pyramid containing the bunds.

The project reports having bunded some 16,000 ha, with about 32,000 ha protected. Both a negative and a positive side to the bunding program are recogized. Loss of land to the actual bund is estimated at 5% by the project, and 10 to 15% by SOGREAH. The construction process also uses the more fertile topsoil and exposes the subsoil, which is likely more compact and has a lower infiltration rate. Shallow ripping of the surface, after bunding, is not an adequate solution to this problem. In terms of fertility, the project claims that the fertility status of the soil is regained after about three years, although there is no supporting soil laboratory data. It is of equal interest to know whether the soil regains its structure, and the long-term effects on infiltration. However, despite these questions, the project reports a very impressive yield response to the bunding program.

An overall average 64% yield increase over unbunded fields is reported, the increase being lowest in the Hargeysa area and highest in the Boorama district. This is supported by farmers interviewed who appear enthusiastic about the bunding and report yield increases in the Hargeysa study area of up to 100%. It is also in line with yield increases reported from the bunding program of the British, with up to 500% yield increases claimed (Roy Green, Personal Communication). Similarly, USAID (Impact Evaluation Report No. 62) reports 100% increased yield response to their bunding, although this is based on interviews conducted 17 years after the event. It is also claimed that bunding has had a significant effect in controlling erosion. The reported yield increases, and the project's achievement in meeting or exceeding production goals, appear to provide the primary basis for highly favorable appraisals of the project. However, the reported yield increases run contrary to an independent survey carried out by SOGREAH. They report a 43% increase in yields due to bunding in lowland (valley) areas but no increase on sloping (2-3% slope) or plateau areas. With regard to the latter areas they write:

> "It would therefore appear that the construction of bunds in such situations does not bring about any improvement in yields. On the contrary, instead of 1 ha of crops harvested, there is only 0.85 ha, due to the land taken up by the bunds themselves, i.e., a decrease in the actual area which can be planted, and thus a loss of production for the area.
>
> In these situations, therefore, bunds should not be constructed. Their only purpose would be to mark the limits of individual properties." (SOGREAH Report No. R14: Agricultural Development Programme A. Rainfed Agriculture, Vol. 1)

During the present mission, a general resource analysis was undertaken of the 40,000 ha Hargeysa study area, with more detailed data collected from the two pilot project areas. The Hargeysa study area falls within the driest part of the plateau area and, largely, within the area with the lowest reported yield response to bunding. It is not known to what degree observations made here are representative of the remaining 60,000 ha or so dryland farming area on the plateau. Moreover, the TAMS mission arrived at the end of the cropping season, and no independent analysis of the benefits of bunding was carried out. However, many observations relative to the bunding program were possible, and these both raised many questions, and suggested several possible improvements.

1. The yield response to bunding is the inverse to the moisture deficit. Thus, in the Hargeysa area, the project reports the lowest incremental yield response, whereas the projected moisture deficit is the highest on the plateau; conversely, in the Boorama area, where the moisture deficit is the lowest, the percent yield increase is the highest. Given an equal incremental moisture increase, an equal or greater response in yields would be expected in areas of greatest moisture deficit. The anomaly noted may be related to many factors, but the most probable is that the moisture increment is lower in Hargeysa than Boorama, as a function of lower overall rainfall. This may suggest that some design modification may be required, such as lower density of bunding/greater catchment area in the Hargeysa district. It has also been suggested (Roy Green, Personal Communication) that this anomaly may reflect the direction of cultivation knowledge and ability, with the longest cultivation tradition being found in the Boorama area.

2. As previously noted, the favorable evaluations of the project seem to be based heavily on the quantity of work carried out and the yield improvements reported by the project. However:

A) The procedures used to collect yield data do not appear to meet acceptable statistical standards, especially as regards data on unbunded fields. Selection of samples of fields bunded by the project may be made from lists compiled at the time of bunding; however, no maps or other inventories are known to exist for unbunded fields or fields bunded outside the NWADEP program. There appears to be a need to review the sampling scheme, both in terms of number and selection of samples. Information on data variation, within each district, would also be informative. Further, there is no correlation of results to parameters other than bunding. Other important factors include: local rainfall; seeding date relative to rain; management practices; slope; soil; slope position of the field; bund characteristics; catchment area; seed type and sources. In a climatically marginal area such as the N W, management practices and, especially seeding date relative to specific rains, are considered to be critical in terms of crop response.

B) In the area studied during the mission, a number of problems of bund implementation were noted, beyond those previously described (loss of topsoil, etc.). Specific examples of many of these problems are given in the PPA descriptions. Problems included:

a) Bunds not following the contours

b) Interbund area not level

c) Poor bund condition, including breaking of bunds constructed as recently as 1983. This, in part, may be attributed to lack of compaction, excessive steepness of bund sides, lack of protection by a vegetation or mulch cover, and uncontrolled trampling by animals. However, given that the soil takes 3 years to recuperate after bunding (project figures), a bund life of considerably longer than 3 years is necessary for economic viability.

d) Bund design not as per World Bank design (1), vis. no wings. This means that ponding behind the bund is reduced as water flows around the bund, with a resultant gully erosion effect. It also means that bund size far exceeds the storage capacity.

e) Lack of adequate catchment to lower bunds in a series, due to approximately uniform length of the bunds and, usually, no drainage diversion into the bunds.

f) From d) and e), and from analyses undertaken by SOGREAH (Report No. R14), the bund height of 1 meter would appear to be excessive. Even if this height is justified by the rains/surface flow (see SOGREAH), the lack of catchment and wings limits both potential collection and storage. Meanwhile, the loss of land to the bund and the use of topsoil for bund construction is a negative factor. Further, if a lower bund

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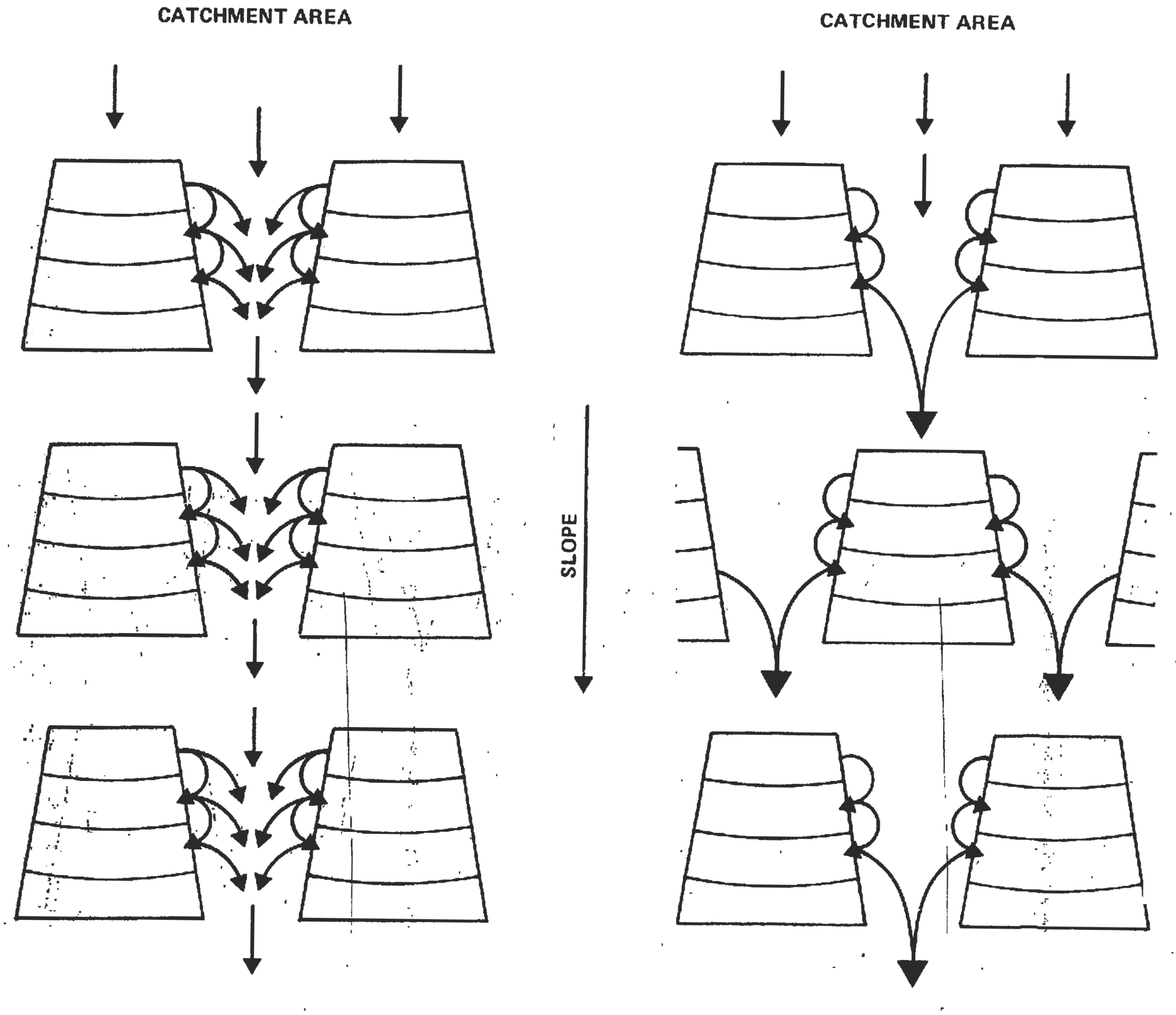
[1] As interpreted by SOGREAH in Technical Report No. 8, Soil and Water Conservation

height is accepted and the bunds are not to be compacted - as is the present case - then the justification for the use of heavy machinery is reduced. If bund height is maintained, and wings added to assure storage, there is a danger of bund collapse under the stress of stored water, especially given the bund construction and condition. Should an upper bund so collapse, the resultant flow would likely break lower bunds, and cause serious erosion.

g) A linear arrangement of bunded fields downslope, such that excess water is channeled in a line, downslope, between bunds (see Figure 1.7a). Lack of adequate drainage facilities means that this is causing erosion. The bunds should be integrated and/or have an offset layout which would interrupt drainage flow, and provide for the maximum use of water; overflow from one bund should be channeled into the next (see Figure 1.7b). Proper drainage should be provided for excess water.

Items a) to e) would appear to limit the efficiency of the bunds for water conservation. Examples of all these problems were observed. It is difficult to know how extensive these problems are; however, it seems reasonable to assume that where some examples may be seen, others may be found. It seems probable that the existence of these problems has a negative impact upon yield response and the cost-benefit relationship, within the area studied.



1.7a IMPROPER LAYOUT OF BUNDED FIELDS: LINEAR ARRANGEMENT DOWNSLOPE AND LACK OF INTERBUND SPILLWAYS CONCENTRATES DRAINAGE AND CAUSES EROSION

1.7b INTERBUND SPILLWAYS MINIMIZE DRAINAGE WATERS WHILE INTEGRATED/OFFSET LAYOUT OF FIELDS INTERCEPTS FLOW AND MAXIMIZES WATER USAGE

FIGURE 1.7
TYPICAL PRESENT AND ALTERNATIVE BUNDED FIELD LAYOUTS

3. Slope. In the Hargeysa study area most cultivated land, of which the majority is bunded, occurs on slopes of less than 2 1/2%. Bunding extends onto slopes of less than 1%. The SOGREAH analysis suggests that the yield response to bunding is minimal on such slopes, except in lowland (valley) areas. Likewise, a review of the literature provides no suggestion that land reshaping is appropriate on such slopes (see section 3.1.4; see also 5, below). However, Roy Green (Personal Communication), from his eight years experience in the area, remains convinced that bunding is appropriate on these low slopes, especially given the problems of implementing alternative integrated strategies.

4. Experience in the study area, and especially in the two PPA areas, suggests that factors other than physical factors (yield response) need to be considered in evaluating the bunding program. Some bunds, especially older bunds but including some project bunds, have been abandoned. Other bunds lie fallow, which fallow has sometimes continued for several years. Such fallow bunds may lie side by side with cultivated unbunded fields owned by the same farmers. If the yield response to bunding is as reported, then it is difficult to understand why preference is not given to the bunded area. Interviews with the farmers produced various reasons, the most interesting of which was that improved moisture behind the bund promotes weed growth making it more difficult to cultivate. Given the reported problems of obtaining tractors at the right time, this might well be a significant factor; if the improved moisture promotes greater weed growth during the growing season, this may also be considered detrimental, demanding a lot of work and not fitting well with the semi-nomadic lifestyle of many of the farmers. However, there are probably a host of other contributing factors, including some questions about the commitment of the people to cultivation and to production of surplus crop.

The question of commitment to agriculture - or lack of commitment - was central to the conclusions of an evaluation of the USAID bunding program (AID Project Impact Evaluation Report No. 62, 1985). The authors concluded that the bunding program had not been a success, not because it failed to produce higher yields, but primarily because the farmers were not committed to cultivation. Cultivation is seen as a marginal and supplemental activity whose unpredictable return is not worth the high labor investment involved. They also found that the bunding program responded to national and international concerns, but not to local needs or perceived needs. Negative impacts were also noted, including an abandonment of traditional crop rotation and a move away from animal traction to less labor intensive tractor power. In summary they conclude:

> "The question arises as to why they did not "want to." We cannot answer it. However, two aspects of our findings are suggestive. First, we found labor, or effort, to be a constantly recurring theme in people's explanations of their choices in agricultural action. Farmers would agree, or even suggest, that a certain activity was perfectly logical, it would have increased production or maintained an increase, but it represented "too much work." Small farmers who can afford it, hire tractors to plow their fields more in an effort to save labor than to extend cultivation. In general it appeared to us that, at some level above subsistence, the trade-off between investing additional labor in agriculture and achieving increased crop production becomes very "expensive" in the perception of farmers who use traditional technologies.
>
> Second, it appears to us that the agropastoral families on the Teysa and Xidhinta hills are cropping in order to diversify and supplement the family living, but not as a substitute for pastoralism. If this is so, it is not surprising that they were less energized to maintain and propagate an agricultural innovation than were those at Ceel Bardaale, which has staked its future almost completely on cultivation. The investment choices that farmers said they make with spare cash - livestock enterprise rather than the farm except for

> tractor rental - certainly suggest that the marginal rate of return from nonessential hard work may be similarly perceived: not worth it on the farm."

Relevant sections of this document are reproduced in Appendix A1.5.

The tractor problem mentioned earlier is a critical one in this area where it is imperative to catch what little rain there is. This problem may be expected to impact negatively on overall crop performance. However, the farmer may concentrate his input resources, including tractor power, in the bunded areas in anticipation of greater yields; the unbunded fields may receive a more traditional treatment. The negative impact of unavailable tractor resources would therefore be expected to be higher in the bunded than unbunded areas, especially in years of more critical rainfall. Certainly this problem is one which needs investigating, along with the alternatives of animal traction. Animal traction has the advantage of availability and energy source, given the fuel (deisel, petrol) problems of the region. In the 1950s, the oxen numbers were larger than at present, and were used both for cultivation and for bunding (Roy Green, Personal Communication). Some farmers complained that sufficient depth of cultivation was not possible with animals. However, animal traction is used the world over and some investigation of, and research on, this subject seems appropriate. The depth-of-cultivation problem may also be related to the loss of topsoil during bunding, and the exposure of more compact subsoils; this possibility, and possible solutions, should be investigated.

Some farmers interviewed reported repeated crop failures over the last few years, on both bunded and unbunded fields, despite years during this period where rainfall has been "normal."

Out of 30 farmers interviewed in the pilot project areas, only 4 reported yields surplus to requirements in 1985, a "normal" rainfall year, and indeed most farmers reported needing to buy additional grains. During the interview process, large groups of farmers would gather, many from outside the pilot watersheds. When the above questions were opened to the whole groups, the group responses were identical to the individual responses reported. This of course does not mean that bunding has failed to give improved yields. Pre-bunding yields may have been even less, while other factors as suggested above may have influenced yields. However, the surpluses to provide for farmer repayment of the bunding to not appear to have been forthcoming over the last few years, at least in the pilot project areas.

Further, it was noted that, despite experience with bunds since the 1950s, despite the reported yield increases, and despite a strongly expressed desire for more bunding, nobody interviewed has sought alternative sources of bunding, but were waiting for the project to bund the land.

Finally, comparison of the present to the 1950s (Roy Green, Personal Communication and report on visit, 1983) suggests no advance - and even a decline - in crop and land management, and in yields, despite the extensive bunding program. The aforementioned reduction in oxen numbers is one aspect of this. The present state of dryland husbandry (above and 5, below) contrasts sharply with the efforts apparent in the irrigated areas and apparently previously made in the (dryland) qat fields.

The points brought out above are many and diverse, and raise many questions. Answering all of these questions was beyond the scope of the present mission. Unfortunately that understanding is essential to the effective planning for the use and management of these lands. A program of physical and sociological research is urgently required, to answer these questions and seek effective solutions.

5. Dryland cultivation on the Northwest is dominated by sorghum and maize. These, particularly maize (1), are not the most drought-hardy crops. Varieties used are mostly local; seeds are local and untreated; seeding is by broadcasting; land preparation varies but often involves shallow cultivation (pseudo-ploughing) after seeding, a very questionable practice; fertilization is rare; there is little or no crop maintenance - weeding, cultivation, etc.; there is little control against losses to diseases and pests; and storage of harvested grains is primitive and possibly unhealthy (2). The farmers in the pilot project areas claimed that they have received no extension education since the bunding. The question therefore arises as to whether an equal or greater benefit could not be achieved through other land and crop management strategies backed by a concentrated research and extension effort, especially in those areas of low slope. SOGREAH (Report No. 14) is quite definite about this. Losses due to pests and diseases alone are assessed as being in the order of 30 to 50%; yield improvements possible with an intensive phytosanitary program are estimated at 50 to 70%. Their comments on this, relative to bunding, are reproduced in Appendix 1.6. The extension service is destined for expansion under Phase II of the project. However, any extension effort will be hampered by the apparent lack of reliable data from the Aubrriin experimental farm. Interestingly, both fertilization (camel dung) and seed

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1 SOGREAH estimates that maize requires 15% more water than sorghum, and is also less resistant to periods of drought (Report No. 14).

2 Farmers interviewed reported treating the grain with kerosene, and occasionally with other toxic chemicals, as a protection against rodents and insects.

dressing were undertaken in the British era (Roy Green, Personal Communication). This provides another example of agricultural decline, despite the investment in the region.

6. The Project concept appears to violate some of the principles previously outlined for soil and water conservation (see section 3.1.4), as expressed in the many technical treaties on the subject. Specifically, the program has concentrated on the agricultural lands, rather than the watershed as a whole, and has moved directly to major, and expensive land reshaping. The project has recognized, to a degree, these problems and Phase II includes pilot work on management on a watershed basis, and an increased research and extension effort. However, there remains a heavy emphasis on further bunding, and by the end of Phase II most of the dryland area with any slope is destined to be substantially bunded. Unfortunately the bunding itself becomes a limiting factor as, once done, it is very difficult to undo, and the possibilities for alternate and integrated strategies are reduced.

It is recognized that different approaches have been tried previously, especially by the British, with little success. This reflects, to a considerable degree, a sociological impasse and, in the short term, bunding may be the only approach which provokes a positive response by the local population. That response may have little to do with yields, but rather the bunds provide visible evidence and definition of ownership, and are a visible deterrent to erosion. However, the situation has changed since the 1950s. The people are more settled, a new generation has been born on the land, and the awareness of the need for land management has been brutally impressed upon the population by the rapid advance of the gullies. Conversely, the bunding program, being on a farm-by-farm basis, may be reinforcing a resistance to integrated measures, and the program's success in increasing yields up to those required for family subsistence, may reinforce resistance - or at least reduce the apparent value, in the eyes of the farmer - to other, perhaps more labor intensive, cultivation practices.

In summary, bunding is a measure of soil and water conservation appropriate to semi-arid regions. However, in the study area, evidence of its effectiveness, especially with respect to slopes, is both limited and contradictory. Field observations certainly suggest that the present design and implementation are not providing the water increments expected or required for economic viability. However, other factors intrude, especially the equipment and husbandry problems described. The apparently greater success of the British program deserves evaluation. In a sense, the bunding program has been developed as a blanket response to the agricultural problems of the region but may be outstripping the capacity of the local population to make use of it.

As previously described, planning for the use and management of the lowland land units is severely constrained by existing and projected soil and water conservation measures, specifically bunding. By the end of Phase II of the NWADEP, most of the dryland agricultural area is destined to be bunded; this leaves little room for planning beyond some suggestions for improving the bunding program. This is not a serious problem if the existing favorable appraisals of the bunding program are accepted. However, many of the observations made during this mission, as well as in relevant documents (SOGREAH; USAID) as described above, appear to be inconsistent with these favorable reports. It would therefore seem appropriate that a thorough review of the bunding program, and of alternate land management strategies, be undertaken <u>before</u> further bunding is undertaken. Details of such alternate land management strategies are not included in this report as the extended bunding program is already proceeding; a full evaluation of the bunding program was not possible within the timeframe of, and with the data available to, this mission; and any such strategies must draw on data from local research trials, which reliable data is not available. Development of a research program, to provide such data, as a prelude to land use planning, is a principal recommendation; this is discussed below.

On the assumption that the bunding program will proceed as planned, and that major changes (e.g., integration) within existing bunding are impractical, the following recommendations relative to bunding are made:

1. There needs to be an improvement in training and supervision of those responsible for bunding, especially as regards layout (alignment along the contour, levelling, decreasing bund length upslope). A quality control program should be implemented, with selective evaluation of new bunds, and reconstruction as necessary.

2. Bund layout and design should be analyzed, and adjusted as appropriate to each situation, with respect to the rainfall pattern of the plateau (catchment area), slope angle (distance between bunds), desired storage (height, wings) and catchment areas (bund length and layout). Catchment can be increased by providing drainage diversions into the bunds, especially in the drier Hargeysa area, and by installing overflow channels linking the bunds. Similarly, bund construction needs to be improved; the bund should be compacted and side slopes should be less steep (maximum 40% slope angle) and seeded to grass and/or mulched. (For typical design, see section 3.6.)

3. Special consideration needs to be given to the question of bund maintenance. With proper construction (2, above) the maintenance requirement will be minimized. However, maintenance will always be required, and should meet some minimum standards. The bunds represented a multi-million dollar national and regional asset; present policy leaves their maintenance to the whim and limited capability of the local farmer. Many of these farmers neither understand the need for maintenance, nor want the job. In some cases, the willingness and ability of a farmer to benefit from the bunding is questionable. In other cases, poor bund construction under Phase I has led to maintenance problems which exceed the present resources of the farmer. The overall result is that maintenance is not being undertaken and the investment represented by the bunding is not being protected. A major extension effort, in the need for and methods of bund maintenance is required. This will undoubtedly need to be followed by technical assistance to the farmer, if he is to retain responsibility for maintenance. A greater concern for bund maintenance might be achieved if farmers were more involved in bund construction. Alternatives include the takeover of maintenance by an outside agency (the NWADEP), and political coercion (legislated responsibility). Such policy decisions are beyond the scope of the present analysis.

4. Topsoil removal should precede bunding, which then uses the subsoil. After bunding, the borrow areas should be deep ploughed, and the topsoil returned.

5. All future bunding should be integrated, and this should be a condition of bunding, in the same way that a 25% downpayment is now required.

6. The integrated bunding layout must have proper provision for drainage of excess waters. A fully protected drainage system

needs to be introduced into areas of existing bunding. Possible measures include revegetation and grazing control either of the whole drainage or in strips across the line of flow in present drainage lines; gabion and/or other structures to check and disperse flows; and construction of proper drainage ditches, graded and lined or grassed, with grazing control.

7. A thorough sampling and evaluation program needs to be developed.

8. Bunding on slopes of less than 2% should be evaluated; prior to such an evaluation, such slopes should not be bunded.

9. A major extension program needs to be undertaken, emphasizing, in particular, use of animal power, seed dressing, row planting, crop maintenance, and improved grain storage. Improvements in crop type and variety may have to await research results.

B. Water points comprise the other major project effort in the area of water conservation. These are divided into livestock and human water points.

Livestock water points: These are large, shallow ponds, excavated by machinery with the excavated material piled up in a large bund on the downslope side. The upslope catchment is usually uncultivated and water catchment is often facilitated by diversion canals. The present mission was in-country from mid-September until mid-December, that is from the end of the rainy season into the middle of the dry season. During this period, all the water points in the Hargeysa study area were visited but only one was found to contain water (at Dhaboolaq). It would seem that the expense of such water points is hard to justify if they do not extend water availability significantly beyond the end of the wet season.

During the mission several problems were observed. Firstly, reference to Drawing 102 shows that many of these water points are located on or close to the watershed divides. Simply put, these water points have no catchments. In some cases, gullies were noted to be eating back into the water points and in at least one case had cut the main feeder canal. The water points themselves are too large and too shallow, giving overall small water volume but large evaporative surface. Conversely, the downslope bund has sides which are too steep; erosion of these sides is destroying the bund and helping to silt up the water point. This latter problem is exacerbated by lack of surface cover or other protection to the bund, and uncontrolled trampling by animals.

Greater care needs to be taken in locating these water points to provide for sufficient catchment. One problem here, however, is that the more effective the water conservation measures (bunding) on the agricultural land, the more the water points will be pushed upslope, above the bunds where catchments are small. The water points could perhaps be tied in with the drainages suggested for the bunded areas; however, this could become a problem if ever agricultural chemicals are introduced and used extensively. The catchment areas should be revegetated and protected against indiscriminate grazing, such that a ground cover is always maintained. This will release water more slowly, reduce siltation, and reduce the headward advance of gullies from downslope. The water points themselves should be deeper and have less surface area. The downslope bund should have slopes which do not exceed 40% and should be vegetated. The bunds should be compacted and protected by rock at the location of the spillway. The water point and bund should be fenced against any animal incursion. Instead of the animals being taken to the water, the water should be taken to the animals, through feeder distribution to a number of points. Rotational use of these points would help reduce the animal pressure on the environment. Distribution could be by pumping (hand, wind), by the present hand-and-bucket system, or by gravity feed to downslope outlets.

Human water points: Only one project human water point was studied within the Hargeysa study area. This was visited twice, the first time there being water, and the second time the point being dry. The point was a deep, cemented basin, with a small cemented desilting basin. The main basin was covered with a wood and tin cover. The cement walls only came up to the ground surface and there was no obstruction to the entry of dirt, by water or wind, between the wall and cover. A simple extension of the walls, to form a lip 25 to 50 cm high, would stop most of the dirt entry. The cover was already deteriorating, with damage to the tin sheeting; the wooden framework must also surely be susceptible to insect attack in this environment. A framework of curved cement struts would offer lifetime wear, and could be made by the project itself - either pre-molded or molded on site. Alternatively, this could be undertaken by a private contractor, who could also sell them to the numerous private water points which, at present, are mostly uncovered.

Complete closure of the basin would be desirable, with a locked inspection hatch. A simple hand pump could give access to the water. Such pumps are relatively cheap, reliable, and easy to service by project personnel. The desilting basin was observed to be too small, and should be larger on future models.

Proposed improvements to livestock and human water point designs are given in section 3.6 and Volumes II and III.

I - Inclined: These are generally sloping (1.1 - 3%) areas, sloping down from the "upland" areas towards the drainages. In reality, within the study area, very little of this unit exceeds 2 1/2%. Small areas of steeper slope (to about 4%) are included for convenience, to avoid creating another unit; however, should such areas be found to be more extensive, in any extension of the resource analysis, they should then be considered as another unit. The soils are deep with subsurface textures generally in the range of heavy sandy loam, heavy loam, sandy clay loam, and clay loam, depending on the proximity to the "upland" areas. The soils are stone free. This unit has a high potential to erode and much land has already been lost to gullies while more is under immediate threat (see section 3.4.3: Erosion and Erosion Hazard); however, gullying within the mapped units is generally confined to "incipient gullying" (.G1), recognized by dark linear lines on the aerial photographs, generally running down to an existing gully system. Sheet erosion is difficult to assess as the soil surface has been largely disturbed by bunding, and the bunds now provide some protection against sheet erosion. On the other hand, the bunding process, in stripping the topsoil to build the bund, effectively simulates very severe sheet erosion. Prior to bunding, the uncontrolled flow from the surrounding deforested hills may be assumed to have caused significant sheet erosion. Presently, within the bunds, seeds are generally broadcast; row seeding would provide more protection against sheet erosion. Further, the soil has a tendency to form a surface crust, which impedes moisture infiltration and seedling emergence, and facilitates sheet erosion.

