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Djibouti Water Resources and Soils Analysis

FINAL REPORT

Volume I - Main Report

Resources Development Associates

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ACKNOWLEDGMENTS

This report has been prepared by Resources Development Associates for the United States Agency for International Development under Contract Number AID/afr-C-1673.

Dr. Joseph E. Goebel, Soil Scientist and Senior Technical Advisor, directed the technical assistance provided under this project and contributed the majority of this Final Report. Assisting Dr. Goebel was the staff of the Djiboutian Soils and Water Analysis Laboratory. Mr. Aboubaker Douale, Chief of the Laboratory, was the Senior Djiboutian Soil Scientist and was responsible for soil inventory and mapping and for overall administration of the laboratory. Mr. Farah Omar, technician for the Soils and Water Laboratory, conducted chemical analyses of both soils and water and assisted with the inventory of soils.

This project could not have been successfully concluded without the interest and assistance of several key persons and offices of the Government of the Republic of Djibouti, foreign donors, and USAID. Particular thanks go to Mr. Ahmed Hassan Liban, the Minister of Agriculture and Rural Development, for his general support of this project; to Mr. Mohammed Awale, Chief of Service Agriculture and Forestry Service, for his assistance in achieving autonomy for the lab and in personnel administration; to Mr. Mohammed Waberi, Chief of Service, GENIE Rural, and to his staff, for their assistance in construction of the laboratory and for their administrative assistance prior to laboratory autonomy. Additional thanks go to Mrs. Beverly Rollins of the Agriculture and Forestry Service for her assistance in preparation of the land ownership maps; to Dr. Mueller, Dr. Bornhorst, Dr. Merkt and Mr. Traeder of the Cooperation Hydrogeologique Allemande who kindly shared technical information and assisted with logistics; to the staff of Djibouti's National Higher Institute of Scientific and Technological Research (ISERST) for their technical assistance; and to the Governors of the Departments of Obock, Tadjoura, Dikhil, and Eli Sabieh for their kind hospitality to the project team while in the field. Finally, particular thanks are due to Mr. Ellsworth Amundson, AID Affairs Officer for USAID/Djibouti. Mr. Amundson has been instrumental in successful coordination of many of the administrative and political issues inherent in a project of this sort.

1.0 EXECUTIVE SUMMARY

Upon its independence in 1977, the Republic of Djibouti (Figure 1) found it necessary to have an independent agricultural capability and entered into an agreement in 1979 with the United States of America to assess national agricultural and water potential. A Soils and Water Laboratory was established to identify, locate and evaluate suitable agricultural areas.

An American specialist, Dr. Joseph E. Goebel of Resources Development Associates, with Mr. Aboubaker Douale and Mr. Farah Omar of Agricultural Service, Djibouti, established a soils and water testing lanboratory in GENIE Rural of the Ministry of Agriculture to inventory and evaluate the country's soils and test for fertility and water quality. They also evaluated the results of their studies from 1980 to 1982 to determine where and which techniques would be applied to develop the agricultural potential.

A soil survey of the entire country resulted in 55 soils identified and located on maps of 1:25,000 scale, 1:100,000 scale, 1:300,000 scale and 1:500,000 scale. These maps show the location of soils suitable for irrigated agriculture, rainfed agriculture, range and watershed. The Soils and Water Laboratory has been installed with ~~all~~ the equipment necessary to conduct tests for soil fertility and management as well as tests for water quality.

The result of this effort is the identification of a significant agricultural resource capable of supplying a large portion of the country's agricultural needs. Suitable soils and good quality water are associated with the wadis. Therefore, farming will be widely distributed and rainfall dependent. The information collected in this project should permit the Republic of Djibouti to initiate and develop national agricultural objective and policy to reach agricultural self-sufficiency. Photos #1 through #6 illustrate the present status of agriculture in Djibouti.

1.1 Project Goals

The goal of this project is to expand Djiboutian agricultural production through irrigated gardens to the level that the country can realize import substitution, primarily in vegetables and fruits. This goal probably cannot be achieved in its entirety in less than twenty years.

At issue are the economics of developing an agricultural base in Djibouti. This project will serve to provide a data base for decision-makers. However, in the ultimate analysis, it is

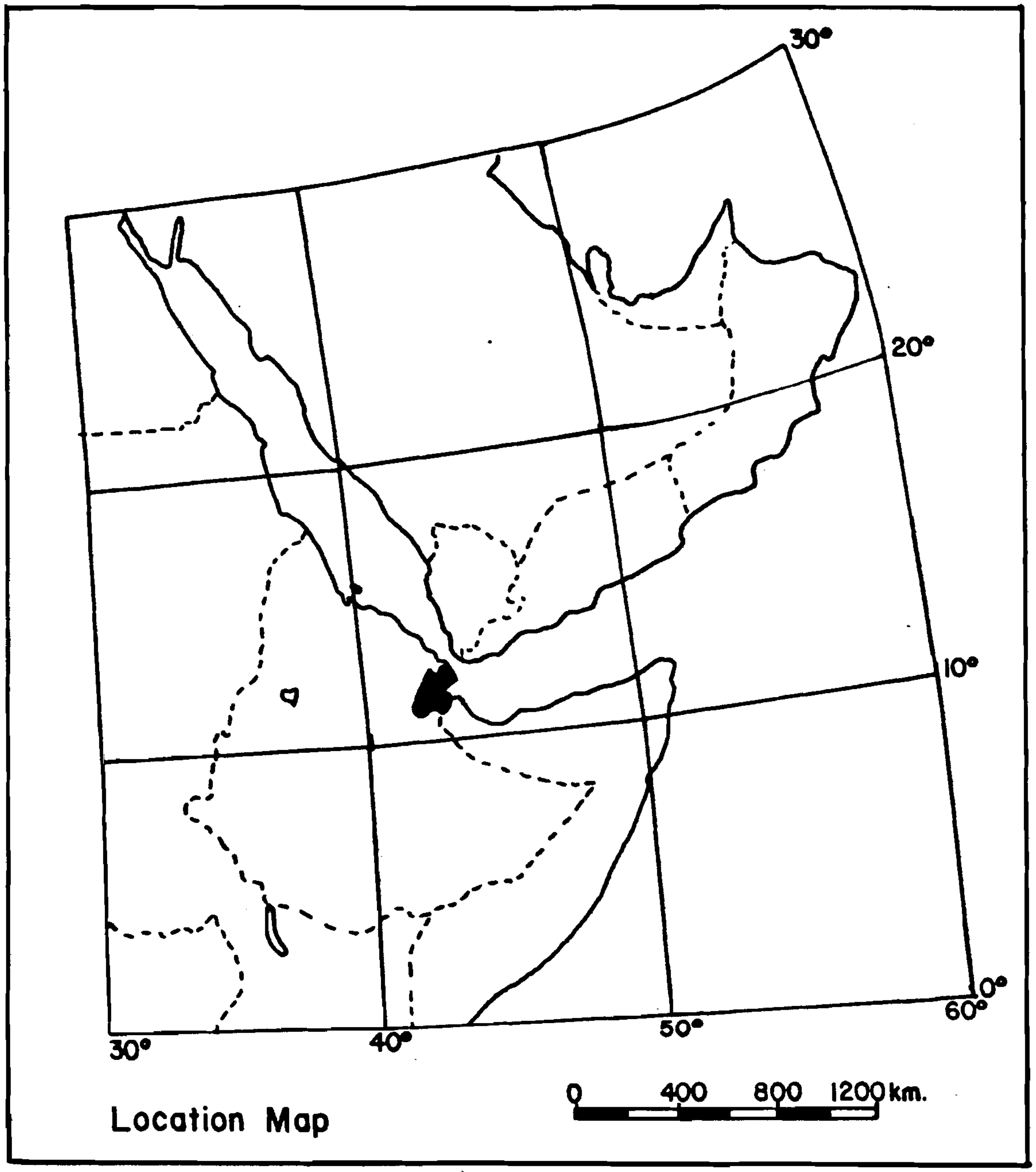


Figure 1: Location Map of Republic of Djibouti

Photo #1: Dates are one of Djibouti's oldest and most successful crops

Photo #2: Gardens like this show agriculture is already established in Djibouti

Photo #3: This is the channel for the Houmbouli Wadi. It moved to this location exposing this old irrigation well. The water in this channel is low in salt, and should be taken to the nearby Houmbouli gardens

Photo #4: We see mangoes, dates, oranges, lemons, and guava well established. The field will be planted to tomatoes, okra and eggplant

Photo #5: This is a typical wadi channel that soaks up flood water quickly. Flow is retarded by the natural dam in the center of the photograph

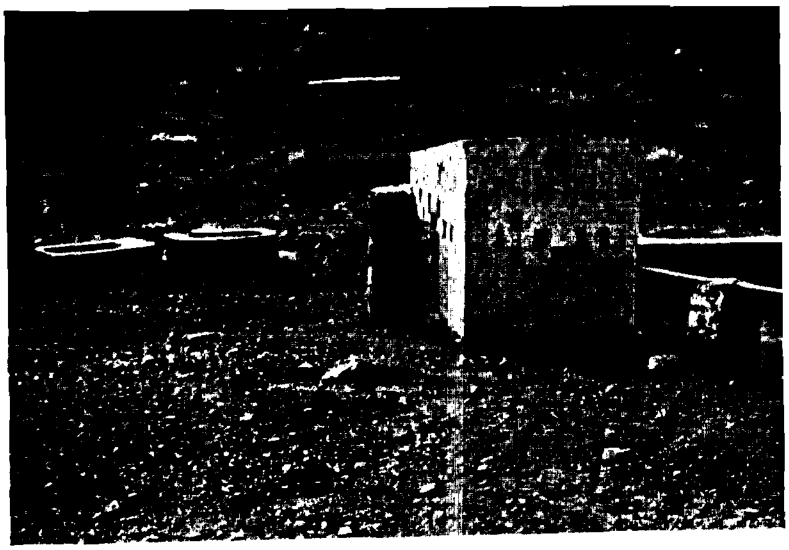


Photo #6: Pictured is a well that has been developed in a wadi channel to provide water for a new garden not soils nor necessarily even water, that will prove the limiting factor, but rather the investment costs versus the returns. Agriculture can be capital-intensive and presently the return worldwide is low on that investment.

1.2 Project Purpose

The overall purpose of the Soils and Water Laboratory project is to institutionalize the capacity to (1) analyze ground and surface water quality as well as compile, catalogue and disseminate hydrological information, and (2) classify soils, prepare soils maps and provide evaluations concerning the proper utilization of soils within the MADR.

In practical terms, farmers can be advised on soil treatments to obtain sustainable yields. Achievement of this project purpose should impact on the sector goal of developing an information base for use by the GROD in national agricultural planning and its dissemination to farmers through an agricultural extension service.

Now, at the end of the project, the staff of the Water and Soils Laboratory:

> possesses equipment and technical expertise to independently analyze all water and soils types in Djibouti; has necessary data upon which to base recommendations for water and soil use for crop production and provide guidance for subsequent soils and water resource analyses in the field; has undertaken a soil inventory and developed a land classification system in selected priority areas.

1.3 Beneficiaries

The immediate target is a Djiboutian infrastructure capable of addressing the needs of present and future Djiboutian farmers. While this project will not have a direct impact in and of itself, it will, coupled with water data furnished by another donor, provide a solid base upon which the Government of the Republic of Djibouti can make rational and positive decisions regarding diversification into the agricultural sector. More importantly, it will allow the government to reap maximum benefit from any investment into the agricultural sector.

1.4 Project Schedule and Progress

The Government of the Republic of Djibouti requested assistance from the U. S. in determining its long-term potential for agricultural development. By analyzing data on soils and water resources, Djiboutian officials are able to make rational economic decisions regarding Djibouti's future development in food production.

In January, 1979, the two governments entered into an agreement. In April, the scope was limited to soil survey and laboratory establishment. West Germany offered to evaluate the hydrogeologic capabilities. In February, 1980, a building was constructed by the Government of Djibouti to house the laboratory. In March, the initial equipment arrived. In July, 1980, technical assistance from Resources Development Associates arrived and the Agricultural Service assigned a degree-trained pedologist, Mr. Aboubaker Douale, for training as a counterpart. In August, additional equipment and supplies were ordered and the layout for the laboratory facilities were drawn up. During construction, work began on the soil survey. In October, the Agricultural Service assigned Mr. Farah Omar to assist with the effort. Field work and map compilation continued until the construction of the laboratory facilities were essentially finished in January, 1982. The equipment was then installed and training began on laboratory procedures in soil and water analyses. Chemical supplies arrived in February, 1982. The reconnaissance and semi-detailed soils mapping was completed in March by helicopter where remote sites were not accessible by vehicle. During the winter of 1981/82, the agricultural areas of Houmbouli and Douda were monitored for electrical conductivity of the irrigation water. At the same time, the property ownership maps for these two areas were begun. In June and July the soils were interpreted and a report prepared. At this time, the laboratory also received an institutional budget and autonomy under the Ministry of Agriculture.

The laboratory will continue to receive technical assistance for a few years from the U. S. Department of Agriculture. Further, the laboratory technicians are scheduled for formal training outside Djibouti. This will include one and one-half years of graduate study in soil chemistry; six months of USDA-NSSL and USGS laboratory training. The laboratory assistant will receive two months training at USDA-NSSL, and each of the two new employees will receive one year basic laboratory training. The laboratory should then be fully functional and operating on its own.

1.5 Project Results

In crossing the country and describing the soils at the sample sites, the Project Team acquired first-hand knowledge of each of the soils in the country. The Djiboutian technicians were trained to describe, sample, classify and map the soils. The team made a 1:300,000 general soils map of Djibouti and described and evaluated the major soils of the country. It also made a 1:100,000 scale reconnaissance soils map of the country and 1:25,000 scale soils maps of selected areas. Semi-detailed soils maps of selected watersheds were produced using the reconnaissance soils legend. The team located and identified potential agricultural and range sites. It described, classified, and interpreted the soils identified to date. To help farmers and to give them scientific recommendations for farming and ranching, laboratory facilities were established to test the soil and water, and properly inform the land-user.

Other accomplishments included establishing a technical reference library. Land ownership mapping was initiated at a scale of 1:5,000. Watersheds were mapped at a scale of 1:100,000. Major land slope categories were mapped at a scale of 1:100,000. Both of these maps are necessary to evaluate water availability. A soil climate map was constructed at a scale of 1:300,000. A general elevation map was constructed at the same scale. A five percent (5%) one-square-kilometer random sample was established for continuing resources evaluation and land-use monitoring for better agricultural information.

Nearly all of the equipment and chemicals are installed and in place. The only equipment remaining to be delivered are items for the Perkin-Elmer analytical apparatus and the conductivity meter. These items have been shipped. Training has been received on soil survey, laboratory techniques and management. The laboratory has been established within MADR to better serve its diverse users. A budget has also been established to meet the operational needs of the laboratory. Further training of present and future personnel has been planned. The laboratory is operational. The following analyses can be made: with the laboratory as it existed six months ago: particle size, calcium, magnesium, total salts, sodium, SAR, pH and phosphorous index. These are the determinations needed to answer most of the questions dealing with agricultural development. It needs time and practice to become efficient and to achieve its potential. Additional tests needed to answer classification questions will be started this year as soon as the last two pieces of analytical equipment are operational. These tests include potassium, saturation extract, NO3, Carbonate equivalence, CEC, base saturation, OC, Boron, gypsum, sulfate, chloride, carbonate and bicarbonate.

1.6 Recommendations

1.6.1 Agricultural Recommendations

Water is unquestionably the most important factor in agricultural production in Djibouti. Large quantities are required over one to several months and the quality must be very high to prevent rapid salt accumulation in the soils. As a result, one must look seriously at where the water occurs, the quality of water available, and how to manage the water in agricultural production.

The locations of accumulated water are basically four in nature. One area is where the rainfall occurs on mountains having elevations over 900 meters. Rains occur more frequently throughout the year in these areas. Floods of these areas replenish the water within the wadis of Weima, Sadai, Gobaad, and Hanle. This area is the source of water for all the wadis from Sublali, along the coast, all the way around the Goubbhet.

The second place that can be considered is the wadi channels in the interior of the country. Wadi channels flood from time to time. The wadi water infiltrates rapidly into the channel, and if the alluvium is thick enough, a temporary reservoir is established which can be used for some period of time to irrigate crops, depending on local wadi conditions.

A third position suitable for collecting water is the foot slopes of the mountains and the hills where sheet erosion and even gully erosion are presently active. This water can be channeled and directed to accumulate on more level areas, as a consequence, increasing the moisture availability for crop production.

A fourth place is playa basins. Often, the short slopes and the narrow watersheds around the playas supply run-off water into the playas. If this is redirected and ponded, it can be concentrated on select areas to increase water availability and thus crop production.

It must be remembered that the water available and stored by the present active system is about as efficient as can be expected. When the rainfall is high and the run-off is high, the water flows down the permeable channels and infiltrates them, recharging the groundwater, and recharging alluvium. It also permits the accumulation in playas, which have a silt cover and are semi-impermeable to the water. As a result, any kind of engineering would probably eventually inhibit this recharge rather than improve it. Therefore, agriculture should adapt itself to the natural flow and availability of water rather than attempt to dominate it.

Throughout the country, highest quality water occurs in the wadi channels where it is recharged regularly with fresh clean rainwater. After leaving these channels, it encounters bedrock and sedimentary rock, which are impregnated with salts. The salt content rises and the toxicity of some elements increase.

At this point, it seems that we can consider the deep groundwater from deep aquifers to contain toxic levels of boron, which inhibits full healthy plant development. As a result one should look to utilize the water as soon after it rains as is feasible.

1.6.2 Soils

Soils are the next significant factor in crop development. The soils in Djibouti near the geomorphic positions associated with water accumulation are normally suitable. Except on the coastal plains, the soils are not salty, although they are calcareous. Most soils are coarse texture and will have moderate to high permeability. The soils suitable for agriculture occur on the first and second terraces along the wadis. They also occur on the colluvial deltas and on the footslopes and pediments. The soils in the playas are also suitable for cultivation. There are other areas which are suitable for cultivation but don't have water available. Most of the other areas with soil are suitable for range and also as watersheds for accumulating water.

1.6.3 Soil and Water Development

Any agricultural system in Djibouti will depend on rainfall. Rain is the only source of salt-free water. Water is only available where the rainwater accumulates. Rain occurs in short intense episodes. Because agriculture requires water on an intermediate to long-term basis, two months to a year, the water must be stored. It must be available at the time of the crop requirements. Water storage is a rate-of-time function. Rainwater accumulates in the wadis during floods. It infiltrates into the channel and flows along slowly inside the channel sediment. Hére, the rainwater is protected from evaporation by the channel sediments. It is available over several months or several days in the channel by this retarded movement. Several years later, it may reappear as groundwater in deep aquifers.

Rainwater on the pediment slopes, that is, water running off as sheet erosion, distributes water that infiltrates in the soil where it is stored for one to two months. Water may be stored in channel sediments, in groundwater aquifers, or in the soil itself until it is used by the crop. Therefore, it need not be stored in reservoirs. The main concept of water availability in Djibouti is knowing how much water is flowing through the system during a given period of time, so that one can know when and how much water is available to the crop during that period. This is related to the time between a rain and the time the sediments have too little water for crop production. Knowing this, one can calculate the kind of crop and the type of water retrieval system needed to grow that crop.

The following is a strategy for crop production. The longest-lived most valuable crops must have the highest quality and most dependable water source. The lowest quality crop and the fastest growing should be relegated to the most unreliable water source. Water from the high mountains represents the most dependable, high-quality water supply. Tree, bush, and vine crops are the most valuable, long-lived plants. They should be planted in association with water from the high mountains. This suggests that deltas and colluviums from Tadjoura west around the Goubbhet should be planted in fruits.

Cereal grains and oil crops represent intermediate growth crops requiring extensive areas and water supplies from three to nine months. These crops should be planted along any of the other wadis on the first and second terraces anywhere in the country. They can be planted after the rain has established how much water is available in the alluvium to plant the crop. This means that the wadis of Weima, Hanle and Gobaad are particularly suited to grain production. Frequently, other smaller watersheds near Eli Sabieh, Dorra, Khor Anghar, etc., may have water available for grain production.

Finally, the short-lived forages should be planted where the water has the least durability, the lowest-quality, and the highest risk factor. That is, it should be planted on extra land by the wadis or in the areas where the water is concentrated along pediments, and in playas. They should be short-lived cereals and grasses which are harvested as soon as they show drought stress.

1.6.4 Environmental Impact

This strategy and these concepts will, of course, have environmental impacts. These include the following:

1. There will be an increase in the number of birds, insects, and wild animals due to the increase in vegetation.

2. There will be an increase in domestic livestock with added occupancy and grazing in areas near to livestock concentrations. This would tend to encourage over-grazing near farmsites.

3. Due to the agricultural settlement, there will be a general increase in the cutting of bushes for fencing.

4. Since the rainwater is the source of ground-water recharge, the use of water for irrigation will directly affect the recharge rates and lower water availability from the deep wells. Water availability at some of the permanent well sites will also be reduced or eliminated as the water is withdrawn upstream from the alluvium. The use of the remaining water sites for longer periods without flushing the water holes and also bringing the livestock to permanent water sources, will probably increase livestock disease. Finally, because of water diversion structures, natural erosion and gully and sheet erosion will be diverted and reduced.

1.6.5 Preliminary Needs

The Ministry of Agriculture and the

Government of Djibouti have some initial requirements to meet before agriculture can begin. One of the things that should be initiated early is more active contact between the Ministry of Agriculture and present farmers, principally to develop a program for assisting the farmers when development is completed. There should be a more active Agricultural Service which will function in a direct association with the farmers and farmer organizations.