Most of this unit is considered to be bunded, and therefore "agricultural" (dryland cultivation). A few areas are uncultivated, with a thin to dispersed tree cover, with an understory of bushes (land uses P3 and P4). Trees and bushes are primarily Acacias. Elsewhere, some areas have been mapped as a complex of cultivated and pasture/forest land. The reasons for non-cultivation are unclear, especially in areas of mixed land uses. Many of the completely uncultivated units occur upslope, merging into the upland units; soils tend to be lighter textured (sandier) and may contain pockets which are shallower, over rock, although this possibility was not investigated. The proximity of the unprotected "upland" units, with uncontrolled runoff therefrom, and the subsurface presence of rock at relatively shallow depths, likely combine to cause an erosion problem, and these areas may have been deliberately, and wisely, left vegetated as an impedence to runoff flow, for erosion control and downslope protection.

The majority of this unit has been mapped as cultivated (C2), although significant uncultivated land is contained within, up to 25% uncultivated being permitted within the "cultivated" land use (1). Occasionally, non-cultivation may be associated with a rocky inclusion, but mostly this land is left idle for other reasons. These reasons were never entirely clear. Farmers interviewed most frequently cited lack of labor, a situation which is caused in part by their semi-nomadic nature. Some of this land may be "fallow," although it was never clear whether any, or how much, of the uncultivated land is ever cultivated; however, it is logical

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1 This 25% figure was based on a visual estimate, from the photos, for the overall area. Subsequent work in the pilot project areas suggests that, in fact, a figure of 50% may be closer to reality.

to assume that once a farm is bunded, the farmer will concentrate his activities within the bunds, where the return on his labor is theoretically greater, and will rarely cultivate adjacent unbunded areas. However, field observations, as reported under the section on bunding, sometimes contrast with this assumption. The uncultivated land may also be linked to cultural trends, the farmers maintaining some land uncultivated to provide grazing for the herd, which remains an important farm resource. Further, uncultivated areas are associated with the bunding, as previously described.

This land, properly managed, has a high potential for sustained agricultural production; improperly managed, it will rapidly wash to the sea. The major constraints are moisture availability, erosion, and cultural traits. Moisture availability may be improved by a number of measures, of which bunding is one. The cultural traits of importance are the dietary habits which influence crop type and variety; the traditional importance attached to, and methods of, animal husbandry; and the fierce independence of the farmers. The question of land holding is also important here because officially, all land is government-owned, land tenure being by long-term lease, although "squatter's rights" may be a more apt description (see Appendix 1.7 and Volumes II and III - Social Survey/Land Tenure). The unit approach to bunding is in part a function of the farmers' desire to define and legitimize their holdings, and from interviews it is clear that they will reject anything which they feel threatens their position, such as integrated land management. Moreover, the farmers have a cost-recovery agreement on bunding and will resent changes to something they are already paying for. In terms of erosion, gully erosion is not usually severe <u>within</u> the units, but only because the major gullies have sufficient dimension to be mapped as separate units. These gullies are rapidly cutting back into the unit and in many areas threaten the continued viability of cultivation. Erosion and gully control, and soil moisture conservation, are closely related. Check structures within the gullies interrupt flow within the gullies but do nothing to stop the headward advance of the gullies. Gully erosion can only be stopped by stopping runoff water from reaching the gully head. Measures to effect this overlap with measures for soil moisture conservation. The planning for the use of this unit, and proposals for soil moisture conservation and erosion control measures, must start by taking into account the present situation - that the land is already cultivated and to return it to pasture or forest is not an option; most of the land is already at least partially bunded, and further bunding is planned; the cultural traits previously described impose limits on possible developments; reliable research results on crops and land management are not available; and erosion is not only serious, but appears to threaten the future viability of this unit.

The question of bunding has already been explained and recommendations given. Suffice it to say that many of the existing bunds do not appear to meet acceptable standards of design, layout and construction, while the value of bunding on the lower slopes remains to be proven. Bunds should be repaired, where necessary, but removal or re-bunding are not considered to be viable options. Firstly, the bunds are liked by the farmers for various reasons. Much of the bunded land is only just beginning to recover from topsoil loss, and further disturbance is unthinkable. Moreover, large amounts of money have been spent on the bunding, and farmers are now being asked to make payments on the cost of bund installation. Thus, rebunding can only be considered where necessitated by bund breakdown, as in the Boorama district (see Third Quarterly Progress Report, 1985, NWADEP, P. 3, Section 5.5). Integration of the bunding would be possible, and certainly desirable, but interviews with farmers indicate a strong resistance to such a move.

The sum of the above is that planning options are very limited. Within the constraints outlined, measures must be sought to minimize erosion and to improve production. Both soil and water conservation start upslope, in the "uplands." Implementation of the proposed "uplands" measures will benefit these agricultural lands. In the longer term, full revegetation of the uplands is desirable. Until this is achieved, and while bund layout, design and lack of integration continue to promote a concentrated drainage, a properly designed and protected drainage system is required, as previously discussed. Likewise, measures have previously been proposed related to road construction and associated erosion control. The areas around the gullies should all be revegetated and protected against grazing and wood cutting. Where this is not sufficient, graded and grassed diversion ditches may be necessary, with properly designed and protected outlets into the gullies.

For improved production, a serious research and extension effort is required. This should concentrate on crop types and varieties; rotations which serve to build and protect the soil; row cropping along the contour; weeding; use of fertilizer, especially animal wastes which are presently unused; and promotion of animal power for cultivation such that seeding is not delayed by tractor non-availability. A more detailed assessment is given under the section on the Aburriin experimental farm. As fodder crops are introduced, extension services should be developed in animal husbandry, especially in the principles of penning and feeding the animals, and of quality over quantity.

These lands have a potential for cultivation and, especially given the cereal deficits in the region (1), sustained cultivation is the preferred use of this land . However, proper management here is integrated management, which is constrained by the existing situation. Within these constraints, only a few measures may be proposed. These, however, may only provide temporary relief.

Recommendations

1. The planned use of this land should be sustained agricultural production.

2. Carry out measures within "upland" headwaters, as previously proposed, for downslope protection.

3. The recommendations outlined in the section on bunding should be implemented. Drainage from existing bunds is necessary. New bunding should be integrated, and conform to design, layout and construction standards.

4. Revegetate and protect all lands around gullies.

5. Develop research and extension services to promote new crops and better crop and land management.

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1 This is proposed as a political reality. However, as pointed out in the USAID Project Impact Evaluation Report No. 62, intensive cultivation may not fit in well with the prevailing socio-economic climate of the region.

L - Level: This unit is essentially flat, with slopes of less than 1%. The soils are deep, tend to be silty, with a typical subsoil texture of silty clay loam. These are the best agricultural soils of the project area and are intensively cultivated. Both bunded and unbunded fields may be found. Uncultivated units are still extant, but are less than in the I-units. The largest occurrence of this unit occupies an extensive area in the south-west of the study area, with little visible drainage. This, and the very low slope, combine to minimize erosion within the unit. However, deep gullies may be seen to be rapidly eating back into this silty, highly erodible soil, as, for example, north of Aburriin, between Aburriin and Xidhinta. Where this unit is disected by gullies (e.g., south or Arabsiyo), erosion may become a problem.

These are the soils, within the project area, most suited to permanent cultivation, with few requirements in the way of specialized management. Agriculture is primarily constrained by climate. This unit already occupies the moistest sites of the project area (moisture reception area and limited drainage). The limited moisture can be used most effectively by the use of cultivation practices aimed at facilitating infiltration (e.g., row cropping, strip cropping, breaking the soil crust), and by the selection of appropriate crops and varieties. However, as previously discussed, this involves research which is dependent upon the revitalization of the Aburriin experimental farm (see section 3.4.1.3). Erosion may be controlled by upslope measures, as previously described; by revegetation and protection around the gullies and along drainage lines; and by the introduction of contour strip cropping back from the gullies for at least several hundred meters. Water conservation and erosion control would be facilitated by the introduction of new crops, and of a more effective rotation including a permanent (fodder) crop at intervals within the strips. The recommendations previously made regarding roads should also be applied.

Much of the discussion undertaken for Unit I is also pertinent here. Where bunded, the recommendations previously made regarding bunding should be applied; however, new bunding should not be considered in this unit, unless research proves it beneficial.

Recommendations

1. Revegetate and protect areas around gullies and within drainage ways.

2. Introduction of strip cropping around gullies, back from vegetated area.

3. Research into alternative crop types and varieties, rotations, cultivation techniques, fodder crops, and animal husbandry.

4. Extension of 3, above.

5. Implementation of upslope control measures, as previously described.

T - Terraces: The terraces along the toggas are included here for convenience, although they have little in common with the other lowland units. Within the study area the terraces occupy less than 1% of the total area and could be ignored except that they provide the sites for almost all the irrigation which, though limited in area, probably contributes more to the economy than all the dryland farming put together (1). As the terraces occupy such a limited area within the study area, the observations made here also draw on terrace situations seen outside of the study area, during the investigations described in Volume IV: Small Irrigated Garden Development.

The terraces themselves vary from level to gently sloping. Some of them are very narrow - in the order of 200 - 300 m - while others may be extensive. Soils are deep, and for the most part loamy, although deep sands were also observed. Considerable variation in soil may be expected, both laterally and with depth, reflecting both the normal variation in river alluvium and the admixture of colluvial deposits from the surrounding slopes. The vegetation, where not cleared for agriculture, is often the densest and most diverse of the project area, often being classed as land use P2. Where this land is cultivated and irrigated, orange groves, papayas, lemons, guavas, and a mixture of vegetables may be found. As these irrigated lands are carefully managed, visible erosion is minimal. However, many of these areas are threatened with extinction by erosion, both of the togga banks by the togga floods, and by lateral gully erosion; indeed, in some areas these gardens are completely surrounded by severely gullied land, with the irrigated garden precariously perched at the base of a deeply gullied slope. Many terraces are backed by rocky hills, sometimes immediately behind the terrace and at other times at some distance. These hills generally lack an

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[1]The total production value of the irrigated farms is estimated, for the North West Region, as substantially lower than that of the dryland farms. However, most of the dryland production is consumed on the farms, whereas most of the irrigated production is sold, providing employment and income to those transporting and selling. The irrigated farms also purchase far more than the dryland farms (pumps, pipes, fuel) and employ more people per unit area.

adequate vegetation cover and the uncontrolled runoff from these hills during severe storms poses a threat to irrigated gardens in the terrace, either by erosion or by flooding or both.

The variable situation of these terraces makes it difficult to make general recommendations. Implementation of the general recommendations for upslope runoff and erosion control made in previous pages would help those threatened by gully erosion. Where necessary and feasible, check structures in the gullies may be considered. For those areas backed by hills, reforestation of the hills and possibly diking and water diversion between the hills and the garden, are possible measures to be taken. All the terraces should probably be protected against togga erosion by gabion breakwaters and stone walls. An example of this may be seen in the Horahaadley area.

These lands should be used, as far as possible, as they are now being used -- for irrigated agriculture. This is both the most productive use of these lands and assures the wisest management. However, irrigation expansion is limited by water availability and quality (see Volume IV). Elsewhere these lands should be considered for intensive fodder production and energy farms. These sites receive much water from runoff; upslope measures, as previously described, would make this more available over a longer period. Terracing and perimeter bunding of the terrace may help conserve runoff water. Limited supplemental irrigation could be supplied from the toggas or from water points. Once established, the trees will be able to fend for themselves in this location. For fodder, investigation needs to be made into suitable species which may produce several cuts during the wet season, but can survive the dry season with zero or with minimal irrigation.

Recommendations

1. Protect terrace togga embankments with gabion breakwaters and rock walls.

2. Implement upslope moisture conservation and erosion control measures, as previously detailed.

3. Investigate fodder species and tree species with a view to intensive fodder production and energy farms.

Due to the variable situation of these terraces, other recommendations would have to be specific to the individual situation.

(3) Gullies (G1, G2, G3, X)

The gullies are not just a major feature of the landscape, but a major component, occupying about 12% of the surface area. Interviews with farmers and field observations suggest that much of the erosion is of recent origin, although severe and active erosion was apparent in the 1950s and had presumably been going on for at least 20 years previously (Roy Green, Personal Communication). Presumably this is linked to increased cultivation, and an increasingly settled population, and, more recently, drought, which have combined to rape the environment, stripping it of its protective layer of vegetation, and leaving it exposed to the ravages of wind, rain, and flash flood.

The gullies frequently traverse all the previous units, rising in the highest areas, such as unit S, and then crossing the pediment (unit P) before incising deeply into the lowland units. In a sense, the gullies form part of the lowland units as it is these units where soil is most susceptible to gully erosion, and where the impact of gullying is most evident and detrimental. Even those units with almost no slope (unit L) may be slashed by a sheer sided gully cutting down several meters through the deep rich soil. The gullies themselves have steep sides, typically marked by slumping at the gully heads. With time, lateral gullying carves the sides of the main gully into a series of ridges and islands. The more severe the gullying, the less the vegetation supported by these "interfluves"; at the extreme they may support almost no vegetation, and they are always sparsely vegetated. The drainage ways, on the other hand, typically support a moderate cover of trees and bushes. When mapping the gullies, they have generally been classed for land use as a compromise between the two included land use classes. The gullies are criss-crossed by animal trails, typically running straight down the side slope and initiating further lateral gully development. Grazing and trampling help maintain and extend these gullies.

The extent and rapid development of these gullies is described in Section 3.4.3; suffice it to say here that they appear to pose a more serious threat to sustained agriculture than do climatic limitations. The gullies pose many problems in terms of land use planning and management, the latter comprising mainly measures aimed at stabilization and control. Ideally, the gullies should be treated and then protected against use, such as grazing or wood and fodder cutting; once stabilized, limited and controlled use may be possible, especially if measures have been implemented upslope to control runoff. However, these gullies cover extensive areas and are an important grazing area which will not readily be abandoned by the farmers. Similarly, the notion of "controlled use" in these common lands is simply impractical. On the other hand, continued uncontrolled use will only lead to further degradation and erosion.

The gullies themselves may be stabilized in a number of ways; for instance, grading, check structures, canalization, revegetation, etc. Specific measures must be designed to fit each individual situation and, as the gully form may change along its length, many different situations may be encountered within one gully. One particular problem, however, common to most of the gullies along most of their lengths, is the lack of stable foundation (e.g., rock) to which structures may be anchored. However, whatever measures are used within the gully, they do nothing to stop the headward advance of the gullies. Green belts and, possibly, drainage diversions, around the gully may help, but ultimately the headward advance of the gullies can only be arrested by preventing runoff water from arriving at the gully, at least in any volume or with any force. This can only be achieved by upslope control through measures already described; that is, gully control is dependent upon the integrated management of the associated watershed.

Four classes of gully were recognized during the study, based on overall characteristics. Some general observations may be made about each class but, as noted above, each case is unique and any gully may, while classed overall as one class, vary along its length and thus contain elements of one or more of the other classes. The four classes are:

G1 - moderately gullied, with a principal drainage line and low frequency of lateral gullies with significant level to rounded interfluve areas, which may be cultivated. Significant vegetation cover. These gullies offer good potential for reclamation. Apart from upslope control, typical measures might include grading and grassing the main drainage ways and side slopes, installing check dams, terracing side slopes, and bunding interfluve areas.

G2 - severely gullied, with a high frequency of lateral gullies giving ridges but interspersed with areas of lower frequency and broader interfluves, with occasional cultivation. Mixed vegetation cover; sparse on eroded interfluves but P3 or P4 in drainage. Main emphasis should be to stabilize gullies; reclamation will be difficult. Measures might include grading and grassing where possible, installing check dams upstream where the gully is not too wide and in main laterals, revegetation especially in and around gully heads, terracing where side slopes are not too steep, bunding of broader interfluves and around edges of threatened areas, and possibly drainage diversion around gully.

G3 - very severely gullied, with very high frequency of lateral gullying giving ridges, peaks and islands; very few broader interfluve areas and no cultivation. Interfluve areas very sparsely vegetated. Not cost effective to try and reclaim; only gully stabilization should be attempted. Apart from upslope control, possible measures include check structures, canalization, protection of gully heads with vegetation and stones, grading where possible, and possibly diversion ditches around gullies.

X - Badlands. Extreme frequency of lateral gullying which has completely dissected the landscape creating "a moonscape" of ridges, peaks and islands devoid of vegetation. Limited vegetation may be found in the drainages, but this unit is essentially unvegetated. The badlands are beyond redemption or stabilization. Apart from upslope measures, these areas should be left as they are. Although no badlands were mapped within the study area, examples may be found just outside the area, as on the main road between Arabsiyo and Abaarso.

3.4.1.3 The Aburriin Experimental Farm

This farm is located at the southern extremity of the study area, within the level land unit (L). Soil textures also tend to be heavier here than in much of the Hargeysa study area. It is thus not representative of the predominant agricultural land unit (unit I) of the area and, similarly, unrepresentative of the areas of primary intervention by the NWADEP. A topographic map, at an unknown scale, is alleged to exist, but copies were not available to this mission. There is no known soil survey of the farm. In theory, this lack of physical description precludes any experimental work as background variation cannot be controlled, although the soils and topography of the farm appear quite uniform. At the time of the visit of this mission, there was no evidence of experimental plot work. Some "field trials" were being undertaken, the nature of which appeared to be simply to see if the crop would grow under normal farm conditions. These normal farm conditions apparently included lack of maintenance; the fields needed weeding, and none of the farm laborers were working in the fields. Documentation of the research effort is best described as haphazard. Despite being in operation for some 33 years (1), there were almost no research records available; records were produced for a couple of years, which included good documentation of the trials, except that no results (yields) had been recorded.

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[1] Started in 1953

The farm itself is in a run-down state. The buildings are in poor condition, office space is poor, there is no electricity, and both the livestock and human water points were dry. Little farm machinery was evident either on the farm or in the field. The farm manager was not in residence.

As previously noted, experimental results are urgently required, both as a means of evaluating existing soil and water conservation measures, and as an input into detailed land use planning and extension work. Some of these requirements cannot be effected on the present farm, due to its non-representative location. However, the present location could be valuably used for research into crop types and varieties; crop response to fertilizers and other inputs; crop response to weeding; land preparation, and various land management strategies, especially different crop rotations. Grazing and fodder species, and animal husbandry might also be researched and demonstrated here. Careful selection within bunded areas could provide locales for trials and evaluation related to bunding, in cooperation with the farmers. Likewise, there is a need for experimentation in re-vegetation (grasses, trees) in the rocky uplands, which could be accommodated by sites selected outside the farm boundaries. The farm itself is centrally located, with good access to both bunded and rocky areas.

The farm structures need renovating and expanding to allow more office and residential space, and for a documentation center. The existing water point is well-constructed and receives water from one of the farm roofs. That collection system could be simply extended to all the roofs, for greater water supply. A desilting basin should be built. Local winds appear sufficient to drive small windmills, to provide electricity, water pumping, and milling. A soil laboratory apparently exists on the farm, but the person in charge lives some 50 kms away. This laboratory should be renovated, supplied with electricity, and upgraded to be able to do routine soil and plant analyses. A workshop, for equipment repair and the construction of simple implements, should be considered. Farm and laboratory staff should be properly trained and motivated; expatriate supervision seems desirable in the early stages. Integration of the farm with the NWADEP should be considered, as the NWADEP forms the primary operating agricultural agency in the region. Full integration of the farm and extension services is also necessary, to permit the rapid dissemination of favorable research results.

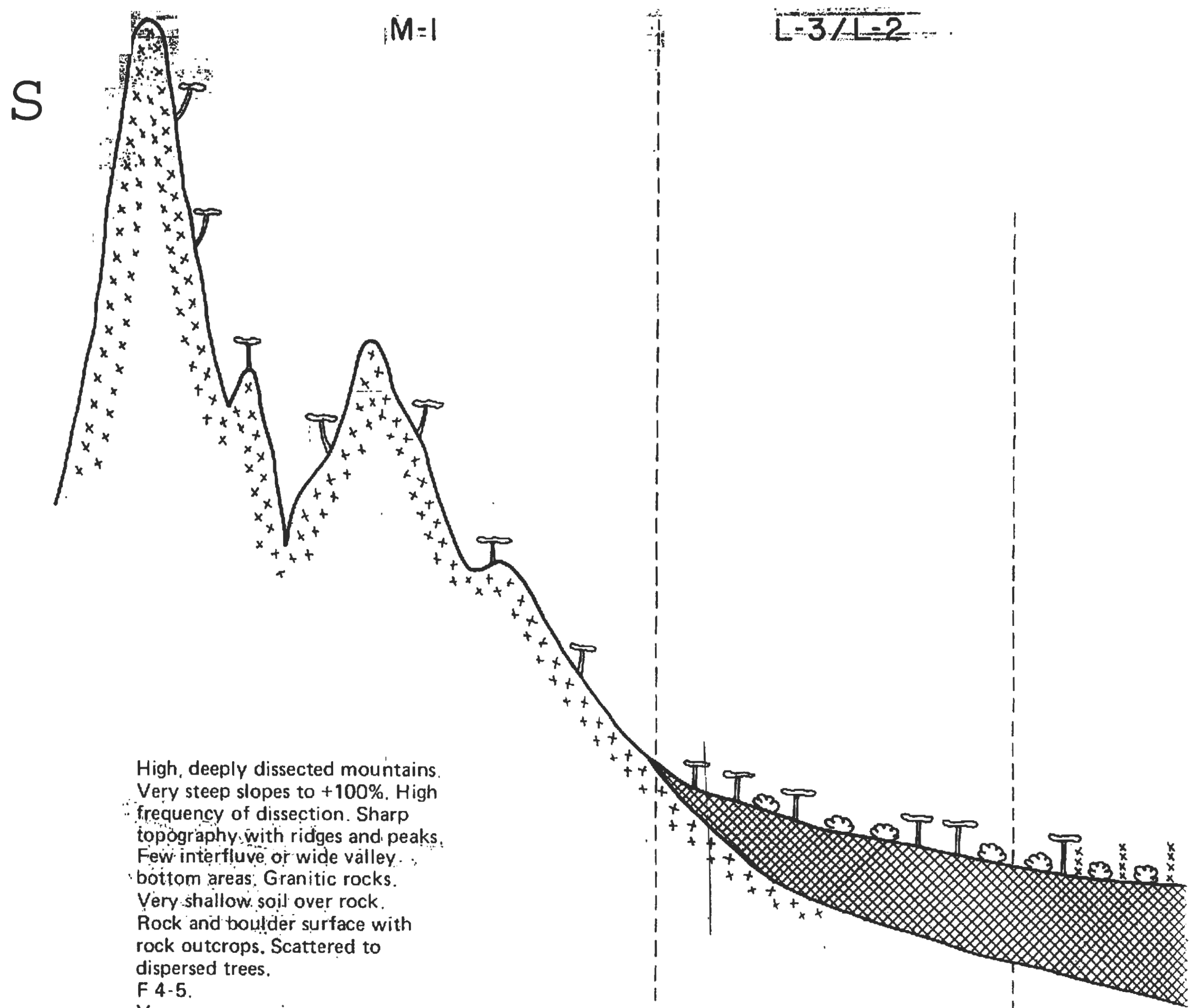
After a more intensive study, SOGREAH made similar, and more extensive recommendations. Some of these are incorporated into the proposals for Phase II. However, the farm needs a major overhaul, and rapid development to support the agricultural development work in the region. While expatriate advisers are being assigned to the NWADEP under Phase II, none will be able to devote his energies full time to the farm. Supplemental funding, for full-time expatriate staff, and suitable housing and facilities, should be considered. Again, the farm is a priority concern as research results are essential to evaluation and planning.

3.4.2 Baki Study Area

3.4.2.1 Overview

The Baki study area is a rectangular area stretching roughly from Baki in the north west to Ceel Bardaale in the south east. The area is about 24.1 kms long by 9 kms wide, for a total area of approximately 217 sq km, or 21,700 ha. It consists essentially of the valley of the togga Dibira Weyn, from the confluence with togga Bira to form togga Sooda Haada flowing north, and upstream to its division into togga Beeg Dhaadheel (togga Kabaab) and togga Dhabiyo.

From Baki to Ruqi, the area consists of a broad plain (approximately 4 to 5 kms wide) of deep colluvial-alluvial deposits. It is backed on both sides by high mountains. (See Fig. 1.8.) To the south (southern mountain zone) these are mostly of what SOGREAH calls the basement complex (granites, granite schists, and gneisses), while to the north (northern mountain zone) the predominant rock is limestone. To the east of Ruqi, the mountains close in and the agricultural lands are restricted to relatively narrow terraces and flat bottomed valleys. The climate of the area is sub-marginal for dryland agriculture. SOGREAH estimates rainfall at between 300 and 350 mm; however, the area is almost 400 m lower in elevation than the plateau (Hargeysa study area), with higher temperatures, such that evapotranspiration is higher. The rainfall has traditionally been supplemented in places by "spate irrigation" - capturing and utilizing the flash floods which come out of the mountains. In the Ceel Bardaale area, extensive work has been carried out to construct bunds and canals to try to make use of this water, primarily to supply the qat plantations, which were the primary crop until its banning by the government in 1983. Elsewhere the



High, deeply dissected mountains. Very steep slopes to +100%. High frequency of dissection. Sharp topography with ridges and peaks. Few interfluve or wide valley bottom areas. Granitic rocks. Very shallow soil over rock. Rock and boulder surface with rock outcrops. Scattered to dispersed trees. F 4-5. Very severe erosion.

Sloping plain, slopes. 1-5%. Dissected by gullies. Deep loamy soil, typically sandy loam over sandy clay loam. Typically thin to dispersed trees, bushes, P3 to P4. Some recent clearing for cultivation. Severe sheet erosion E 2. Slight to moderate gullying. G 1-2.

Level to gently s
plain, slopes 0-1
Dissected by gul
and toggas.
Deep loamy soil
typically sandy l
over fine sandy c
loam.
Typically patter
hedged fields, nc
generally fallow
reverting to bush
Mixed with P3 o
Severe to very se
sheet erosion E
Slight to modera
gullying.
G 1-2.

LEGEND:

xxxxxxx	ROCK
(cross-hatch)	SOIL
(x column)	HEDGE OR FENCE
▲	BUND
T	TREE (PRIMARILY ACACIA BUSHES)
(symbol)	DRYLAND CROP
(symbol)	IRRIGATED CROP
(symbol)	BUSH

NOT TO SCALE

spate is largely uncontrolled, except by hedges and occasional bunds; it is uncertain whether the hedges are a soil and moisture conservation measure or for parcel demarcation and animal control. The destructive force of the largely uncontrolled flood waters is seen in the very severe sheet erosion evident throughout the area; in places evidence was observed of over 1 m of soil loss. Even in the better managed lands of Ceel Bardaale, sheet erosion is severe. Gully erosion also cuts deeply across the plain; frequently, the several outlets from the mountains converge to form one main drainage line, thus forming a triangle of erosion, with the base along the mountains. The gullies appear to be extending, cutting rapidly back into the deep, unprotected soils.

The last five years are reported to have been years of below average rainfall. Most of the previously cultivated land has not been cultivated for several years and is said to be in fallow; it is struggling to revert back to grass and bushes. However, the land is being severely overgrazed which, combined with the lack of soil protection measures, and the problem of soil crusting (which stops water infiltration and seedling emergence) exposes the soil to both sheet and gully erosion. In the Ceel Bardaale area, the drought has disrupted the orderly transition from qat to other crops, and even this land, with its expensive infrastructure, is mostly lying idle.

Reflecting these severe agricultural problems is the apparent absence of population in the area. Apart from Ruqi, Baki, and the settlements associated with the Ceel Bardaale project, only 2 settlements of any size are seen in the 1985 aerial photos. (This may be compared to the density of settlements in the Hargeysa project area.) Both Ruqi and Baki are very small; Baki is a newly created administrative center for the new region of Awdal, and apart from the newly constructed government buildings, it consists of only about a half dozen huts.

There is almost a total lack of climatic or togga flow records pertinent to this region. The nearest climatic station is at Boorama, which is located at about 450 m higher elevation, on the plateau, and thus the records are not applicable to the study area. It is therefore difficult to make further comment as to the climatic situation, the reported drought in the area, or the probability of a future return to climatic "normality." However, there is evidence pointing to the influence of man and erosion in the apparent drought. Similarly, it is hard to estimate what vegetation the mountain areas used to support and might support again. Certainly the hills have a very thin cover of vegetation - typically a thin to scattered cover of trees with little understory. In other words, there is almost no natural restriction of the water flow from the hills. This, combined with the steep slopes, presumably makes for occasional but very severe floods, with great force of water, and the resultant sheet and gully erosion of the soils of the plain. As previously noted, the volume, flow rate, velocity, duration and periodicity of the water is unknown, as there are no stream flow records of sufficient exent. The flow can be imagined, and the effects seen, but actual data is a prerequisite to designing control structures and planning the land use.

Any management of the land must first seek to reduce the destructive effects of the runoff flow and, secondly, to try to make better and more sustained use of this water; unfortunately, as pointed out above, the latter is impossible to do without reliable data on the climate and stream and overland flow. Unquestionably, little of the rainfall received in the area benefits the vegetation; most escapes to the toggas, and thus to the sea, carrying with it the precious land resource of the country.

As is discussed below, and in section 3.5, technical and cultural characteristics limit the possibilities for flow control in the mountainous headwaters. If the flow cannot be controlled here, then it must be controlled within the plain, with structures designed to interrupt and spread the flow, and land management designed to limit the amount and velocity of runoff. When reviewing alternatives, consideration must also be given to the economic return on what would be costly interventions. Dryland agriculture, even supplemented by limited spate flood/irrigation, would seem to have limited potential beyond self-sufficiency for a small local population. The land appears to be suitable for irrigation; both water storage possibilities and the market potential would have to be explored, but present indications do not suggest that this is an economic option, except for small scale development such as that considered under Phase II and as discussed in Volume IV of this report.

Given these problems in planning for a more intensive use of available land and water resources, the only land use planning that can be suggested, in the short term, is that designed to limit erosion and preserve the land resource base for future use. That future use can be designed when appropriate data have been collected. In order to preserve the land it is imperative that a ground cover be established, and maintained <u>at all times</u>. The grass will help hold the soil, protecting it from both rainfall and flood, as well as helping to interrupt flood velocity and facilitating infiltration. Mechanical impediments to flow, such as bunds, could also be considered, both on the plain (earth and/or rock) and small rock structures on the lower mountain slopes. However, such interventions would be costly, requiring importation of heavy equipment. At the base of the hills, at the break of slope, a dense vegetation cover (grasses, bushes, trees) should be established and protected from all grazing, providing a natural barrier to interrupt the flow from the hills, dispersing it and reducing its velocity. Beyond, on the plain, grazing could be permitted but should be controlled so that a grass cover is maintained; sheep, and in particular goats, should be excluded unless they can be penned and the feed brought to them. There will thus be a requirement for some form of grazing management and control. Fodder production could be considered on the lower slopes and terraces, especially where it may be supported by limited supplemental irrigation. This scenario might well be supported by a small research station to carry out research into range and fodder species, range management, as well collecting other necessary climatic and togga flow data. The same facilities may be used to direct necessary measures of revegetation, fencing (natural fencing, such as sisal, by preference), and grazing control (policing). Grazing management and revegetation in the mountain areas is not considered viable at this time. However, trial reforestation plots might be tried, supported by an irrigated nursery located in the small gardens planned for the plain.

The gully erosion, previously described, also threatens the land resource base, but is much harder to control. If the volumes, rates and velocities of flow were known, the ideal solution would be a series of control structures, starting back in the mountains, designed to interrupt the flow and reduce velocities. Canalization - direction of the flow down main gullies, properly straightened, graded and protected against erosion - would then serve to shed the excess water to the toggas, in the least destructive fashion. However, lack of data and aparent high cost both militate against this solution. However, significant protection could be achieved at low cost through development of a series of gabion breakwaters in the gully channels, and rock and gabion protection of gully walls, especially at erosive points (e.g., outside curves). The wire mesh would need to be imported, and a couple of lorries might facilitate transportation of rock from the mountains to the construction site. Otherwise, such construction demands only hand labor and locally available materials. Transportation of the rock using animals might also be considered, especially as the animals would probably allow greater accessibility into the mountains.

The land use plan described would provide for protection of the land resources at minimum cost, while providing for the development of a viable alternate use of the land (livestock production). Use of the land for livestock may fit in well within the existing socio-economic infrastructure, and this plan might therefore have greater local acceptibility than one designed to develop cultivation. The plan may also be implemented immediately. Development (and monitoring and maintenance) of a climatic and flow recording network should be a first consideration. A complete resource inventory at appropriate scale is a longer term objective. Implementation will conflict to some degree with traditional land uses, especially free range grazing; an extension program stressing erosion control, and grazing management for long term grazing viability, is a necessary component. As previously suggested, a limited research effort could be established to support the plan. The technical assistance being provided under Phase II could undoubtedly help the project establish this management plan, and the extension and research effort.

3.4.2.2 Study of the Major Land Units

The major land elements of the region have been identified and are presented in Drawing 107 (cross-sections) and Fig. 1.8 (hypothetical cross-section). Four major land types have been identified:

(1) the mountain units

(2) the lowland units

(3) the toggas and their terraces

(4) gullies

Each general land type and component land units are evaluated, followed by a general Land Use Planning assessment and management recommendations.

1. The mountain units (M1, M2, M4, M5)

The mountainous areas are characterized by their higher elevation, high frequency of dissection, sharp topography with ridges and peaks, steep slopes, very shallow soils, a rocky and stony surface with rock outcrops, and limited accessibility. They form the most important land type in the Baki study area, occupying about 57% of the area (see Table 1.17). Most of these areas could not be visited during the study because of lack of access. Land use is invariably grazing/forestry, with the vegetation typically consisting of a thin to scattered cover of trees with very few bushes and a limited ground cover. In the absence of an understory, the structure of the vegetation here shows similarities with the vegetation of steeper slopes recognized in the Hargeysa study area (P3A, P4A, P5A); areas of lower slope appear to have more understory and in structure are more comparable to the main pasture/forest units recognized in the Hargeysa study area. However, this area is part of the Acacia bussei zone, described by SOGREAH, whereas the Hargeysa area falls into the Acacia etbaica zone.

Table 1.17 Approximate Area of Major Land Types Within Baki Study Area

	Area (Ha)	% of Study Area
Mountain units	12370	56.9
Lowland units and terraces (1)	6950	32.0
Gullies	1830	8.4
Togga beds	580	2.7
	21730	100.00

(1) Within this area, some 230 ha are irrigated (about 1.1% of total Baki study area).

The primary land use is for grazing. However, these elevated areas are mostly accessible only to sheep and goats, slope angles being too steep for cattle. Unfortunately it is the sheep and goats which do the greatest environmental damage and they have undoubtedly helped strip the hills of their protective cover, with a consequent loss of soil and a reduction in both the quantity and quality of grazing. It has also removed any control on the runoff and erosion which has not only left the mountains severely eroded, but exposed the lowland units to the full force of the runoff waters.

Planning for the use and management of these lands is difficult. Reforestation to check both the volume and velocity of runoff, is an obvious first measure in the use and management of both these lands and the lowland areas. While these mountains may once have supported a more vigorous vegetation, their present degraded state makes it doubtful whether a substantial increase in vegetation can be achieved without some form of terracing, which would be both difficult and very expensive in hills with slopes which may exceed 100%. Further, such management immediately comes into conflict with the traditional nomadic grazing of this land. Any attempt to restrict this traditional grazing activity will be fiercely resisted; yet there can be no management plan without grazing control.

Controlling the flow in the drainages will also be difficult in these mountains. The high frequency of dissection requires a large number of control structures; the large flows and high flow velocities will mean large and more frequent structures; and the narrow, v-shape of the drainages and steep slopes cause difficulty in construction and limit the possible water storage potential. The geological suitability of the rock to support structures and for water storage, is unknown. Furthermore, while a high volume and velocity of flow are assumed, there is no measurement data; such data is essential for designing structures.

Under the circumstances just described, it is suggested that these mountains be left essentially in their present land use. The land degradation is already so severe that little further deterioration can occur. Frequent, small, rock-filled dams, with downstream rock protection, could be attempted on the main togga tributaries to facilitate energy dissipation. This would require a relatively low investment, relative to masonry structures, but would require continuous maintenance. Protected reforestation should be carried out on the lower slopes adjacent to the plain. Some protected experimental plots for reforestation (species, density, soil and moisture conservation measures, different slopes, etc.) should also be tried, with a view to the longer term rehabilitation of this land.

Four different mountain units have been recognized, based on geology and land form:

M1: This comprises the mountain range to the south of the study area. The geology is described by SOGREAH as "the basement complex" - a mixture of granite schists, gneisses, and other rocks. The mountains are high, deeply and frequently dissected, with very steep slopes (to +100%). The surface is comprised of rock and rock outcrop, with little soil, and tends to be unstable because of the steep slopes. The intense dissection tends to provide for sharp ridges and peaks rather than extensive interfluve areas. The drainages, including the main toggas, are very narrow with steep gradients. Vegetation is sparse, but varies according to specific site.

These mountains are used almost exclusively for grazing of sheep ard goats; the slopes are too steep for cattle and camels. While there is no definitive knowledge on vegetation changes, the area is believed to be seriously overgrazed, with destruction of the vegetation cover, loss of soil through erosion, and the loss of any control over runoff.

This unit poses the most difficult management problem of the area. The mountains probably receive the highest rainfall in the area and are certainly the primary watershed to the lowland plain. The necessity for management is therefore high. However, the combination of physical characteristics (steep slope, lack of soil, high frequency of dissection), inaccessibility, and cultural tradition (nomadic grazing) combine to defy the development of any realistic management plan. At the present time, probable cost of any management would seem to far outweigh any conceivable benefit.

These mountains extend far beyond the project area, continuing as a series of ranges and intermontane valleys, south-westwards to the edge of the plateau. Many of the drainages which flow across the Baki plain actually start back on the plateau, compounding the problem of implementing local control measures. Any planning for the management of these lands should consider the entirety of the unit, rather than just the fringe which edges the Baki study area. Looked at in its entirety, other possibilities arise, including water storage in the intermontane valleys and diversion for irrigation. However, such a proposition must be seen as no more than a vision for the future. For the present, efforts should be directed at controlling grazing, revegetation, especially of the lower slopes, and protection of the valley lands.

M2: This unit is found mostly to the north of the togga Dibira Weyn and is the primary unit forming the northern mountain zone. Many of the characteristics described under unit M1 exist here, including deep and frequent dissection, steep slopes (to 75%), sharp topography with ridges and peaks, and severe land degradation. However, the geology is very different being limestone. Some of this limestone, at least, is bedded almost vertically, and can be recognized on the air photos by the striated pattern. In principle, this geology is favorable to recharge of the water bearing limestone and theoretically this should result in lower volumes of runoff compared to unit M1. Slopes are typically less steep than unit M1 and drainages broader. Some of the drainages contain deep soils, with a medium to heavy texture; deforestation has exposed these soils which are now severely gullied. The hills have very shallow soils, the surface consisting mostly of rock and rock outcrop, with a very thin cover of acacias.

This unit is used almost exclusively for grazing of sheep and goats, access being too difficult for cattle and camels. As with unit M1, overgrazing and land degradation is presumed to be severe. Very occasional fields may be found on the deeper soils of the drainages.

Being to the north of the togga, drainage towards the main Baki plain is effectively intercepted by the togga. Drainage from these lands does not therefore pose any special problems to use of the lowlands, unlike unit M1. From the point of view of use and management of the Baki lowlands, therefore, management of this unit is not of major concern and the unit itself has no great value or potential which would justify any extensive or expensive management. As with unit M1, inaccessibility, high frequency of dissection, steep slopes, soil erosion, and cultural tradition all make management a difficult and expensive proposition. The preferred use of this land would be for forest, with controlled grazing confined to the lower slope and valley areas. However, for the reasons already given, this is not a realistic proposition in the immediate term. The recommendation for this unit, therefore, is essentially to leave it in its present use. If possible, revegetation and grazing control of the valley lands is desirable, which would help preserve these better lands for future uses; but their limited area and isolated occurrence makes implementation of this recommendation difficult. For the rest of this unit, continuation of the present mismanagement offers to damage the environment little beyond its present degraded state.

M4 This unit is again found north of the togga Dibira Weyn, and forms part of the northern mountain zone. It is a small and relatively unimportant unit but is very distinctive on the aerial photography, having a very dark tone. This tone apparently is given by the gabbro, which is important in the unit. Topographically, the unit is quite different from the surrounding unit, M2, being less dissected, with rounded interfluve areas and lower slope angles (typically 10-15%). Soils are still very shallow, with rocks and rock outcrop dominating the surface. However, the vegetation, which still is dominated by a scatter of Acacia trees, shows a better developed understory (bush layer). Land use is, again, grazing.

Being of limited area mostly contained within areas of unit M2, land use planning of this area can be considered to be an extension of that described by unit M2. Thus, afforestation is desirable but probably impractical and the short-term policy should be to leave this unit in its present land use. The location of this unit north of the togga Dibira Weyn means that lack of management will not detrimentally affect the more important lands of the Baki plain.

M5: This unit is extensive and occurs both north and south of the togga Dibira Weyn. It is a very distinctive unit, both on the aerial photos and in the field, being composed of gently bedded limestone giving a "cuesta" form, with very steep scarp slopes (to 80%) and extensive, moderately sloping (to 15%) dip slopes. This unit occurs as an extension of the southern mountains (unit M1) in the Ceel Bardaale area, as the primary unit between toggas Beeg Dhaadheel and Dhabiyo, and extensively in the northern mountain zone. Dissection is less than in the mountain units but, where dissected, side slopes are steep.

The soils are typically very shallow to shallow over rock, with a surface of rocks and rock outcrop. Deeper soils, of medium to heavy texture, occur in the drainages. Here occasional cultivation/fields may be found. However, most of the unit is occupied by the thin Acacia tree cover, with little understory, typical of most of the mountain units. Again, serious overgrazing and environmental degradation is assured.

Any attempt at management of the mountain units, should probably start with this unit. It is important within the Baki plain and therefore important to management of that plain, although its runoff contribution is minor compared to the mountains of unit M1. However, within the plain, this unit is moderately accessible and the moderate slopes of the "dip" slope probably offer the greatest potential for development. Experience gained in this unit, within the plain, can be extended into the extensive occurrences of this unit in the northern mountain zone. Lack of experience with afforestation in this region, potential conflict with traditional land uses, and the high costs and low apparent benefit, militate against any extensive afforestation program. However, a number of small plots could be fenced and a program implemented of afforestation research and trial. This could be carried out within the project, managed from the proposed research center; or the matter could be handed over to the government agency responsible for forest and range; or implementation could be handled by one of the other development agencies working in the area and/or experienced in afforestation (e.g., TransCentury, OEF). The third alternative is the solution preferred here, but it must be in close collaboration with the project research center.

Apart from these trial areas, and the deeper soils in the drainages, the rest of the land of this unit can, for the moment, be left to the traditional open grazing use. Revegetation and grazing control are desirable on the better soils of the drainages, to preserve them for future use. However, limited accessibility outside of the Baki plain, may make implementation of such a program difficult.

Most of the mountain units recognized may be divided into sub-units, such as areas of deeper, better soil. Time, mapping scale, objective, and inaccessibility prohibited more detailed mapping under the present mission. However, a detailed land use plan for this area will need to be preceded by a complete and detailed resource inventory at appropriate scale.

(2) <u>The lowland areas</u> (L0, L1, L2, V1, V2)

The lowland units essentially comprise the valley plains of the togga Dibira Weyn and its principal tributaries. They occupy about 31% of the Baki study area. Elsewhere in this document these lowlands have been referred to as the Baki plain or Baki lowlands, although Baki is actually at the eastern extremity of the lowlands. The main part of the lowlands is found between the togga Bira, just west of Baki, and Ruqi, and bounded to the south by the granitic mountains (unit M1) and to the north by the togga Dibira Weyn. The mountains are the principal source of drainage into this area. Narrow lands along the other principal toggas have been included within the "lowlands" although their extent, form (old terraces), relationship with surrounding units, and possible soil parent material and characteristics might, in a more detailed analysis, suggest their separation into a separate unit. The lowland areas, by virtue of their slope and soil characteristics, provide the only extensive areas with an immediate potential for the intensification of land management. The terraces (see below) are very limited in extent, and are, to a substantial extent, already being intensively managed. The mountains, as previously described, do not lend themselves to serious management at this time, and even in the long term, management options are very limited.

The lowlands have been divided primarily on the basis of slope, the divisions being less than 1% (L0), 1-3% (L1), and more than 3% (L2). The L1 and L2 units occur primarily along the footslopes of the mountains (unit M1); the majority of the lowlands consist of unit L1. Within the lowland area, small depressional drainages, with a better moisture situation, have been recognized (V2). Outside the main lowland area, a few valley lowlands have also been recognized (Vl). As the characteristics of these lowland units do not vary significantly, except as just described, they are described together.

Throughout the area, the break between the mountains and the lowlands is very distinct (see cross sections in Drawing 107 and Fig. 1.8). The steep mountain sides (slopes to 100%) abruptly give way to the plain, on which slopes rapidly decrease to about 3% and less. Similarly, from the very shallow, rocky soils of the mountains, the soil quickly becomes deep and loamy. Soil subsurface textures observed were typically very fine sandy loam to very fine sandy clay loam. The soils throughout the main part of the lowlands have probably been significantly influenced by the materials washed out of the high granitic mountains to the south. The possibility of heavier soils should be expected as the togga is approached, where fine textured river alluviums might be encountered. Heavier soils may also be associated with some of the smaller tributaries feeding from the limestone hills (1). Many of the soils are stony, stoniness being a function of distance from the mountains or rock outcrops and of erosion. In general, stoniness decreases with increasing distance from the mountains. However, between Baki and Ruqi, the lowlands are punctured by a number of rock outcrops, some upstanding but others topographically indistinct from the surrounding plain. Elsewhere, some soils were observed to contain water laid stones and gravel, and erosion has often left these soils with a stone/gravel surface.

Erosion is severe everywhere, both sheet/rill and gully erosion. Occasional upstanding islands, surrounding old trees,

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[1]Heavier textured soils were not observed during the current investigations. However, the number of soil observations was very limited. The SOGREAH soil study reports the presence of heavier soils in this area, but their extent is not indicated.

provide evidence of the loss of over one meter of soil by sheet/rill erosion. The plain is also deeply cut by gullies which may be seen to be cutting back rapidly. Within the main part of the plain, the gullies are typically fed from the mountains, their courses converging with distance from the mountains, to form a triangle of erosion, whose base lies along the base of the mountains. Such areas have been described as gullies, and offer little or no potential for development. While the gully erosion is the most evident, the sheet erosion may be the most insidious; while not always obvious to the untrained eye, it removes the productive topsoil, exposes compact subsoils, and helps seal the soil surface, inhibiting plant emergence and water infiltration and thereby contributing to runoff and further erosion. This may well be one of the causes of the drought described in this area (see below).

Most of the lowlands were once cultivated, as evidenced by the remaining field pattern. However, most of the agricultural land has lain fallow for several years. This has been ascribed to drought. However, as described in section 2.3.3, the evidence for recent and prolonged drought is not strong and, as described above, the "drought" may in part be a self-inflicted wound. The tendency of the cultivated soils to crust, and the effect of sheet erosion in sealing the surface and exposing compact subsoils, along with loss of vegetation cover due to overgrazing, combine to limit infiltration and maximize runoff. Thus, rainfall <u>effectiveness</u> could be reduced without any general reduction in rainfall <u>quantity</u>, the resulting "drought" being realized in reduced vegetative growth and plant available soil moisture, but not in total rainfall. However, whatever the cause, dryland cultivation has been largely abandoned. Occasional cultivation may still be seen, especially in shallow drainage ways (V2), where there is some concentration of moisture, and in newly cleared (last five years) land upslope towards the mountains. The latter situation provides some support for the theory of a link between "drought" and erosion. Lands cleared in the last few years have not yet been subjected to severe erosion and surface sealing, moisture can still infiltrate and (marginal) crop production is still possible. Soil degradation will also be less in these lands - that is, their fertility status will be higher. This certainly appears to be the most obvious explanation for crop production on these sites while apparently more suitable sites lie abandoned. However, the new areas already are being eroded, and their ultimate demise may be predicted.

Cultivation in the shallow drainages (V2) is frequently supported by bunding. Bunding may also be seen elsewhere in the lowlands. However, it is rare and intermittent and, while it may be locally helpful, it does not provide overall control. Elsewhere, most of the previously cultivated land is hedged. It is not clear whether this was an attempt at contour hedging, for soil and water conservation, or merely an attempt to demarcate property limits and/or control animal incursions into the crop. To the extent that erosion has caused land abandonment, these hedges stand as a monument to poor land management.

With the abandonment of cultivation, the land is slowly reverting to a scrub-bush and is being used - or abused - for uncontrolled grazing. At the time of the visit of this mission, there was little evidence of ground cover, and the soil was fully exposed to erosion. The settled population is very small and many people have apparently left the area as the land has become unproductive.

Planning for the use and management of these lands poses special problems, the first of which is the almost total absence of reliable data. SOGREAH estimates, from extrapolated isohyets, that the area receives between 300 and 350mm of rainfall. When combined with the high temperatures and consequent evapo-transpiration demands, this suggests the area is very sub-marginal for dryland agriculture; indeed, it is hard to explain the extensive cultivation that once occurred here. Given this very severe climatic constraint, agriculture would have to be supported by the use of runoff flow from the mountains. This in turn poses special problems of capturing and distributing this water <u>without</u> causing erosion. Information on the agricultural and erosional history of the area, and the grazing history in the mountains, is also absent. The area appears to have undergone extensive sheet erosion which may reasonably be attributed to high velocity floods from the mountains. Was the erosion initiated simply by land clearing for agriculture or has flooding increased with overgrazing and vegetation destruction in the hills? In either case, redevelopment of this area for agriculture must start by flood control back in the mountains, by revegetation (if the second scenario holds) and/or through artificial structures. All these measures are expensive, and revegetation and grazing controls will bring the development into conflict with traditional grazing rights. Such developments are difficult to justify when designed to develop only about 4,000 ha of land which is, to start with, sub-marginal for agriculture. There is also very little population in the area, and so both the local demand and labor for development are minimal, while the area is distant (distance and time) from any potential market.

The available evidence suggests, therefore, that agricultural development for crop production is not a viable option in planning for the use and management of the lowlands. Erosion, however, is seen as the major, and continuing, problem in these lands with soil protection thus a primary consideration in the land use plan. The cheapest, fastest, and most effective way of preserving and protecting what remains of the soil resource is to establish a permanent ground cover of grasses and herbs. "Permanent" means "year-round" which in turn means grazing control. There is no reason why the land should not be grazed once a vegetation is reestablished, provided that the grazing is properly managed for land protection. Given the crusted nature of the soil, cultivation and seeding may be required. All grazing must be prohibited until the grass cover is established. Consideration should be given to establishing natural fencing as part of the management. Both the quantity and quality of grazing might be improved by the selection and seeding of appropriate grasses and herbs. A number of projects have provided rangeland experience in northern Somalia (1) and these sources should be tapped for recommendations on species and grazing management strategies. Additionally, a small research unit might be established in the area to carry out research and trials.

The volume and force of the waters coming out of the mountains is unknown, but a ground cover alone may not be sufficient to protect the soil. Trees and bushes should be encouraged as far as grazing strategies permit. A forest zone, protected from all grazing, should be established and maintained at the base of the mountains. This will serve to reduce velocity and disperse the flow. The measures described here should be tried and tested; if erosion remains a problem then artificial barriers to flow will have to be considered, such as earth and/or rock bunds, both on the plain and on the lower slopes of the mountains. In the longer term, of course, reforestation of the mountain area is desirable but, as previously explained, is not a practical proposition for the near future.

The above discussion has focused on the main lowland areas. A few small valley lowlands (Vl), located within the

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[1]SOGREAH; Watson; FAO

mountain zones, also occur. The broad principles of management discussed above also apply here - that is, to preserve the resource through the establishment of a permanent ground cover to minimize erosion. However, the isolation of, and difficult access to, these areas will negatively impact upon implementation of a management plan.

(3) Toggas and terraces

The toggas form a distinctive and significant feature of the landscape of the Baki study area. The toggas are sandy flats supporting little or no vegetation, but they are an important source of water for human and livestock consumption and for irrigation. A whole series of terraces, at different elevations, may be discerned along the toggas. The upper terraces, generally sloping, have been included, in the mapping, with the "lowlands"; it is only the lowest, essentially level terraces that are described here. They provide important sites for irrigation, with irrigated oranges, guavas, papaya, and vegetables. This is further discussed in Volume IV of this report - Small Irrigated Garden Development. As reported in Volume IV, there appears to be room for extension of this irrigation, both in terms of water and of land availability. Indeed, in terms of land, irrigation could easily be extended back onto the "lowland" area; the limiting factor will be water availability. The question of market must also be considered, especially given the distances and road condition involved.

As far as water availability and market allow, these togga terraces should be used for irrigated agriculture. This provides for the highest production, best return on investment, and that investment assures the most careful land management. Consideration should be given to whether the recharge of the togga aquifer can be improved through upslope measures; similarly, any detrimental effects of flooding might also be controlled by upslope measures. Should the limit of water availability be reached, the remaining terraces could be considered as sites for fodder production; these are amongst the moistest sites in the area, and have the potential for limited supplemental irrigation, if necessary, during the dry season. This integrates well with the grazing proposal made for the lowlands. An energy farm, to supply wood to the local population, should also be considered, thus relieving one of the pressures on the surrounding land.

(4) Gullies

The importance of gullied land in this area has already been described. The gullies occupy about 8.4% of the Baki study area. In mapping, the same gully designations were applied as used in the Hargeysa study area, and the same land use and control concepts apply. The reader is therefore referred to Section 3.4.1. As details of form and control vary both between and within gullies, any further detail would have to be site specific.

3.4.3 Erosion and Erosion Hazard

Erosion is a very serious problem in the two study areas. The gullies, which are probably the most visible characteristics of the landscape, occupy about 12% of the Hargeysa study area, and about 8.4% of the Baki study area. However, all other land units suffer, to varying degrees, from sheet and gully erosion. Indeed, soil degradation - loss of the more fertile and better structured topsoil, exposure of compact subsurface soils, surface sealing against infiltration and seedling emergence - may be more important than the visible losses to gullies. In particular, as suggested elsewhere in this report, this process may be partially responsible for the present "drought," which may in part be a product of reduced rainfall effectiveness rather than simply reduced rainfall.

Discussion of the erosion situation is hampered, as is everything else in the N W, by lack of reliable data on the extent, origins, and rates of erosion. For instance, it might be shown that these areas have been historically subjected to erosion, and that some equilibrium exists between land use and erosion; in this case, erosion would be considered as less of a problem. However, field observations and interviews with local farmers suggest that the severe erosion is a recent problem, a product especially of the last 30 to 50 years; the erosion is known to have been severe as early as 1951. (Roy Green, Personal Communication and SOGREAH (Report No. 8) quotes Peck (1943) as commenting on the erosion problems of the area.) This would appear to coincide with the period of increased population settlement, vegetation clearing, cultivation, and overgrazing.

Various authors quoted by SOGREAH (Report No. 8) support this view. As part of the investigations carried out by SOGREAH, an erosion map, at 1:500,000 scale, was prepared for the whole N W Region. This shows the whole dryland farming area to be suffering from severe accelerated erosion, especially sheet erosion, with the worst problems occurring between Arabsiyo and Gebiley. They attributed the erosion problem to geological uplifting, accelerated by the actions of man, specifically cultivation and overgrazing.

During the present mission, a thorough analysis of the erosion problem was not possible. However, observations suggest it to be of critical importance and, indeed, to be perhaps the factor most threatening the continued viability of the study areas for sustained agriculture. Because of this assessed importance, it was decided to give the problem special attention. Drawings 105 and 109 show present gully erosion; these now occupy 12% and 8.4% of the Hargeysa and Baki study areas, respectively. Two erosion hazard isolines are shown, for 150 m and 300 m distances from the gullies. Gully head advance of up to 15 m per annum was reported by farmers interviewed. Using maximum advance rates of 12 to 15 m per annum, and assuming uniform expansion of the gullies, these isolines would represent 10 to 15 and 20-25 years time horizons for gully erosion. Thus, based on these assumptions, within the next 25 years, gully erosion may be expected to expand to include 31% and 18% of the Hargeysa and Baki study areas, an increase of 161% for Hargeysa, and 116% for Baki. For Hargeysa, this involves a net loss of usable (1) lowland areas of some 7600 ha, or about 31% of the presently existing usable land. For Baki, the respective figures are 2122 ha and 32%.

The assumptions used in the analysis are, of course, unlikely to be fulfilled. Maximum erosion rates were used, whereas in reality erosion varies from location to location, even within the same gully, and from year to year; bunding is also providing localized temporary relief. Likewise, a uniform lateral expansion of the gully is improbable. However, the analysis focuses attention on the severity of the problem and the necessity of control; whether the endangered area is lost within 25 or 50 years is really a minor consideration. Further, the analysis does not include soil loss and degradation by erosion in the non-gully areas.

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1 Usable is defined as total lowland less towns and toggas.

Based on available evidence, it is believed that erosion is the primary problem in the N W, and erosion control for the protection of the agricultural lands should be the priority for the NWADEP. Soil moisture conservation will be achieved as a by-product of measures directed at erosion control. As previously described, bunding provides temporary and localized relief. However, gullies continue to eat-back, even into the bunded areas themselves, and many examples may be seen of bunded fields now abandoned to the gullies. Likewise, gullies are developing and advancing between bunded fields, and the design and layout of the bunds may actually be contributing to this problem. The bunding certainly provides some control of surface flow, and thereby reduces losses from sheet erosion. However, the bunding process simulates very severe sheet erosion by removing the topsoil; the area so effected is also the area of subsequent maximum sheet erosion (see Figure 1.6). One might therefore question whether the protection against sheet erosion, provided by the bunding, is sufficient - in the short to medium term, at least - to compensate for the damage caused by the bunding process.