Djibouti also should establish clear land ownership policies and laws and should develop procedures for land users to acquire title. The country's land can be considered as capital to repay the potential land-user for a certain number of years of man-labor which could be performed in public service to assist the country in achieving many of its public works programs.

Further, the country needs now to begin to establish legal rights to water, for the livestock, for industry, for urban needs, as well as for agricultural needs so that programs can be designed to meet those needs. In this way, a farmer enters his project knowing he has the assurance of continued water supply.

In order to continue with national development of agriculture in Djibouti, additional technical assistance is required. The following is a list of short-term specialists that could make a meaningful contribution. These would include:

Agricultural Economist
Cadastral Expert
Agricultural Engineer
Irrigation Engineer
Water Rights/Distribution Specialist
Cooperative Expert
Animal Husbandry Specialist
Agronomist/Horticulturist/Agricultural Extensionist
Social Scientist (able to look at the impact of the agricultural developments on the attitude of the people and monitor the change)

Djibouti is no longer a nomadic state; it has farmers; it has agricultural production; it has agronomists; it has governmental and private agricultural institutions, and it has agricultural experience. It has identified more agricultural resources than were previously known. If Djibouti dedicates its effort to the established objectives, and is willing to commit itself fully, it should be able to produce enough crops to feed the current population or more.

1.6.6 Problems Encountered

Several factors affected the efficient

completion of this project. If they had been rectified earlier, the laboratory would have progressed further in meeting these objectives.

In the initial agreement between the two countries, no provision was made for an operational budget. This resulted in spending a large segment of time and effort searching for a solution, writing the required law to establish legal status for the laboratory and subsequently authorizing personnel positions and budget. Without this authority, it was often impossible for the personnel assigned to the project to acquire basic assistance and funds to meet the objectives. This problem was successfully resolved by an act of the National Assembly and the President of Djibouti.

Personnel management also presented complications. All of the personnel were assigned from outside institutions. None of them had internal authority to specifically execute the responsibilities assigned. This conflict was resolved by the goodwill and cooperative assistance of everyone in the laboratory and everyone connected with it. Particular thanks are due Mohamed Awali, Chief of Agricultural Service, who supervised the men assigned to the project. His cooperation and support was not only essential, but outstanding.

Construction presented another serious series of delays. Without a budget materials could not be purchased. Mr. Mohamed Waberi, Chief of Genie Rural, used funds from his budget, where and whenever possible. He also assigned laborers to the work. Nevertheless, the construction of the laboratory facilities took one and one-half years and required constant supervision. Training for laboratory analysis of soils and water was delayed such that some training will have to be done in short intervals over the next few years. This also resulted in a small extension to the project in order to complete the reporting.

Yet another major delay was the acquisition of material and equipment. It was over a year and one-half between the time the necessary chemicals and other materials were selected and their delivery effected. This had the same detrimental effect on the project as the delayed construction.

2.0 INTRODUCTION AND BACKGROUND

The purpose of this report is to outline the activities of the Soils and Water Laboratory Project, to submit the findings of the investigations conducted in this project, and to present the recommendations concerning agricultural development in Djibouti resulting from the effort of this project. The government established a soil and water analysis laboratory for the analysis and inventory of the soils and water resources and to provide technical assistance to range and agricultural development. Field information was transferred onto a 1:100,000 scale topographic map and a more detailed soil map was generated. Semi-detailed mapping was done at 1:25,000 scale for selected areas. Land ownership mapping was done at 1:5,000 scale. The building for the laboratory was constructed and equipment and materials installed. Training was given on soil fertility and water quality testing. The results of this project indicated that Djibouti has an agricultural resource capable of meeting most of its needs. The laboratory personnel will receive further formal introduction on laboratory and soil survey methods and procedures. Photos #7 and #8 show traditional agricultural practices in Djibouti.

2.1 Project History

2.1.1 Pre-Project Documentation

In October of 1977, a team of three individuals surveyed the status of Djiboutian agricultural development. This team, comprised of Madison Broadnax, James McDermott and Claudio Sherftons, prepared a report for USAID (Appendix A-1) which was to develop alternatives and recommendations for specific AID action in the newly-created Republic of Djibouti, based on a reconnaissance of the country's natural, human, and institutional resources. Regarding soils and water, this team recommended that:

> "The soil base is adequate to support a significant agriculture." "A study by a soils expert is needed, and our judgments are that there is enough good soil to justify such a study."
>
> "In the soils area, a survey is needed, but the extent and nature is in question. The first task that we see needed is to evaluate the soils in the spots where there is currently some water available for irrigation. The second priority need is for surveys in those areas in which Djibouti is interested in drilling more wells, or in helping determine future well sites. Some study should be made of the Gobaad and Hanle Plains."

Photo #7: Traditional agriculture - at the beginning of this project there were perhaps 400 hectares of such farms as this in all of Djibouti

Photo #8: Traditional marketing of agricultural produce. These fat tailed sheep, along with goats, camels and cattle supported the Djiboutian population for 12 centuries

"We recommend providing some soil testing laboratory equipment and supplies along with the survey, but do not know what is needed."

"Water is the critical element in any of Djibouti's development alterntives."

"More information about the water supply is needed, particularly with respect to the annual yield capacity of the major aquifers and to water quality, especially in those reservoirs in which the danger of salt is recognized. The Pouchan data would yield considerable information, but he claims that adequate information will require more test borings. The team's judgment is that the water supply potential is adequate to support some agriculture and thus, it justifies further attention. Water expertise is needed to help determine both study needs and exploitation needs."

In February of 1978, Dean Peterson, Chief, SWM, DS/AGR, USAID and Professor Pouchan, Professor of University of Bordeaux conferred with USAID/Djibouti regarding hydrological aspects of an AID agricultural development project. They found that:

"There are limited groundwater resources that could support some cropping in Djibouti." "The exploitation of the more important soil and water resources could proceed. There seems to be no overwhelming reason to make a complete assessment of resource potential immediately, but soil reconnaissance in the most promising areas of water supply potential should be checked out."

The complete report is to be found in Appendix A-2.

In March 1978, an agricultural economist, Raymond Tremblay, in a report to USAID/Djibouti, recommended support for a laboratory for water and soil surveys. He stated,

"Its (laboratory) cost-effectiveness is very high. It is the logical step to follow in development. Instead of going full-flight into agricultural development in an area where little knowledge exists, the needed knowledge will be obtained. Personnel of the country will be trained to take over and carry on. In alternative two the existing laboratory, which is in the process of further being developed, will be supported. This is imperative as conjunctive soil and water surveys are badly needed. A systematic organization and some sort of central availability of data are high priority requirements. A little information already exists but is found in various places such as in France and different ministries in Djibouti. There is a need for Djibouti to properly assess its water and soil resources. The country must know its water resouces to develop its urban and possible industrial potential. Its national policy gives the cities the first priority for the use of water. Currently the port, when servicing ships, sells them water at four times the rate paid by the people of Djibouti. There is certainly a need for water for development of any kind. Some water records have been carefully collected, but there has been no central reporting and no central authority.

Little equipment is currently being used and additional equipment is urgently needed for soil and water analysis. Sending soil samples half-way around the world to Hawaii for analysis is costly and not the best use of funds. But of even greater concern is the amount of time lost. Thus, soil and water analyses ought to be done in Djibouti as a basis for further development.

Training of local personnel is an excellent and highly recommended use of funds. The USAID staff should train the local personnel while doing the soil and water inventory analysis."

The full Tremblay report is found in Appendix A-3. It was the first document to specifically recommend establishment of a soil and water laboratory.

In August 1978, Frederick Berlatt prepared a report on "Potential Agricultural Studies" in Djibouti. He too found a need for a laboratory in Djibouti and further went on to recommend that an inventory of Djiboutian soil and water resources be begun. The text of his report is found in Appendix A-4.

2.1.2 USAID Project Paper

In January 1979, a USAID Project Paper was developed to design a Water Resources and Soils Analysis Project to "assist the Government of the Republic of Djibouti (GROD) in establishing a research capacity in the Ministry of Agriculture and Rural Development (MOA) capable of collecting and analyzing water and soils samples." The Project Paper stated tht the project will institutionalize, through training in the Ministry of Agriculture and Rural Development (MOA), the capacity to undertake studies supportive of long-term agricultural sector development, that is, the capacity to do basic applied research which has immediate practical benefits to the Djiboutian farmer.

Over the two-year life of the project, AID will provide resources to finance the long-term services of a hydrogeologist who has had experience in soil sampling. This advisor will work with and train Djiboutian counterparts in exploring for aquifers, analyzing water samples, taking soil samples, directing soils analyses and interpreting the results to the farmers who work those soils. He will also assist in the establishment of a water and soils analysis laboratory which is being built and partially equpped by the GROD.

Supplementary equipment and supplies will be purchased for the laboratory, as well as a project vehicle and camping equipment to assure maximum mobility for the long and short-term technical advisors. Funds will also be provided for aircraft rental, communications, vehicle operation and maintenance, temporary lodging and miscellaneous operating expenses.

In support of this project, the GROD is prepared to provide complete access to and use of a water and soils laboratory, including equipment and supplies, plus services of the following Djiboutian laboratory personnel: one hydrologist, one water quality chemist, one or two soils scientists, one librarian, one lab assistant and nonprofessionals, as required. These technicians and facilities will backstop the 10-man agricultural extension service, which will bring soils and water samples to the laboratory and take the practical advice derived from laboratory findings to the farmers.

The full Project Paper is contained in Appendix A-5, and the resultant PIO/T is contained in Appendix A-6.

2.1.3 Technical Assistance Contract

In October of 1980, USAID contracted with a California firm, Resources Development Associates (RDA) to provide Technical Assistance services in support of the Water Resources and Soils Analysis Project. This contract required that RDA provide a contract team to:

a. Establish a water and soils data collection system as well as a system for the data's dissemination and use by other GROD, private and donor institutions;

b. collate existing and past water and soils data and to extent possible other donor data collection activities;

c. provide training to GROD personnel in water quality testing and soils data collections and analyses;

d. undertake soils studies and analyses supportive to ongoing donor studies and independent of other donor efforts in several MOA-USAID targeted areas;

e. given data obtained, provide estimate of further requirements needed to undertake a national overview of soils research.

Indication that the contractor had satisfactorily attained the above would be evidenced by the following:

a. Re soils: has developed field survey and testing methods, such that the country or at least areas showing greatest potential may be methodically covered (duly classified) in the ensuing 5-6 years. Survey and analysis should follow normal "ground truth" practices so that it will complement existing or planned satellite or aerial imagery. Further, has developed map units with appropriate soils classifications, relying on field data, lab reports and other information sources. Also, has developed laboratory (equipped) to point that soil testing requirements can be independently handled therein.

b. Re water resources: coordinated equipping of laboratory and established practices for water quality testing and recording. (Certain commodities deemed critical to functioning soils-water lab are funded under this project; others will be forthcoming from GROD and other donors);

c. A "user service" will be established which will list institutions, GROD, and other Donors, which are intimately involved and concerned with Djibouti's land-use. A means and format for dissemination will be tested and implemented;

d. A technical library established and stocked with relevant texts, manuals and journal subscriptions, (in French) in fields of soil science, hydrology, geology and water resource, planning and land-use management. All past and present information (maps, studies, reports) re soils and water will be catalogued;

e. on-the-job training provided:

1. A GROD-designated degree lab assistant will be trained in water quality testing and soil analysis procedures. He will be under the direction of both the contract-assisted

Djiboutian pedologist and a trained Djiboutian hydrologist who will be assisted/trained by West German Technical Assistance team in well-logging interpretation, aquifer reconnaissance, stream gauging, meteorological and general hydrogeological techniques and data management to extent that he can fully assume and direct ongoing activities at time West German Technical Assistance team's departure.

2. A GROD-designated Djiboutian will receive on-the-job training (o-j-t) in cataloguing and data management.

3. A GROD-designated degree-trained Djiboutian soil scientist will receive "o-j-t" in soil sampling and analysis, mapping and reporting.

f. Identify two candidates for specialized U. S. or third country short-term training in areas: related to soil analyses, and water quality testing.

g. Based upon project soils and water activities and other existing data:

1. Develop comprehensive soils reports. Geographical areas studied by other donors and the Contractor/MOA lab personnel will be analyzed in terms of soil depth, structure (salinity), texture, infiltration and drainage with subsequent recommendations regarding viability of various land-use options, i.e.; intensive irrigated vs. run-off agriculture for selected crops, cropping patterns, pasturage potential. Water resource component will address water quality, i.e.; chemical composition and be supportive to other donors' efforts to determine quantity of ground-surface water in order to develop recommendations for its potential application for human, animal and agriculture use.

2. To extent data available, recommend if further investment in this sector is warranted based upon project findings, as well as address the question of further U.S.G. investment vis-a-vis upgrading capabilities within the soils and water laboratory. (Appendix A-7 contains excerpts from the Resources Development Associates' Technical Assistance Contract.)

2.1.4 Technical Assistance Progress

A laboratory for the purpose of determining water quality, soil fertility and soil characteristics was established in Djibouti with technical assistance from Resources Development Associates a financial and equipment grant from the United States Agency for International Development (USAID) and with personnel and administrative assistance from the Ministry of Agriculture of Djibouti. The successful completion of this laboratory is a major contribution to the development of the limited soil and water resources of this country.

During the two years assigned to establish the laboratory, a rational conclusion has been made about the quantity and quality of both the soil and water resources to meet public, industrial and agricultural needs. It has been determined that sufficient water and soil resources suitable for agriculture exist to supply most of the country's needs.

The building for the laboratory has been constructed; the necessary permanent installations are being made. The testing equipment has been received, the chemicals and field equipment are on hand. A soil scientist and a laboratory technician have been assigned and are at work. Training is complete on field characterization of soils, soil mapping and cartography.

The laboratory is a joint venture between Djibouti and the U. S. under an agreement entered into in April 1979. Implementation of the project was delayed for various reasons until July, 1980. Since that time, activity toward the objective of a fully-functional soil and water laboratory has increased significantly. Dr. Joseph Goebel arrived to direct the laboratory and soil investigations. Aboubaker Douale, a degree-trained pedologist was assigned to assume responsibility for the laboratory. A laboratory technician, Farah Omar, has been assigned to do the soil and water analysis. Final construction of the permanent laboratory facilities continued until January, 1982, when the equipment was installed and training for specific analysis began. In the meantime, assessment of the Djiboutian soils and soil morphology, classification and cartography began.

2.1.5 Legal Status of the Soils and Water Analysis Laboratory

On 29 April 1982, the President of the Republic of Djibouti signed a law which established the Soils and Water Analysis Laboratory as a relatively autonomous organization reporting directly to the Ministry of Agriculture and Rural Development. The law defines personnel positions, authority, and budget. Appendix B contains a copy of that law.

2.2 Reporting

Reporting in this project has taken many forms. Initial reporting requirements included Quarterly Reports, Annual Work Plans and a Final Report. The Quarterly Reports are contained in Appendix C-1; the Annual Work Plans in Appendix C-2. In addition, a Status Report was submitted to USAID during the course of the project. This report is contained in Appendix C-3. A special Status Paper was submitted, upon request, to the Minister of Agriculture. This report is contained in Appendix C-4. The USAID Mid-Project Evaluation is contained in Appendix C-5.

During the course of the project, the United Nations requested a soil survey report on two special locations identified as sites for refugee settlement. These reports are contained in Appendix C-6. Reports were completed on the 1:100,000 and 1:25,000 soil survey investigations. A special report was written on the water quality of the agricultural wells in Houmbouli and Douda. A report was written on the areas of land occuring in each of the seven major slope categories and the areas of each of the watershed areas. A special report was also written for the Minister of Agriculture to explain the agricultural resources of Djibouti.

3.0 WATER RESOURCES AND SOILS ANALYSIS PROJECT

Technical assistance for the Djiboutian "Water Resources and Soils Analysis Project" has focused on two general areas of effort. The first was the establishment of a chemical analysis laboratory to appropriately analyze both soil and water samples collected within Djibouti. This effort included the physical set-up of the laboratory and the training of laboratory personnel in proper laboratory procedures, testing methods and management of the facility.

The second major area of effort was the mapping of the soils of Djibouti. This effort included identification and classification of these soils, mapping of their areal extent (at several scales and in various levels of detail) and training in the appropriate techniques and procedures to accomplish the above.

3.1 Approach and Summary of Activities

The Soils and Water Laboratory staff have:

a) the equipment and technical expertise to independently analyze all water and soil types in Djibouti,

b) the necessary data upon which to base recommendations for the soil and water use in crop production and provide guidance for subsequent soil and water resource analyses in the field,

c) undertaken a soil inventory and developed a land classification system on a general scale and in selected priority areas.

In order to accomplish the foregoing, the following was necessary:

a) A soil and water data collection system was established with an appropriate information form.

b) A system was established to disseminate the soils and water data to other Djiboutian Government agencies and private and donor institutions.

c) The existing and past soil and water data were collated, placed in the library and applied during the project and to the extent possible, data collection activities of other agencies were incorporated.

d) The Djiboutian personnel were provided training in soil chemical analyses, description, classification, mapping, interpretation, inventory and reporting.

e) The Djiboutian personnel received training in water quality analysis and reporting.

f) The project personnel and Djiboutian counterparts have undertaken soil studies of the soils conditions for rangeland and irrigated cropland on both a general national inventory and in several selected priority agricultural sites.

g) Since no 1:10,000 or 1:50,000 scale base maps exist for Djibouti, and there are neither personnel, time nor equipment to make base maps, the national soils inventory was conducted on the best set of topographic maps available at 1:100,000 scale.

h) Without a basic land survey to accurately locate features found on an aerial photograph to the base map (1:100,000), the large scale (1:25,000) maps of high priority areas were made directly on aerial photographs.

i) Because the combined soil and water potential for possible agricultural sites were not established, the high priority sites were evaluated later in the project based on established agricultural capability. In this way, valuable time was not wasted on areas without either soil or water resources.

j) Soil samples from the present agricultural projects were tested as soon as the laboratory facilities and procedures permitted accurate analyses. Preliminary recommendations for soil amendments and practices were made to the fullest extent practicable.

Indication that the foregoing was satisfactorily attained was provided by the following:

a) Field survey and testing methods have been developed such that a small-scale 1:100,000 national soils map was developed to be used in selecting potential agricultural sites and rangeland management capability.

b) A procedure was established to methodically cover the areas of highest priority during the ensuing five or six years.

c) Soil survey and analyses followed practices which permitted the use of existing or planned satellite and aerial imagery for future evaluation and monitoring of the land-use.

d) Satellite imagery and aerial photographs were used to construct the national soils map so future imagery of this type will be easily correlated to the soils map and the multitude of detail associated with such a report.

e) A random inventory based on a sample of 1,000 one-square-kilometer plots was established to be used as an agricultural and rangeland needs inventory so specific sampling and detailed analyses could be directed to specific areas which reflect relative national impact. The data derived from these plots would serve in satellite imagery interpretation, resources inventory, production estimates and provide data for economic evaluation.

f) Map units were established with appropriate soil classification, relying on field data, laboratory reports and other information sources.

g) The laboratory was equipped and developed to the point that soil testing requirements could be independently handled therein.

3.1.1 Laboratory Requirements

Djiboutian personnel were to conduct the following soil fertility tests: nitrogen, phosphorous, potassium, organic carbon, calcium, carbonate equivalence, pH, boron and sodium and other necessary micronutrients. The more specific analyuses would include cation exchange capacity, total base saturation and electrical conductivity.

The soil physics tests which were to be provided by the laboratory included bulk density, soil structure, and particle size analyses. The equipment was not to be furnished for testing water holding capacity, water infiltration, plasticity index, or shear strength. These could be estimated from other data acquired by the labortory.

The needed equipment, chemicals and transportation were to be funded by the U. S. Other commodities deemed critical for this project were to be forthcoming from the Djiboutian Government and other donor agencies. This included buildings, facilities, personnel and hydrologic field support. The layout for the laboratory was to be drawn out and the laboratory so constructed.

A user service was to be established to include Genie Rural, Agriculture Service, ICERST, Public Works, volunteer organizations and private individuals. These people were to present soil and water samples directly to the laboratory accompanied by a form giving relevant information about these samples. The laboratory ws to collect the sample and relevant information for the user. The user was then to receive the results of the analyses and any appropriate and practical interpretation. The results were to be stored and used in future assessments of the status and uses of Djiboutian soils. It was expected that users would furnish information on the practical results of laboratory recommendations so that further recommendations could be more refined. A system was to be designed to accommodate the flow of informtion to and from the field.

A technical library was to be established and stocked with relevant texts, manuals and journal subscriptions in the fields of soil science, hydrology, geology, water resources, planning and land-use management. All past and present information, maps, studies and reports, specific to Djibouti were to be catalogued. This was to be an ongoing effort, extending beyond the project's lifetime.

3.1.2 Training Requirements

Several types of on-the-job training were to be given by the technical advisor to the Djiboutian personnel. They included the following:

a. A Djiboutian-designated laboratory assistant (Farah Omar) was to be trained in water quality testing for the following tests: sodium, calcium, magnesium, manganese, iron, aluminum, silicon, potassium, phosphorous, boron, chlorine, sulfates, carbonates and nitrates and others that were deemed necessary.

b. The West German Technical Assistance team would train a Djiboutian hydrologist in well-logging interpretation, aquifer reconnaissance, stream gauging, meteorological and general hydrological techniques and data management. This hydrologist would supervise the laboratory assistants on water quality testing.

c. A Djiboutian technician was to be trained in cataloguing and data management, including equipment and materials inventory as well as technical correspondence and reports.

d. A Djiboutian-designated degree-trained soils scientist was to receive on-the-job training, in soils description, morphology, classification, cartography, reporting, interpretation and chemical analyses. He will assist the laboratory assistant in soil analyses.

e. There were to be two candidates identified for training in the U.S. or a third country. While most short-term training was presented as on-the-job training, some further structured training was advisable for the candidates. At least, six months should be spent by the laboratory assistant in a functioning laboratory such as the S.C.S. laboratory in Lincoln, Nebraska, and the U.S.G.S. Water Laboratory in Denver, Colorado. The pedologist will need two years of post-graduate training in soil chemistry to assure that he has enough formal background to solve problems that will arise after the completion of the project.