While outside the scope of the present mission, a number of measures are suggested:

1. Inventory the erosion situation. Aerial photos exist for 1952, 1985, and, in theory, for 1973. These permit a comparative study (2- or 3- dates) to evaluate visible erosion. A 3-date study would permit some analysis of changing erosion rates.

2. Monitor present erosion in selected watersheds. Gully advance can be established by staking the perimeters of the gullies, with lines of stakes set back at regular intervals from the gully. Erosion (sheet, rill, gully) within non-gully units, is most simply monitored through silt traps.

Plot work would provide valuable insights into the rates and processes of erosion.

3. Priority delineation surveys. Surveys and measurements should be carried out to identify those sub-watersheds which are eroding the fastest and are therefore priority for erosion control measures. The surveys should consider contributing factors such as land use, slope angle and slope length, soil erodibility, existing erosion control measures, and existing erosion. As a first step, the present topographic and land resource mapping should be extended to the whole plateau.

4. Implement erosion control measures on a priority basis.

5. Measure and monitor (e.g., silt traps) the effectiveness of erosion control measures on protected and unprotected sub-watersheds of comparable character.

3.5 Selection of Pilot Watershed Control Project Areas (PPA)

3.5.1 Introduction

The core of the integrated watershed management component of this assignment was the feasibility study on watershed control in selected catchment(s), for implementation during Phase II of the project. The contract stresses practicality and viability. In order to achieve these objectives, the essential components were firstly to select the most appropriate area for such a pilot project, secondly to describe that area in detail, and finally to prepare control measures and management practices to be implemented in the Pilot Project Area(s) (PPA). This section describes the first component, the PPA selection; the PPA description and proposed control measures and management practices are given in Volumes II and III, and summarized in section 3.6.

3.5.2 Guiding Principles

Selection of a sub-watershed or sub-watersheds for a pilot project was to be made within 60,000 hectares of land previously selected by the project and mapped for topography at 1:10,000 scale by Geosurvey. These 60,000 ha were divided between two study areas - Hargeysa, with about 38,000 ha, and Baki, with about 22,000 ha. The choice of these study areas is discussed in section 3.2 of this report. In order to select the pilot project area(s), the 60,000 ha were assessed according to the following criteria:

1. The PPA should be one, contiguous area, preferably comprising only one sub-watershed. This respects the "pilot" nature of the study (see section 3.1.3) and provides for the most practical application of limited project resources during implementation.

2. The PPA should be entirely contained within the limits of the study areas, thus enabling planning under the present assignment and avoiding further expensive topographic and mapping work beyond the work already carried out under the Project Preparation Facility.

3. The selected PPA should be representative of as much as possible of the north west dryland farming project area and of the conditions and problems found therein. This respects the "pilot" nature of the proposed project - to act as a model for development in <u>similar</u> sub-watersheds.

4. The PPA should have a surface area of not less than 1000 ha and no more than 2000 ha. Sub-watersheds smaller than 1000 ha may not be sufficiently representative in terms of size, runoff flow (and thus of necessary control measures), and/or land components. Conversely, 2000 ha were assessed as the maximum area that could viably be managed by the project, given the technical, financial and human resources available.

5. The PPA should be readily accessible, both for project implementation and for subsequent monitoring and control.

6. The PPA should permit the development of practical measures which would be cost effective. Thus the selection process should be cautious of areas with extreme problems requiring costly control structures or other expensive remedial measures, and take account of both the surface area and agricultural potential of the cultivable land within the PPA, which land is seen

as the primary intended economic beneficiary of the watershed management process.

7. Sociological considerations, notably the availability and willingness of a local population to cooperate in an integrated watershed management scheme.

This selection process was constrained by the lack of available documentation at an appropriate level of detail. Thus the first half of the assignment was used for extensive primary data collection in order to provide a data base which met the minimal requirements for PPA selection (see section 3.3).

Once a data base had been established, selection of the PPA was carried out in two stages. Firstly, the two study areas were compared, in terms of the criteria outlined above, and secondly, the study area with the most favorable characteristics for a pilot project area was further analyzed for PPA selection. Details are given below.

3.5.3 Comparison of the Hargeysa and Baki Study Areas for Pilot Watershed Control Project (PPA) Area Selection

The analyses carried out in the study areas (see sections 2.3 and 3.3) provide for the following assessments of their suitability for a pilot watershed management project. A comparative summary of the two areas is given in Table 1.18.

3.5.3.1 The Baki Study Area

This rectangular area of about 22,000 ha, is located some 30 km east of Boorama. The study area limits do not follow any natural boundaries and cut across the sub-watersheds, leaving many headwaters outside, or partially so, of the study area. The togga Dibira Weyn divides the Baki study area into two. Almost all the lowland - that is, the potential agricultural land -falls to the south of this togga; therefore no sub-watersheds north of the togga were considered, as their management could have no impact upon agricultural development. To the south of the togga, six small sub-watersheds may be identified as falling within or almost within the study area (1). These are identified in Drawing 106. Of these, none are considered representative of the conditions, and management problems, of the Baki study area. A representative sub-watershed would include mountain (M1) head-waters, lowland plain, and gully. Sub-watershed B-1 is outside the main part of the Baki plain and does not include any flow from the southern mountains. Sub-watersheds B-2, B-3, and B-5 have their headwaters in the mountains, but the lowland section of these sub-watersheds is taken up almost entirely by gullies; thus there is little agricultural land in these sub-watersheds to benefit from the management measures. Sub-watershed B-6 includes much agricultural land, but is contained entirely within the plain, with no flow from the mountains. Conversely, sub-watershed B-4 is contained entirely in the mountains. Other sub-watersheds are only partially contained within the study area. Selecting a representative area for pilot studies would require looking at a larger area than one sub-watershed - probably two sub-watersheds and the surrounding plain. At this point the project would have advanced beyond pilot development to a management plan for a substantial part of the Baki plain. It should also be noted that much of the flow arriving in the plain rises far to the south of the mapped study area, back in the mountains and even as far south as the plateau.

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1 The initial analysis, carried out by air-photo analyses only, suggested fewer contained sub-watersheds. A reevaluation was undertaken when the topographic maps were received.

The Baki area also violates the principle of being representative, being located in a very different geographic setting from that of the dryland project area as a whole (see section 2.3). Most of the dryland agricultural land in the project area is located on the plateau, between Hargeysa and Boorama, with between 400 and 500 m of rainfall. The Baki area is at some 400 to 500 meters lower elevation with significantly less rainfall (about 300 to 350 mm - a very significant difference in a semi-arid climate) and higher temperatures which result in higher evapotranspiration. In addition, the topographic situation is also very different from the rest of the project area. In effect, the plateau (where most of the dryland farming area is situated), as the name implies, is a broad plain area characterized by gentle slopes with occasional upstanding cuestas and buttes; conversely, the agricultural lands in Baki form a narrow corridor trapped between high mountains, with very steep slopes, and irregular but large runoff flows.

Another criterion for selection is accessibility. The Baki study area is about 1 1/2 hours, over very rough road, from the nearest project facility, at Boorama. The road from Boorama is of recent construction; however, gully erosion is already in evidence on the hills, and extensive and continuous maintenance is going to be required if the road is to be kept open. The only other access is from Gebiley, about three hours journey along a very poor track. Within the Baki study area itself, accessibility is very limited, and most of those tracks that are trafficable are so only with the use of four-wheel drive vehicles. Even then, much of the study area remains inaccessible. This includes the headwater areas, which are the primary areas for control structures and watershed management. The implementation of any watershed management plan would first require construction of necessary feeder roads to allow access of equipment, materials and construction teams, and for operation, maintenance and monitoring of the project. Costs for basic road construction may be estimated at between $25,000 and $30,000 per kilometer, excluding necessary rock excavation. To develop the whole Baki study area - and a pilot study is clearly intended as a "pilot" for such a development - would require an estimated 200 to 300 kms of road, depending on the total area of headwater which would need to be included; only about 15 kms of principle tracks and 40 km of other motorable tracks presently exist, of which all needs upgrading. At the rates given above, this would require $5 to 9 million of road construction; however, as much of the road area would be in steep, rocky terrain, this estimate needs to be at least doubled, to a minimum of $15 million. Meanwhile, investigations for planning watershed management programs would have to be carried out primarily on foot or by helicopter (many of the mountain areas could not even be travelled by horse). Such logistically difficult and time consuming field surveys are clearly beyond the scope of the present assignment.

Related to this aspect is the absence in the area (at time of visit) of facilities for lodging, food, fuel, equipment maintenance and repair, etc. These facilities would have to be provided by the contractor, at a considerable additional cost.

The above road construction only improves the accessibility within the area. To that must be added the development costs of the watershed management plan, such as control structures in the headwaters and in the main toggas at the break of slope between mountain and plain; togga canalization; canals and other means of spreading the floodwaters; water storage; bunding; irrigation structures; etc. With the steep slopes (see Drawing 107) and the high quantities and velocities of discharge, however irregular, major structures are clearly called for. Such structures would form a major part of the management plan. This, and the road program, are clearly not practical considerations for the project, and both design and construction would probably have to be undertaken by foreign contractors. However, such a plan cannot be worked out without detailed investigations in the area, as basic resource documentation for the area is almost completely lacking; thus the feasibility study and preliminary design of the PPA, called for in the present assignment, is simply not possible in the Baki area.

Necessary investigations would include the soil resource; land use; agronomic investigations; installation and monitoring of a network of climatic and hydrologic stations, for basic climatic and flow records necessary for engineering and agronomic design; geologic investigations for structural foundations and water holding, including field reconnaissance, drilling, sampling, and testing; materials investigations for both structures and roads; extension of the topographic analysis to include the headwater areas and possible sites for water storage; and sedimentation studies.

Against these potential costs must be balanced the potential benefits.

Firstly, the total gross potential agricultural area is assessed at about 6,700 ha or 31% of the study area comprising primarily the low lands, and a much lesser percentage of the total land of the watersheds including the headwaters to be managed. This percentage decreases further when eroded land and other unsuitable areas are subtracted.

The climate imposes severe limitations of this land for dryland agriculture. It is difficult to envisage more than subsistence production under dryland farming for a small population.

The medium textured soils from the lowlands are suitable for irrigation. Extensive supplementary irrigation water from the hills, if it were technically feasible, may raise production and reduce risk. However, this would involve costly structures and careful planning and management and its costs would probably outweigh any conceivable benefits from surplus production given the distance to potential markets, the poor quality of the transportation system and the apparent weakness of certain potential markets such as Djibouti.

Any large scale spate irrigation development, assuming the water resources were available, would involve high development costs in harnessing the flash flood flows (possibly including storage if adequate sites were found), water distribution and control systems, drainage systems, internal roads, as well as necessary structures for protecting the land against flash floods. However, baseline data necessary for planning/design purposes is not available.

Furthermore, the soils in the presently cultivated or fallow areas are generally severely degraded and would require measures to rebuild them and many of the uncultivated but cultivable soils are not only degraded but stony. This would result in high costs for land development.

Likewise, consideration must be given to the sociological characteristics of the area. Presently, there is very little population in the area. Most construction, development, and maintenance work would have to be undertaken with imported laborers. Any intensification of agriculture would also require an increase in population.

Finally, the area is primarily used for grazing, by a nomadic population. Management of the watersheds, especially controls on grazing and wood cutting, would undoubtedly promote conflict with these traditional users of the land.

A final decision on benefits from watershed development would require a detailed economic analysis, including markets and the various spin-off benefits from development. However, at present such a proposition does not appear to be cost effective, especially given the level of farming technology, and reported yields for the N W Region and distance to potential markets. (On the other hand, small garden development as planned for Phase II appears to be a suitable approach which should be pursued.)

Overall, therefore, this area is characterized by incomplete topographic coverage of most sub-watersheds, the non-representativeness of the study area relative to the dryland agricultural area as a whole, lack of accessibility, high cost of control measures in this steep terrain, climatic and soil resources that limit agriculture potential, a sparse population and an almost complete absence of basic resource data necessary to planning. It is difficult to see how the costs of watershed development in this region could ever be justified on economic terms. Indeed, in both technical and economic terms this area is inappropriate for watershed control and wholly unsuited for pilot project activities for dryland cultivation. Conversely, it is central to the new region of Awdal, and includes the new regional capital of Baki. A significant improvement in the infrastructure and an increase in population might therefore be anticipated, which might permit a more favorable review at some future date.

3.5.3.2 The Hargeysa Study Area

This is an irregular shaped area of about 38,000 ha located on the plateau immediately west of Hargeysa. It comprises the eastern two-thirds of the original contiguous

60,000 ha study area selected by TAMS, which extended towards Gebiley. The irregular shape of the study area boundaries on the north, south, and eastern sides reflects the careful patterning of the study area to match the watershed limits. The original 60,000 ha area was designed to include the drainages of both the Togga Maroodijex and Togga Arabsiyo. However, the decision to reduce this study area in order to include Baki in the study, and the subsequent redrawing of the western study area boundary, has effectively eliminated the Togga Arabsiyo from consideration; as may be seen from Drawing 102, only two contributing sub-watersheds of this drainage (H3-1 and H3-2) are entirely contained within the study area. However, the upper basin of the Togga Maroodijex, which is entirely within the study area, contains several sub-watersheds which may be compared for PPA selection.

The study area is part of the dryland agricultural project area of the NWADEP and falls within the principal agricultural region of the North West. It is believed to contain most of the principal land elements of the primary agricultural area of the plateau. However, climatically it occupies the least favorable part of that area (see Drawings 100 and 101), the 400 mm isohyet curving to the south of the study area, while the rest of the rainfed project area receives more than 400 mm, rising to over 500 mm west of Boorama. These are significant differences in a semi-arid region where dryland farming is marginal.

All parts of the study area are within about one hour's drive of the Hargeysa project facilities, and one of the project units is located within the study area, at Xaraf, while others are close to the area. The northern edge of the study area is bordered by the paved road from Hargeysa to Gebiley, and the southern boundary by a good track from Gadhyogol to Xidhinta. Within the study area, access is moderate, being crossed by an

The second criteria, that of size, quickly further reduced the selection. Table 1.19 gives the areas of the sub-watersheds considered, according to the first criteria, above. The sub-watershed H4-2 initially looked ideal, as it contains almost all the land elements mapped in the study area, and extends into the prime agricultural area. However, its size (5,200 ha) far exceeds the limits established in the criteria for selection. Only H2-3 and H4-1 fall within the approximate size limits established.

All of the remaining sub-watersheds have moderately good accessibility, all being accessible within about 20 minutes from the paved road, and within about 45 minutes from Hargeysa. However, sub-watershed H1 was considered to be too close to Hargeysa and is also larger than desired. The proximity to this city of perhaps half-million people has already resulted in the very severe degradation of this sub-watershed, and at present it does not appear a viable proposition to try to stop exploitation by the city dwellers. Similarly, the sub-watersheds H2-1 and H2-2 are cut by the paved road from Hargeysa to Arabsiyo; the accessibility that this provides, for exploitation, by people from outside the sub-watershed, again poses a very severe problem of control.

Application of the selection criteria thus reduced the possibilities to four sub-watersheds, H2-3, H3-1, H3-2 and H4-1 (see Table 1.19). The two sub-watersheds south of Arabsiyo, H3-1 and H3-2, do not individually meet the minimum size criterium; however, the two sub-watersheds are adjacent and the possibility of combining them into one PPA was considered. The three possible PPAs were thus compared in terms of their representativeness. The two sub-watersheds (H3-1, H3-2) south of Arabsiyo are severely eroded. Representation of both the lowland and upland landscape units is limited by this dissection (see section 3.4).

Table 1.19 Drainage Area and Selection Criteria of Sub-watersheds Considered in the Hargeysa Study Area

Sub-Watershed Designation	Drainage Area in Hargeysa (1)	Selection Criteria
H1	3,540	Too large; too close to Hargeysa
H2-1	564	Too small; cut by paved road
H2-2	3,290	Too large; cut by paved road
H2-3	1,480*	Meets size criteria; representative; accessible
H2-4	830	Too small; unrepresentative
H3-1	650	Too small; unrepresentative
H3-2	490	Too small; unrepresentative
H4-1	1,460	Meets size criteria; representative; poor accessibility
H4-2	5,210	Too large
H4-4	310	Too small
H4-5	240	Too small
H4-6	400	Too small
H4-7	390	Too small
H4-8	230	Too small
H4-9	270	Too small
H4-10	390	Too small

Selected sub-watershed for PPA

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1 Measured from maps at 1:25,000 scale reduced from 1:10,000 scale. Values rounded up to the nearest 10 hectares.

These sub-watersheds are also located on a major livestock route south of Arabsiyo. However, these sub-watersheds ideally demonstrate the problem of gully erosion n this area, a problem which has been identified in this study as of primary concern. These two sub-watersheds would make ideal pilot project areas for experimenting, and for demonstrating techniques of gully control. However, as previously described, gully control must ultimately start in the headwaters; the headwater areas here are limited and thus not representative of typical plateau sub-watersheds. The sub-watersheds H2-3 and H4-1 are less representative of this erosion problem, although severe gully erosion is also found here; however, these sub-watersheds are far more representative of the other land components of the study area. All the upland components (D, S, H, P) may be found within these sub-watersheds, as well as the main lowland component (I), and the gully component. As a microcosm of the study area characteristics, these sub-watersheds are almost perfect. Sub-watershed H2-3 is easily accessible, being about 1/2 hour from Hargeysa, but well set back from the principal access of the paved road. Access to sub-watershed H4-1 is significantly inferior. On this basis, sub-watershed 2-3 was preferred over H4-1 for the pilot project. Field visits to both PPAs confirmed this assessment.

The final criteria, the sociological characteristics, is very difficult to assess without undertaking a major sociological study. Given that the farmers within the study area all have similar backgrounds, no great sociological variation is expected between the sub-watersheds. The selection of the PPA was, in any case, constrained by other criteria as outlined above, and little weight was given to sociological characteristics. Once the preliminary selection had been completed, the selected sub-watersheds were visited and discussions were held with available farmers. These discussions indicated an awareness of, and concern for, the problem of gully erosion, and an expressed willingness to cooperate in an overall management project. A detailed social survey was subsequently undertaken within the selected PPA.

Thus the sub-watershed H2-3 covering about 1480 ha was selected as the Pilot Project Area for integrated watershed management. This sub-watershed is of manageable size, representative of a larger area, and easily accessible to existing project facilities at Hargeysa and the Aburriin Experimental Farm.

Subsequent to this selection, the management of the NWADEP requested that pilot studies also be undertaken on a second sub-watershed, totalling about 490 ha, for a total of nearly 2000 ha of pilot area. The management of NWADEP selected the sub-watershed H3-2 as suitable. This request was acceded to by the contractor. However, this decision appears to contradict the concept of "pilot" and, if both pilot projects are undertaken, this will severely strain the resources of the NWADEP.

3.6 Pilot Watershed Control Projects

3.6.1 Introduction

The focus of the present study, within the dryland farming area, was a feasibility analysis and preliminary design of pilot watershed control projects in selected sub-watersheds. Selection of pilot sub-watersheds, and collection of necessary data preliminary to that selection, have been described above (sections 3.3 and 3.5). This section seeks to describe, in general terms, proposed management strategies; present a preliminary implementation plan; provide an assessment of the cost-benefit relationship; and finally to analyze the feasibility of implementing such a project in north west Somalia. The analyses presented here are relevant to both pilot project areas, and are summarized in their individual discussions (Volumes II and III).

As outlined in the Inception Report (TAMS, October 1985), and as previously described, the work plan foresaw selection and description of, and design for, one sub-watershed. The sudden and late decision by the NWADEP management to select a second pilot sub-watershed impacted negatively upon the analysis possible in each. In particular, it was necessary to reduce the intensity and scale of analysis from that originally intended, which proved very limiting in the design stage.

Within each sub-watershed, analysis and preliminary design was preceded by extensive original data collection, additional to that carried out for the general land evaluation of the study areas. This was necessitated by the complete absence of data at an appropriate level of detail. Such additional data included supplementary topographic work, detailed land use and land resources mapping, and a socio-economic survey. These are described in Volume II (Booli Diido PPA) and Volume III (Geed Abeerah).

3.6.2 Pilot Project Data Base

Existing data for the pilot project areas consisted of the Geosurvey topographic maps at 1:10,000, with 2 m intervals, and the resource map (Drawing 104) for the Hargeysa study area. The following additional data was compiled for each PPA and is presented in Volume II (Booli Diido) and Volume III (Geed Abeerah).

Topographic maps, at 1:10,000, with 1 m interval. Apart from contours and spot heights, these maps show settlements, tracks, water points, drainage, and triangulation points.

Slope maps, at 1:10,000, giving generalized slopes for the PPAs.

Land resource maps, at 1:10,000. The primary information is land use, but the maps also present data on physiography and soils, and erosion. Although the legend is simpler than for the Hargeysa study area resource map (Drawing 104), the detail of information is equal or greater than the general Hargeysa map. Being smaller areas, with less variability, it was found possible to include soil characteristics as part of the physiography. Likewise, it was possible to show both sheet and gully erosion within a single symbol. No physiographic or erosion data is given for the cultivated land uses as these all occur on the same physiographic unit (Inclined - I). Erosion is difficult to assess on cultivated fields, especially where the surface has been disturbed by bunding; in general, the cultivated fields are believed to have suffered slight to moderate sheet erosion, and slight gully erosion.

Social data: As indicated, a social survey was carried out in each PPA. A summary of derived information is presented in Appendix 1.7.

Other data: Various other data was assembled for each PPA, including maps of farm locations, gully cross sections and lists of farmers within the PPA. These were working documents and are not presented in this report.

3.6.3 Management Plans

3.6.3.1 Introduction

The proposed management plans for the Booli Diido and Geed Abeerah PPAs are presented, respectively, in Volumes II and III. The plans present detailed proposals on type and general location of interventions. However, as previously explained, exact siting and sizing is not possible with the existing data base. The initial phase of project implementation should include more detailed data collection, in particular topograhic data, and a detailed assessment of existing soil and water conservation works. Therefore, for the most part, typical situations are described. As these are generally applicable to both PPAs, they are described separately, in this volume, and reproduced in the appendices of Volumes II and III.

In developing the management proposals, a number of factors were taken into consideration. The contract calls for the watershed management plans to be "practical and viable," particularly in relation to the socio-economic aspects. One main aspect of that viability is believed to be simplicity in concept and implementation; there is sound evidence that even the present soil and water conservation project has reached or exceeded local abilities of implementation and utilization. However, as previously observed, present measures are offering only a partial solution to yield improvement and erosion control, and more comprehensive management proposals are needed. Indeed, it is recognition of this fact that prompted the present mission. Integrated watershed management, however, is a sophisticated concept and far more complex than the existing program. There would appear, therefore, to be some conflict between producing technically sound proposals, and making them "practical and viable" within the situation of north west Somalia.

The same contract terms were also taken to mean that the management plan had to be designed within the existing physical and socio-economic situation. Thus, particular attention was paid to the existing land use situation, in the belief that it should be considered, as far as possible, inviolable. This, however, imposes many constraints on possible interventions. In particular, the extensive bunding existing within the PPAs cannot easily be removed or changed, but its presence severely limits the possibilities for alternate land management strategies. Similarly, where fields extend onto unstable situations, as around the gullies, policies aimed at land protection may come into conflict with existing land use. Finally, the major land use in the PPAs is extensive grazing of livestock. Any proposal to manage the watersheds will come into conflict with this predominant activity. Part of the response must be the intensification of livestock management and grazing management. Yet within the PPAs there are few places where a livestock program can be proposed which does not come into conflict with existing cultivated land uses.

As previously observed, the existing data base is very limited, and management proposals were constrained by the absence, among other things, of available and reliable data on local climate, and on crop, forest, grazing, and land management possibilities. More detailed topographic and socio-economic data is also required, along with a more detailed assessment of existing conservation works. In consequence, the proposals developed are not as specific as would be liked. Many details are necessarily left to be determined by trials during project implementation. Often these trials can be made within the PPAs, as part of the pilot program; however, much other data, especially agronomic and grassland data, will have to come from an improved research program based at Aburriin.

Finally, the proposals are designed to use, as far as possible, locally available materials and local labor. It is felt that the implementation should be carried out, as far as possible by the local population themselves, supported by technical assistance from the NWADEP. In the structures, as much use as possible is made of rock, which is in plentiful supply locally, either directly or in the form of gabions which can be constructed locally.

3.6.3.2 Overview of Management Strategies

The objective of the watershed management proposals may be summarized as follows:

- improved agricultural production, for both increased food self-sufficiency, improved security of production, and increased yields
- intensification of livestock production
- containment, and ultimately cessation, of erosion.

Generally, these are highly compatible activities. Control of erosion, for example, generally promotes rain infiltration and thus improved growth of crops and grazing species. However, conflicts may arise as, for example, around the gullies, where gully protection may impinge upon existing cultivation or traditional grazing. Given the existing erosion situation, and the threat it poses to the long-term viability of both cultivation and livestock production, it is considered that erosion control should take priority in situations of conflicting land use.

As described in earlier sections of this report, and as stressed in all the literature on the subject, watershed management starts in the headwaters, although the most visible effects of watershed mismanagement will likely be the gullies. References to gully control frequently talk of measures within the gully; while such measures may reduce flow velocities and cause siltation within the gully, gully head advance can only be arrested by controlling the volume and velocity of water reaching the gully. In an ideal watershed management project, only rehabilitative measures would be required in the gully. Control of overland flow will also reduce or eliminate sheet erosion, and promote infiltration for improved vegetative growth.

With these principles in mind, the general framework of proposed management is as follows:

<u>Forestry and Grazing</u>: No separation of these activities is presently made and none seems possible within the foreseeable future. For the present, therefore, they must be seen as integrated activities.

Reforestation/revegetation is proposed for all "upland" units, and on "lowland" units at the base of the uplands where the soils are most susceptible to erosion. The vegetation will provide a control on the volume and velocity of runoff; maintenance of a ground cover is a particularly important characteristic of this. While total runoff may be reduced, the downslope lowland areas will actually benefit from the release of water over a longer period of time, at lower velocities, resulting in reduced destruction (erosion, surface sealing) and increased infiltration. Water effectiveness, and plant available moisture, will therefore be increased despite reduced water volumes. Meanwhile, retention of water in the uplands, through revegetation and other conservation measures, will promote vegetation growth for improved grazing and/or fodder.

Grazing of these lands should be prohibited during the revegetation process. Once a vegetation cover is established, grazing may be permitted, but should be managed in a manner which prohibits complete pasture destruction and allows sufficient time for vegetation regeneration. Grazing can be enhanced, both in terms of carrying capacity and quality, through the introduction of improved pasture species.

Reforestation/revegetation in many of these sites will be very difficult due to their highly eroded status. It may well be necessary to dig holes in the rock and fill them with earth. Small rock bunds (20-30 cms high) built on the contour and servicing one or two holes only, will help retain moisture and soil for plant growth. The layout might be similar to the bunding layout given in Fig. 1.12, but extended over the whole hill area and with each bund on a much smaller scale. The bunds may be built by hand. Limiting their length to 1 or 2 plant holes reflects their unconsolidated nature and likelihood of collapse under heavy water pressure. Other ideas may be obtained from existing literature pertinent to the region (Watson; FAO; SOGREAH). Experience may also be drawn from ongoing forestry projects in the region (OEF; Care). However, these are specialized subject areas, and expertise to evaluate and implement programs, does not exist within the NWADEP. It is recommended that technical assistance be obtained in both forestry and range improvement and management, and that a series of trial plots be established in the different land types within the PPAs. In the first instance, advantage may be taken of expertise existing in the area (OEF. See section 3.6.6 - Implementation); the latter area might be combined with assistance on livestock management.

The question of grazing cannot be limited to the PPAs as the PPA farmers make extensive use of grazing lands outside the PPA. It is as important to address the question of improving these extensive range lands, as of the intensive grazing lands within the PPA. SOGREAH (Report No. 14 - Soil and Water Conservation, Vol. 2) provides some ideas in this regard. This question, however, is clearly outside the scope of the present mission, but should be included in the scope of work of the recommended technical assistants.

<u>Livestock Management</u>: There is a clear requirement to redress the balance between livestock numbers and grazing supply. This can partly be achieved by improving grazing production and better management of grazing lands. However, it appears inevitable that animal numbers must be reduced - a proposal which is likely to meet strong resistance. The farmer must be persuaded of the superiority of animal quality over quantity, and encouraged to adopt new forms of husbandry. Again, this is a specialist area, expertise in which does not exist within the NWADEP; technical assistance should be obtained in this area to develop management strategies, train extension workers, and monitor (periodically) progress.

Broader policies, relevant to livestock, must also be addressed. In the short term, within the PPAs, a change in livestock strategies may be accomplished through various incentives. In the longer term, however, extension of these changes will only be achieved if the farmer can see the economic benefit to himself. The whole question of processing and marketing of animals and animal products, needs to be investigated.

Management of the Agricultural and Associated Lands (Lowlands): Management of the lowlands is substantially constrained by the existing situation, especially the extensive existing bunding. Management proposals fall under four major headings - a) bunding; b) crop and land management; c) livestock management; and d) research and extension.

a) Bunding: The design, construction, and layout of bunds is extensively reviewed in the SOGREAH reports, especially Report No. 14, Agricultural Development Programme. The engineering principles are considered valid and will not be reviewed here. Alternate designs and layouts may be found in the extensive literature on soil and water conservation.

The designs and layouts presented by SOGREAH appear to be based primarily on engineering considerations. Thus the bunds are seen primarily as a soil conservation measure, and designed for a 10-year daily maximum rainfall. However, from the viewpoint of moisture conservation for improved crop production, the objective is to increase the effective rainfall by routinely capturing and storing runoff. Peak flows can be accommodated by drainage. Thus it is believed that the bunded area needs to be integrated with the catchment area, with drainage diversion to, and between, bunds, with any excess water from peak flows safely drained away. Bund design and layout must be related to catchment size, or catchment size adjusted to desired bunded area. Thus, under normal flow conditions, all runoff water will be retained by the bunds.

Catchment size is a function of the bunded area, the runoff coefficient of the catchment area, and the desired increase in moisture. In turn, the desired increase in moisture is a function of rainfall, crop demand, and desired probability of success. A common success rate demanded for economic viability is 7 years out of 10. For Hargeysa, the 75% probability of rainfall level is 348 mm. SOGREAH estimates sorghum annual moisture demands at Hargeysa at 640 to 690 mm, for maximum grain yields. Thus a doubling of effective precipitation would seem appropriate. This requires collecting and diverting water from a catchment area. Runoff will vary with the type and density of vegetation cover. If a runoff coefficient from the catchment area of 50% (1) is assumed, then the doubling of effective precipitation on each hectare of bunded land will require direction of runoff from 2 ha of catchment. Thus a bunded field of 10 ha will require a catchment area of 20 ha; conversely, a catchment area of 30 ha can support the development of 10 ha of bunded land within that catchment.

It can clearly be seen from the above analysis that agricultural development is limited in area by the prevailing climate. Thus a lower density of cultivation/larger catchment areas must be expected in the Hargeysa area than in the Boorama area. Also, careful attention must be paid to the land use of the catchment area, as differences in runoff coefficient will greatly influence the possible cultivation density. In general, it is preferred to keep the catchments uncultivated, with grazing carefully controlled to maintain a ground cover at all times. SOGREAH (Reports Nos. 8 and 14) shows average runoff from rangeland to be 1.5 to 1.7 times greater than from cultivated fields. The present management proposals may reduce this differential but it will likely remain higher on uncultivated land. Maintenance of a vegetative cover should also mean that water release will occur over a longer period of time, offering less threat to the bund

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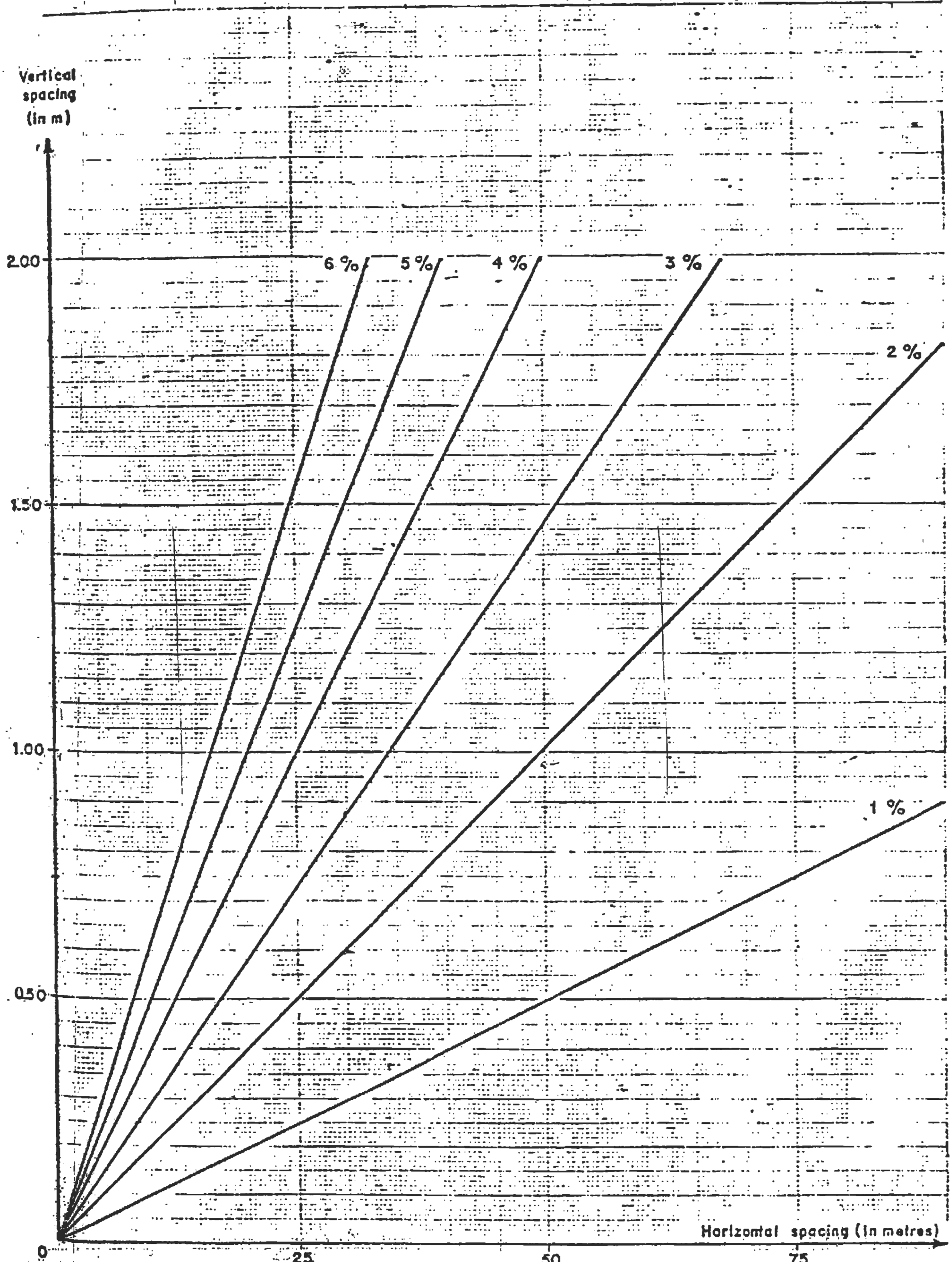
1 After implementation of management recommendations. Presently SOGREAH estimates runoff coefficients as high as 90% on the rocky uplands.

structures and facilitating infiltration. The higher the runoff coefficient, in this region of short, intense storms, the larger the bund required to retain the desired moisture and the longer the drainage required to handle peak flows. Bund and catchment designs must also take account of daily rainfall variations; a 75% probability for annual rainfall has been given, but this may be reduced if account is taken of the percentage of that rainfall which is likely to fall in storms of greater than a defined intensity. Daily rainfall records are incomplete, but review of those presented by SOGREAH (Report No. 2, Climatology) for the years 1944-1980 shows only 15 instances of daily rainfall exceeding 50 mm.

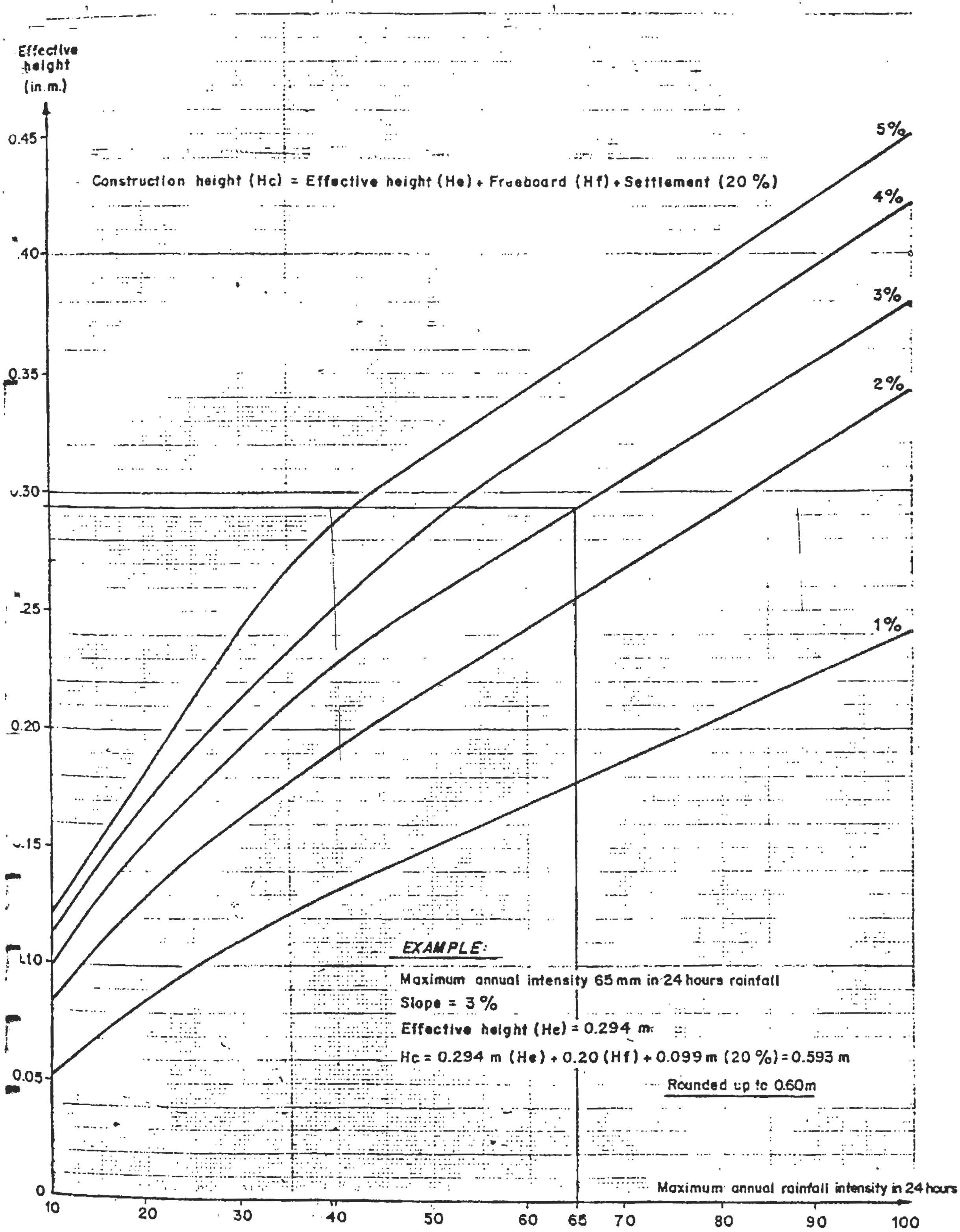
SOGREAH presents graphs showing bund height and spacing for different slopes and rainfall intensities. The first graph shows that with a vertical spacing of 1 m (effectively, a one-meter high bund), the horizontal spacing is 35 m for a 3% slope and 50 m on a 2% slope (see Fig. 1-9). This is considerately greater than the present NWADEP layout on these slopes. Similarly, the effective bund heights for a 65 mm daily storm, on 2% and 3% slopes are, respectively, about 25 and 30 cm (see Fig. 1-10). Allowance for freeboard and settling effectively doubles these heights, but even so they remain well below those presently constructed. If bunds are intended primarily for water conservation,and soil conservation is accommodated by adequate drainage, then the requirement for freeboard is diminished, and an even lower bund height can be accepted. The lower the bund heights, the greater the potential for bund construction by the farmer. With the 50 mm intensity mentioned above, the graphs indicate an effective bund height of only 22 cm on 2% slopes, and 25 cm on 3% slopes.

FIG. 1.9 VERTICAL AND HORIZONTAL SPACING OF BUNDS



Source: SOGREAH Report No. 14, Agricultural Development Program A. Rainfed Agriculture, Vol. 2.

DIAGRAM FOR CALCULATION OF EFFECTIVE HEIGHT OF RETENTION BUNDS



Source: SOGREAH Report No. 14, Agricultural Development Program A. Rainfed Agriculture, Vol. 2

Two bunding designs are presented. The first (Fig. 1-11) is a suggestion for improvement of existing bunds. A worse case scenario is taken, with a series of equal length bunds with minimal upturn of the ends (wings). It is assumed that the present bund follows the contours and is level and in good repair; if not, corrective measures should be taken. It is suggested that the lower bunds in the series be progressively extended, and wings be added to all bunds. On one side the wing will extend almost to the vertical level of the next higher bund; on the other side the wing will end at least 30 cm vertical height below the next higher bund. In this way water overflow will be directed around one end of the bund only; that end should be properly protected and the overflow area maintained with a vegetative cover. (A protected spill-way would be preferred but is not suggested in the interest of maintaining simplicity of design and construction.) Drainage waters from the catchment are directed into the bund system, half to the first bund and half to the second. Depending on the slope angle, a diversion ditch or a retaining bund might be used. On low slopes there may not be sufficient vertical interval for the water outlet, in which case a bund may be used. In both cases, rock protection of the structure is required.

Lower in the sequence, shallow grass waterways or retain-ing bunds collect and direct local runoff. A more complex design might see the main diversion with a spreader, similar to the design given by SOGREAH (Report R14), directing water into the upper two bunds. The second diversion, on the oppo-site side, could similarly direct water into the lower bunds. However, this introduces another complexity into the system and so is avoided here. Excess water from the bunds is safely disposed of by a drainage ditch. This could lead into another set of bunds, into a main drainage ditch, into a gully, etc.

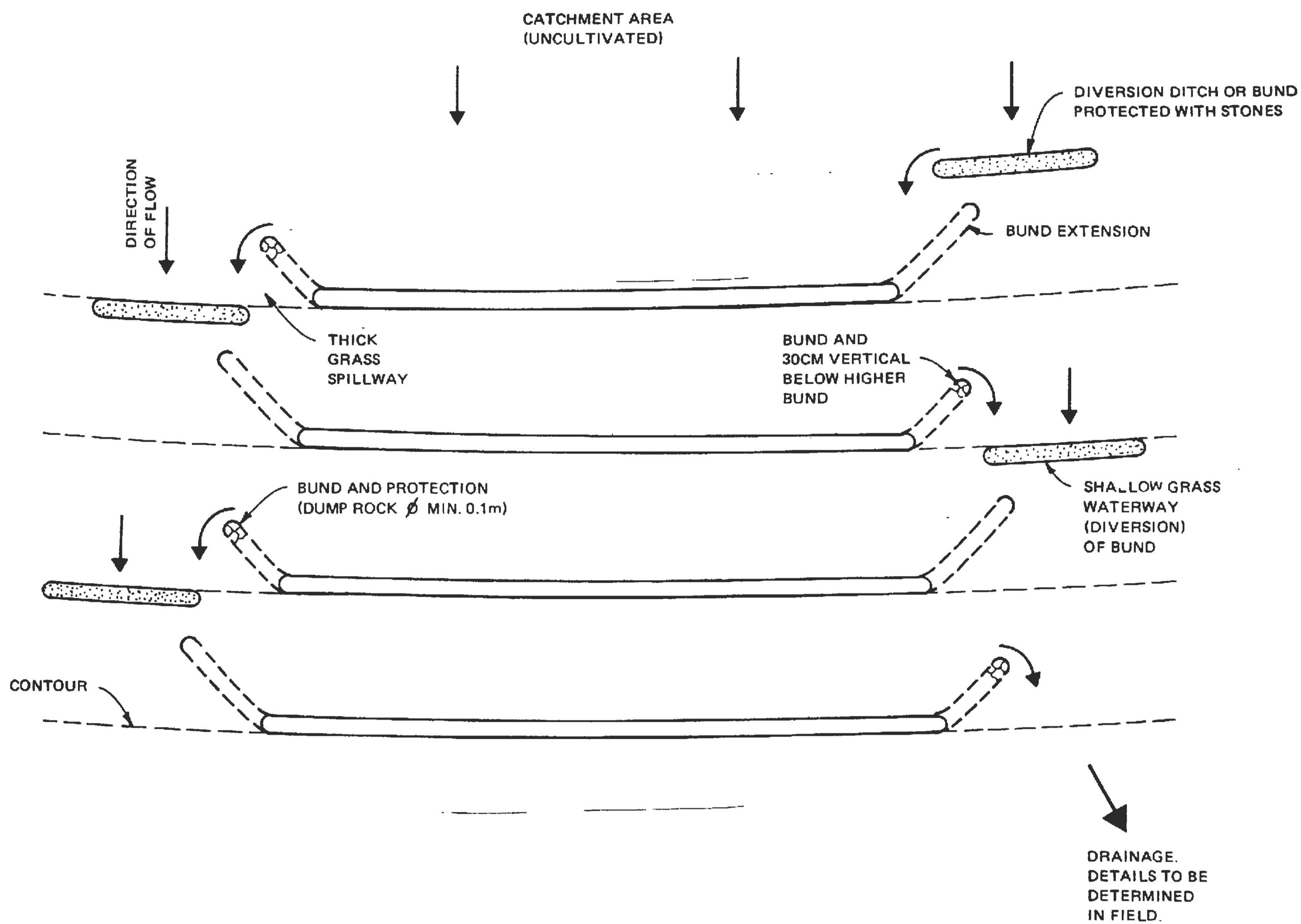


FIGURE 1.11
SUGGESTED IMPROVEMENTS TO EXISTING BUNDS

This will be determined in the field in accordance with the bunding location.

The second bunding design (Fig. 1-12) is intended for implementation in new bunding developments. It is a variation on the scheme presented by SOGREAH (Report R14). However, the spreaders with the spreading bund are left out. Flow is directed around one protected end of each bund. Also, drainage is provided for any surplus flow. SOGREAH shows a multibund system but a smaller system would seem to be preferable. To collect sufficient moisture to supply all the bunds in SOGREAH's plan would require a large catchment and put unnecessary pressure on upper bunds. Should a bund collapse, serious damage could ensue. Further, the smaller layout is better adapted to the farm-by-farm bunding being practiced. However, the bunding sets should be offset on the slope, as was illustrated in Fig. 1-7b. The catchment area requirement is estimated at about twice the bunded area.

b) Crop and land management: Great potential for soil and moisture conservation,and improved yields, would seem to be offered by simply improving agricultural practices, on both unbunded and bunded land. Some possible recommendations must await the results of research trials (see below); others may be too complex, too costly, or reliant upon unavailable supply (e.g, agricultural chemicals) to form realistic proposals at the present time. However, there remain many basic improvements in agricultural practice that could be immediately extended to the population. These include seed treatment, ploughing and seeding on the contour, animal traction, fertilizing with manure, crop maintenance, and improved grain storage. Seed treatment is dependent upon chemical availability, but a small amount of chemical can treat a large amount of seed. Organization of this activity would seem to be an appropriate and

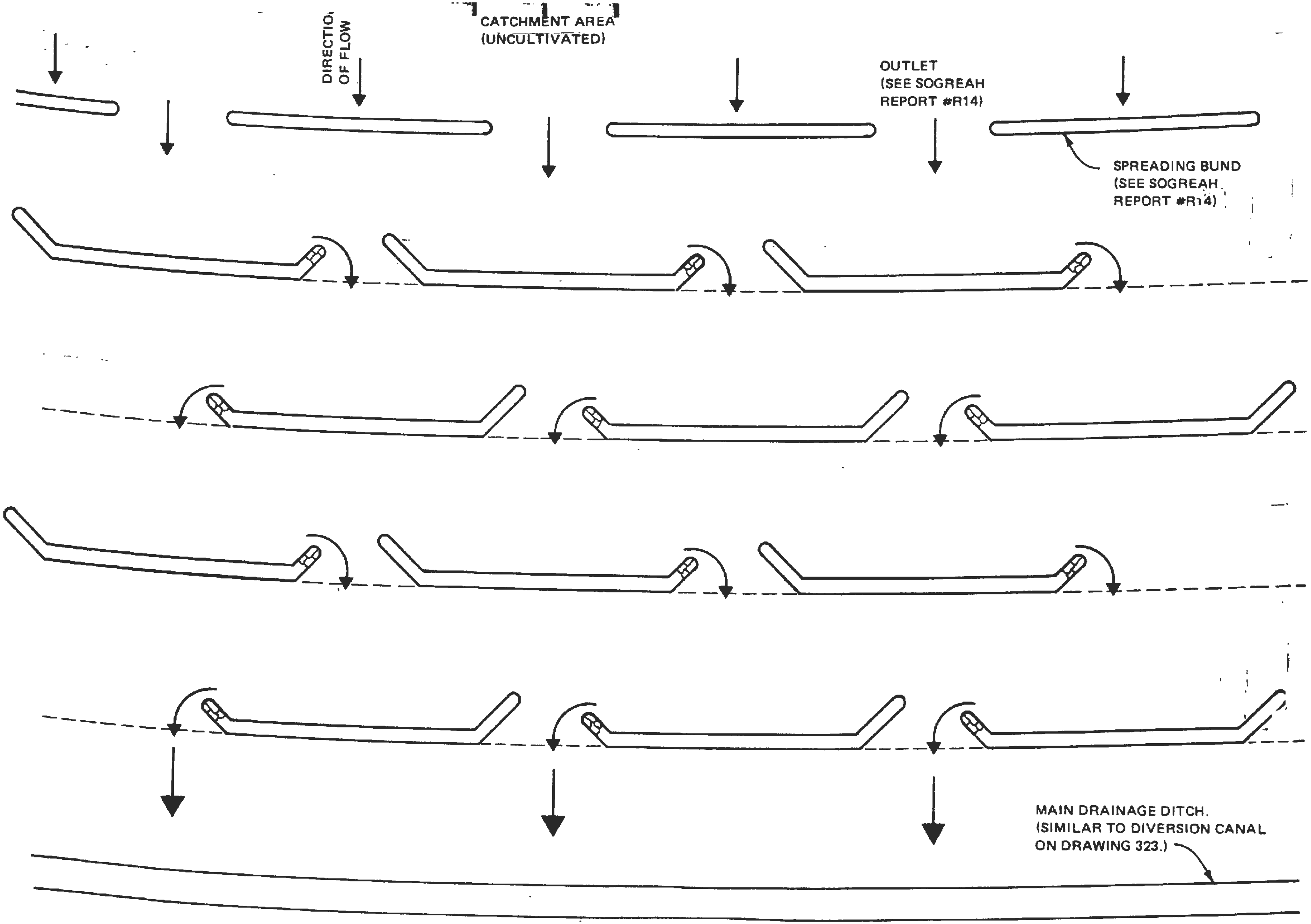


FIGURE 1.12
SUGGESTED BUNDING LAYOUT FOR NEW BUNDING

productive activity for the NWADEP. With a little organization this could be combined with seed production by selected, better farmers, with inspection and grading by trained project personnel. Ploughing and seeding on the contour, and row seeding, are also basic techniques. Simple hand seeders are used in many places in the world and should be introduced into the PPA on a hire or purchase basis. Once a model is obtained from abroad, it could be copied by local craftsmen. Likewise, shovels and wheelbarrows could be made locally and offered for sale or hire. These would facilitate the collection of manure from animal pens, and its transport to, and distribution in the fields. Animal traction does not have to be introduced; it is an old technique that has been neglected in favor of less labor intensive tractor power. The local farmers should be encouraged to return to animal traction which would be available for timely cultivation, and is not dependent upon imported fuels. It is suggested that the use of tractors might be phased out of the PPAs over, say, a 3-year period, unless the availability of both tractors and fuel dramatically improves. The crop losses associated with weeds are well known and reported, and farmers must be persuaded to maintain (weed) their crops. Changes here may well be tied to changes in livestock management. Other crops, such as ground nuts, which were successfully tried by the British, should be encouraged. Finally, resistance to periodic drought, and therefore attachment to animals (which are an insurance against drought), can be reduced by improving grain storage facilities. An internationally recruited expert in this field should be able to quickly provide recommendations.

In unbunded areas of low slope, strip cropping along the contour should be encouraged. One possible scheme is presented by SOGREAH (Report No. 14 - Agricultural Development Programme, Vol 2), involving 15 m strips alternatively seeded to sorghum, maize, and fallow. A contour hedge of fodder trees or shrubs is planted between every fifth strip (See Fig. 1.13) to act both as a guide for field operations and as an erosion control measure. More detail of the system may be obtained from the SOGREAH report. The basic idea is sound, but other crops should be introduced into the rotation, especially legumes which fix nitrogen and improve soil fertility. The fallow strip could be replaced by a fodder crop, which could then be cut and fed to the animals and would offer some protection against erosion in the dry and early wet seasons. Wider strips might also be considered (see Green - Report on Visit). Implementation of this proposal requires cooperation and integration amongst neighbors; resistance by the local population may be expected.

c) Livestock: Those areas which are not being used for cultivation, or used only to a limited extent, could be developed for an intensive grazing program. Experience in other regions of the world suggests that appropriate range management and improvement would permit at least a fourfold increase in carrying capacity. Again this is a specialist subject area and a range and pasture specialist should be engaged to develop, implement, and monitor suitable programs. One possible program is the High Intensity, Low Frequency Grazing System, also known as the Savory Grazing System, and Intensive Rotation Grazing. The basic principles are division of the land into a series of paddocks. Each paddock is grazed intensively over a short period, and then the cattle are moved on to the next paddock (see Fig. 1-14). The rotation period through the paddocks should be as short as possible, for minimum damage in the paddock, but long enough to allow revegetation of the paddocks before they are regrazed. The rest period is more critical than the grazing period. Thus the rotation period may vary with the season. The advantages claimed with this

Figure 1.13 CONTOUR STRIP CROPPING SKETCH

Slope <2 %

(From SOGREAH Report No. 14 - Agricultural Development Program A. Rainfed Agriculture, Vol. 2, Soil and Water Conservation Works, 1982.)