3.1.3 Soil Survey Requirements

Based upon project soils and water activities and other existing data, this project was to develop comprehensive reports on the national soils inventory to be used in the location of agricultural sites and the evaluation of rangeland potential.

Geographic areas studied by this and other projects were to be analyzed in terms of soil depth, structure, salinity, texture and drainage with subsequent recommendations regarding viability of various land-use options to include intensive irrigated row crops, irrigated pasture, rangeland and brushland including cropping patterns, pasture and range potential. This was to be accomplished with maps, tables, dialogue and laboratory results.

The water resource component was to address water quality based on chemical composition and conductivity. This testing will be supportive of other donors' efforts to determine the quality of ground and surface water for human, animal and agricultural use.

Recommendations concerning further investment in the agricultural sector were to be based on the available data. If further investment was warranted the question of further U. S. cooperation by way of upgrading the capabilities in the laboratory would be assessed. At the end of this project the laboratory was to be able to perform all routine soil and water analyses and soil investigations on its own recognizance.

3.1.4 Technical Assistance Activities

In order to implement this project, the advisor pedologist was to accomplish the following:

He was to facilitate equipping the Soils and Water Laboratory by doing the design, layout, equipment inventory, and installation of equipment, testing for serviceability, determine sample flow, decide on testing procedures and techniques and organize the laboratory into a smooth flow of samples, test results and recommendations.

He was to develop an Annual Work Plan for the laboratory with the assistance of the Djiboutian assistants. Soil reports were to be provided.

The advisor pedologist was to conduct family unit and detail scale surveys of potential or existing garden areas where management, irrigation techniques, reclamation procedures, crops and drainage have to be adapted to soil conditions and water quality and availability. This was to include a soil characterization and description for each site. Since the 400 or so gardens average about 0.25 hectares, maps at any scale would not be relevent, so a verbal description of the soils and the geomorphology were to be made and recorded for each farm. A large-scale map on aerial photos of the garden region was to be made when the soils of the country are understood and their relationship to the garden area is understood. The order of priority was to include Moulud, Douduballa, Forage Gran Bara, Houmbouli, and Atar among others. Service at this scale was to be considered a personal service to land-users.

Soil surveys were to be made at a medium-scale of 1:25,000 (the scale of the aerial photos) because there were not sufficient 1:50,000 scale base maps to provide proper control in reporting the survey. It was too time-consuming and costly to make impromptu base maps. The soils areas would be more accurately recorded directly on aerial photographs which could subsequently be referred to for land evaluation. This scale of mapping was to be used on major plains and other areas identified as having both a soil and water potential. These were to include the Gobaad, Hanle, Tadjoura, Atar, Obock and places scattered from Eli Sabieh to Dorra. A soils map was not to be developed until an area was studied sufficiently to verify that it had both quality soils and water, above the needs of the local inhabitants and their livestock, to support irrigation agriculture. Then, only that portion which could be identified as productive would be surveyed to conserve efforts and to focus attention on areas which could be productive. Because of the scattered rainfall and the various drainage conditions and configurations, agriculture will probably consist of many small scattered plots throughout the country instead of one area of concentrated effort.

A plan for a 1:100,000 scale survey was developed to give Djibouti its first national soils inventory. This inventory would serve as a basis for rationally determining high priority areas for agriculture. This plan would also serve for rangeland management. The map scale of 1:200,000 was rejected because the topographic control was considerably better at the larger scale. Further, there were too few maps available at 1:50,000 (one sheet only) to do a survey at the scale. Therefore, a scale of 1:100,000 represented the best available map. Enough could be represented at this scale to give all the information needed in planning and soils inventory evaluation until specific site maps were made at 1:25,000. This inventory was begun while the laboratory was being completed. It also provided soil samples and soil descriptions which were to be used for practice in laboratory training. The survey was to provide basic information on uplands and stratify soil environments according to their potential for grazing, carrying capacity, etc.

Reports on the above surveys were to be prepared with accompanying land-use recommendations. This was to include soil family level description of soils at the individual garden level. It was to include the recognition soil subgroups at the intermediary level of a scale of 1:25,000. It was also to incude soil Great Group subdivisions at the general soil inventory on the national level.

Land-use recommendations for the foregoing areas surveyed was to be developed relying principally upon field estimates to determine permeability and infiltration in areas where irrigation was planned, and also laboratory analysis to determine texture, pH, organic carbon, electric conductivity, total base saturation, cation exchange capacity, bulk density, boron and other relevant indicators.

It was to be determined, as early as possible, that the extent to which the soils and water laboratory could satisfy the above requirements, and where it was determined that it is unable to do so, assistance would be developed outside Djibouti which could perform the analyses. Assistance of this type could be expected for clay minerology analyses, some x-ray diffraction analyses for selected soil minerals, and certain rare micronutrients. This assistance could probably be obtained from the Overseas Technical School in France.

Work-related training for the Ministry of Agriculure's Djiboutian degree-trained pedologist assigned as Director of the Soils and Water Laboratory was to be provided. This included training in soil description, classification and cartography. It was to include soil chemical analyses and procedures as well as soil reports. Training was also to be given on managing the laboratory, maintaining quality control and recommendations based on the analyses and the soils inventory.

Work-related training for the laboratory assistant in soil chemical analyses to be provided was to include nitrogen, phosphorous, potassium, organic carbonate equivalent, total base saturation, cation exchange capacity, micronutrients, sodium, boron, chlorine and electrical conductivity. There was also to be training in bulk density, textural analyses and mineral identification. The laboratory assistant was also to learn to test water quality for sodium, potassium, calcium, magnesium, phosphorous, iron, aluminum, silicon, chloride, sulfide, nitrate and carbonate and any other appropriate analyses. He was further to become acquainted with soil and water field procedures.

A baseline of ground truth was to be developed from 1,000 random samples. It was to be integrated with present and planned satellite and aerial photographs to develop a data base for comparison with future imagery for time-lapse analyses.

Soil sample collection and analyses activities were to be coordinated with other donors as desired by Djiboutian Government-designated priorities. The Government of Djibouti, the Ministry of Agriculture and USAID were to be informed on the quarterly progress of project activities. It was expected that the attention of the Djiboutian Government and USAID to any problems or shortfalls as a result of possible insufficient manpower, training complications, commodity deficiencies, donor coordination, etc., would be sought. Finally, the results of this project were to be synthesized in a final report.

3.2 Soils and Water Laboratory - Progress and Results

The Soils and Water Laboratory is organized into four sections with appropriate subsections as outlined on the Organization Chart, Figure 2. At present, only two individuals are assigned full-time to the lab. These individuals are Mr. Aboubaker Douale, Chief of the Lab, and Mr. Farah Omar, Soil Survey and Laboratory Technician.

To facilitate recognition of progress in the work for the Djiboutian Soils and Water Laboratory Project, a list of work categories that were explicitly or implicitly stated to accomplish the goals and objectives of the project have been included. The subsequent accomplishment of each assignment is appropriately noted.

3.2.1 Facilities and Equipment

A. Building Construction

One of the first objectives of this project was to build a facility to house and expedite the operation of

ORGANIGRAMME du LABORATOIRE

d'ANALYSE des SOLS et des EAUX

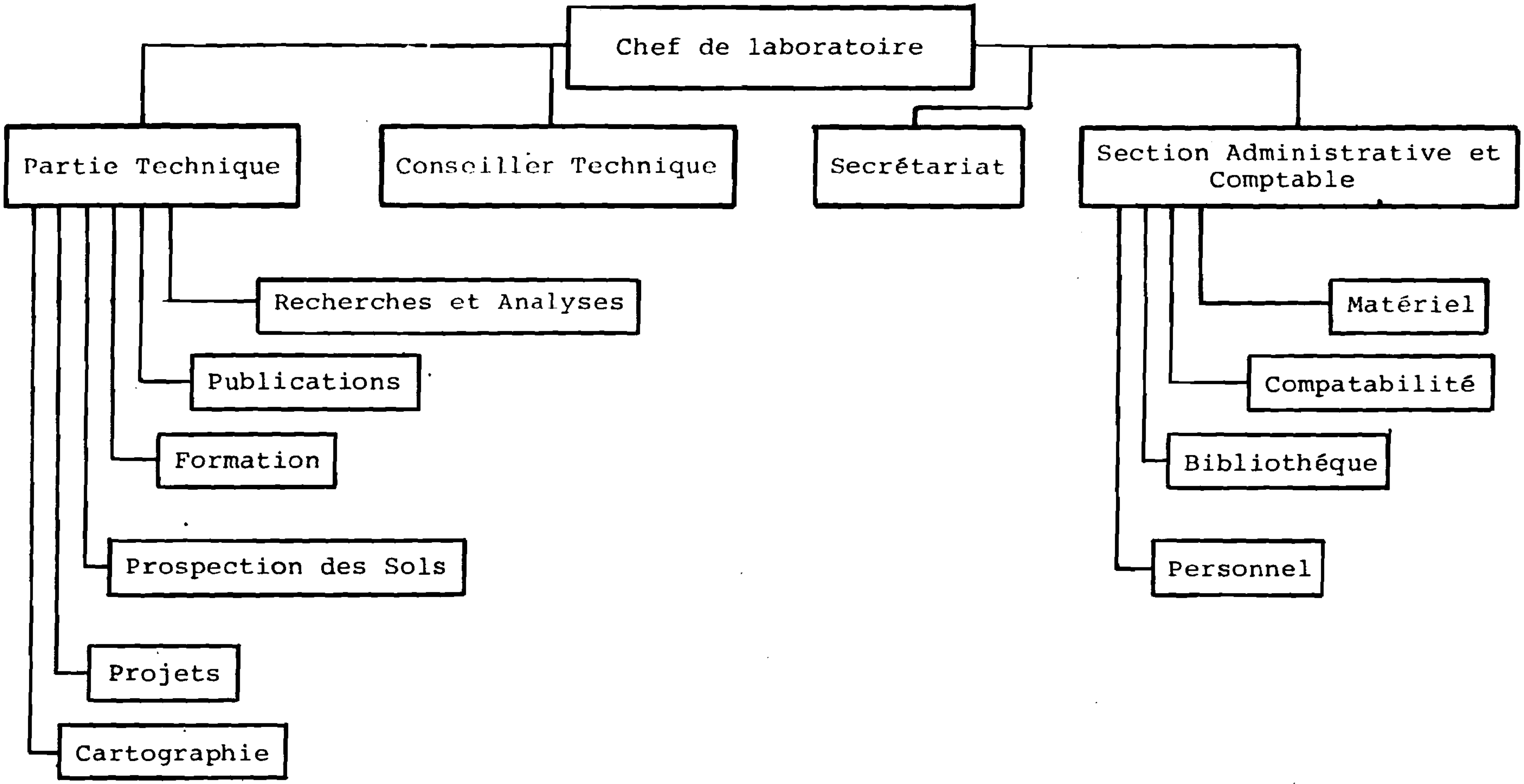


Figure 2

the laboratory. By August, 1980, the building was constructed and the four rooms requested initially were made available to the project.

B. Construction of laboratory facilities

As a first step, it was necessary to draw the following plans (Figures 3 through 8), to install the benches, shelves, and plumbing in a manner that would expedite work and analysis. After several complications, the laboratory was fully installed by the end of the project.

The laboratory is designed for samples to arrive at the office in Room #7 and be logged in on a receiving form. It is then placed on the shelves in the hall to go to storage, drying and grinding, behind the building. When the water and soil samples are ready for analysis, they are placed on the shelves behind the door in Room #10. The sample is assessed and labeled for the laboratory with internal lab numbers (all samples are received by UTM coordinates for identification).

The soil is immersed in liquid or the water is processed on the center bench of Room #10. Soil physics is performed on the next bench. Microanalysis is performed in Room #11 where in-process calculations are performed.

The results of the laboratory is passed for final processing and dissemination in the office in Room #8, which also houses the library. The sample is disposed of in the pit behind the laboratory. Room #7 is used for soil survey needs such as drafting and remote sensing. Overall, the layout was executed as planned. It serves the needs of the personnel and the output of this laboratory. Photos #9 through #15 show some of the general layout of the completed laboratory.

C. Ordering and purchasing equipment, materials and supplies

D. Equipment and materials inventory

Appendix D lists the property inventory for the laboratory as of July 1982. It contains lists of chemical reagents, laboratory equipment, office and drafting equipment, and field equipment.

E. Equipment and maintenance

(An electronics repairman has been located locally.)

F. Restocking materials and supplies

(Catalogues are all available for equipment and chemicals.)

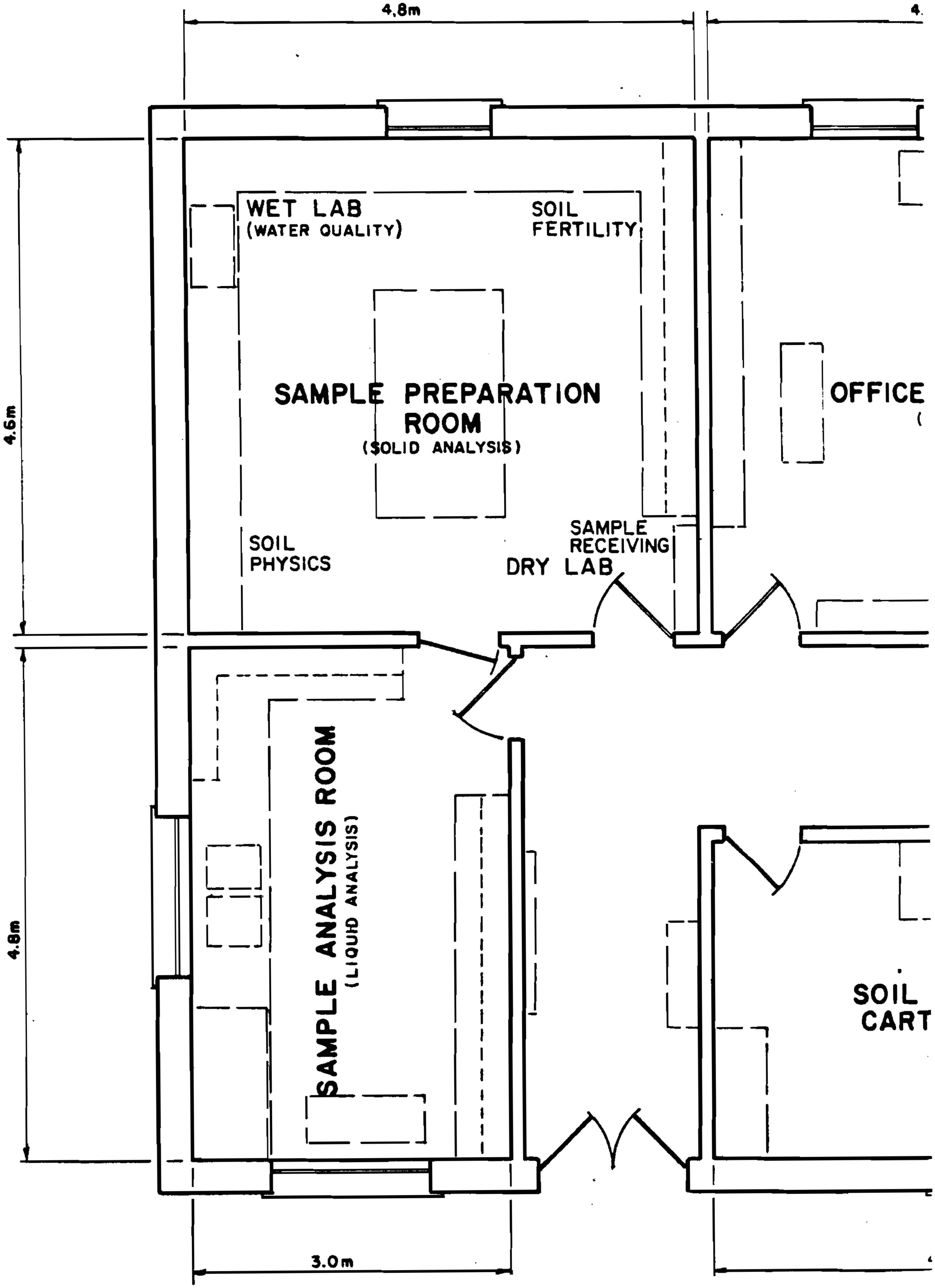
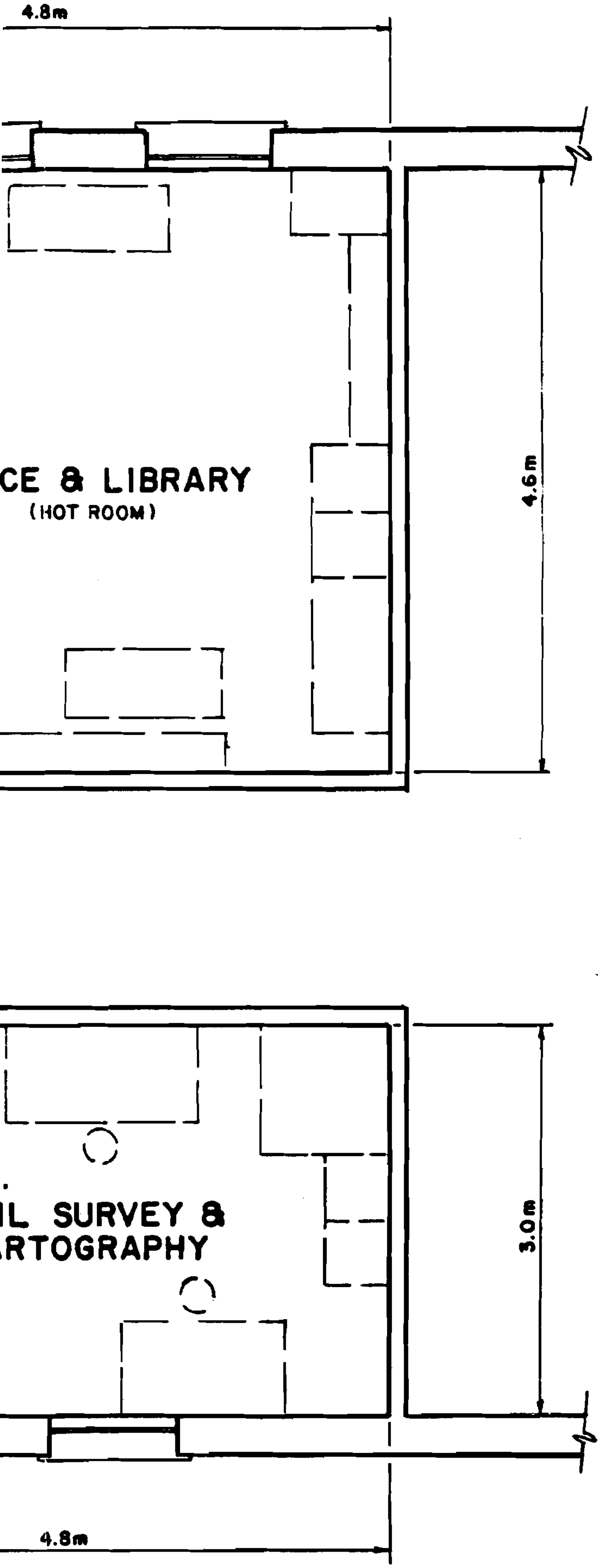
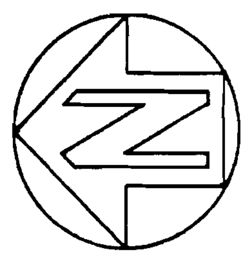