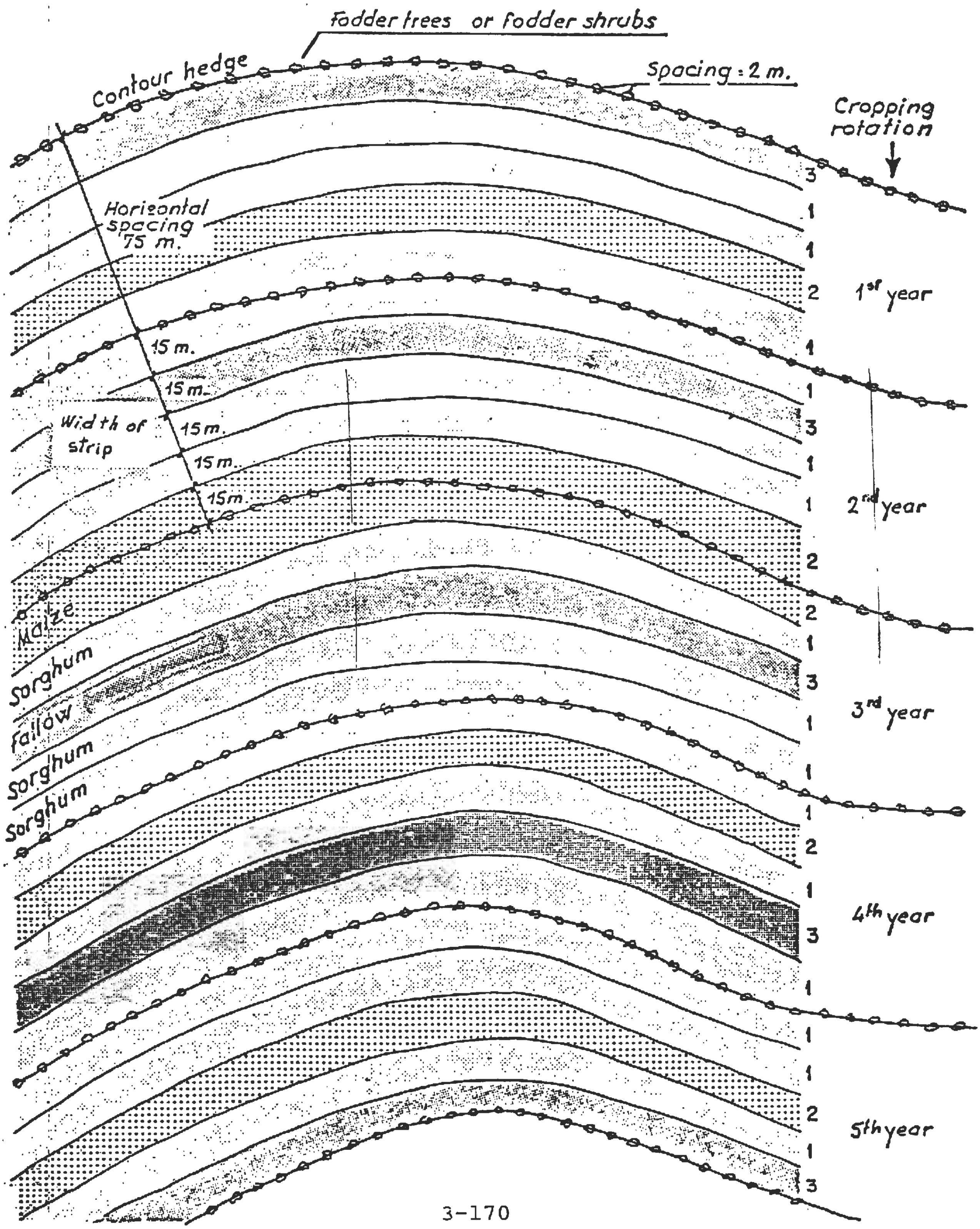
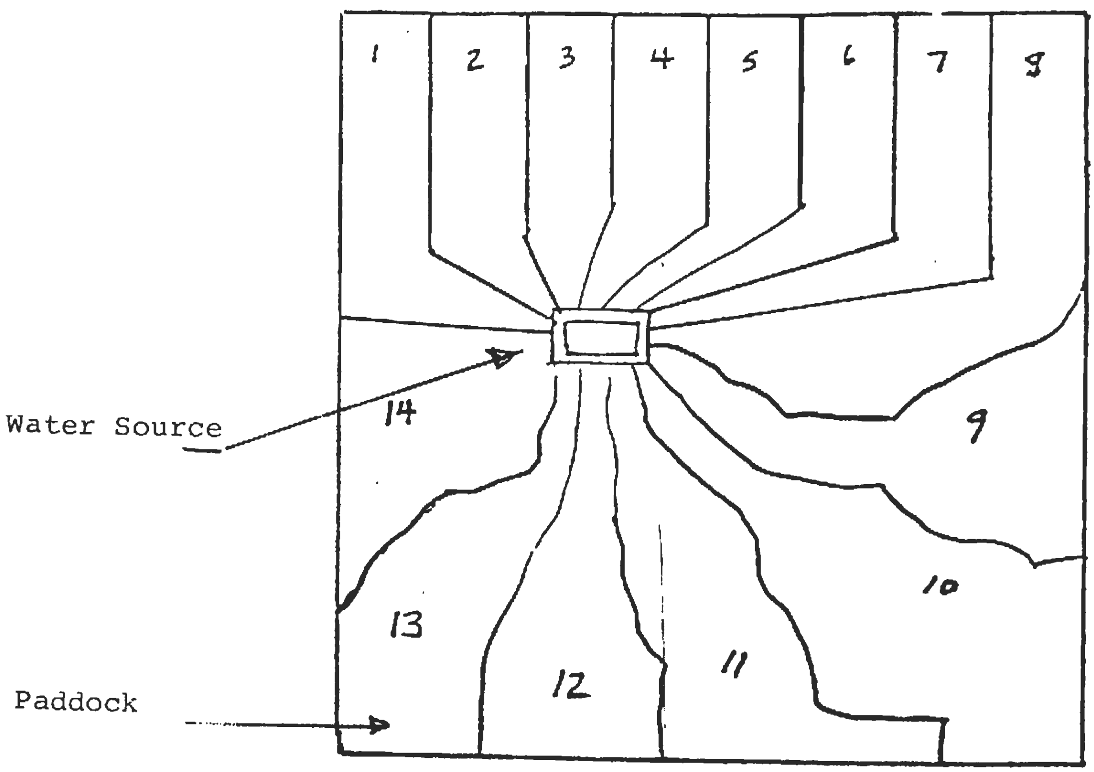


Figure 1.14 A Typical Savory Grazing Cell



Source: Holtman J - The Savory Grazing Methods Works!

Proceedings, "What's In Stock for You?", February 1985, Saskatoon, Sask., Canada system are that it reduces selective grazing of the more palatable species, and the intensive trampling in the paddock being used breaks the soil crust and kills woody and weak plants (i.e., the best species survive), and incorporates the manure. This method is said to permit increases in stocking rate while at the same time decreasing overgrazing and erosion.

The method, briefly described, imitiates the natural approach to grazing. Wild animals tend to move in large herds, graze an area intensively, and then move on. The grasslands of the world survived for millenia before the interference of man. Another advantage of the system, for an area like N W Somalia, is the ease and cheapness of implementation. All fencing may be with electric fencing (see below). While the outside perimeter must be fenced at all times, to control "intruders" (e.g., nomadic herds), the internal divisions, using electric fencing, can be rotated with the animals, thereby reducing costs for imported materials (fencing). A major problem of the system is the provision of water to a higher density of animals. However, other proposals made for the PPAs address this problem to some degree. However, perhaps the biggest problem is that a successful grazing system will likely be the cause of its own demise. If the stocking rate is improved, the likelihood is that the local population will increase the number of head. Again, an intensive extension program is required to combat this effect.

Any program would likely require a minimum number of animals, requiring that the program be implemented as a watershed cooperative. Improved animal husbandry needs to be investigated, including animal selection, and analysis made of possibilities for the production and marketing of dairy products. This would provide a supplementary economic activity, which develops an existing small scale activity.

d) Research and extension: A major activity in the watershed management program must take place outside the watershed. Planning the watershed management program is constrained by inadequate knowledge of the agronomic, grassland, and forestry alternatives. Recommendations for research into these areas, through the Aburriin experimental program, have already been presented (section 3.4.1.3), and further recommendations are contained in the SOGREAH reports. Introduction of new crops and varieties and of grazing species should have priority in the research program, along with a program for seed production and distribution. An upgrading of the experimental farm is included within Phase II proposals, with technical assistance provided as part of the Extension Officer's responsibilities. It is believed that the research program demands full time technical assistance, including an agronomist/plot trial officer; rangeland/livestock specialist; and agricultural engineer/mechanic to develop and maintain equipment (wind power, field tools, etc.). Other short term assistance, such as a plant pathologist, seed propagation expert, etc., should also be considered.

Research and development cannot be divorced from extension, without which the research has little value. An upgrading of the extension services, including (part-time) expatriate technical assistance, is proposed under Phase II. However, based on responses received during the social survey, more than increased manpower is needed. The extension officer should have extension as a full-time responsibility, with research assisted by other manpower (see above). A program of agricultural education and extension training for local extension agents needs to be developed, and a system developed for motivating the agents. The PPAs should have first priority for extension as they will serve as models for the other dryland areas; they may also serve as training grounds for the extension agents, where the agents can be carefully monitored.

Flood and Erosion Control (excluding gullies): The most effective and cheapest method of flood and erosion control is to limit runoff. This has been proposed through reforestation/ revegetation and grazing control. Within the proposed management plans, provision is also made to collect, and safely dispose of, surface run-off water. This is often integrated with improved track design, which is designed for minimum erosion. Where possible, collected waters are distributed to the cultivated fields or to water points; elsewhere they are safely drained to the gully channel. Improved track design uses mostly locally available selected construction materials. Tracks presently running across the contour are banned from future use. Improved tracks are safely protected by natural fencing. Typical track sections are presented in Volumes II and III (Drawings 208, 308). The drainage features, stripping of undesirable materials, fill compaction and selected roadway materials are the most important characteristics of the proposed designs.

Gully Control: As previously noted, gully control can only be effected through measures in the catchment area (the rest of the sub-watershed). Reforestation, land management, and run-off collection have been proposed for these lands. Should water continue to arrive at the gully, drainage diversion around the gully, and safe disposal into the gully, are provided for. A revegetated and protected strip around the gully controls surface runoff into the gully. The gully itself, as far as is possible, will be graded and grassed. Check structures within the gully are prepared as necessary. These measures are supplemented by the addition of living weirs, as outlined by SOGREAH (Report No. 14). During gully remodelling and vegetation, grazing and use of existing water points should be prohibited. Once the gully is stabilized, controlled grazing will be possible, along principles already discussed.

As far as possible, proposed structures use locally available materials and local labor. In particular, emphasis is placed on rock and gabion structures. Once understood, these gabions may be produced locally, either by the NWADEP or by a local contractor. It is proposed that specialized technical assistance be acquired to teach methods of gabion construction. Typical designs of gully control structures and measures are presented in Volumes II and III (Drawings 206, 306). Typical designs were prepared for both rock and earth foundations. Gabion structures contain flow gauges. Minimum right of ways and other features are also indicated. Proposed locations are presented in drawings accompanying Volume II (Drawings 204, 205) and Volume III (Drawings 304, 305).

Human and Livestock Water Supplies: Typical design improvements for both human and livestock water points are presented in Volumes II and III (Drawings 207, 307). Possible locations of water points are presented in Drawings 204 (Volume II) and 304 (Volume III); the proposed locations are designed with respect to catchment area, proposed drainage diversion, and accessibility to grazing areas. It is believed that these designs and locations will improve both the quantity and quality of water. Some well drilling is also proposed for improved domestic water supply where adequate catchments are not available. Such drilling program should also be used for exploration purposes. Due to lack of information, well characteristics and costs cannot be given at this time. Well drilling and testing should be directed by an experienced hydrogeologist. Reportedly NWADEP is presently procuring a drilling rig which may be used in this program. It is also important that an experienced master driller and a qualified mechanic be hired if NWADEP is to conduct a successful program.

Energy: The question of energy cannot be forgotten. Presently the primary energy source is wood. This is cut for local consumption and for conversion into charcoal for sale. Concurrent to the implementation of the management proposals, sites should be sought on the plateau for the development of energy farms. Once the potential is demonstrated, operation can be left to private entrepreneurs. Once operating, wood cutting for fuel should be banned. Along with the production of fuel-wood, methods of more efficient charcoal production should be introduced. Methods of more efficient fuel use should also be introduced, such as cooking stoves, which can give up to a 50% reduction in fuel use.

The replacement of wood as the family energy source is not considered to be a viable proposition at this time. However, other energy sources, especially wind and solar, should be investigated to provide energy for water pumping, milling, electric fencing, and operations at the Aburriin experimental farm. These installations should be run and maintained by a qualified person.

Fencing: The traditional fencing is brush fencing, which involves destruction of the vegetation cover and is counterproductive in terms of watershed management. This may be retained for livestock pens, which are small and where the visibility of the fence, to the animals, is important. However, the grazing management programs should use alternate fencing. Natural fencing, such as sisal, is preferred. While this is being established, 3-strand electric fencing, powered by solar energy, is proposed.

This fencing is effective, relatively light and easy to import, and may be moved regularly and easily.

Data Base: The analysis and management proposals have emphasized the lack of an adequate existing data base. Proposals have already been presented for agronomic, grazing, forestry, and livestock research. It is also recommended that a meteorological network be established throughout the plateau; failing this, recording stations should be established in both of the PPAs. Some equipment already exists in the NWADEP, and is presently unused. Likewise, a hydrological network should be established, recording flow volume and velocity,and silt loads. If established for the whole plateau, this will provide a basis for a priority delineation of sub-watersheds for management, based upon their erosion rates. If only possible to install locally, they should be installed within the PPAs and in at least one comparable (to each PPA) sub-watershed, for monitoring the impact of the control measures. More detailed topographic work is also necessary for final design and development within the PPAs. Plot experiments, to measure run-off and erosion on different combinations of slope and vegetation cover, would also be useful.

Co-operatives: The management strategies proposed involve considerable cooperation amongst farmers, both for land, water and livestock management. Cooperative action can also promote significant advantages in terms of input purchases, equipment purchase and utilization, grain storage, and marketing. It is therefore proposed that the sociological and economic studies proposed also investigate the feasibility of creating and operating sub-watershed-wide cooperatives.

3.6.4 Economic Analysis (Costs and Benefits)

It proved extremely difficult to obtain data relevant to an economic analysis. The project Financial Controller was absent from Hargeysa throughout most of the team's in-country mission, thus making relevant documents not accessible to the team. Several requests, both verbal and in writing, were made to the project for specific information on project costs and implementation. This information was not provided. A request was made for a letter giving access to project records in Washington; this request also failed to provide a response.

With regard to benefits, a thorough theoretical analysis of the return to bunding is provided in the World Bank Appraisal Report (1984). This report utilizes yield data derived from Phase One of the project. The validity of applying this data to Phase Two is questionable. There appears to be an urgent need to collect data on existing yields in order to form a baseline from which to monitor and evaluate yield responses to bunding, increased labor input and uses of other inputs within the pilot project.

The proposed watershed management program is designed as a pilot project. As previously explained, the experimental nature in developing, defining and evaluating alternative management strategies must be recognized. And this is as true of the economic aspects as it is of the physical aspects. One aspect of the pilot project should be an analysis of the costs and the benefits of the alternative strategies tried. (In fact, pilot watershed management program costs are excluded from the proposed Phase II cost recovery proposals.) Without a careful collection and evaluation of economic data, much of the value of the pilot project will be lost. Data collected will be of value beyond the limits of the project as there is an almost total lack of experience and collected data for agriculture in this northwestern area which severely limits the present capacity to define appropriate response.

Given the unavailability of reliable economic data and the trial nature of many of the management strategies proposed, any detailed economic analysis would be little more than a wild guess. Approximate costs of construction of proposed infrastructure, based on preliminary design of typical structures and unit costs gathered during the in-country assignment and additional estimates in the home office, are given in Volumes II and III. However, final costs cannot be determined until the detailed design and sizing is done. This will vary with site and situation (catchment areas, water volumes). An indication of the number of bunds where relevelling is required is given for each PPA in the respective volumes. But implementation of bund improvement will demand a bund by bund analysis of condition and necessary improvements. It is thus impossible to cost this portion of the plan at present. Almost no experience exists in the region with reforestation; some data was obtained from the OEF project and this is presented in Volumes II and III.

Given the experimental nature of the pilot project, there can be little doubt that, given the large input of technical aid required, an evaluation that only measured increased yields as a benefit would show a low rate of return to the project. However, the potential benefits of the development of successful strategies, of knowledge, of experience and of training will, if properly utilized beyond the pilot project, be considerable. At this stage they are also virtually unquantifiable.

There are additionally some benefits to the project that are not easily captured in conventional cost-benefit analysis.

The first of these is presented by the potential for famine in the project area. Insofar as the project, by increasing food production, helps to prevent famine, there is a benefit, represented by the value of lives saved and the cost of famine relief averted, greater than the value of increased output. A second benefit that will be undervalued, due to the relatively short time horizons of cost-benefit analysis, is that of the prevention of erosion. If bunding and/or other control measures were not to take place, erosion would increase. The irreversible nature of erosion represents the loss of a factor that we normally consider fixed, that of land. If this loss is not arrested, the PPA will not merely suffer a loss of output during the period of the project, but much of the land will be rendered uncultivable for all time. By bunding, and reducing the erosion, there is a benefit that continues well after the life of the project.

It is probable, though by no means proven, that the building of bunds in itself increases crop yields. The possible yield increase will not be sufficient in itself to ensure the economic viability of the project. If full utilization of the bunding is to be realized, improved cultivation techniques and the utilization of inputs need to be combined with the bunding. One of the most important inputs that will need to increase is that of labor. Yet, as pointed out in the USAID Project Impact Evaluation Report No. 62, the local population may be very reluctant to increase labor input into cultivation.

At present the PPA population consists of both farmers and semi-nomadic herdsmen. Normal practice is to farm for a subsistence level of crops only and, between planting and harvest, to drive the herds. A shift to the cash cropping of maize and sorghum will require a change in this practice. There will need to be a shift in the allocation of labor input away from herding and into crop farming with much of this labor applied between planting and harvest. If yields are to be greatly increased, farmers will need to stay close to their fields. This is incompatible with the present semi-nomadic existence.

At present the PPA population has given no indication that they are prepared to make such a major change.

There are at least two possible reasons for a reluctance to shift from herding to crop farming:

One is that of traditional social and cultural practice. It is possible that the people see themselves as herdsmen rather than farmers and that they attach a great social value to this and have no desire to change.

An alternative possibility is that the economic return to the PPA population from the herding of cattle (even with the present decimated herds), sheep and goats is greater than they would derive from the farming of maize and sorghum as cash crops. Related to this is the further economic consideration that, in this marginal farming area, the risk-averse individual might find himself better protected against famine by the mixture of semi-nomadic herding and subsistence farming than he would by a purely crop farming existence.

If the PPA population does change from semi-nomadic herding to crop farming, there is no possibility of replacing the loss of the nomadic herd with an increased sedentary herd. There is insufficient land for this. Such a shift will therefore mean the loss of the largest part of the herd. This should clearly be counted as a cost to the project. To the population it would represent a considerable loss as the herd represents both a store of wealth, a source of food and a means by which they derive a cash income.

For the project to be economically viable, two conditions need to be met. The first one is that the PPA population must be willing to shift from herding to crop farming. The second one is that such a change needs to make economic sense for them. That is, the income lost from giving up the nomadic herd must be at least compensated for by the income derived from the cash cropping of maize and sorghum.

That these two conditions can be met by the project still needs to be established. In order to establish whether there are social and cultural barriers to a shift from semi-nomadic herding into cash cropping amongst the PPA population, it is recommended that a social study be included within the pilot project to examine this potential problem.

It is further recommended that a study of present farm incomes, including income from all sources: nomadic herding, sedentary herding and cropping, be included within the pilot project and that this study further consider the economic viability, from the point of view of the farmer, of giving up the nomadic herd in order to concentrate on the cash cropping of maize and sorghum.

In order for the above studies to be conducted, an internationally recruited social anthropologist and an internationally recruited agricultural economist will need to be added to the project.

It is also recommended that a thorough and careful collection be made of the economic data generated by the different strategies tried. This will require a proper system of evaluation and monitoring, especially of yield responses to different measures. This data should then be utilized to produce the final cost benefit analysis of the pilot project.

3.6.5 Feasibility Analysis

A feasibility analysis of a program such as the proposed watershed management program (section 3.6.3) has many components - technical, environmental, economic, sociological, and institutional. They will be discussed separately. However, it must be remembered that the proposed program is a pilot program; one aspect of a pilot program is to collect data relevant to evaluating the feasibility of extending all or part of the pilot program to environmentally comparable situations.

Technical: Development of the technical proposal involved a catch-22 situation. To some degree, there is a trade-off between technical simplicity and the effectiveness and efficiency of the proposal in terms of the objective of soil and water conservation. Conversely, there is negative relationship between increased complexity and the probability of effective implementation in the Somali environment. Thus a balance was sought requiring simplicity while retaining technical soundness. However, the primary consideration was always the technical soundness of the proposals, and within the limits of available environmental data, the proposed measures are believed to be technically feasible.

Environmental: The environmental situation has been extensively analyzed in sections 2 and 3 of this report, and in the SOGREAH report and other studies. The plateau area of the North West Region is considered only marginally capable of supporting agriculture. The limitation is primarily climatic, although the soils clearly require careful management to prevent crusting, promote rainfall infiltration, improve and maintain soil structure and fertility, and prevent erosion. The climatic limitation becomes more severe in the direction from Boorama to Hargeysa. The PPAs are located in the Hargeysa area, in the driest part of the plateau. This is a major constraint on any agricultural project here. For Hargeysa, the 75% rainfall probability is calculated as 348 mm; SOGREAH estimates water requirements for sorghum for maximum grain yields, at Hargeysa, as between 642 and 690 mm (Report No. 17 - Agronomical Survey). However, moisture availability can be substantially improved through techniques of water harvesting and conservation, as previously discussed. The climatic limitations are not so severe as to make the project technically not feasible.

The present land use situation imposes severe constraints on what may be proposed. In particular, it has been assumed that presently cultivated fields and existing bunding are both essentially inviolable. It has been necessary to violate this principle where gully control is required. Also, delimitation of grazing lands has involved some loss of agricultural area. For existing bunded areas, only bunding improvements have been proposed. However, even these limited changes are likely to be fiercely resisted by the local population. Likewise, it has been clearly demonstrated that a first priority of management must be to bring the animal population and grazing resources into better balance. Again, fierce resistance can be expected. Conversely, the grazing proposals made respond to the priority given, by the farmers, to livestock. The success or failure of the grazing program may well make or break the project.

Lack of data, particularly on yields, grazing management, and reforestation, make it difficult to predict the environmental response to the proposed measures. Conversely, it is relatively easy to predict the environmental response to continuation of present land utilization and management. At present, there is no reason to believe that the proposals are not environmentally viable.

Economic: An economic evaluation has already been presented (section 3.6.4). The inadequacy of existing economic data is discussed and one of the objectives of the pilot program must be to provide such data. However, in terms of the pilot program, it is difficult to evaluate either costs or benefits in straight economic terms. The proposed program is a pilot program, with a high investment in experimentation and technical assistance; unless these costs are amortized over the entire dryland farming area, the return on investment will inevitably be low, and the proposals assessed as economically unfeasible. However, there are many benefits which are difficult to quantify. Finally, the sociological constraints (see below) on economic viability must be considered. These constraints may be compounded by a perceived economic disincentive to reduce livestock and increase cultivation.

Overall, therefore, a long-term view needs to be taken of the economic feasibility of the proposed measures, with extension of successful techniques to the other dryland farming areas. Even then the project may not be justifiable in terms of simple yield increases, but must consider increased security and quality of life, and the benefits of erosion control.

Sociological: Within the PPAs, the Somali farmer has but a short tradition of cultivation and land management, and retains a strong attachment to livestock. A full sociological study is recommended elsewhere (sections 3.6.3 and 3.6.4). However, preliminary indications are that the farmers in the PPAs are not making full use of the bunds. Part of this may be attributed to lack of agricultural extension, but the suspicion remains of a more fundamental sociological constraint. This needs to be fully investigated, along with possible solutions, but could prove a major constraint on project feasibility. Further, the farmers are fiercely independent and are likely to resist any efforts to integrate conservation works; yet without such integration and cooperation, it is hard to see how the project can succeed. Finally a reduction in animal numbers and changes in animal husbandry are essential, but unlikely to be willingly accepted by the local population. Ironically, while the farmer of the Somali North West is a proud and independent person, he is not averse to letting the NWADEP initiate and undertake the work program. Greater involvement by, and commitment of, the local population would appear to be essential.

Institutional: The NWADEP has a solid physical institutional base. Extensive facilities exist at Hargeysa, Xaraf, Gebiley and Boorama. The project is well equipped with buildings, vehicles, a variety of modern construction and other equipment, and more equipment is being procured under Phase II. Facilities exist for the maintenance and repair of equipment. Additional facilities will be built in Phase II. The project is well staffed with 228 people (4th Quarterly Report, December 1985). A small network of extension agents is already in place and is planned to be extended in Phase II. The institutional structure appears sound. Overall, therefore, the project would appear to be institutionally sound and capable of carrying out the work.

There are, however, some other points to consider. By and large, project personnel are poorly trained and there is a problem in retaining those who have received outside training. However, an extensive training program is called for under Phase II. There is also the conceptual and attitudinal character of project personnel, in particular the management. There is reat pride in, and enthusiasm for, the bunding program. However, unless the management can pass that enthusiasm down, to motivate the work force, there could be problems in implementation. Further, the watershed management is a considerably more complex concept than simple bunding. The management must fully comprehend the need for, and methods of, such an integrated program. The 3 months spent in-country, with attention focused on selecting and analyzing the PPAs, was insufficient to evaluate the institutional situation. However, little evidence was seen of any attempt to implement SOGREAH's various proposals and, indeed, a certain resistance to alternate ideas was encountered. Unless all project personnel are conceptually aware, and committed to project implementation, then the project can never be feasible.

Overall, integrated watershed management is considered necessary to protect and enhance the environment, and to improve the security and quality of life through improved crop production. From a technical and environmental point of view there would appear to be no serious limitation on project feasibility. The economic, sociological and institutional aspects are hard to assess and are recommended for further study. However, preliminary indications lead to some doubts about project feasibility, in these terms, without extensive technical assistance and a long time frame for project implementation and benefit return.

3.6.6 Proposed Implementation and Monitoring

The state of land degradation in the PPAs calls for urgent implementation of the proposals. However, the lack of an adequate data base and, more particularly, the socio-economic situation of the PPAs, militate against rapid implementation. In the view of the consultant, implementation must be slow, and will exceed the 5-year time frame of phase II; a more rapid implementation will impact negatively upon project feasibility.

The first stage of suggested implementation involves expansion of the data base, detailed planning and design, upgrading of NWADEP institutions, and extension work in the PPAs. The management plans call for extensive additional data collection, including detailed topographic work in the gullies; a detailed evaluation of existing bunding; research results relative to the agronomic, grazing, and forestry proposals; and, most importantly, a detailed and complete socio-economic survey of the plateau.

The socio-economic survey will require foreign technical assistance - a social anthropologist and an agricultural economist. The study is estimated to require about one year - 2 months preparation, 6 months field work, and 4 months for report preparation. The study should cover the social background of the people of the plateau; their current socio-economic situation and attitudes; the potential for a shift from nomadic herding to cash cropping; present farm income services and levels; marketing possibilities and constraints; and investment opportunities, for surplus funds, other than livestock.

The detailed topographic and bunding analyses can make use of the topographic and soil conservation technical assistance already being supplied under Phase II. About 3 months are estimated for the work. Subsequently, location of gully structures and the design of all civil engineering features must be carried out; this will require the short-term input of a civil engineer, and the resident soil conservation officer. The civil engineer should supervise construction. A field laboratory should be used for quality control (aggregates, compaction, concrete work). The il engineer will early specify any supplementary construction ipment required.

The upgrading of the Aburriin experimental farm is proposed either as an extension of existing funding or as a separate sub-project to the NWADEP. (Close liaison with the NWADEP st be maintained.) It is suggested that the World Bank consider as urgent the provision of the necessary technical assistance and other funding. Expatriate technical assistants gg sted are a research agronomist, agricultural engineer/chanic, and a livestock/grazing specialist. Housing should be ovided on the farm for these experts, along with necessary cilities (water, power). A fully equipped workshop is required, as well as an upgrading of the soils laboratory and of her existing facilities. Provision should be made for equipment purchase and construction as suggested by the team. A site s by the agronomist, prior to installation of the team, would rmit definition of necessary immediate development and purchases. Design and construction management expertise should be rovided as required.

Research data is also required on reforestation, and improvement possibilities for extensive grazing. It is suggested that reforestation/revegetation trials be undertaken through greement with OEF who are already doing reforestation work in he area and who operate a tree nursery at Arabsiyo, with an abundant supply of young trees. They have indicated an interest in carrying out plot trials in different physiographic situations, within the PPAs. In return they would be interested in an occasional use of NWADEP heavy equipment for earth moving and transportation of supplies. The extensive grazing aspects are probably best left until return is demonstrable, within the PPAs, in grazing development and control. Prior to that, it seems unlikely that the local population will accept help in the traditional free-range areas.

Two other areas of short-term technical assistance are called for. A hydrologist is required to help install the hydrological and meteorological network and to train observers, and a hydrogeologist is required to investigate and develop ground water supplies. A specialist in gabion construction is required to instruct project personnel and/or local entrepreneurs in the art of gabion construction.

The NWADEP institutions need upgrading, particularly in the area of training. There is also a requirement to improve the capability to undertake planning and design tasks (e.g., topographic survey and drafting support). The foreign extension officer hired under Phase II should be directed, in this early stage, to concentrate on improving the quality of the NWADEP extension agents, through internal training, and should not be involved in farm management. Motivation of these, and all NWADEP personnel is required. This can partly be achieved by financial incentives; the present government pay scale is so low that it is a disincentive to work, and encourages employees to seek ways of subsidizing their salaries. However, such an incentive program should be accompanied by a thorough evaluation of project personnel. It was an observation of the team that there is a lot of "dead wood" in the NWADEP, which needs to be removed, as it discourages others. Further, permanence of employment should no longer be assured, thereby providing an incentive to produce. In these ways, it is possible that a reduction in total staff may be achieved, for some cost saving. Another incentive may be provided by the lure of foreign training. Such training should emphasize <u>practical</u> aspects, such as in the various vocational agricultural courses available. A condition of such training should be a minimum 5-year commitment to the project upon return from training.

By far the most important aspect of the first phase of the implementation program will be liaison with the local farmers. The consultant is convinced that the feasibility of project implementation is substantially dependent upon the active involvement of the PPA populations. They must first be persuaded as to the nature of the problems and the possible solutions. The proposed management plans must be fully discussed with them, and their understanding assured. Once done, they must be persuaded to form sub-watershed cooperatives or farmers' association to undertake the work and share in the benefits. It is difficult to predict how long this process of persuasion might take - perhaps as long as 2 or 3 years. However, it is considered to be fundamental to success. Should the farmer in the PPAs prove impossible to convince, another sub-watershed should be sought.

Once the cooperative or association is formed, the work should be undertaken <u>using local labor and materials</u>, as far as possible. The NWADEP should act only as a technical advisor, except in the case of a few more complex activities (e.g., gully grading and construction of some of the larger structures; road upgrading). Any attempt by the NWADEP to do the work themselves is considered detrimental to the long-term success of the proposals, which success is dependent upon local participation and cooperation. Actual implementation should start with the priority I reforestation areas, gully protection and control, and the intensive grazing schemes, including waterpoints and necessary drainage diversions. These address the most urgent problems of the PPAs. This should be closely followed by bunding components and drainage diversion. An internal extension effort will be required in all aspects - crop and land management, the grazing system, reforestation, construction methods, groundwater development, etc.

From the above discussion it is clear that it is impossible to give a detailed implementation schedule. Implementation - both initiation and the speed - will depend on the local population, and may vary between PPAs. Each stage of the implementation should be carefully monitored and recorded, including all associated costs and benefits.

APPENDIX A1.1

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IDENTIFICATION OF A 60,000 HA ZONE IN THE NORTH WEST REGION AGRICULTURAL DEVELOPMENT PROJECT AREA

During the period March 28-31, 1985, John Buursink of Tippetts-Abbett-McCarthy-Stratton (TAMS), and Hassan Abdo Munye, General Manager of the North West Region Agricultural Development Project, went to the offices of Geosurvey in Nairobi, Kenya to identify 60,000 ha in the project area to be topo-mapped at 1:10,000 by Geosurvey. The 60,000 hectares were to include cultivated portions of catchment basins to allow subsequent detailed study of watershed control measures necessary to increase productivity of dryland farming.

The identification was based on analysis of:

1. Russian topographic maps at scale 1:100,000 dated 1976 (without drainage data), and

2. Geosurvey aerial photography of 300,000 ha at scale 1:25,000 dated February 1985 and consisting of 13 runs of about 50-60 photographs each, covering a zone of 50 x 120 kms from the Hargeisa area Northwestward to the Boraama area.

The maps and aerial photography fully cover the current project area shown on the attached location map.

During Phase I of the North West Region Agricultural Development Project in 1980 three main pilot zones were identified. During the March 1985 mission to Nairobi, one 60,000 ha zone, instead of the original three areas, was selected for reasons which will be detailed below.

The 60,000 ha zone selected is located in the eastern portion of the project area, near Hargeisa. This zone comprises the cultivated, upstream portions of two major representative drainage basins with an average annual rainfall of 350 to 450 mm. The upstream portions of the drainage basins were included so that an appropriate watershed management program can be established in the areas, as well as future expansion downstream. This fulfills the technical requirements for selection of the 60,000 ha area. The two basins are:

- The Toga Arabsiyo draining northward, and
- the Toga Marodijeer draining westward toward Hargeisa.

The southern boundary of the selected zone coincides with part of the main divide between the drainage systems of the Gulf of Aden and those of the Indian Ocean. The northern boundary is the limit of the dominantly cultivated area and its eastern portion is also the limit of the Toga Marodijeer basin. The eastern boundary is the approximate town limit of Hargeisa. The western boundary is relatively arbitrary and was chosen to limit the selected zone to about 60,000 ha.

The selected zone incorporates the two main pilot zones identified in 1980 in Phase I of the project, e.g.,

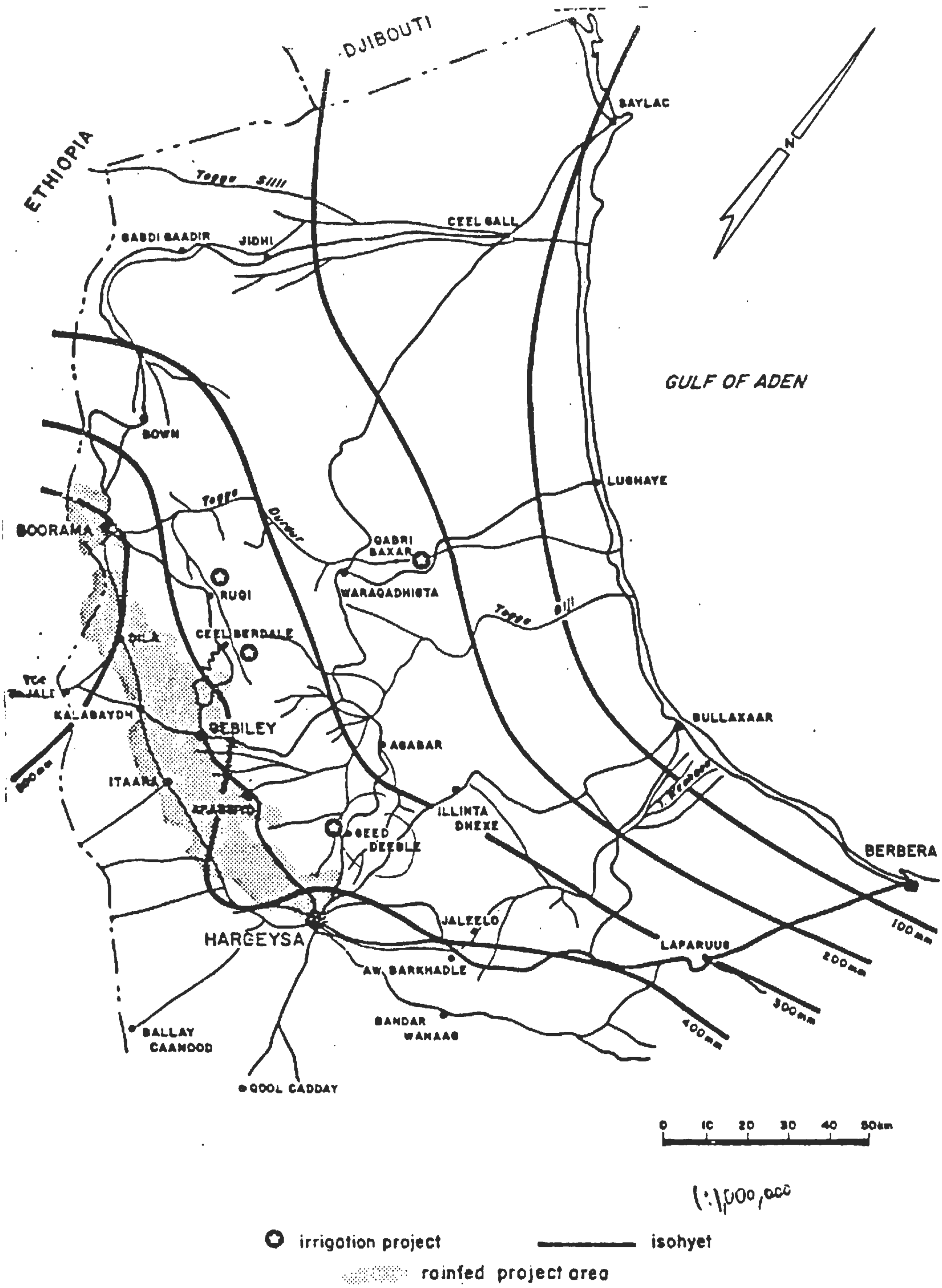
- the Xaraf area, west of Hargeisa
  (Report R14.A1 - Drawing 5.2, October 1981, scale 1:25,000)

- the Arabsiyo - Gebiley area
  (Report R14.A1 - Drawing 5.1, March 1982, scale 1:22,500)

The third pilot zone near Boraama originally identified in Phase I of the project is now in disputed territory and was not covered by Geosurvey's February 1985 aerial photography due to security reasons and thus was not included in the present study.

The 60,000 ha zone is demarcated on one set of aerial photography scale 1:25,000 left at the Geosurvey office in Nairobi. The demarcation in shown in red pencil on photographs with even numbers only, as follows:

Run 7:	728
Run 6:	334, 336, 328, 326, 324, 322
Run 5:	448, 446, 442, 438, 430
Run 4:	140, 148, 150, 152, 160
Run 3:	488, 506, 508
Run 2:	208, 198, 196, 194, 192
Run 1:	238, 240, 242, 244, 246, 248



NORTH WEST REGION AGRICULTURAL DEVELOPMENT PROJECT

LOCATION MAP

Recommendations

In order to speed up and improve the quality of project operations, I recommend that the project request:

1. Geosurvey to produce five sets of two controlled mosaics at scale 1:25,000 covering the 60,000 ha zone, once ground controls are established. This will facilitate orientation in the field of project staff and allow for better recording of field data related to land use and land improvement.

2. TAMS to purchase at least one mirror stereoscope to permit full stereoscopic interpretation of the wealth of aerial photography now available.

JOHN BUURSINK
Revised, June 1985

APPENDIX A1.2

TAMS SELECTION OF STUDY AREA - JUNE 1985

TAMS
TIPPETTS-ABBETT-McCARTHY-STRATTON
ENGINEERS, ARCHITECTS AND PLANNERS

25 June 1985

Dr. Hassan Abdo Munye
General Manager
North West Region Agricultural
Development Project
Somalia

Re: NWRADP - Selection of 60,000 Ha Pilot Zone

Dear Dr. Munye:

This letter is in response to your request for justification of the above referenced area. On March 31, 1985, immediately upon completion of our joint mission and work at Geosurvey's Nairobi office, I mailed you a concise report on the selection of the above area and sent a confirmation copy of the report a few days later. Perhaps you never received either copy of the report.

Enclosed please find a more detailed version of my report on the selection of 60,000 ha zone in the project area set aside for detailed mapping. I hope this meets your requirements.

In the meantime, I hope we'll have a chance to meet again soon, either in Washington or in Somalia.

Sincerely yours,

John Buursink

John Buursink, Ph.D.

xc: Nils Wiklund/Geosurvey/Nairobi, Kenya
John Stemp/World Bank/Nairobi, Kenya

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310297 R8 - T.R. No. 8 - Range and Livestock Survey
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APPENDIX A1.3

RESOURCE METHOD

APPENDIX A1.3

RESOURCE METHOD

1. Development of a Classification for Land Characterization

No existing comprehensive classification, or maps, of land use or other land characteristics were known to exist, and so a classification system had to be designed. Such a system must:

i) Respond to the objective. The TOR calls for a map of present land use, as a basis for land suitability analysis and land use planning. However, in the absence of adequate existing documentation, it was decided to include in the land characterization other characteristics critical to planning and implementing land development proposals, vis. physiography, soil and present land condition (erosion, stoniness). This was most critical in the Hargeysa study area where the selection of a pilot watershed had to be made. The Baki area was quickly recognized as inferior to the Hargeysa area for a pilot study, and so, if necessary, a lower detail of information would be acceptable.

ii) Be appropriate to the scale of mapping (1:25,000) and data presentation (1:50,000). A common minimum mapping unit (MMU) (smallest area to be presented on a map) is 1 cm^2, which at 1:25,000 represents 6.25 ha, and 25 ha at 1:50,000. Presentation of such small areas, however, is avoided as far as possible. Thus most mapping units will be greater than 25 ha. The MMU will only be used where necessary to highlight contrasting or important features, or where its use helps maintain map unit purity, avoiding complexes of land types. An example in the project area is the presentation of small, rocky hills upstanding from the surrounding cultivated plain.

iii) Reflect the principal variations within the environment of the study area, while respecting both objective and scale.

iv) Provide sufficient information, within the constraints of time and scale, for other probable and possible uses; and also to be broad enough to permit extension of the classification to areas beyond the study area.

v) Be workable within the resources (time, facilities, etc.) available to the study. The minimal accessibility within the Baki study area made a more generalized mapping inevitable, given the time and facilities available to this mission.

Many land use legends exist in the literature, and these may be drawn on for their principles (approaches) and, to some extent, content. However, every situation is different, both environmentally and in objective, and land classifications need to be "custom made." Ideally the legend will be developed both by analyzing data (in this case aerial photographs) and through repetitive field visits to analyze, define, and test the classification. In this particular assignment, problems with transportation (vehicles and fuel) severely restricted field access during the first half of the in-country assignment. Only one one-day reconnaissance trip into each of the study areas was possible during this period and both legend development and initial mapping were undertaken primarily through air-photo analysis. This analysis consisted of a definition of land use, density of vegetative cover, physiography, and indicators of erosion. This information, along with map unit boundaries, was annotated directly onto the aerial photographs using a grease pencil. Subsequently, a 3-day field trip was undertaken in the Baki study area, and about 5 days were spent in the field in the

Hargeysa area. These allowed verification and modification, as necessary, of the interpretation and the addition of some basic information on soils and on erosion. Fortunately, the photo interpretation work was found to have been effective and little modification was necessary. The field work consisted both of "wind screen survey" for comparison of the interpreted aerial photographs, and stops in representative areas or at selected features. The stops are located, approximately, on the maps. Inevitably, the limited access within the Baki area made the field time less effective than in the Hargeysa area, both in terms of the percentage area visited and the detail of information obtained.

Subsequently, the data was transferred from the photos to the base map. In the absence of the topographic maps, maps derived from an uncontrolled photo mosaic were used. The distortions inherent in such an uncontrolled mosaic posed some problems, and further problems were encountered where there was less than the 20% minimum photographic side-lap. These maps were used in all in-country analyses, as complete topographic coverage was not received until the end of the in-country mission. With the acquisition of the topographic maps, 1:25,000 scale reductions were made and the data again transferred directly from the annotated aerial photographs.

Land Use. The primary land uses recognized were cultivated and pasture/forest. There is no such thing as a forest reserve in the region, all uncultivated lands being exploited for both grazing (grasses and tree leaves) and wood (primarily for fuel). Forestry and grazing were therefore presented as one class. These areas were classified according to the apparent vegetation density of the principal vegetation components (trees, bushes) and the vegetation structure (relative importance of trees, bushes and grasses). Such estimates were based largely on photo interpretation modified as necessary by limited visual field inspection; no attempt was made to quantify the classification (e.g., number of trees per unit area, tree sizes, etc.). Nor was the vegetation classed by species, association, community, etc. The necessary botanical expertise, relevant to the region, did not exist within the consulting team nor in the project. Reference was made to "A Short List of Somali Plant Names" (Hemming, FAO, 1971), but the accompanying Somali counterparts were frequently unable to name the plants and, when able to do so, these names could often not be located in the FAO listing. However, this lack of information is not considered critical. No great variation in tree and bush species was observed that would be significant to fodder potential. Most trees and bushes are acacias, primarily Acacia etbaica (Suqsuq) in the Hargeysa study area, and Acacia bussei (Galol) in the Baki study area. Only along the main toggas was there any significant variety. The grass and herb layer was, at this time of year (October to December), almost non-existent, and therefore not available for analysis.

Within the Hargeysa study area, agricultural areas were divided into bunded and unbunded areas, as observable on the aerial photos. Most "cultivated" areas contain significant proportions of uncultivated land, partly as a function of the bunding, both its pyramidical structure and its non-integrated development; and also as a function of land deliberately left for grazing. Inclusion of up to 25% (1) of such land was considered acceptable within the "cultivated" category, there being no "pure" areas, and the uncultivated lands being too small for separation at the scale of working. When the uncultivated land occupied greater area, the unit was mapped as a complex of cultivated and pasture/forest land. We were unable to satisfactorily

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1 Subsequent analysis within the pilot project areas suggests that a more accurate figure is about 50%.

determine whether some or all of the included uncultivated lands are ever cultivated (i.e., they were in fallow); therefore, "fallow" land was never mapped.

In the Baki study area there was little evidence of current cultivation although contour hedging, and some bunding, indicated extensive previous cultivation. It was generally not possible to determine if this land was fallow or abandoned; it was therefore mapped according to field pattern - contour hedged, bunded, unbunded - without defining its present status. Further, its present use for grazing, and the encroachment of trees and bushes onto this land, made it difficult to separate from the forest/pasture units. Therefore a combined hedged field-forest/pasture unit was created.

While land use patterns follow soil potential to a broad extent, they also reflect a complex mix of ownership, management decisions (requirements for grazing, labor availability, etc.), history of development, etc. It was beyond the capacity of this assignment to analyze and incorporate such information.

Physiography: Physiography was analyzed almost entirely by air photo interpretation and merely gives some general expression of relief and land form vis: level; gently sloping; elevated area (hill); the sequence of steep "scarp" face and gently sloping "dip" slope; gully; and togga. Several classes of gully were recognized, as outlined below, under "Erosion." In the Baki study area, large parts of the area consist of mountains, and a division is made on the basis of broad geological separations and apparent variations in relief.

Slopes were initially assessed in the field by visual estimate or with a hand level (Abnay level). These were subsequently confirmed from the 1:10,000 scale topographic maps.

Soils: The soils were spot-checked using an auger or natural cuts. Textures were rapidly hand checked for the surface and for the subsurface at about 50 cm depth. Augering was continued to one meter only where there was a question as to probable depth. The difficulty of augering in the hard, dry soil mitigated against routine augering to 1 m., given the time constraints on the analysis. The number of soil observations made was very small. Within the agricultural areas of the Hargeysa study area, soil subsurface textures were quite uniform (heavy loam to clay loam, varying from sandy to silty), with an apparent tendency to being sandier near the hills and becoming siltier near the rivers. This general and unsubstantiated observation was used to extrapolate soil textural information into unobserved areas. In the Baki area, soils again appeared to be medium textured. Sandier soils might be anticipated closer to the granitic hills, with heavier soils associated with the limestone. However, as with other resource characteristics, soil observations were restricted by the limited access. In consequence, only depth, and not texture, is presented on the maps (drawing 308).

The soils information presented on the maps is broad, general, tentative, and based on very limited field inspection; these should not, under any circumstances, be considered as soils maps.

Erosion. Analysis revealed erosion to be a primary - perhaps the primary - concern in these areas. Four classes of gully (areas with a dominant gully form) were recognized (3 gully types, plus "badland"), reflecting degree of lateral development; frequency of dissection and, conversely, amount of interfluve area; and potential for, and costs of, rehabilitation and usage.

For non-gully areas, erosion was assessed both for existing sheet/rill erosion (essentially, loss of topsoil) and degree of gully development within, and dissection of, the mapping unit. Again, this was based primarily on air photo interpretation, supplemented by field observation.

Stoniness: Stoniness is a factor in any agricultural development as it is an impediment to cultivation and may require clearing. It was mapped initially through field observation, and subsequently by extrapolation through photo-interpretation. However, in the Hargeysa area it was found to be so strongly linked to physiography and soils, that it does not significantly add to the mapped information. However, if this analysis is to be extended into other plateau areas, stoniness should continue to be assessed. In the Baki area, stoniness is more variable but, again, the validity of the presented data is limited by the accessibility within the study area. With these considerations in mind, and in the interests of map space and clarity, stoniness is not presented in the maps but the typical situation is included in the accompanying descriptive legend.

Roads, Water Points and Settlements. Information on roads, water points and settlements were also recorded by air photo interpretation, supplemented by field observations (primarily for road condition). This information should properly be included under "land use" as it represents use of the land. However, the analysis was carried out independently from the analyses for land characterization, and is presented on a different map. Its separation here conforms to that map separation.

A detailed classification of roads was found to be inappropriate as there is only one paved road within the project areas; all other routes must be considered as tracks as there is no

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A detailed classification of roads was found to be inappropriate as there is only one paved road within the project areas; all other routes must be considered as tracks as there is no of its relative size and importance in the area. All other settlements are very small and were classed as villages; this includes Baki. Although the new administrative center, Baki remains very small and, at time of visit, offered almost nothing in the way of services.

No refugee camps occurred within the 60,000 ha study areas. Their size, structures and function would require a category separate from village or settlement, should this analysis be extended into areas containing such camps.

Data Presentation

Drainage, water points, roads, and settlements are presented on the maps by use of lines and symbols, as described in the accompanying legends. On the land resource maps, in order to present the spatial variation of parameters (land use, physiography, soil erosion), the project area is divided into mapping units and the parameter characteristics defined by symbols. A mapping unit is an area of land for which the defined parameter characteristics are relatively homogeneous. Variation of parameter characteristics will inevitably exist within a map unit, but will normally be less than the corresponding variation between map units. Thus for planning activities appropriate to the scale of data presentation (1:50,000), the map units may be considered to represent uniform areas. However, contrasting inclusions may occur due to scale limitations. A unit, recognizably distinct in the field or on the aerial photos, must occupy a minimum ground area before it can be cartographically presented. A common cartographic minimum map area is 1 cm^2, which represents 25 ha at a scale of 1:50,000. This is referred to as the minimum mapping unit (MMU). It has been attempted to show all major contrasting features down to this size; below this size, such features may be lost in a larger map unit.

Extension of the Analysis

The above information is contained on the maps of Land Characterization. Elsewhere in this report it is recommended that this analysis be extended to the whole 480,000 ha of the N W project area. Should this be undertaken, then the following information should be systematically recorded for representative sites; a form could be devised to facilitate this recording.

Site number: (also to be located on the aerial photo)
Photo: (line and photo number)
Location: (e.g., distance and direction from a known village)
Physiography:
Slope (%):
Soil - depth:
- surface texture:
- subsurface texture: (at 50 cm)

Land use:
Sheet/rill erosion:
Gully erosion:
Stoniness:
Comments/observations:

APPENDIX A1.4

THE LAND RESOURCES MAP LEGENDS

APPENDIX A1.4

THE LAND RESOURCES MAP LEGENDS

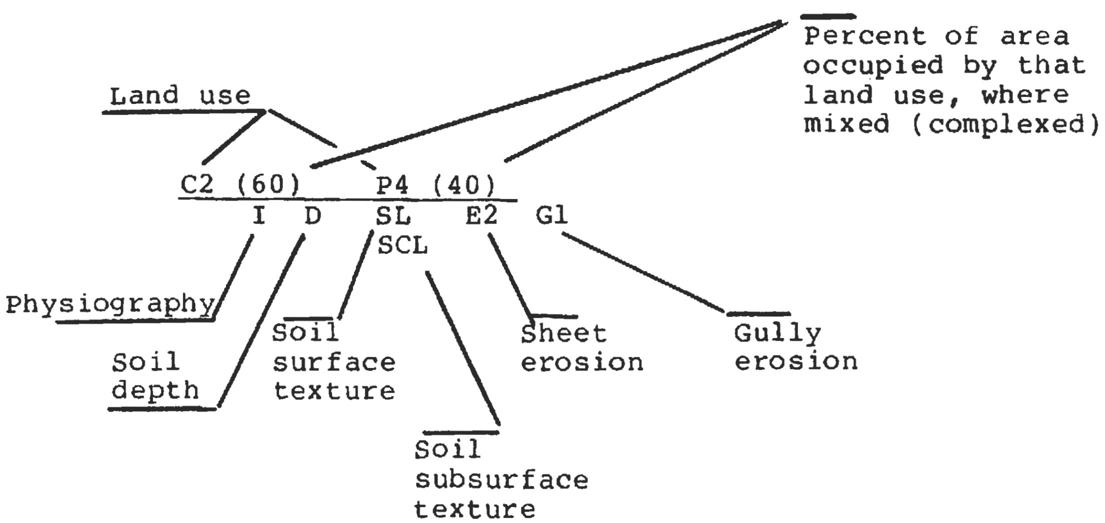
1. Hargeysa Study Area (Drawing 104)

The Map Symbol

The map symbol has the following general form:

Land use
Land physical characteristics

Both differentiated and undifferentiated versions of this general format are used. The differentiated form is used for lowland areas (except irrigated terraces where map space does not permit the general map symbol) where land physical characteristics may be quite variable. An example of the differentiated form is as follows:



Within the upland units and gullies, there was found to be relatively little variation (at the mapping scale) of land physical characteristics, and an undifferentiated version of the map symbol is used, as follows:

P5-6 — Land use or uses

H — Physiography with defined (stable) physical characteristics

The land physical characteristics (soil, erosion) associated with the defined physiography, are presented in the accompanying descriptive legend.

Irrigated gardens generally occur in very small areas and are designated only by land use. The associated land characteristics are fully described in sections 3.4.1.2 and 3.4 of this report.

The Map Legend

Map 1: Land Categories

Land Use

Cultivated land uses:

C1 - Dryland agriculture, dominantly unbunded - up to 25% (1) uncultivated

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(1) Detailed work in the pilot project areas suggests that 50% may be a more accurate figure.

C2 - Dryland agriculture, dominantly bunded - up to 25% [1] uncultivated

C4 - Irrigated land

Forest/pasture land uses:

P1 - Dense tree cover, almost complete crown closure

P2 - Moderate tree cover, open canopy

P3 - Thin tree cover, bush understory

P3A- Thin tree cover, very thin understory

P4 - Dispersed trees, bushes (dominant)

P4A- Dispersed trees, very thin understory

P5 - Bushes, with scattered trees

P5A- Scattered trees, very thin understory

P6 - Grasses, with thin bush cover (the occasional tree might be found)

P7 - Very thin vegetation cover, mostly grasses with scattered bushes

The A-modified (P3A, P4A, P5A) types are found mostly in steep, rocky slopes.

Other:

E - Large excavations (other than water points)

B - Togga bottoms - broad, flat, sandy bottoms, mostly devoid of vegetation

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(1) Detailed work in the pilot project areas suggests that 50% may be a more accurate figure.

Physiography

Upland Units:

D - Dipslope or butte top. Level to gently sloping (0-3%) elevated plateau area (high plateau area)

S - Steep slopes, to more than 20% slope. Typically scarp face or butte side slopes. Where the footslopes (pediment slope) are too narrow for separate delineation at the scale of 1:50,000, they are included within this category. This unit represents the primary erosional surface.

P - Pediment slope, or footslopes. Sloping (to 10%) erosional surface. May be dissected and undulating.

H - Defined as a rocky outcrop. Originally recognized as a series of low, rocky hills with slopes to 10%, similar land types (soil and vegetation) have been recognized in two other situations - as an exposed, erosional shoulder along the sides of gullies, and as a narrow undulating, dissected crest, between scarp and dip slope.

Lowland Units:

I - Inclined. Gently sloping (1-3%) plain. Occasional steeper sloping areas have been included because of their very limited extent. However, if this mapping is to be extended to the rest of the plateau, a separate, steeper category might be considered.

L - Level plain (0-1%)

T - Terrace. Narrow, level (0-1%) slope, alluvial terrace along major toggas.

Gullies: Areas dominated by the gully form. Depending on the severity of erosion and the nature of the soil, slopes may vary from gentle to vertical. The gullied areas have been subdivided into four, depending on the degree of gullying, as assessed from the aerial photographs. Essentially this represents an assessment of the degree of lateral gully development, frequency of dissection and, conversely therefore, of the potential and cost of erosion control, land rehabilitation, and present and future use.

G1 - Moderate gullying, gentle to moderate slopes, minimal lateral gullying with low frequency of dissection, leaving extensive interfluve areas which often contain bunded fields.

G2 - Severe gullying. Extensive lateral gully development, high frequency of dissection, moderate to steep slopes and very severe sheet erosion. However, within the gully unit, areas of lower frequency dissection may be found, where occasional bunded fields may be supported.

G3 - Very severe gullying. Extensive lateral development, very high frequency of dissection, steep slopes, very severe sheet erosion, very limited interfluve areas, and no possibility of cultivation.

X - Badlands. Extreme gully formation, with extreme land dissection into ridges and islands, almost no vegetation, and beyond land redemption. (Although no badlands were mapped within the study area, they occur just adjacent to the area.)

Soil

Soil depth:

V - very shallow	0 - 20 cm
S - shallow	21 - 50 cm
M - moderately deep	51 -100 cm
D - deep	greater than 100 cm

Soil texture:

- LS - loamy sand
- SL - sandy loam
- SiL - silt loam
- L - loam
- CL - clay loam
- SCL - sandy clay loam
- SiCL- silty clay loam

Modifiers- + heavy e.g., L+ = heavy loam (on the border between loam and clay loam)

- light e.g., L- = light loam (on the border between sandy loam and loam)

G gravelly e.g., GL = gravelly loam.

Sheet/rill Erosion

This is surface erosion caused by sheet flooding and rill channel action. The tendency of the soil to crust, the compact sub-surface horizons, and the frequent shallow depth to rock all facilitate this type of erosion. Due to the extensive vegetation degradation in the project area, and consequent uncontrolled runoff, it is assumed that all areas, except the extensive level areas, suffer from at least significant erosion. This is supported by the rate of siltation of the few check dams located within or near the project area. However, in bunded areas, the disturbance of the surface soil by bunding and cultivation, makes this type of erosion difficult to assess. Elsewhere, some impressions of soil loss can often be obtained from remnant soil mounds attached to old trees.