Figure 3: Laboratory Assignment of Soils Laboratory

LABORATORY ASSIGNMENT
OF
SOILS LABORATORY
REPUBLIQUE DE DJIBOUTI





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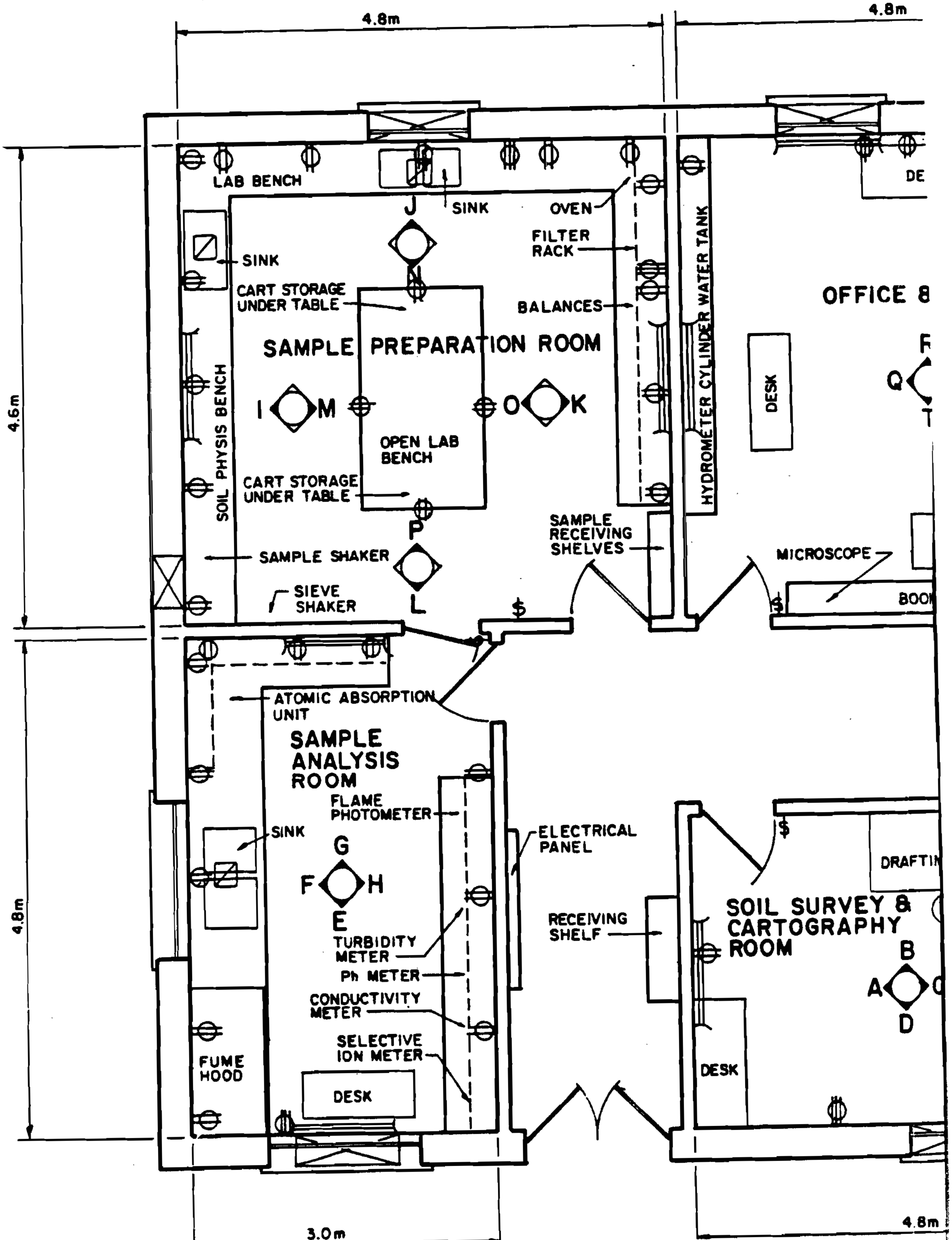

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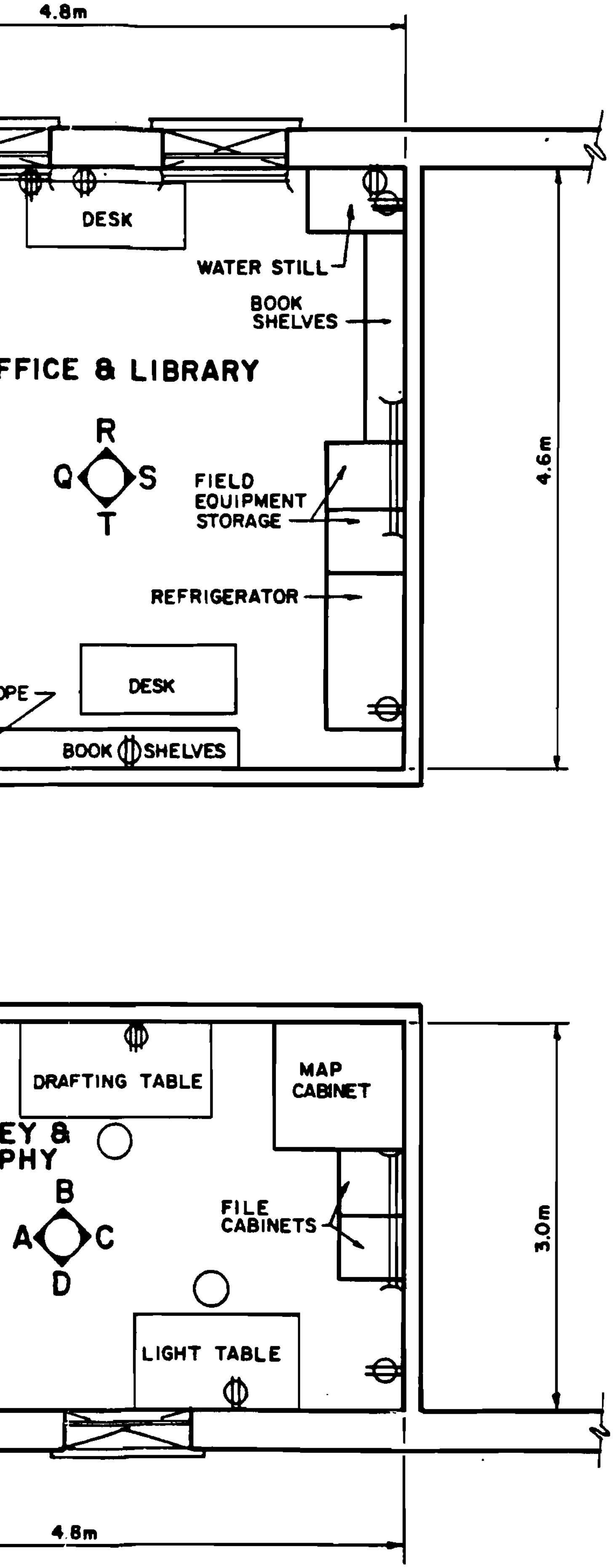
Figure 4: Floor Plan of Soils

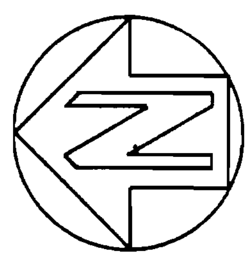


FLOOR PLAN OF SOILS LABORATORY

REPUBLIQUE DE DJIBOUTI

LEGEND:

- Light switch
- 110 V outlet
- 220V outlet
- Soil trap under sink
- Air conditioner
- Fluorescent fixture



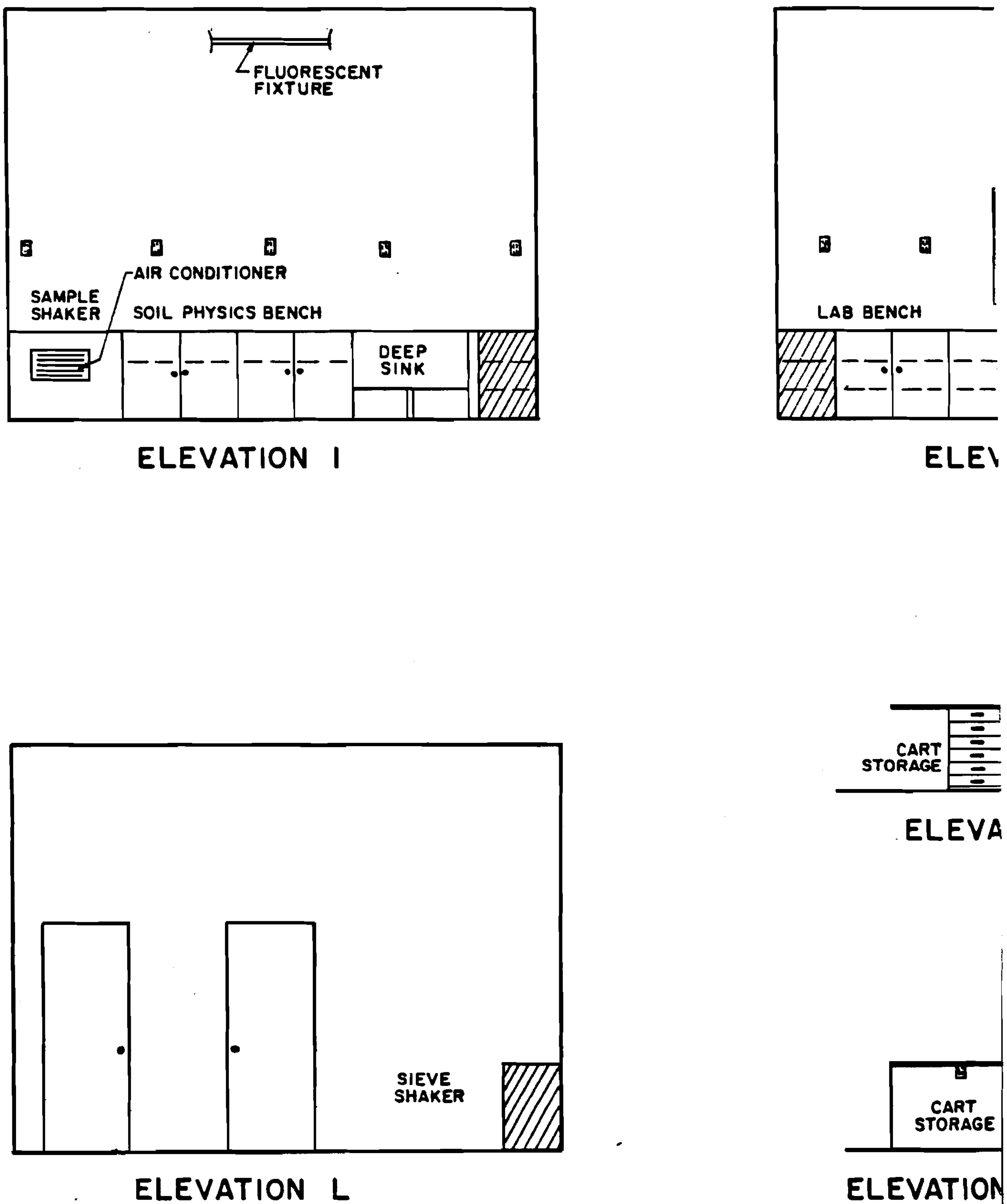
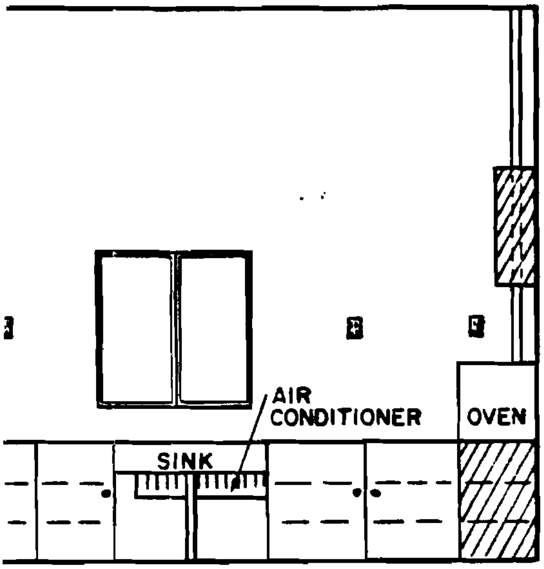
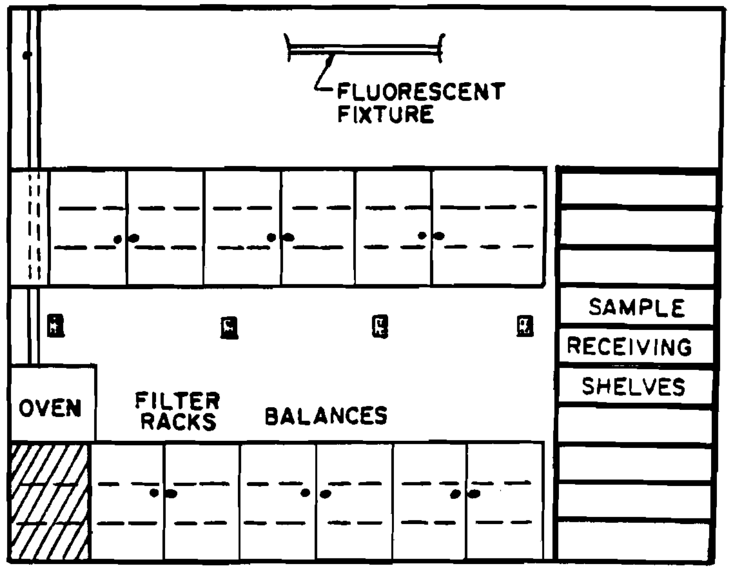


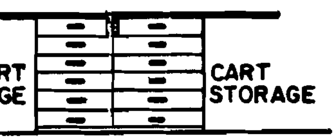
Figure 5: Elevations/Sample Preparation Room



ELEVATION J



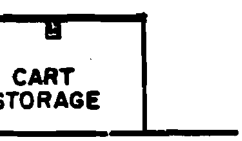
ELEVATION K



LEVATION M

ELEVATION N

ELEVATION O



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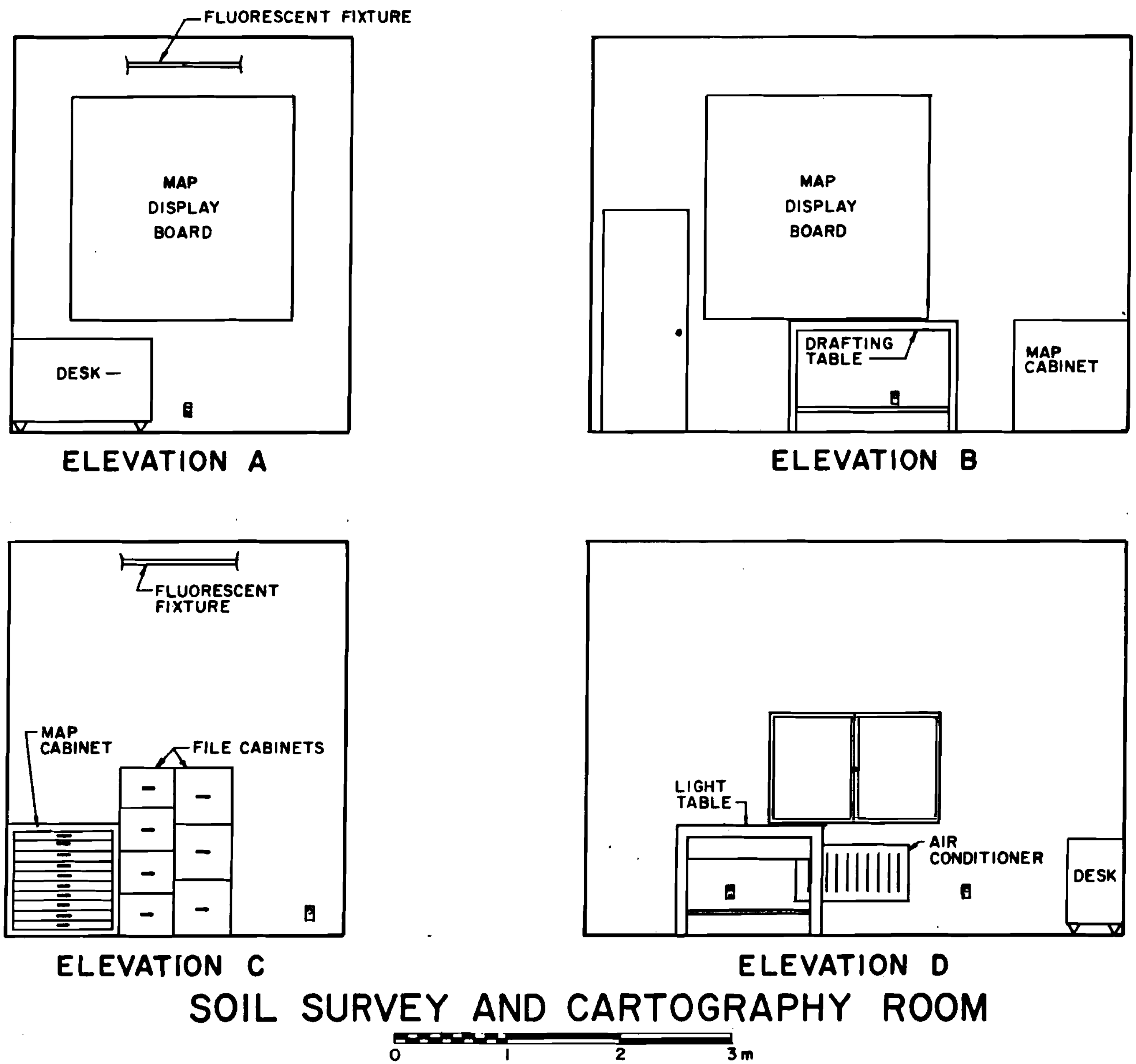
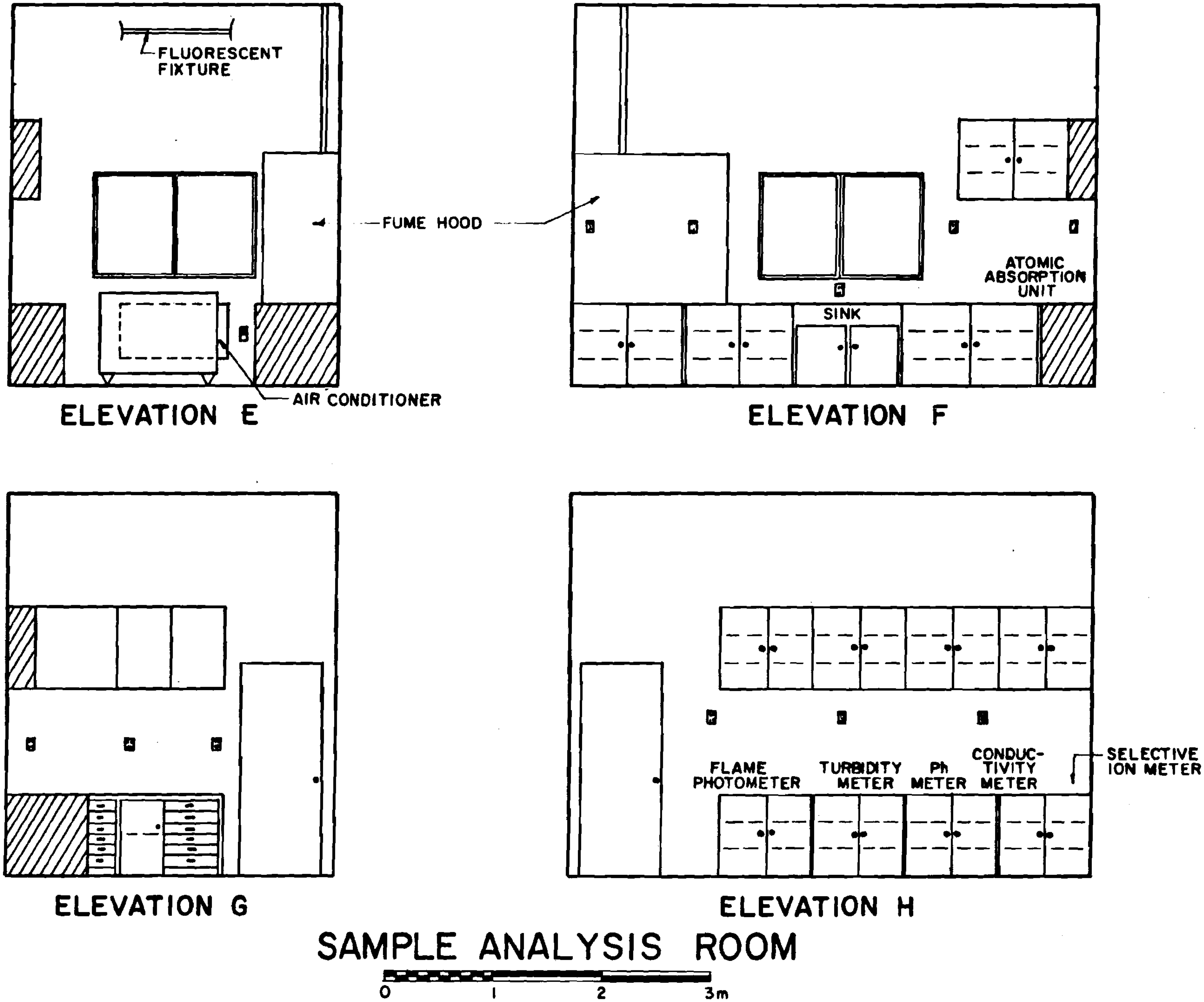
SAMPLE PREPARATION ROOM



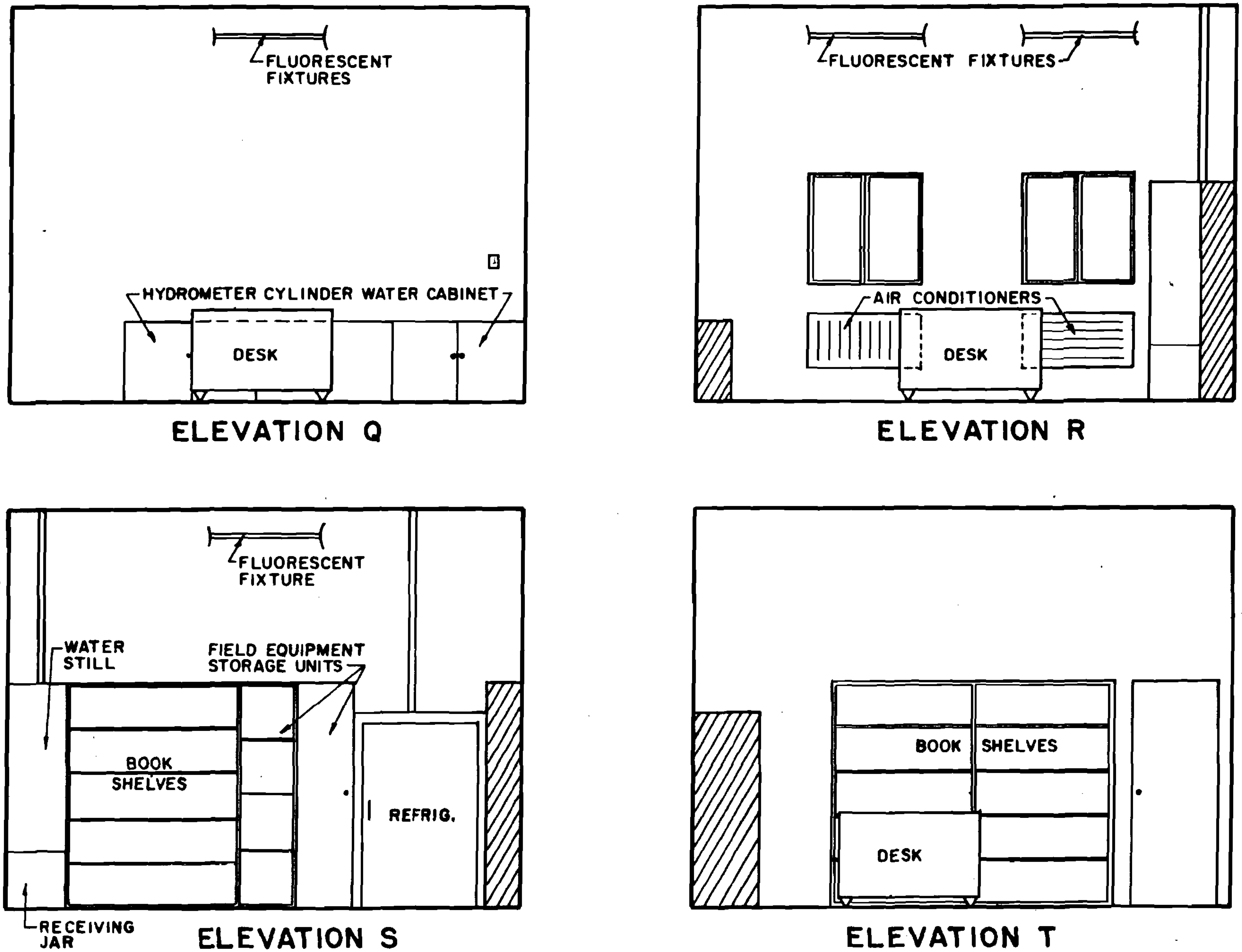
SOIL SURVEY AND CARTOGRAPHY ROOM

Figure 6



SAMPLE ANALYSIS ROOM

Figure 7



OFFICE AND LIBRARY

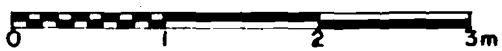


Figure 8

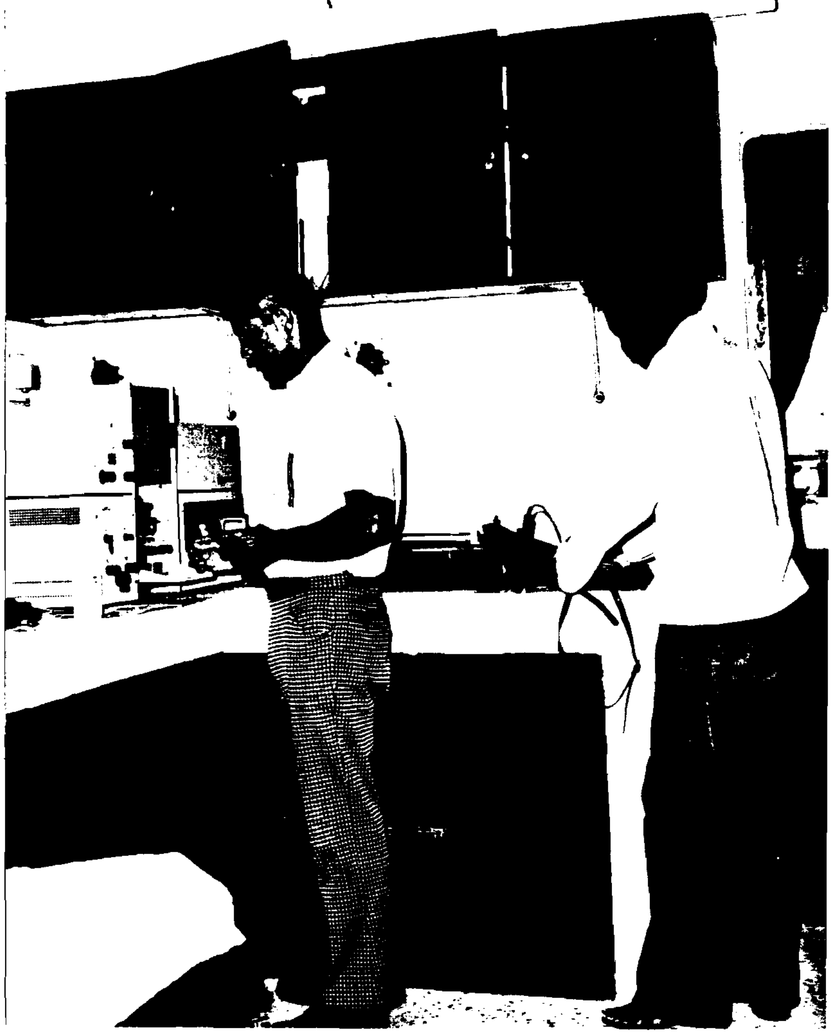


Photo #9: Mr. Aboubaker Douale and Dr. Joseph Goebel analyzing soil and water in the laboratory

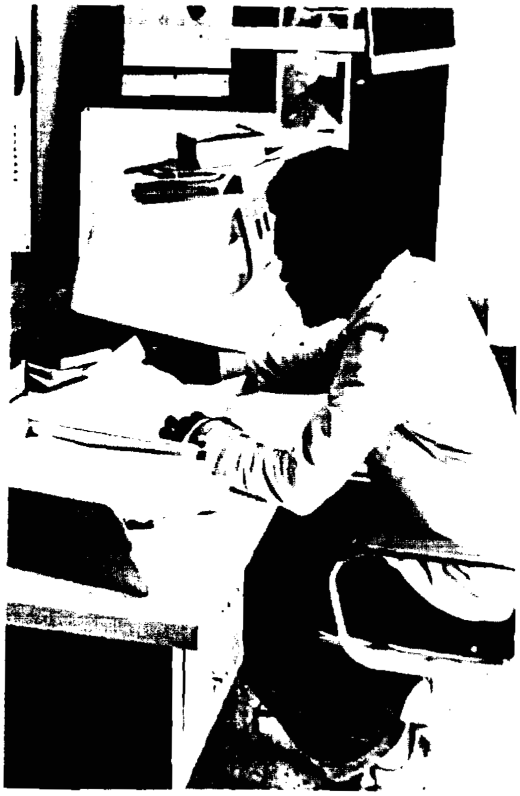


Photo #10: Aboubaker Douale, Laboratory Chief, is working at his desk directing laboratory and soil investigation

Photo #11: Aboubaker Douale is carefully mapping the soils in the Tadjoura area

Photo #12: Farah Omar, Soils Technician, measuring one of the soils maps produced on this project

Photo #13: Farah Omar preparing a sample for soils analysis

Photo #14: Secretary typing a soil description performed during this study

Photo #15: Beverly Rollins, agronomy volunteer, correcting distortion in photographs used to map 1:5,000 scale land ownership maps

3.2.2 Laboratory Analyses

A. Test soils for nitrogen, phosphorous, potassium, micronutrients, salinity, conductivity, carbonates, lime, texture, structure, bulk density and others -- accomplished. Photos #16 and #17 show soil test pits.

Following are test procedures for moisture content and particle size analysis:

1. Procedure for Moisture Content

- To do a moisture content evaluation, place approximately 200 grams (record the exact weight) into a small container that has been weighed. Put the sample in the oven at 50 degrees C for at least twelve hours and weigh immediately upon removing from the oven. Subtract the weight of the container. Subtract the dry weight from the moist weight and divide the remainder by the initial weight and record.

2. Procedure for Particle Size Analysis

- Prepare dispersing agent by dissolving 50 grams of Calgon in water and dilute the solution to one liter by volume.

- Weigh approximately 100 grams of soil (record the exact weight, which has passed through a 2 mm sieve, and add 125 milligrams of dilute Calgon solution and let soak -- with occasional stirring -- overnight.

- Place approximately 20 grams (record exact weight) in the drying oven to determine moisture content. After obtaining the moisture content, correct the weight of the sample by testing by subtracting the weight of the water.

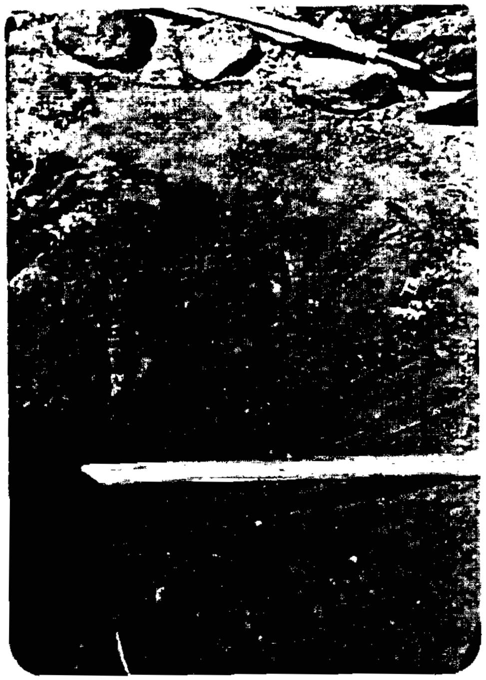
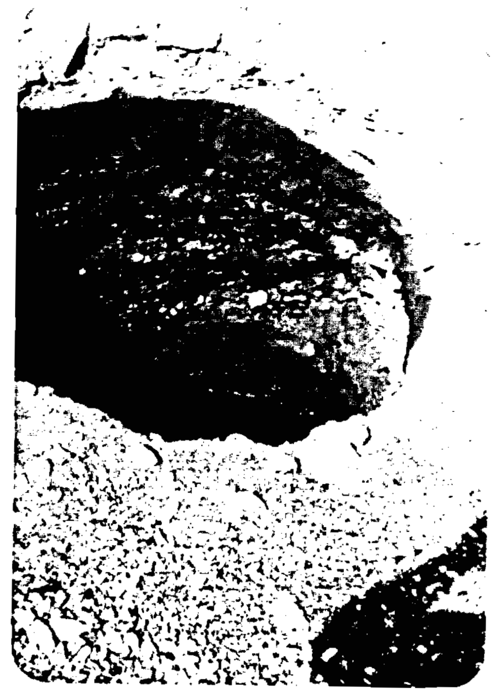


Photo #16: The laboratory tests soil sample from soil like this Balambal on plateaus between 600 - 900 meters elev.

Photo #17: Maarigi Soil above 1200 meters. Laboratory confirms the organic content of top layer

Photo #18: Water such as this is assessed for salt and boron

Photo #19: Waters unusually good for drinking/irrigation. Laboratory confirms actual content of water



- The following day pour the sample into the mixer, rinsing the beaker, and add water if necessary. Mix for three minutes. Place the sample in a one-liter straight-walled cylinder. Clean the mixed container and add water to make one liter.

- Prepare a standard cylinder with 125 ml of dispersing solution and water to make one liter. This serves for temperature and density correction for the hydrometer. Also, the hydrometer can be stored here between readings.

- Begin the hydrometer test: Take the stirring rod and stir for 30 seconds. Note the time when the stirring is stopped. Remove the stirring rod. Carefully and promptly insert the hydrometer. Record the reading at 30 seconds, one minute, followed later by other desired times calculated to give the particle size desired.

- Repeat the process in the next cylinder. Recommended readings are: 30 seconds, one minute, three minutes, 30 minutes, 1.5 hours, 4.5 hours and 24 hours.

4. Particles Larger Than 2mm Sieve Analysis

- Begin by drying and grinding the soil (weigh approximately 20 grams or less than 2 mm soil sample for moisture content). Weigh approximately one kilogram of soil (record the exact weight). Correct the weight for the moisture content. Stack the following sieves: 9.5 #4, #8, #20, #30, #60; pan after weighing and recording. Pour the soil in the top and shake well and weigh each sieve. Subtrct the weight of the sieve. Then, subtract the weight of the moisture. Divide the results of each sieve by total dry-weight of the sample.

- This procedure gives the percent of the total sample in each size class. If this percentage is preferred for particles less than 2 mm, then multiply the results of the hydrometer test by the percentage of the one kilogram sample passing the last (2 mm) sieve.

The repetitive nature of the particle size analysis was assessed. The same soils were run four times. By comparing the difference of one evaluation to the other on the same sample, it was possible to determine the reliability of both the procedure and the technician. In this case, the 15-second reading varied from 2% to 5%. This is always the least accurate reading due to time constraints. The one minute reading varied between 0% and 3% in four repeats. The three-minute readings varied between 0% and 2.5%. This is compared with up to 7% variation for other established laboratories.

B. Test water for sodium, potassium, calcium, magnesium, phosphorous, manganese, iron, carbonate, sulfur, nitrate, chloride and others.

. The Laboratory tests and procedures for salinity, pH, cloride and conductivity were conducted on twelve samples of 25 grams dry weight diluted to 50 milliliters and evaluated by an appropriate conductivity meter. The meter failed in the middle of the test. Therefore, no results are available. Further work on these tests are being conducted by the staff of the SCS-USDA. Training will also be given in Lincoln, Nebraska. Photos #18 and #19 show typical water sources.

C. Independently analyze all soil and water types in Djibouti -- accomplished. The Laboratory Chief has demonstrated excellent training in soil laboratory methods/procedures and he is able to do them on his own.

D. Established proper laboratory techniques -- accomplished.

E. Established proper laboratory procedures -- accomplished.

F. Established sample flow -- accomplished.

G. Compute results of analyses -- accomplished to the extent of training.

H. Record results -- accomplished.

- Appendix E contains copies of the Laboratory reporting forms developed in or recommended for use in this project.

I. Make recommendations -- accomplished for those requested.

J. Arrange for outside analyses of clays and trace elements -- accomplished. Relevant laboratories are listed in the library.

K. Make farm visits

- Eleven individual farm sites were visited. Reports were made to document each visit and to provide recommendations. These Farm Visit Reports are found in Appendix F. Photos #20 through #23 show typical farm sites.

3.2.2.1 Water Quality Analyses

Water quality analysis was delayed until arrival of the 110VAC 60Hz alternators so that the analytical equipment would function. Training has been arranged.

A. Test all samples received -- partially accomplished, testing continues.

B. Receive all samples presented -- accomplished.

C. Test each specific analysis -- partially accomplished, assistance is provided.

D. Record and report results of tests -- accomplished.

Photo #20: Aboubaker Douale, Chief Soils & Water Testing Analysis Lab w/Allen Hidlebaugh and George Holmgren of USDA Soil Conservation Service for soil survey and soil laboratory divisions

Photo #21: Traditional well dug in wadi channel supplying quality water according to lab tests in this project

Photo #22: Quality soils and quality water can produce variety of crops, i.e., cane, dates, oranges, mangoe, tomatoes, eggplant

Photo #23: Farm site location is one of responsibilities of lab. This site was located on road to Eli Sabieh built w/hand labor

- A special water investigation was conducted in Houmbouli and Grand Douda area. Salinity of well water was analyzed in order to determine if unsafe drawdown stress was being placed on the main aquifer of the area as a consequence of a prolonged drought. Appendix G contains the report produced as a result of that investigation.

E. Coordinate the efforts with other agencies, i.e., ISERST public water and public works -- accomplished. All agencies agree to cooperate with the laboratory.

3.2.2.2 Soil Chemical Analyses

A. Collect soil fertility samples -- accomplished

B. Make appropriate tests for each user -- pending equipment functioning. Training will be provided.

C. Acquire a predictive capability for recommendations based on laboratory results. This will be done based on general plant requirements until further analysis is conducted to establish the nutrient capability of the soils in Djibouti.

D. Distribute the information -- accomplished

E. Report results -- accomplished.

F. Make recommendations on soil amendments and land-use options -- accomplished.

G. Cooperate with extension service -- accomplished.

3.3 Soil Surveys

The national soil inventory was undertaken to supply Djibouti with suitable basic information to make decisions on land use development. This includes water recharge, agricultural development, rangeland development, resettlement and engineering projects. This inventory also made it possible to prioritize the better soils areas with the better water supplies for agricultural development.

The national soils map and its attached descriptions and interpretations will permit more rational and informed planning in development. It has enough information to make preliminary decisions on development use and location. When more detailed information is needed, a more detailed study can be made. Development need no longer be delayed for lack of soils information.

3.3.1 General Approach

At the beginning of the project, before any field work, the team made a preliminary soils map based on the 1:200,000 scale geologic and topographic maps. This map assisted in the determination of the soils in the field. Next, a half-percent random sample was drawn to establish ground truth and describe and sample the soils to define general soil resources. Each sample site was one square kilometer established by the Mercator grid system. Each sample site was visited and the major soils were described and sampled. At the laboratory, each site was located in the kilometer grid system on the 1:250,000 false color composite Landsat images of the country. The soils were named according to the information obtained by visually interpreting the information on the Landsat images for each sample site. This map was then combined with the topographic information on the 1:100,000 scale topographic map to create a reconnaissance soils map.

This reconnaissance soils map, in conjunction with hydrological data from a collateral project, was used to select appropriate watersheds for semi-detailed soils mapping on aerial photographs at a scale of 1:25,000. For semi-detailed mapping, we used a random sample of five percent (5%) of the area to collect the basic field data. Following this procedure specific agricultural sites are determined in accordance with the limited water potential of the area.

3.3.2 The Random Resource Sample

A set of 1,000 sites, each one square kilometer, were taken at random across the country. This sample represents approximately five percent (5%) of the land area of Djibouti. It is the purpose of this sample to expedite the collection and accurate description of the natural geographically-distributed resources. It is also intended to facilitate the collection of data by various scientific investigators with diverse interests.

The sample sites are organized in one list by the order of occurence of the numbers when they were selected. This is important for further subdividing the survey for analyses. A second arrangement is based on their arrangement by UTM coordinates to facilitate locating the sites on the map. It is further divided into groups related to the 1:100,000 scale topographic map. The entire list of randomly-selected sample coordinates is found in Appendix H.

The number 'universe' for the same lists all of the UTM coordinates, wherein the designated site north and east of the coordinate intersects, and lies wholly within Djibouti and on land. The list is organized from west to east followed by ordination by south to north.

It is the intent of this project to encourage other investigations to use this sampling device to facilitate the compounding of detailed information based on the same sampled areas so that they may draw extensively on each other's expertise in a specific manner. A 1:100,000 scale map of the distribution of these 1,000 sites can be viewed at the soils and water laboratory.

3.3.3 Mapping Procedure

This soil survey was conducted by first selecting 100 randomly distributed sites throughout the country as specific objectives to search out and describe. The first 100 samples of the 5% random sample were set aside specifically as a 1/2% coverage of the country for especially rapid assessment of the resources. All of the sites were visited. The first attempt was made by an all-terrain vehicle and the remainder by helicopter.

A significant soil was picked within the one square kilometer site and thoroughly described in profile and geomorphic distribution. On site, the relationships between soils was estimated and clarified. The UTM coordinate numbers were used to identify the sites along with a local site name. All of this information was acquired and recorded on the 1:100,000 topographic map. Figure 9 shows a characteristic soil site description. Similar descriptions for all 100 soils are found in Appendix H.

These sites were then located on 1:500,000 colored Landsat image and photographic characteristics identified and mapped-out in similar areas. Figure 10 shows a portion of a 1:500,000 Landsat False Color Composite (FCC) of Djibouti. This information was then enlarged and compared to the features of the 1:100,000 topographic maps and the slope maps. The final map is registered to the 1:100,000 topographic map and drafted on mylar to facilitate reproduction. Copies can be obtained from the laboratory.

ARTA

Site No. 57

Location: 267.1 E
1274.9 N

0-15 cm: All horizon; dark yellowish brown 7.5YR 3/4 (moist); clay loam (very gravelly), very fine and weak granular structure; soft and friable. pH=7.3 (pH meter); strongly effervescent many fine roots; thin film of $CaCO_3$ on the rocks, it is covered with 75% of cobbles, stones and boulders of 10 to 75 cm; clear and smooth boundary.

15-40 cm: A12 horizon; dark yellowish brown 7.5YR 3/4 (moist); silt loam (very gravelly); medium weak sub-angular blocky breaking to weak fine granular structure; pH=7.3 (pH meter); strongly effervescent; common fine roots; 60% coarse gravels; soft friable soft fine dissumulated powdery $CaCO_3$; gradual and wavy boundary.

40-70 cm: ACca horizon; yellowish brown 7.5YR 5/4 very gravelly clay loam fine granular structure; 60% gravels; pH=7.1; strongly effervescent; gradual, diffused and irregular boundary.

70-200+ cm: C horizon; dark yellowish brown 7.5YR 3/4; volcanic lava fractures; coarse gravels; many films of $CaCO_3$ on the gravels; mildly effervescent.

Inclusions: These soils occur on slopes of 25-50% which represent about 35% of the area. 10% of the area is occupied by the tops of the mountains with thin soils, 10% with rock outcrop, 20% with slope shoulders, 20% with steep valley slopes with thin soils, 10% with vegetation cover (sogsog dominant, guud rare, kulan 1% dhidin...)

Parent Material: steep mountains, 50 to 70% cover of large volcanic bombs.

Comment: Location: 5 to 7 m from the road to Arta on the west side and at 3 km from the junction of the roads to Arta and Queah.

Classification: loamy skeletal mixed hyperthermic Aridic Calciustoll. (Typic Torriorthent)

Figure 9
CHARACTERISTIC SOIL SITE DESCRIPTION

Figure 10: Landsat 1:500,000 False Color Composite

Mapping unit descriptions are illustrated in Figure 11. Figure 12 describes the photogeologic appearance of the major soils on the FCC images. Approximately 35 mapping units were so described. Figures 13 and 14 show symbols and areas of these mapping units.

The mapping units were then subdivided and reported by soil series. Interpretations were then made for each series member and the soil series was classified. Figure 15 shows the soil series names and their associated descriptive sites. Figure 16 shows soil series by classification and compares Djiboutian to American (well described) soils.

Symbol: Ba 16

Name of principal soil: Balambal - Derokoma

Location and distribution: all over the country west of the mountain ranges, and the plateaus.

Climate: Warm and dry

Predominance in the country: one of the major soils in the country.

Composition of Mapping Unit:

1) Name of the soil series: Balambal

Classification: fine loamy, mixed hyperthermic, Typic Calciorthid.

Brief description: between 50-75 cm. thick, yellowish red to dark reddish-brown, stony clay loam.

Percentage of the mapping unit: 40%

Geomorphic position: silt mantle on the lava plateau.

Parent Material: Eolian silt and sand

Slope: 1-3% sometimes up to 5%

Dominant uses: range

2) Name of the soil series: Derokoma

Classification: fine loamy, mixed hyperthermic Typic Torriorthent.

Brief description: 75-125 cm. thick, dark brown, or brown stony sandy clay loam B horizon.

Percentage of the mapping unit: 30%

Geomorphic Position: on the lava plateau

Parent Material: eolian mantle

Slope: 1-5% mostly 1-2%

Dominant uses: range

Minor inclusion of 10% Easa Do and 10% of Garrayto are included in this mapping unit.

Figure 11
CHARACTERISTIC DESCRIPTION OF MAPPING UNIT

MAJOR SOILS OF DJIBOUTI

Aal5 - Playa basin with colluvial sand.
Appeared as long narrow bluish gray ares on Landsat image.
Texture sand over silt; slope 0-2%; depth more than 200 cm; rock fragment free; 10% shrub cover.

AF 9 - Steep slopes of basaltic plateaus.
Appeared as long narrow dark brown areas streaked with green on the Landsat image.
Texture gravelly sand; slope 40-70%; depth 50 cm; rocks 90% cobbles and stones; vegetation 1% shrubs and grass.

At 1 - Recent marine sediment.
Appeared as moderate areas of bluish gray near the sea.
Texture silt loam; slope 1-2%; depth more than 200 cm; few 2-7 meter sand dunes; vegetation 20% brush and shrubs.

Bal6 - Thin silt sediment on lava flows.
Appeared as very dark brown with common green spots on the Landsat images.
Texture clay loam; slope 2-5%; depth 50 cm; 75% stones and boulders; vegetation 2-3% shrubs.

Da9 - Steep ryolitic mountains.
Appeared as broad areas of very light brown mottled with light green and brown on the Landsat images.

DA16 - High lava plateaus.
Appeared as dark brown mottled with very dark brown or bluish gray and fine light green spots on the Landsat images.
Texture gravelly loam; slope long 1-8%; depth 50 cm; 90% cobbles and boulders; vegetation 15% brush, shrubs and grass.

DI 5 - Wadi delta.
Appeared as long narrow areas of light bluish gray on Landsat images.
Texture sand; slope 0-2% depth 75 cm; 3-4 meter sand dunes; vegetation 5% grass.

EG12 - Basin playa with sand dunes.
Appeared as broad areas of blue and light blue mottled with dark blue and green on Landsat images.
Texture sand; slope 1-2%; depty 75 cm; 3-4 meter and dunes, vegetation 5% grass.

Figure 12
Photo-Interpreted Soils Descriptions

GB-12 - Basin Playa-barren.
Appeared as broad smooth areas of white and light blue on Landsat images. Texture loam; slope 0-1%; depth more than 200 cm; rock fragment free; vegetation barren.

GM9 - Steep sandstone mountains.
Appeared as blue with verigated dark blue on Landsat images.
Texture gravelly sandy loam; slope 24-35%; depth 50 cm; 80% gravel and cobbles; vegetation 1% shrubs.

Ha10 - Weathered granite basin floor.
Appeared as irregular areas of grayish blue on Landsat images.
Texture sandy clay loam; slope 2-8%; depth 60 cm; rock fragment free; vegetation 3% brush and shrubs.

HH27 - Steep slopes of lava flow.
Appeared as long narrow very dark brown and bluish gray areas on Landsat images.
Texture bouldery loam; slopes 70%; depth 100 cm; 70% boulders; vegetation 20% brush.

JA16 - Thick silt mantle on lava.
Appeared as extensive broad areas of molted light green and light greenish blue on Landsat images. Texture silty clay loam; slope 0-2%; depth 150 cm; 50-80% cobbles and boulders; vegetation 10% shrubs.

Ko 3 - Wadi channel.
Appeared as long narrow white or light gray areas on Landsat images. Texture gravelly sandy clay loam; slope 0-3%; depth more than 200 cm; 40-80% gravel; vegetation 20% brush and shrubs.

Ma12 - Basin playa delta.
Appeared as broad purple areas streaked with light blue and brown on Landsat images. Texture loam; slope 5-25%; depth 120 cm; 60% cobbles and stones; vegetation 1-2% bushes.

Du 9 - Faulted lava flow mountains.
Appeared as dark brown broad areas mottled with very dark brown onb Landsat images. Texture gravelly loam; slope more than 65%; depth 75% cm; 70% stones and boulders; vegetation 10% brush and shrubs.

Figure 12 (continued)
Photo-Interpreted Soils Descriptions

RD12 - Saturated basin playa.
Appeared as broad areas of green and brown on Landsat images.
Te3xture clay loam; slope 0-1%; depth more than 80% cm; rock fragment free; vegetation rare.

WD17 - Basaltic plateau.
Appeared as broad areas of brownish green mottled with very dark brown and light green on Landsat images.
Texture silt loam; slope 5-25%; depth 25 cm; 80% stones and boulders; vegetation 5% shrubs and grass.

6 - Colluvial gravel.
Appeared as moderately wide long grayish blue areas with small brown blotches on the Landsat images.
Texture silt loam; slope 5-25%; depth less than 100 cm; 70% cobbles and stones; vegetation 1% shrubs.

22 - Salt.
Appeared as brilliant white on Landsat images.

25 - Mud flat.
Appeared as broad areas mottled with light blue and blue on Landsat images.

28 - Lacustrine marl.
Appeared as white and light blue on Landsat images.

29 - Coral islands.

30 - Volcanic cones.
Appeared as small areas of very dark brown on Landsat images.

Figure 12 (continued)
Photo-Interpreted Soils Descriptions

Map Symbol	Series Name
Aa15	Aada
AD9	Afnada Daba
AK33	Al Kibo - Easa Galaw
Ar9	Arta - Dagah Dere
At1	Atar - Eoulma
Aw6	Awdiea
Ba16	Balambal - Derokoma
DA16	Daba Eabdalle
DG1	Dabagalaley
DD10	Dagah Dere - Goendale Madobe
Da9	Damerkaddae - Afnaba Daba
Di5	Didjan Der
DB33	Dimo Le Boda
Dt10	Dita
EG12	Eado Gafan
Ea31	Eangalalo
Eo4	Eoulma
Ga16	Garrayto
GB12	Grand Bara
Ha10	Hadkodley
HH27	Holl-Holl - Afmeeaytou
JA16	Jaban Eas - Guistir
K14	Kallolou
Kn4	Kenannaba
LD9	Lahi Daddaeo - Afnaba Daba
Qu9	Oueah - Degamankal
RD12	Riffor Damoun
WD13	Wanni Daear - Malhadlou
17	Lava flow
19	Wadi channel
20	Beach
22	Salt
25	Mud flat
28	Marl
29	Coral slopes

Figure 13

SOIL MAPPING SYMBOLS

AND SERIES NAMES

(1:100,000 SOILS MAP)

Symbol	Name	Area (Square Kilometers)
Aal5	Aada	483
AD9	Afnaba Daba	807
AK33	Alkibo - Easa Galaw	371
Ar9	Arta - Daga Dere	1100
At 1	Atar - Eoulma	90
Aw6	Awdiea	442
Bal6	Balambal - Derokoma	2772
DA16	Daba Eabdalle	1381
DG1	Dabagalaley	277
DD10	Dagah Dere - Goendole Madobe	66
Da9	Damerkaddae - Afnaba Daba	1219
Di5	Didjan Der	298
DB33	Dimo le Boda	543
Dt10	Dita	741
EG12	Eado Gafan	504
Ea31	Eangalalo	169
Eo4	Eoulma	363
Ga16	Garrayto	309
GB12	Grand Bara	1562
Ha 10	Hadkodley	156
HH27	Holl-holl - Afmeeayton	1108
JA16	Jabaneas - Guistiv	1099
KI4	Kallolou	582
LD9	Lahi Daddaeo-Afnabadaba	1108
Ma16	Maarigi	144
Qu9	Oueah - Degamankal	1840
RD12	Riffor Damoun	517
WD13	Wanni Daear - Malhadlou	566
17	Lava flow	1030
19	Wadi channel	510
20	Beach	8
22	Salt	61
25	Mud flat	136
28	Marl	169
29	Coral Slopes	7

Figure 14

AREAS OF SOIL MAPPING UNITS

Map Symbol	Series Name	Description Sites
AA15	Aada	100;83
Ay5	Adoyla	11
Af9	Afmeeaytou	48
AD9	Afnaba Daba	82;30;2
AG9	Easa Gelaw	7
AK33	Al Kibo	49
AO9	Arraha Ommane	71
Ar9	Arta	57;47
At1	Atar	18
AW6	Awdiea	56;6;84
Ba16	Balambal	19;78;74
DA16	Daba Eabdalle	87;42;76
DG1	Dabagalaley	93
DD10	Daga Dere	95;75;40;17;36; 55
DL4	Da le Dola	51;39
Da9	Damerkaddae	66
Di5	Didjan Der	26;61;81
DB33	Dimo Le Boda	90;29
De16	Degamankal	43;3
Dr16	Derokkoma	70;37;69;59;23
Dt10	Dita	14;13
ED9	Easa Do	92;15
Eg12	Eado Gafan	91;74;32;65
Ea31	Eangalalo	46
Eo4	Eoulma	89
Ga16	Garrayto	89;34;72
GE6	Goray Eeeb	94
GB12	Grand Bara	8;27;31
Gu16	Guistir	20;45
Ha10	Hadkodley	24
HH27	Holl-Holl	67;80;38
Ho3	Houmbouli	86;54
JA16	Jaban Eas	52
K14	Kallolou	85;60
Kn4	Kenannaba	98;62
LK9	Lahi D'addaeo	9;79
Ma16	Maarigi	1
Ma6	Malhadlou	21
Mi16	Minkille	28;96;77
Ou9	Oueah	68;33;63

Figure 15

SOIL SERIES SYMBOLS

AND RANDOM SAMPLE SITE INCLUSIONS
(1:100,000 SOILS MAP)

Map Symbol	Series Name	Description Sites
RD12	Riffor-Damoun	4
WD13	Wanni Daear	53
9	Talus slope	44;88;35
17	Lava flow	16;12;22;64;5
19	Wadi channel	50
20	Beach	
25	Mud flat	
28	Marl	10;73
32	Salt marsh	92
33	Rock outcrop	41;25

Figure 15 (Continued)

Similar American Soils	Djiboutain Soils
<u>Aridisols</u>	
<u>Calcorthids</u>	
sandy, mixed hyperthermic, Typic Calciorthid	
Eastland	Afmeeaytou
fine loamy, mixed hyperthermic, Typic Calciorthid	
Lareen	Atar
Wintersburg; Sotim	Jaban Eas
loamy skeletal, mixed hyperthermic, Typic Calciorthid	
Tonopah	Easa Gelaw
Gunsight	
Whitlock	Goray Eeeb
coarse loamy, mixed hyperthermic, Typic Calciorthid	
Masonfort	Al Kibo
Masonfort	Awdiea
Masonfort	Malhadlou
loamy skeletal, mixed hyperthermic, Lithic Calciorthid	
Hobog; Lozier	Dita
fine loamy, mixed hyperthermic, Typic Camborthid	
Lalande	Grand Bara
Lalinda	Guistir
Adelino	Hadkodley
loamy, skeletal mixed hyperthermic, Lithic Camborthid	
Laposa	Arraha Ommane
<u>Aridisols</u>	
<u>Salorthids</u>	
fine loamy, mixed hyperthermic, Typic Salorthid	
Bunker Hill	Riffor Damoun

Figure 16

SOIL SERIES BY CLASSIFICATION

Similar American Soils	Djiboutian Soils

Natrargids

fine loamy, mixed hyperthermic, Typic Natrargid

Casa Grande	Eangalalo

Inceptisols

Halaquepts

fine loamy, mixed hyperthermic, Aeric Halaquept

Hilmar	Dabagalaley

Entisols

Torriorthents

loamy skeletal, mixed hyperthermic, Typic Torriorthent

Laposa	Easa Do
Arizo	Maarigi
	Oueah
Cottonwood	Afnaba Daba

sandy skeletal, mixed hyperthermic, Typic Torriorthent

Kokan; Arden	Da le Dola

loamy, mixed hyperthermic, Typic Torriorthent

Kimberlina; Seaman	Wanni Daear

sandy, mixed hyperthermic, Typic Torriorthent

Aco; Yellowrock	Eado Gafan

loamy skeletal, mixed hyperthermic, Lithic Torriorthent

Tecopa; Upspring	Dagah Dere
Minlith	Garrayto

sandy, mixed hyperthermic, Lithic Torriorthent

Cantua	Degamankal

loamy, mixed hyperthermic, Lithic Torriorthent

Trigger; Delgado	Lahi Daddaeo

Figure 16 (Continued)

Similar American Soils	Djiboutian Soils
Entisols	
Torrifluvents	
loamy, mixed hyperthermic, Typic Torrifluvent	
Ireteba; Anthony	Adoyla
sandy skeletal, mixed hyperthermic, Typic Torrifluvent	
Momoli; Ripley	Kallolou
Psamments	
mixed hyperthermic, Typic Torripsamment	
Rositas; Yturbide	Houmbouli
Mollisolls	
Calciustolls	
loamy skeletal, mixed hyperthermic, Aridic Calciustoll	
Pozo Blanco	Arta
loamy, mixed hyperthermic, Aridic Calciustoll	
Engle; Sarnosa	Daba Eabdalle
loamy, mixed hyperthermic, Pachic Calciustoll	
Elfrida	Minkille
Haplustolls	
loamy, skeletal, mixed hyperthermic, Aridic Haplustoll	
Wainee	Dimo Le Boda
Miscellaneous Land Types	
Talus slope	
Lava flow	
Wadi channel	
Beach	
Mud flat	
Marl	
Salt marsh	
Rock outcrop	

Figure 16 (Continued)

Finally, interpretations were made for each soil series. Figure 17 shows the key to the interpretations and Figure 18 shows a typical interpreted soil series description.

Complete data for all the Djiboutian soils are found in Appendix I, Report on the National Soil Survey. Figure 19 shows a 1:100,000 scale base map utilized in the study and Figure 20 gives an example of the 1:100,000 scale soils map of the same area, the Sadai region.

During the course of the project, an opportunity arose to present technical papers at the First Thematic Conference on "Remote Sensing of Arid and Semi-Arid Lands" in Cairo, Egypt. Two papers were presented. The first dealt with identification of natural water containment sites in Djibouti and the second dealt with the status of agricultural resource assessment in Djibouti. Copies of these papers are to be found in Appendix N.

During the course of the project, it became apparent that a means of introducing visitors to the soils of Djibouti was desirable. Toward this end, a field trip guide was developed to allow one to visit (via automobile) many of the representative soils of the country. This guide, for a trip from Djibouti to Atar, is presented in Appendix O.

Land Capability Classification

The Soils are divided into 8 (I-VIII) categories depending on the intensity of land use (see Buchman and Brandy) from well tilled row crops to watershed and wildlife habitat. For all categories, except I, there is a limitation to the use of that soil for agriculture. All of Djibouti is too arid for class I land because these soils require irrigation for agricultural production. Therefore, the arid limitation is assumed for all soils of the country. The following list of letters which follow the Roman Numerals of this classification system indicate the important specific restraint:

w = available water capacity
r = rooting zone depth in less than one meter
s = slope is greater than 5 percent
d = drainage for leaching salts
c - susceptibility to water overflow
a - alkalinity
g - stoniness
v = wind erosion and blowing
e = erosion susceptibility

Irrigation Suitability Classification

The code for irrigation suitability is the same for all 8 (I through VIII) categories of the land capability classification without the aridity limitation as a constraint. The same symbols of limitation are indicated as they affect irrigation agriculture. Therefore, irrigation is assumed for all these soils and no additional symbol is used.

Internal Drainage Classification

Here the land capability categories are:

I no limits to internal drainage practices
II moderate limits
III severe limits

The limits considered to affect internal drainage are:

t = permeability, texture and structure
r = depth to bedrock
w = depth to the water table
i = steepness of slope
b = ditch bank stability
c = flooding or ponding
a = salinity or alkalinity
s = available outlets

Figure 17: Key to Soil Interpretation Symbols

Terraces and Diversions Suitability Classifications

The categories here are:

I no limits to building terraces
II moderate limits
III severe limits

The factors determining the suitability for terraces are:

p = slope, steepness and length
r = depth to bed rock
f = stones and outcrops of bedrock
w = wind hazard
t = texture and permeability
c = channel siltation
s = outlet availability
e = flooding hazard

Embankments Suitability Classification

The major categories are:

I no limits to construct embankments
II moderate limits
III severe limits

The factors determing suitability are:

r = depth of the soil
t = soil texture
e = Soil erosiveness
p = percent and length of slope
g = presence of gypsum or salt
c = stones

Pond Reservior Suitability Classification

The major categories are:

I no limits to pond construction
II moderate limits
III severe limits

The factors determing suitability are:

t = permeability
w = depth to the water table
r = depth to bedrock, less than 2 meters
p = slope
e = flooding hazard

Figure 17 (Continued)
Key to Soil Interpretation Symbols

Rangeland Classification, Estimated Production

I	good production of 200-500 K per Ha
II	limited production of 50-200 K per Ha
III	non-usable production 0-50 K per Ha

Figure 17 (Continued)
Key to Soil Interpretation Symbols

BALAMBAL

Location: 251 E
1260 N

-5-0 cm: volcanic bombs of 5 to 30 cm. covering 75% of the area.

0-2 cm: A horizon; 5YR 4/6 yellowish red (dry) 5YR 3/4 dark reddish brown (wet); strong clay loam; moderage medium and fine subangular blocky structure; friable (dry and moist); common pores (1-2mm); thin discontinuous $CaCO_3$ layer on rock fragments below the soil surface; sgrongly effervescent, fine disseminated $CaCO_3$; pH 7.5; abrupt boundary;

2-35 cm: B horizon; 5YR 4/6 yellowish red (dry), 5YR 3/4 dark reddish brown (wet); stony clay loam; firm, friable, nonsticky; strong medium and large subangular blocky structure; strongly effervescent, finely disseminated $CaCO_3$; pH 7.5; few coarse woody trees roots; clear and wavy boundary;

35-45+cm: Cca horizon; many continous white $CaCO_3$ coatings on gravel uncemented; loose.

Slope: Slope of 2 to 3%

Position: On a plateau, flat top

Vegetation: 2 to 3% cover; "bilcin", "ibateys"

Classification: fine loamy mixed hyperthermic Typic Calciothid

Soil Interpretation:

Land Capability Classification: VII r;g

Irrigation suitability classification: none

Range: III 5% bush

Internal drainage: III r

Terraces and diversions: III r;t

Embankments, dikes and levees; III r;c

Pond reservior: III r

Figure 18

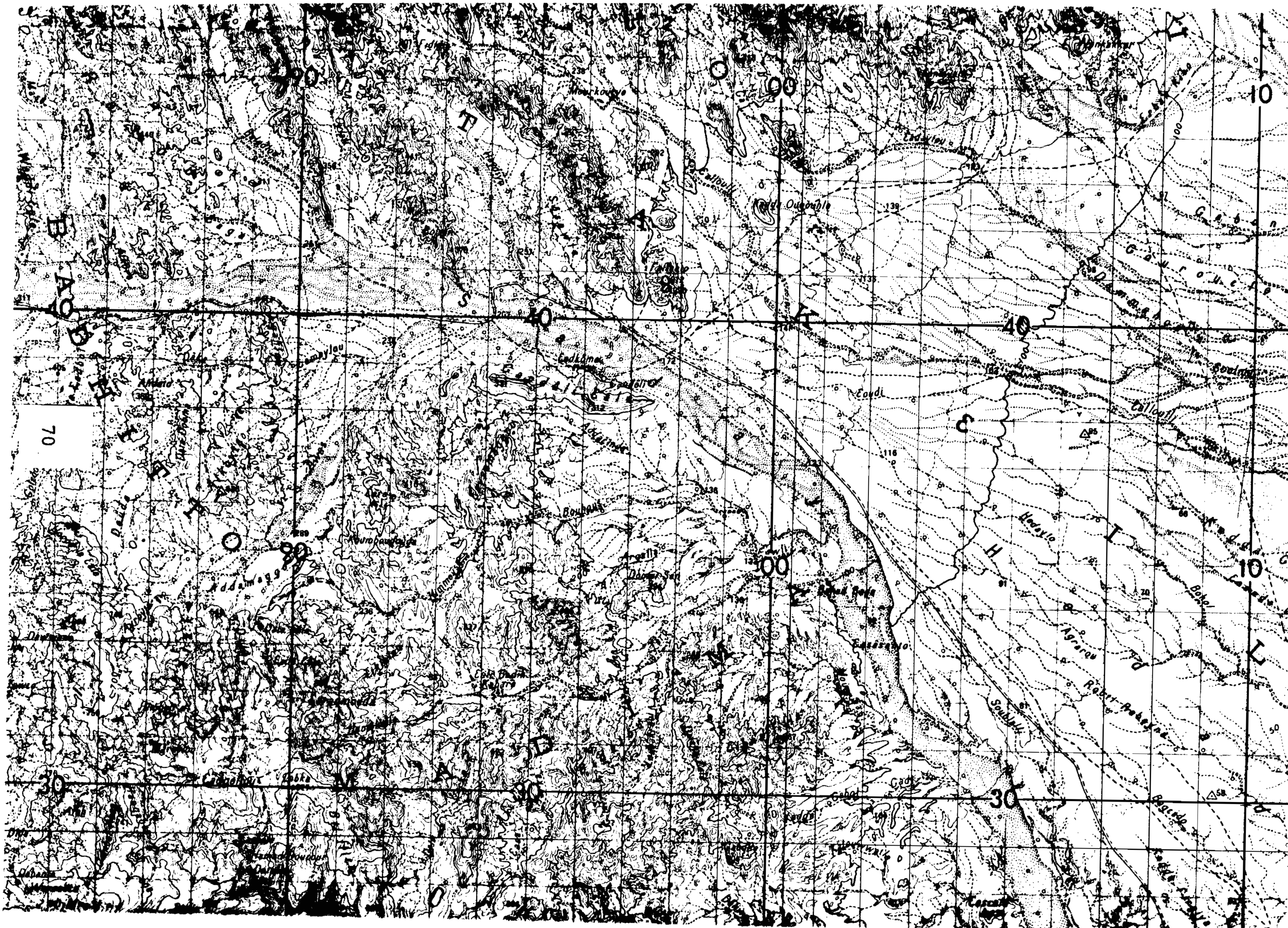


Figure 19: Example of Base Map, Scale 1:100,000, Sadai Region

BEST AVAILABLE COPY

Figure 20: Example of the National Soils Map, Scale 1:100,000, Sadai Region

BEST AVAILABLE COPY

3.3.4 Medium Scale Mapping

In addition to the small-scale mapping conducted for the National Soils Inventory, the soils of several areas were mapped in greater detail at a larger scale, 1:25,000. These areas include Sabbalou and Chekheyti near Dikhil (see Figures 21 and 22, Location Maps), and the watershed of Dey Dey (See Figure 23).

3.3.4.1 Soils of Sabbalou and Chekheyti

The maps produced in this study have been made specifically to serve as a guide for decision making on the placement of dispossessed people residing in Djibouti and under the responsibility of the United Nations. The objective is to establish the feasibility of a resettlement project. If this project is approved, the team will make a more detailed and specific soil study of specific lots for development to assist concerned technicians.

This soil study is only a guide to the soil conditions of the region. Eventually, more specific data will be collected on the region. Due to the very short time alloted to do the project, soil conditions have been estimated based on soils in nearby areas, and soil availability is assumed.

Since it is still uncertain where and how much water will be available, the descriptions and their interpretations on site will not be accomplished until the productive wells have been located and the project approved. At that time, soils for each lot will be determined and specific interpretation made.

The soils described here are those encountered in Djibouti during the National Soil Survey. Also included is the name of an American soil which is identical to that soil found in Djibouti based on their interpretation. More specific interpretations will be furnished when the sites are definitely selected. Photos #24 through #27 show some of the soils of the area.

Figures 24 and 25 show some of the 1:25,000 scale maps prepared for this medium-scale mapping project. The full report on the soils of these areas is found in Appendix J.

Esquisse de Carte Pédologique Region de Sabbalou

Octobre 1981

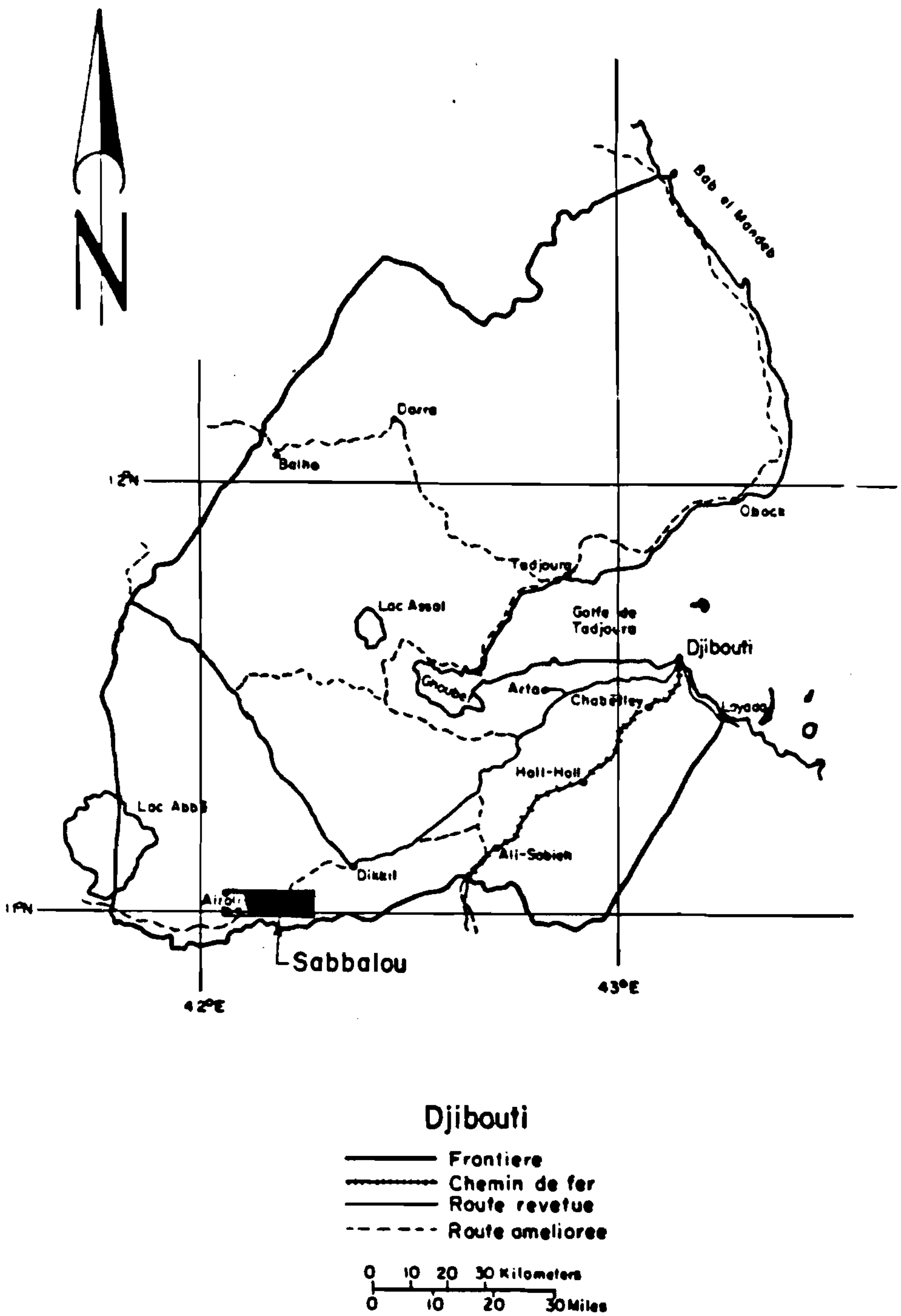


Figure 21: Location Map, Sabbalou

Esquisse de Carte Pedologique
Region de Chekheyti

Octobre 1981

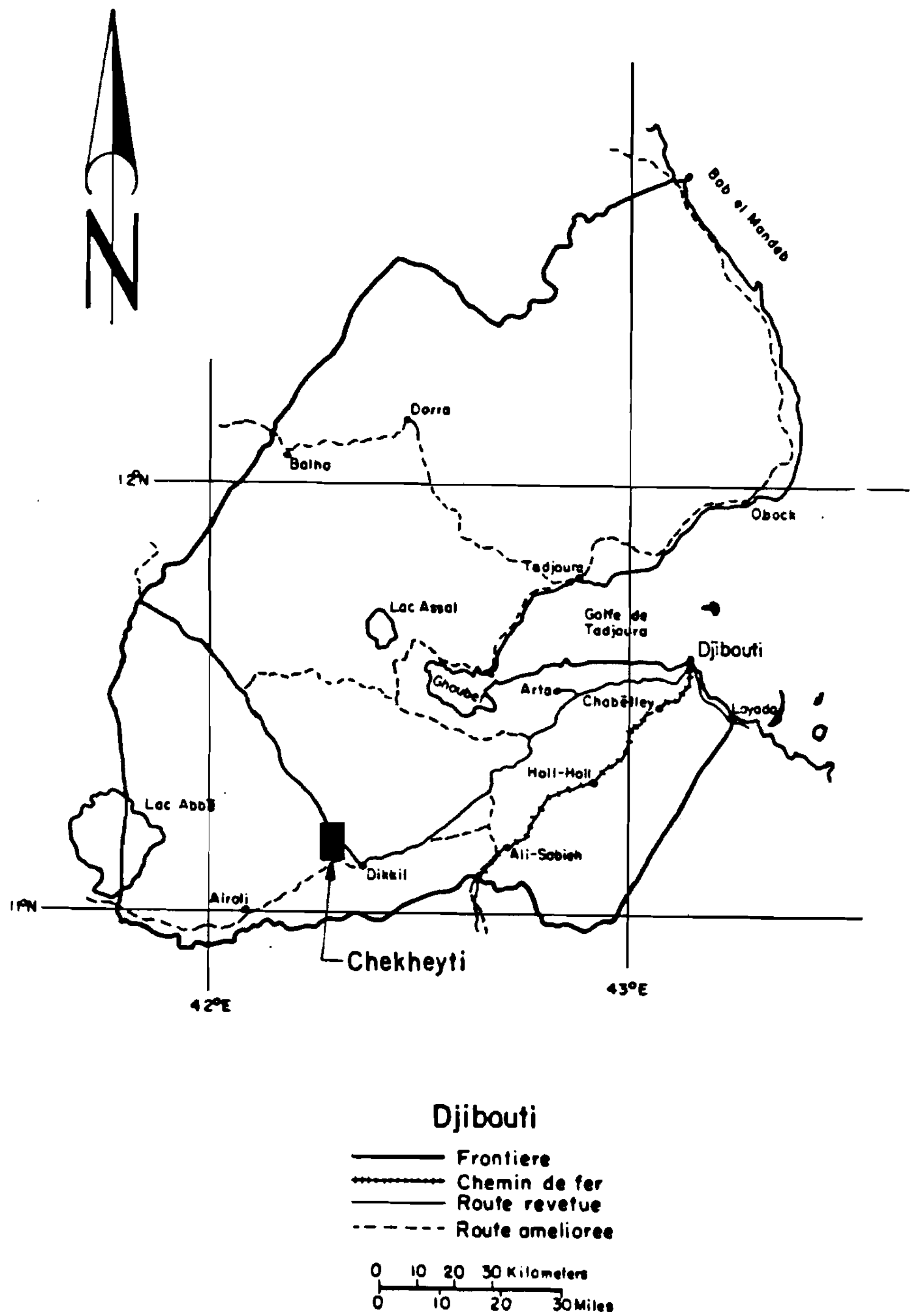


Figure 22: Location Map, Chekheyti

Esquisse de Carte Pédologique
Region de Dey Dey et Damerjog

Juin 1982

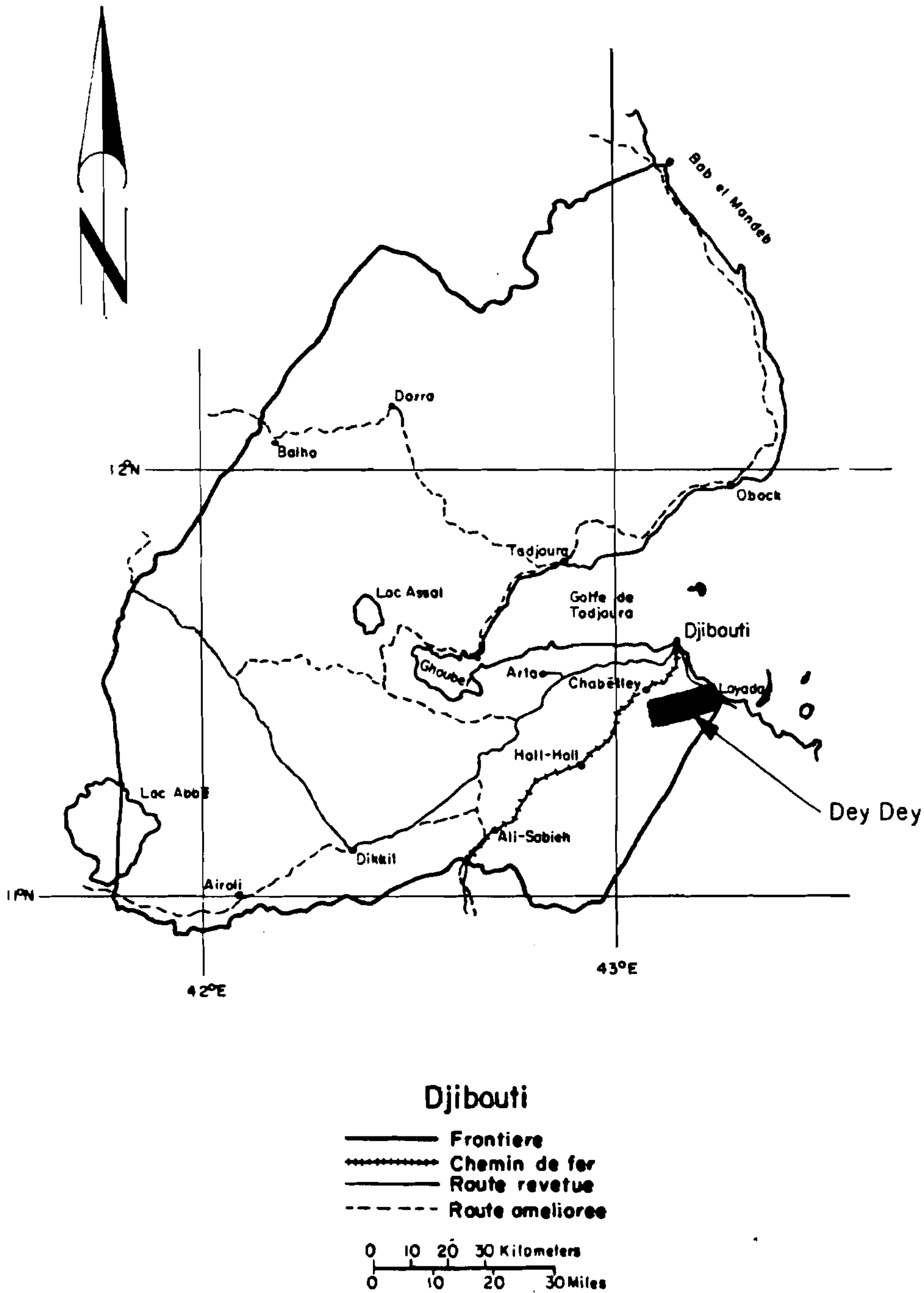


Figure 23: Location Map, Dey Dey

Photo #24: A garden on the Houmbouli soil along the Gobbaad wadi near Eas Eyla

Photo #25: Eado Gafan soil on road to Eas Eyla

Photo #26: Balambal soil north-west of Eas Eyla

Photo #27: Chekheyti wadi channel west from recent flood. Water is safe from evaporation below the surface.

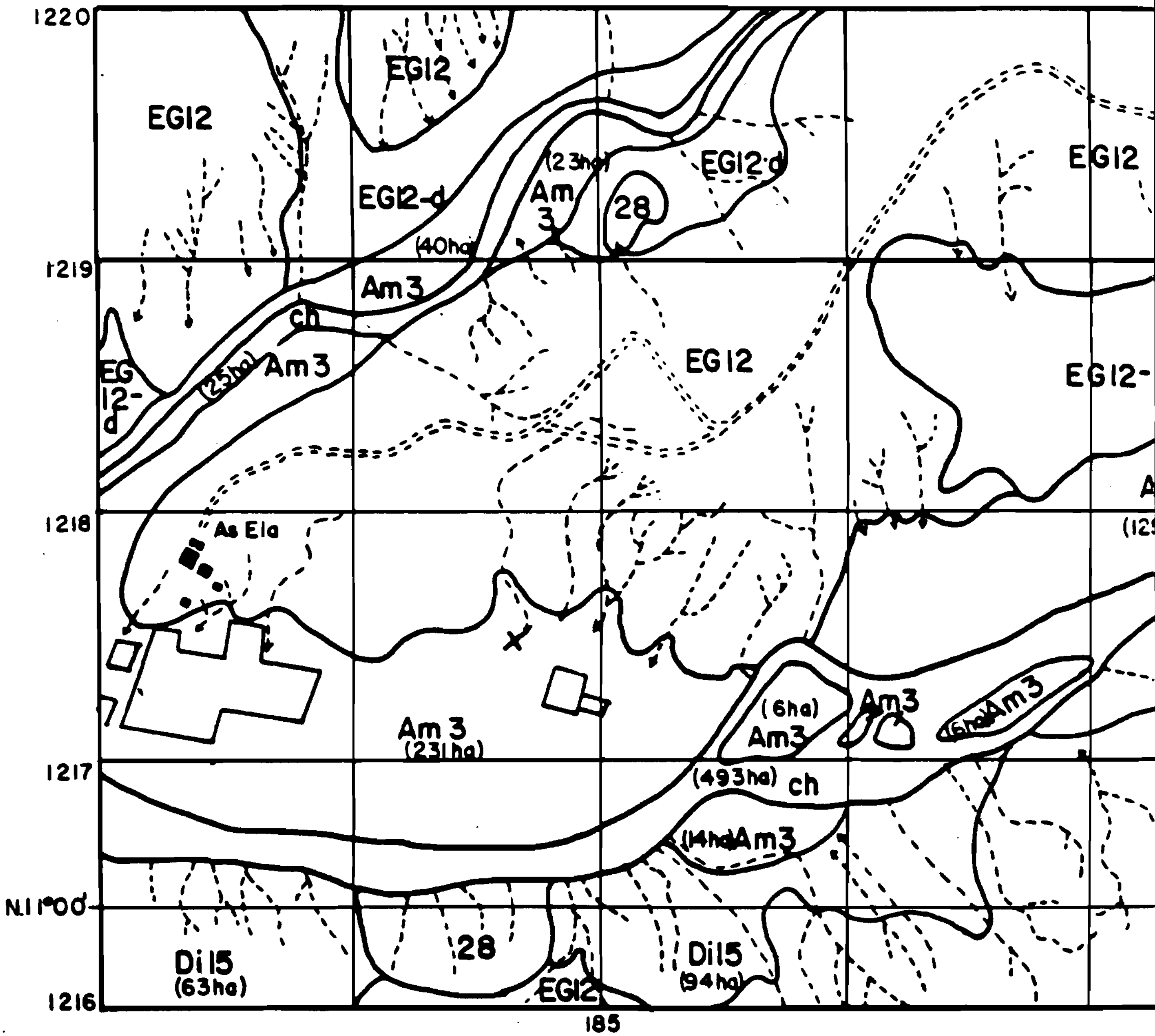
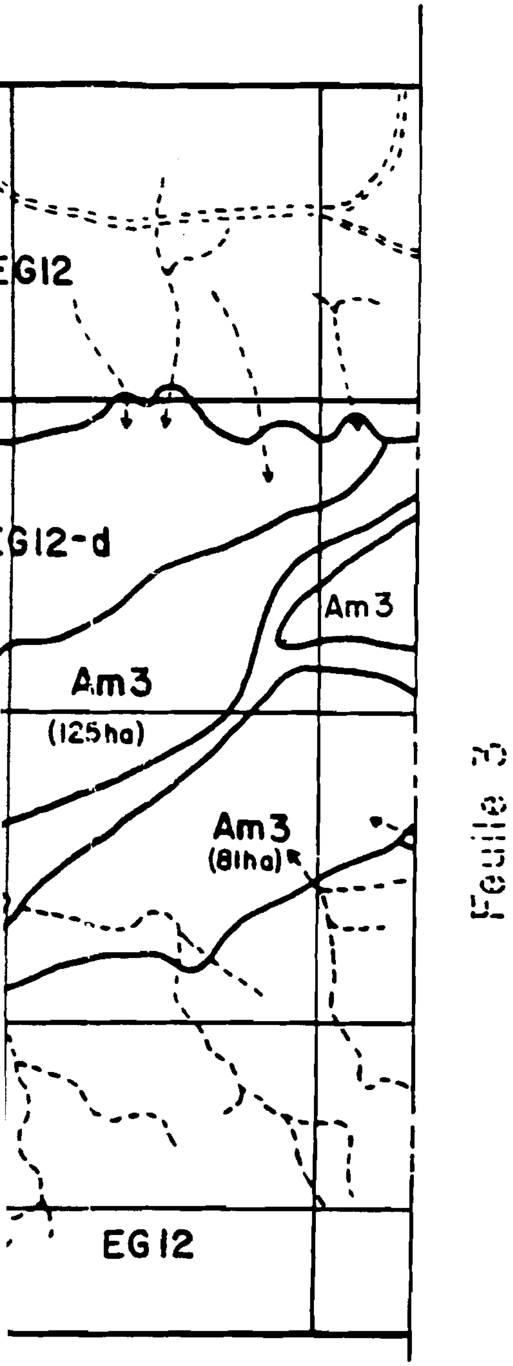


Figure 24: Soils Map of Sabbalou



Esquisse de Carte Pédologique
Region de Sabbalou

Octobre 1981

Feuile 2 de 4

Legende

Aa 15	Aada (274 ha)
Am 3	Houmbouli (940 ha)
Ba 16	Balambal
Di 15	Didjan Der (387 ha)
EG12	Eado Gafan
EG12-d	Eado Gafan avec dunes
Ou 9	Oueah
WD17	Wanni Dacar
ch	lit d'oued
x	forage proposé
⊗	limnigraphe
- -	oued
···	piste
□	jardin actuel
28	Dépouillé

Echelle 1:25.000

Dr. Joseph E. Goebel et Mr. Aboubaker Douale
Laboratoire d'analyse des sols et des eaux

97a

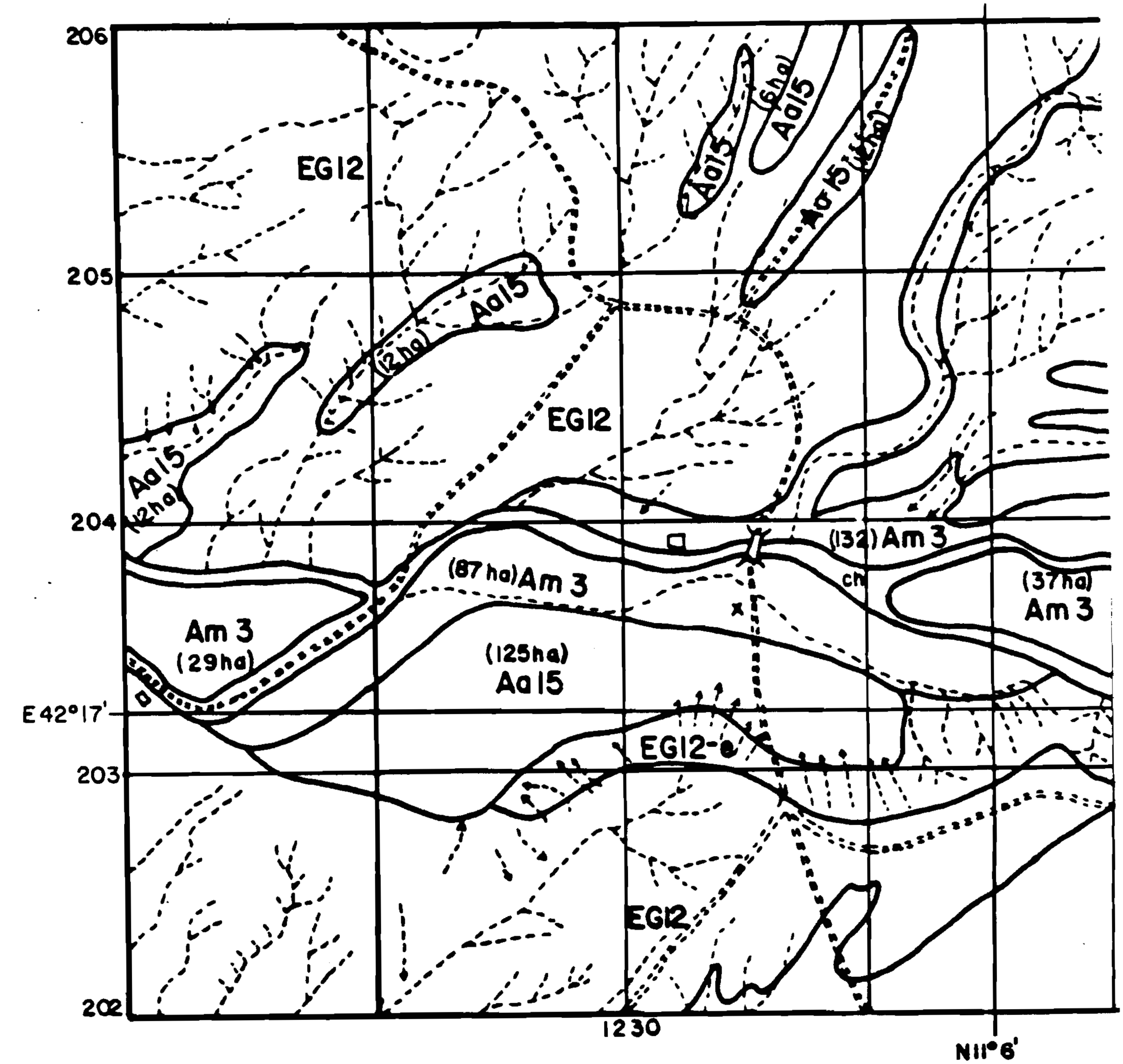
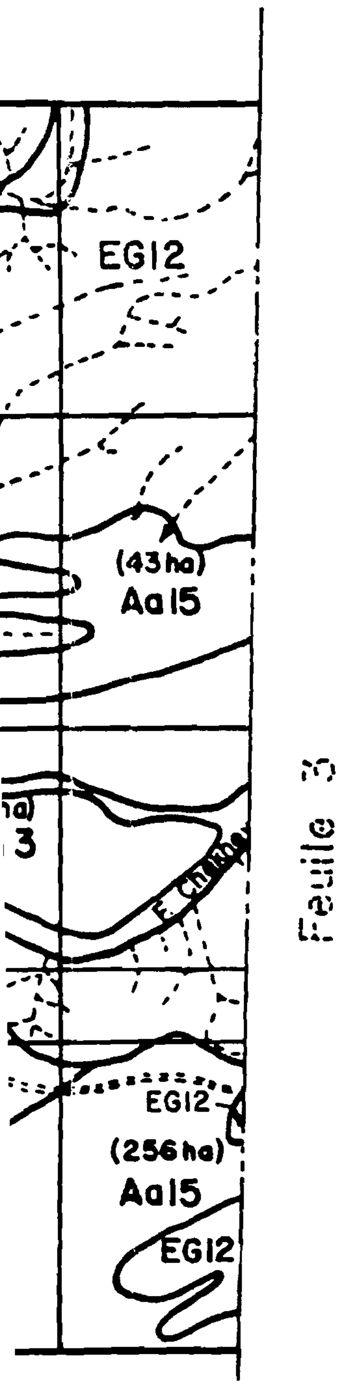


Figure 25: Soils Map of Chekheyti

Esquisse de Carte Pédologique
Region de Chekheyti

Octobre 1981

Feuile 2 de 3



Legende

Aa15	Aada (1058 ha)
Am3	Houmbouli (363 ha)
Di 15	Didjan Der
EG12	Eado Gafon
EG12-e	Eado Gafon erodé
ch	lit d'oued
x	forage proposé
	oued (125 ha)
	piste
□	jardin actuel

0 — 1 Km — 2 Km

Echelle 1:25.000

Dr. Joseph E. Goebel et Mr. Aboubaker Douale
Laboratoire d'analyse des sols et des eaux

18a

3.3.4.2 Soils of the Dey Dey and Damerjog Watersheds

A medium scale soils map was made of the Dey Dey and Damerjog watersheds because of their proximity to the city (see Figures 26 through 28). They were also chosen for their size. It was important to learn more about the soils and water near the city of Djibouti to help answer development questions. The Houmbouli watershed was too large for this project. The information will be helpful for water development for the farms of Atar.

It is recommended that the soils mapping proceed on the watershed basis because all development in Djibouti is dependent upon water resources which are only available from rainfall. Since a watershed is the catchment basin for rainfall runoff, it becomes the logical working basis. Djibouti has no fences or other features to locate political boundaries nor maps to substantiate these, but the crest of the hill that divides the rain water between two valleys is real, everyone can see it and it can be agreed upon in most cases.

There is room for some agricultural development near Damerjog, based on excess flood water seeping into the channel. A boulder back filled trench in the Dey Dey Wadi would supply better water for the Atar Agricultural Project and its neighbors. There is probably enough water for one square kilometer of vegetables.

The following procedures were followed in preparation of these watershed soils maps:

1. Make 1:100,000 scale map of the watershed for slopes, contours. drainage network and national soils map to serve as guidance; also locate the 5% random sample sites that occur in the watershed.

2. Acquire the 1973 aerial photographs that cover the watershed (scale approximately 1:25,000).

3. Match the photos by establishing a common line on alternate photos for the flight line and adjacent photos between flight lines. Establish north and indicate this on the photo. Write the number of the matching photo.

4. Locate at least 3 UTM coordinates for each photo to be used in mapping. Select those with the best certainty of identifying the spot on both the photo and the map. This will establish the UTM grid on the photographs and provides ground control and orientation. Write the grid coordinate numbers on the photo.

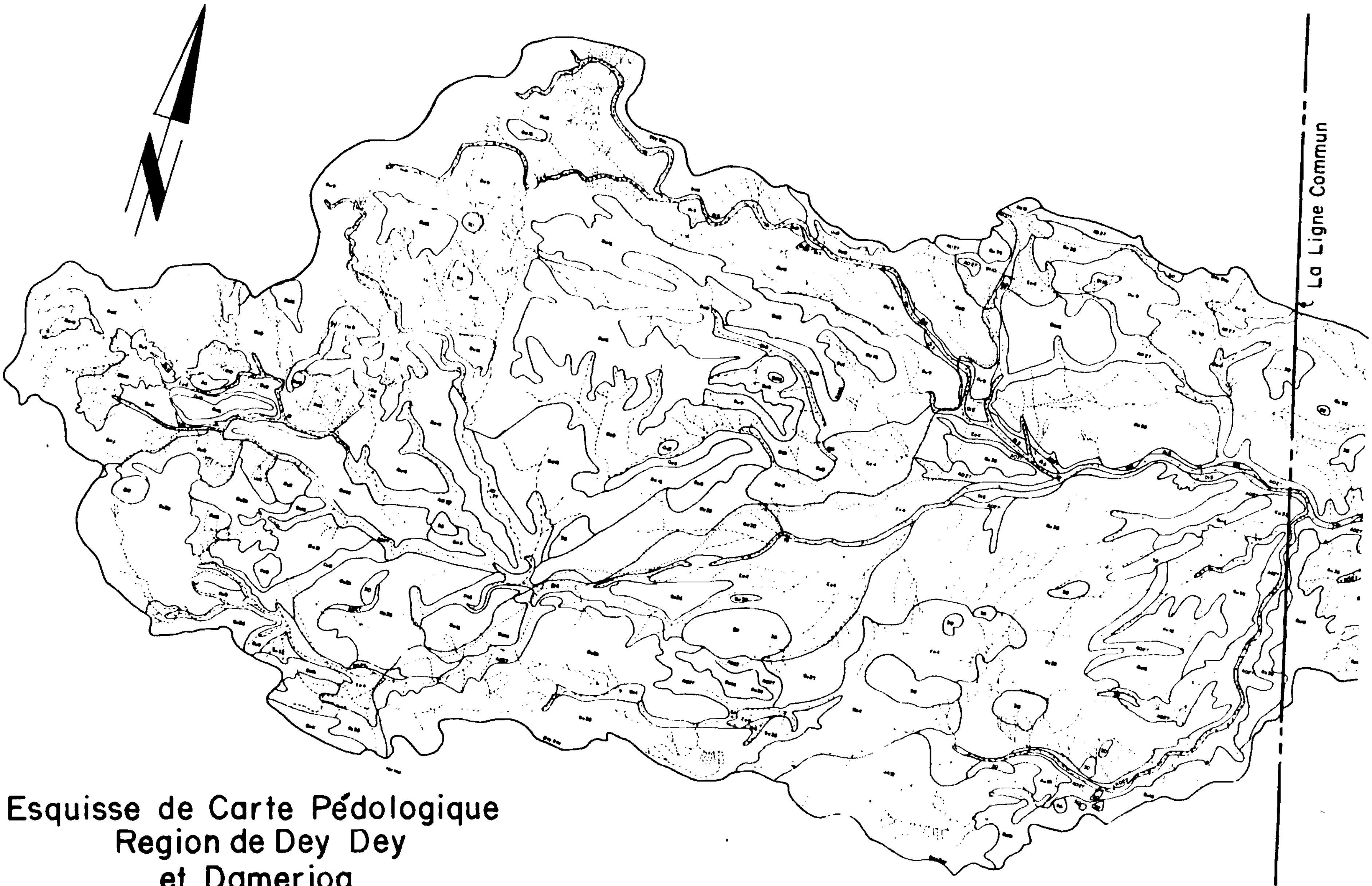
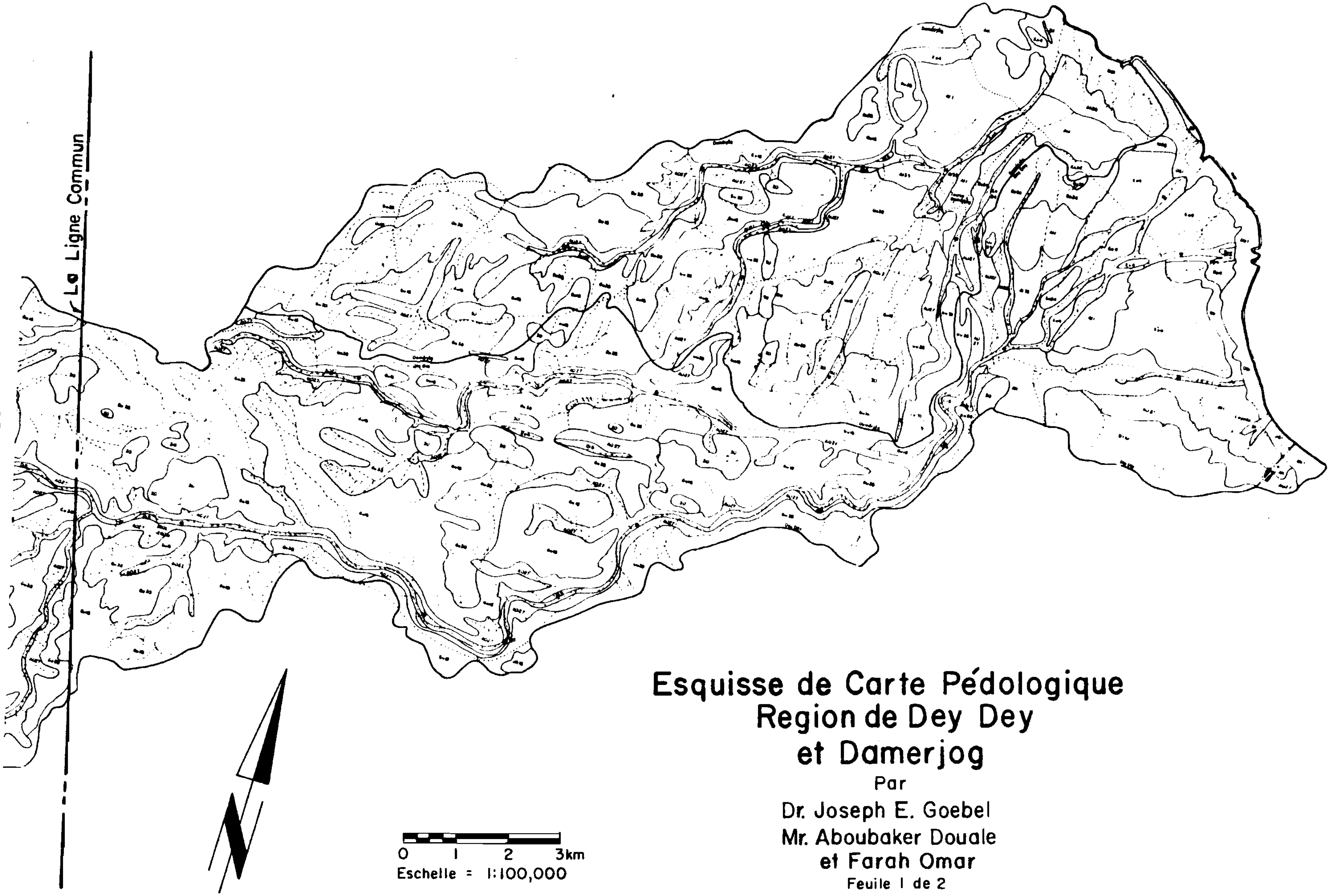


Figure 26: Dey Dey Soils Map
Western Half



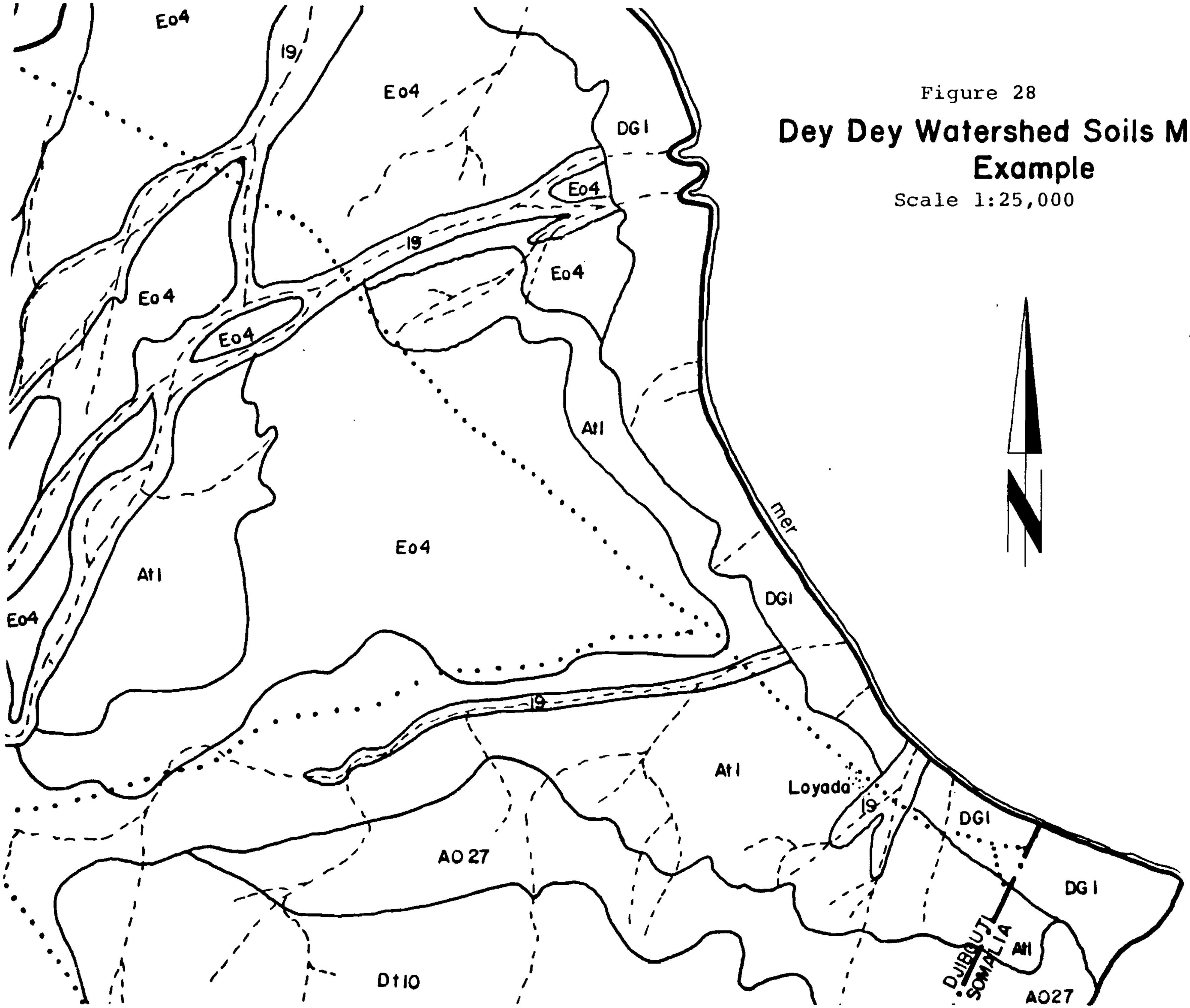
Esquisse de Carte Pédologique
Region de Dey Dey
et Damerjog
Par
Dr. Joseph E. Goebel
Mr. Aboubaker Douale
et Farah Omar
Feuile 1 de 2

Figure 27: Dey Dey Soils Map, Eastern Half

Figure 28

Dey Dey Watershed Soils Map Example

Scale 1:25,000



5. Take a large sheet of paper. Pick one photo near the center of the watershed and place it in underneath the center of the paper and trace the matching lines. Write the number of the photo in the upper left corner of this square. Trace the UTM coordinates on the map and give them their proper number. Place the matching photo on the matching line under the paper, after removing the other photo. If possible, it is good to have all the photos spread to make a rough mosaic. Copy the same information, matching lines and coordinate numbers, pencil on the paper. Do this for all of the photos to the edge of the watershed. The photos will not fit exactly.

6. Establish the scale of the map by measuring between 2 grid coordinates. The further apart the better. You may check several photos for the scale in the same manner.

7. Draw a UTM grid on the new map by passing through the most UTM grid points possible with a east-west line through the middle. Then establish perpendicular lines near both east and west ends passing closest to the same row of coordinate points. Armed with the scale and orientation east-west and north-south, mark off one kilometer units on all these lines. This requires patience because when connecting the lines to make the grid the intersection often will not coincide with those associated with the photos. That's due to distortion in the photos.

8. Locate the random sample sites on the map.

9. Punch register clear acetate to the photos and trace the information on the photo. Now with the scaled grid place the intersects on the sites identified between the photo and the 1:100,000 map. Establish the location of the random sample sites and ink them on the acetate and label them.

10. Take the photos to the field and discribe and sample the soils in the random sites. Map features as needed Aerial support for field work is necessary.

11. Return to the