E0 - insignificant
E1 - significant
E2 - severe
E3 - very severe

Gully Erosion

Many areas which are not gullies, are however dissected by drainage lines and gullies. This can generally be observed on the aerial photos. Incipient gullies appear as dark linear patterns, although dissection is not apparent. Where dissection is apparent, the area may be assessed according to degree of dissection. The distinction between severe gullying (.G3) and the physiographic component G1 (moderate gullying) is somewhat subjective, but rests largely on whether the area has a gully form, or a slope form which is severely gullied.

G0 - insignificant
G1 - incipient gullying
G2 - moderate gullying
G3 - severely gullied

Stoniness

This is an estimate of surface stones, which affect cultivation and therefore impose a cost of clearing in land development. This is only presented in the descriptive legend accompanying the map.

none	- no or very few stones
slight	- some stones, which might require some clearing for cultivation
moderate	- significant stones, requiring clearing for cultivation
severe	- surface covered with stones, serious impediment to cultivation
very severe	- surface composed almost entirely of rocks and stones

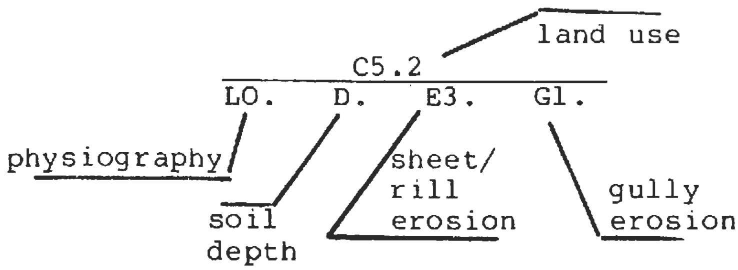
2. Baki Study Area (Drawing 108)

The Map Symbol

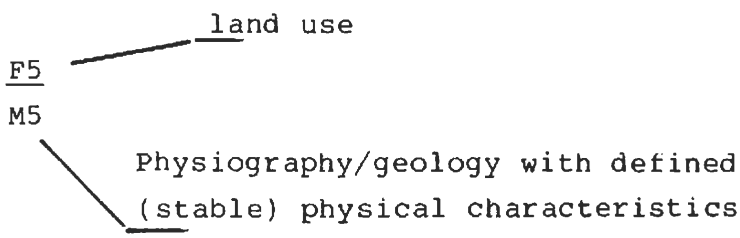
The map symbol has the following general form:

$$\frac{\text{Land use}}{\text{Land physical characteristics}}$$

Both differentiated and undifferentiated versions of this general format are used. The differentiated form is used for lowland areas (except terrace areas where space is limiting) where land physical characteristics may be quite variable. An example of the differentiated form is as follows:



Within the mountain units, gullies, and terraces, there was found to be little variation (at the mapping scale) of land physical characteristics, and an undifferentiated version of the map symbol is used, as follows:



As explained elsewhere, information presented on the map is less certain than that for the Hargeysa area, as a result of the very limited accessibility, even in the lowland areas. No attempt is made to present soil textural information as a sufficient distribution of observations was not possible. Soil depth and erosion are more amenable than texture to estimation by airphoto analysis. The limitations on the analysis, however, do not detract from the overall mission as decisions on the Baki area, specifically its rejection for pilot studies, were based on other factors vis: lack of climatic and flow data, cost of necessary structures, poor accessibility, topographic coverage, limited amount of potential agricultural land, non-representativeness of the dryland farming areas, and agricultural potential (based on general climate). Details on the natural resources were not an input into this analysis and would have been required only if a pilot project area had been selected here.

Land Resources Map: Map Legend

Land Use

Cultivated Land Uses:

C1 - Dryland agriculture, dominantly unbunded - up to 25% uncultivated

C2 - Dryland agriculture, dominantly bunded - up to 25% uncultivated

C4 - Irrigated land

C5 - Dryland agriculture field pattern (hedged)

- 5.0 Dominantly field pattern; up to 25% with no field pattern
- C5.1 Partial field pattern, mixed with P3 or P4 - 50 - 75% field pattern
- C5.2 Partial field pattern, mixed with P3 or P4 - less than 50% field pattern
- C5.3 Occasional field pattern, mixed with P3 or P4

Most of the land in the Baki area is hedged, usually showing some conformity to the contours. However, it is far from certain whether the intent of the hedge rows is soil and water conservation (contour hedging) or merely definition of land ownership and protection from animals. The hedges are sometimes natural -narrow strips of bush left between the fields - and sometimes dead brush hedges.

While there is plenty of evidence of field patterns, almost no evidence was seen of recent cultivation. However, it was unclear whether the land was fallow or abandoned. Thus the legend refers to field pattern rather than assumed use, and no fallow land was mapped.

Forest/pasture land uses:

F1 - Dense tree cover, almost complete crown closure
F2 - Moderate tree cover, partial closure
F3 - Thin tree cover, open canopy
F4 - Dispersed trees
F5 - Scattered trees
F6 - Occasional trees

This F-series was developed for the mountain areas. On the steep, rocky slopes, very few shrubs and bushes were apparent, the vegetation structure consisting of trees, of varying density, and a thin herbaceous layer. In many ways these are similar to the P3A, P4A and P5A land uses described for the Hargeysa area.

On the lowland areas, the P-series of forest/pasture land uses was found to remain appropriate.

P1 - Dense tree cover, almost complete crown closure
P2 - Moderate tree cover, open canopy
P3 - Thin tree cover, bush understory
P4 - Dispersed trees, bushes dominant
P5 - Bushes, with scattered trees
P6 - Grasses, with thin bush cover; occasional trees might be found
P7 - Very thin vegetation cover, mostly grasses with scattered bushes

Other land uses:

B - Togga bottoms - broad, flat, sandy bottoms, mostly devoid of vegetation

Physiography

Mountain units:

M1 - High, deeply dissected mountains; very steep slopes (to +100%); high frequency of dissection; sharp topography with ridges and peaks; few interfluve or wide valley bottom areas; granitic rocks (basement complex of SOGREAH)

M2 - Lower than M1, but still deeply dissected mountains, with high frequency of dissection and steep slopes (to 75%); sharp topography with ridges; few interfluve areas but some valley bottom areas; limestone rocks; a structure is sometimes apparent on the air photos, where the rocks are sharply tilted.

M4 - Lower, rounded, less dissected areas, with gentler slopes (typically 10-15%); primary distinction is dark tone on air photos, presumably due to rock type (gabbro).

M5 - Cuesta type limestone areas. Long moderate "dip" slopes ending in very steep escarpments. Dissection much less than other mountain types, but giving steep slopes. On some flatter areas, occasional cultivation may be found.

Lowland units:

L0 - less than 1% slope
L1 - 1-3% slope
L2 - more than 3% slope

V1 - Narrow, undulating valley lowlands, well defined between two mountain areas (M2, M5). Slopes 1 - 3%.

V2 - Slightly depressional drainage in lowland area. Frequently bunded for cultivation. Slopes 0 - 2%.

T - Terraces: Narrow, level (0-1% slope), alluvial terrace along major toggas. Higher terraces, with steeper slopes, have been excluded (included within L-units.)

Gullies:

G - Gullies. (For explanation, see description for Hargeysa study area.)

Soil, sheet/rill erosion, gully erosion, and stoniness are as for the Hargeysa study area.

APPENDIX A1.5

ABSTRACT OF USAID DOCUMENT

replicable technology, water gathering, which could substantially increase grain production in other similar areas during years of subnormal to good rainfall, although not during drought.

Approximately half the watershed was bunded. Late in the project period a second project was added: a brief intervention at another site to demonstrate flood-irrigation techniques by building three dams in the dry riverbeds that flow only after upland rainstorms, and canals and watergates to channel the diverted floodwater to fields.

This impact evaluation was done in March 1983, 17 years after AID's participation ended. The team found that grain production on the cultivated portion of the bunded watershed effectively doubled in the early years, with no other development inputs beyond the construction of bunds. However, subsequent maintenance by individual farmers was generally spotty; 16 years later the bunds had broken down in places and had not been built up to compensate for silting behind them, which led to a decline over time in the efficacy with which they trapped runoff and prevented erosion. Even so, at the time of our assessment, bunded farms were still yielding, on average, 50 percent more grain than similar but unbunded holdings.

The demonstration impact of this project turned out to be modest. Some private farmers subsequently hired tractors to bund their own lands. The Ministry of Agriculture followed up only years later when other international donors became interested in pursuing bunding in the northwest. The project's implementation style--use of heavy equipment instead of the earlier practice, which employed oxen teams or small-wheeled tractors for bund construction--clearly encouraged a trend that was only embryonic at the time: substitution of mechanical for animal traction by those farmers who could afford to own or rent tractors. Further replicable technology, water gathering, which could substantially increase grain production in other similar areas during years of subnormal to good rainfall, although not during drought.

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The team concluded that ignoring the agropastoral nature of food production in this semiarid area led to several sorts of slippage from the original plan. First, the environmental focus was ironically undercut by planners' ignoring the second farm crop--small numbers of home-kept livestock. Planners did not consider the potential impact of permanently cultivating the best watered part of the farm and its reverse implication, perennial grazing on the rest. Second, they assumed or hoped that crop production increases would provide sufficient incentive so that farmers would maintain the bunds. However, it appears to us that even bunded small-scale farming remains an unpredictable enterprise, useful as a supplement to extended family subsistence but not worthy of serious private "investment," and that maintaining the bunds properly seemed, to these professional agropastoralists, simply too labor-extensive to be worthwhile within their overall economic context.

The flood-irrigation subproject demonstrated a viable water-conservation technology to a religious community that was developing communal farming. Here the demonstration impact was significant; without any systematic training inputs from the project, the community observed the construction and the product, and subsequently replicated the technology at four new sites. The result was cultivation of enough grain to feed themselves and, of economically greater significance to them, the ability to produce for sale an important cash crop, gaad--a mildly stimulant drug that is widely used in East Africa and much of the Arabian

Peninsula. This strategy allowed the community to create dependable cash reserves and obtain farm machinery and chemical inputs in an environment in which the individual farmer finds these latter all too often unavailable through either Government or market channels. However, the cultivation and use of gaad were outlawed by Government decree during our evaluation visit; whether this community can make an adequate living cultivating only food crops with flood irrigation remains to be seen.

Like a stereoscopic photograph, these two very different approaches to the water-gathering problem illustrate a complex of issues that come to a focus in the nature of the development relationship between the less powerful but more knowledgeable rural "beneficiaries" who wish to get along and, if possible, get ahead, and the more powerful outsiders--government and international "development agents" who come with greater technical and financial resources and, all too often, predetermined policies and plans. We found that national and international goals were well served by the bunding project, which did and does contribute to reducing the national grain deficit. But at the local level, most of the resulting quality-of-life gains were captured by others rather than by the "beneficiaries." Conversely, national and international goals were poorly served by the flood-irrigation work, which has not contributed significantly to reducing Somalia's need to import grain, but has ensured its recipients of a degree of material security and well-being not found in the average Somalia community, as well as resources with which to continue their own development.

These results correlated, in the bunding case, with outside planning which then sought community acquiescence. By contrast, the flood-irrigation case evinced active community intervention in seeking out assistance with planning and implementation. These behavior-result clusters also correlated with the question of whether the activity aided was of paramount or merely secondary importance in the recipients' subsistence profile.

In other words, there was a conflict between local and outsiders' priorities. Where this was resolved in favor of the recipients, with the outsiders taking a responsive, technical assistance role, self-reliant behavior and local economic empowerment resulted, although the national and international economies were not necessarily helped. Where the conflict was resolved in favor of the outsiders, local people resisted until they had rendered the intervention safe; they subsequently remained uninvolved, although they extracted what benefits they could. "Community participation" may be a less manipulable commodity than is often supposed. In this particular case, the degree of participation (including subsequent maintenance) seems to link most directly to how important the aided activity was in the local, as opposed to the international, economic context.

It seemed to us that the local attitude, as expressed through reactions at the time of the project and subsequently, made sense. To aid small rain-fed farming in such an area, without considering possible long-term impacts on herding, is to ignore the economic, productive, and nutritional strengths of the area in favor of a weaker, secondary activity. Although pastoral production probably cannot be further intensified and farming can, we feel some doubt as to the marginal impact on the local economy, on rural food security, and on the national economic position of encouraging any large-scale conversion of pasture land to cultivation, or of further promoting unrotated grazing on already existing farms.

The scale of the AID bunding project was not so great as to create major adverse impacts on local herding. Thus, in general, it enhanced the dry-farming activity without seriously supplanting the area's economic mainstay. However, on a regionwide scale, the sort of policy most likely to lead to long-term food security is probably not a global drive to intensify and extend crop agriculture, but an eclectic one that exploits each area's profile of productive strengths and weaknesses to meet its profile of nutritional needs. Such an approach should be based on dispassionate and open-ended research, which gives rural producers voice-and-vote participation from beginning to end. It looks as though they know what they are doing.

2. Lessons Learned

1. Agropastoral subsistence depends more on the pastoral than on the agricultural base. Our observations and earlier findings in the northwest show that farmers cannot exist without herds, although herders can exist without farms. The interest in experimentation evidenced by exceptional communities like Ceel Bardaale and the willingness of individual farmers to seek out labor-saving developments or high-yield cash crops certainly suggest that the subsector may be less stable and more amenable to change than is the pastoral subsector. By comparison, the latter seems more stable, mature, and resistant to experimentation. However, in the absence of a major qualitative leap in the water-gathering potential of family farming, the secondary nature of this subsector will probably continue to dominate and limit the impact of agricultural interventions in agropastoral areas.

2. Projects that aim to enhance a productive subsector with a low relative priority for producers themselves (e.g., the agro in agropastoralism) should be designed so that basic success is not dependent on substantial community inputs before, during, or after project implementation. The bunding of the Arabsiyo

Valley delivered local and national economic benefits for a considerable period, even though most farmers did not consider it worthwhile to invest substantial work in maintenance. (This behavior is in sharp contrast to that of families and communities with respect to their wells and water holes.)

3. Projects that aim to enhance a weaker productive subsector should be preceded by sufficient research to ensure that the enhancement of the one will not occur at the expense of another, more valuable subsector. In the case of agricultural interventions in an agropastoral system, research questions should include (but not be limited to) such items as the potential impact on the farm family's entire nutritional profile; potential impact on the movement, browsing/grazing, and watering of pastoral herds that use the area; potential of the proposed intervention to encourage extension of the aided activity into other economic niches, and the likely impact such an effect would have on the area's overall economic well-being; and the like.

4. Projects that seek to enhance areal or national food security should be based on comprehensive, open-ended and dispassionate study of the entire set of nutritional resources and problems of each area, the overall productive resources and problems of each, and how these two may best be brought into congruence. This report has suggested some of the strengths and weaknesses of arid-land farming and its nutritional product. But the stronger subsector, nomadic pastoralism, also evinces weaknesses in meeting a spectrum of nutritional needs. The main ones are two: recurring seasonal scarcity, which affects nearly everyone; and, beyond that, a profile of access to livestock products that discriminates against women and young children, the most vulnerable rural groups.

The complementary strengths and weaknesses of different parts of the resource base can best be combined and enhanced by an eclectic approach to the broad issue of food security, which seeks to build on local and national strengths. Once the basic research is done, such an approach can utilize a small number of basic strategies, tailoring them in their relative emphasis according to the problems and resources of each area and allowing heaviest dependence to be placed on the strongest capacities of each.

5. An "appropriate" rural technology fits into existing social organization rather than depending for its success on social tinkering by outsiders. The principal strengths that AID and urban professionals from the host country bring to the development relationship are specific technical capabilities and great material resources. Creating, transforming, or simply building up rural organizations to meet new needs is, in most cases, probably best left to the discretion and greater social skills of the beneficiaries themselves.

6. Local communities invest themselves according to their own, not donors' priorities. Where local priorities do not coincide reasonably closely with those of the national government and the international development movement, some trade-off will have to be made between a public-works approach, wherein "community participation" will be more or less limited to being persuaded to accept implementation of the project, and an empowering approach, which responds to urgent local expression of priorities, even if current national or international goals will not be served by the resulting project.

Arabsiyo and Ceel Bardaale contrast so sharply that they almost define this spectrum, and from them a sharply separated group of correlations can be drawn. We found that the degree of learning (not training) that occurred--of active community participation before and during implementation, subsequent maintenance and replication of the technology provided, and resulting quality-of-life gains by beneficiaries--was high in the case of Ceel Bardaale, which pestered AID until it got the necessary technical help, and then used the result to serve its own interests far more than those of outsiders. The converse occurred at Arabsiyo, where the initial plan was formulated by AID and the Ministry, and (undoubtedly) rubber-stamped by local leaders when they were consulted; early implementation met not even with complete acquiescence but with scattered violence, although recipients of bunding ultimately accepted and were pleased by the results. Bunding supported the nationally and internationally important goal of increased grain production, but by all indications did not greatly help its primary beneficiaries to get ahead.

The findings of our study strongly suggest that, by their long-term patterns of choice if not in explicit conversation with outsiders, rural people in northwest Somalia and perhaps in many other places are more in tune with the long-term productive and nutritive realities of their area than are the development outsiders. If this is the case, local communities should be better heeded during project planning.

7. As a step toward this goal, the current trend to cross-disciplinary baseline studies, in AID as elsewhere, should be encouraged and refined. Rural people must be brought into the research, planning, and resource-allocation processes not as subjects of inquiry, but as participants with voice and vote. Otherwise, they have no reason to trust us with their knowledge. Such studies and planning should guide the formulation of policy rather than be directed by it.

APPENDIX A1.6

SOGREAH BUNDS VS. HEALTH

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SOGREAH BUNDS VS. HEALTH

(The Health of Rainfed Crops and Deficiency Phenomenon)[1]

1. Crop Health

Before going on to discuss the health of rainfed crops, principally sorghum, in the North West Region, several comments must be made.

At the present time, bunds are being constructed at great expense, supposedly as a protection against erosion and to improve crop grain yields, and consequently the total production of the region. In reality what can be observed? The yields do not increase at all after the construction of the bunds (these are more than 1 metre high, are of variable length and are spaced at 30 m intervals whatever the topography of the site). The only change in yields has been noted in the low land areas (cf. Agronomy Report No. 7) and sometimes on the steeply sloping transition areas. But when it is recognised that the yields have only increased slightly, in actual fact the production per hectare has effectively diminished. This is because the bunds occupy about 15% of the land area and reduce the cultivated and sown area by a corresponding amount. The area actually available for agriculture is thus only 0.85 ha for each hectare of arable land originally available. In addition, part of the fertile horizon is very often removed and used in the construction of the bunds this is also prejudicial to the improvement of yields.

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[1]Excerpt from: Agricultural Development Programme A - Rainfed Agriculture, Vol. 1, Agricultural Development. SOGREAH Report No. 14, June 1982.

This method is therefore not an ideal way of improving the output of the North West Region, however this does not mean that this procedure should be completely discarded. However, if an effort has to be made to prevent soil erosion, it is not sufficient to create bunds anywhere and anyhow and only in the cultivated fields according to the whims of the farmers, but it is essential to have an overall policy which will make an effective contribution to erosion prevention not only in the agricultural and pastoral areas (pasture with good potential) but also on the plateau region where rainfall can be high.

Consequently this physical action at present being undertaken should not, and must not, make the responsible authorities forget the very serious health problems which are being experienced with the main crop productions (sorghum for example).

Without any doubt, taken as a whole, crop health is in a deplorable state, not that it could be described as dramatic. However the additional yields which could be obtained by instigating a phytosanitary crop protection campaign as part of the project would be relatively very considerable compared to what is at present being achieved by the land improvement schemes (the bunds in their present state of application). These gains would be very much more noticeable than those already achieved in the developed lowland areas, given that a crop health campaign would have an impact over the entire cultivated area. The result obtained would, without any doubt, be very considerable as regards the grain production aspect of the agricultural development of rainfed crops in the North West Region.

Although these may be useful for various reasons in certain landform situations, the construction of bunds must not allow the considerable production losses due to different causes to be forgotten. These production losses are caused by cryptogamic diseases, insects, soil mineral deficiencies and the degeneration of the crop varieties (in some of the low land areas which have been developed using bunds the vegetation is sometimes more luxuriant. However all the crop enemies have been attracted to this luxuriance and are correspondingly more numerous and it is difficult at times to find a healthy plant).

During the agronomic investigations, the main causes of production losses were investigated; however no attempt was made to find direct links between the rainfall or cropping practices. The main characteristics of these factors and the means of combatting them are discussed below.

APPENDIX A1.7

SOCIAL SURVEY WITHIN THE PILOT PROJECT AREAS

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SOCIAL SURVEY WITHIN THE PILOT PROJECT AREAS

1. Population

The Booli Diido and Geed Abeerah PPAs have been settled since 1896 and 1920, respectively. Respondents said they think of themselves as farmers and that past experience has shown them that the land is always there, while livestock can be eradicated. However, all respondents kept livestock because harvests did not always meet family requirements and livestock could be sold or slaughtered to supplement the family's food supply. Livestock is also a traditional Somali symbol of wealth.

Much of the male population drive the herds to the southern pastures during the growing season. Some said they would give up their semi-nomadic existence if harvests alone could assure their subsistence. In this case they would reduce their herds.

There is a single clan living in each PPA, the Hassan Mikael in Booli Diido and the Abdale Aboucar in Geed Abeerah. A nabadon is the leader of these clans. The fact that the PPA population belong to a single clan should facilitate cooperation on watershed control measures.

Lack of money was cited as a major problem by most persons interviewed. About one quarter of the population leave the PPAs in order to work in Hargeysa or Djibouti as unskilled workers. Some of these send money back to their families in the PPA. A few of those still in the PPA earn additional income by charcoal production, selling stones for construction, and doing construction work in Abarso or Arabsiyo.

2. Land Tenure

The October 1975 land reform law nationalized privately-owned land, and land concessions were granted to farmers which are transferable to their heirs, but cannot be sold or leased. According to the law, if a farmer does not cultivate the land for 2 successive years, he can lose the concession.

In practice, however, the farmers in the PPAs only register their land with the government as a prerequisite for project bunding. Although the law says land cannot be sold or rented, in actual practice it is, though only to members of the same clan. The sellers are usually members of the clan who have permanently left the PPA. The majority of the land is transferred by inheritance from father to son. Sometimes several brothers inherit a farm and they decide amongst themselves who will farm it, or they divide the land if the farm is large enough. If the land cannot support all the brothers, some brothers leave the area.

3. Agriculture

As mentioned above, the PPAs have been settled for quite a while, and the inhabitants say they consider themselves to be farmers. However, they also rely on livestock and men leave the area to drive the herds from after seeding to harvest time. When they are gone, women sporadically take care of the crops during the growing season.

Constraints to agriculture were reported by different farmers as being lack of money (almost all respondents stated this), lack of rainfall, lack of bullocks for land preparation, lack of maize seeds, unavailability of tractors, and diesel shortages at critical periods.

Only sorghum and maize were grown in the PPAs in 1985. Farmers reported having grown tomatoes, watermelon, onions and beans in the past. While some had success with these crops, most did not. Qat was a major cash crop before its being outlawed in 1983, and farmers have keenly felt the loss of this income. When asked why they did not grow millet, farmers stated that birds like millet too much, that animals do not eat millet straws, and many said they were unfamiliar with the crop. As for wheat, they said it's a short crop and the digdig attack it, that they were unfamiliar with the crop, or could not obtain the seeds. They also lack seeds for other crops. Women interviewed in the PPAs said they didn't know how to prepare millet or wheat.

Farmers were generally unaware of the use of inputs. Only two applied animal manure to their fields. No farmers used treated seeds. Farmers purchased seeds locally or used the seeds from previous harvests.

Farmers reported washing their sorghum grains and the barrels or pits used to store them with kerosene in order to repel insects.

4. Extension

While many farmers in the Booli Diido PPA reported having spotted project extension agents in Abarso, none of the farmers interviewed had ever been visited by extension agents since installation of the bunds. A few respondents had approached the agent in Abarso to request a visit to their farms in the PPA, but apparently got no response. Two of the Geed Abeerah farmers had visited the Aburriin Demonstration Farm, located approximately 12 km from the PPA. One of these farmers got insecticides in 1978 and used them successfully. The other requested treated seeds, but did not receive any. Most of the farmers indicated they wanted advice on cultivation techniques and the use of inputs. Most said they had no knowledge of row planting, the use of fertilizers and other inputs, or improved varieties of seeds.

It is recommended that an extension program be set up within the PPAs to provide agricultural and watershed control information. As described in the agricultural sections of each PPA, few farmers had sufficient production from their land to market surplus. In fact, many farmers' production did not meet their family requirements. As NWADEP expects farmers to benefit enough from bunding to pay back the cost of these measures, efforts must be made to increase yields.

5. Livestock

There are many livestock in the area, and though farmers are aware that uncontrolled livestock grazing contributes to the erosion problem, they were unwilling to part with their livestock. This is partly because of the importance of livestock as wealth in the Somali society, and partly because livestock could be sold in bad agricultural years.

6. Erosion

All the farmers interviewed were very aware of how serious the erosion was in the area, as most had lost a part of their land to this. Some of the farmers attempted erosion control measures on their own (diversion canals, trees, etc.), with variable results. Almost all wanted additional bunding because of its role in reducing erosion losses.

When the team spoke to farmers about their readiness to accept and participate in various erosion control measures, at first they indicated that they were willing to cooperate with any necessary measures (integrated bunding, tree planting, control of livestock grazing). However, as word got around of proposed measures, objections began cropping up, mainly with regard to integrated bunding. The main concern was the issue of farm boundaries. They envisaged problems between neighbors and families, strife, conflicts and arguments if the bunds crossed farms. The farmers expressed concern that if fences were used to demarcate the limits of farms (running across the integrated bunds), that these fences could be moved. They reluctantly agreed that cement monuments marking farm boundaries could be a solution. They also raised the issue of access paths and claimed integrated bunds would be obstacles for walking.

Farmers said that in the past they had cooperated on harvesting, fencing, lending bullocks, and taking care of another's farm if he was ill. They said they would be willing to cooperate on fencing, controlling livestock grazing and reforesting. The nabadon of the Booli Diido PPA said he could coordinate such activities. We did not speak with the nabadon of the Geed Abeerah PPA, but he or the local committee would be a good contact point for organizing farmer participation in erosion control measures.

Unless the farmers themselves participate in and accept erosion control measures, the likelihood of success is not great. Farmers have become accustomed to the NWADEP providing free bunding, and do not even attempt to repair the bunds themselves. They all requested additional services such as additional bunding, extension, wheelbarrows, bush clearing, land leveling and water points. Though they said they would pay for bunding if they had the money, most claimed to not have any money. They all seem to expect that they will continue to receive goods and services free.

Erosion control measures such as fencing and tree planting could be performed by the farmers, if given the materials.

NWADEP QUESTIONNAIRE TAMS

1. Farmer Name ______________________

2. REER ______________________

1985 Land Allocation

3. Cultivated area ________
   Fallow area ________
   Bush area ________

4. No. of bunds ______ Year bunded _______ By whom _______

5. Is bunding successful? _______ % increase __________
   Do you want additional bunds? __________
   Willing to pay for it? __________

6. Date farm established? ______ Date land acquired? _____
   Land registered? _______ Year _______

7. Total household _________ Any literate? ________
   Males over 15 _________
   Females over 15 _________
   Males under 15 _________
   Females under 15_________

8. Males involved in cultivation ________
   Females " " " ________
   Children " " " ________

9. Males involved in livestock ________
   Females " " " ________
   Children " " " ________

10. Other economic activities or income?

11. 1985 Crop Production

Sorghum: Allocation ________ Production ________

Is yield avg.? ____ How stored? ________

Was prod. fully consumed by household? _____

Did it meet 1985 requirements? ________

If marketed, how much, where and what price? _____

Maize : Allocation ________ Production ________

Avg. yield? _______ Storage? ________

Consumed? _______

Meet req.? _______

Marketing? _______

Any other crops (millet, wheat)? _______

Why not? ________________

12. Constraints to production ___________________________

13. 1985 Inputs

Land preparation: Mechanization? ____ Source: ________

# of hours ____ Cost per hour___

Animals? ____

Seeds: Purchased? ___ Source:______ Cost ____ Kg used ___

Other inputs: (fertilizer, insecticide, pesticide, or disease control?) ____________________

14. Hired labor in 1985? _______
How many? ____ Cost per man/day:_____ Total man/days _____
What operations? __________

15. Credit obtained in 1985? __________ Source:_________

16. Current livestock

	(Head) Sedentary	Nomadic
Cattle		
Goats		
Sheep		
Camels		
Donkeys		
Bullocks		
Chickens		

Total value animals sold: _____________
" " " bought: _____________

Income from milk products? _____________

17. Any extension services provided by project?

18. Any erosion problems?

19. What are you doing to combat erosion?

20. Comments: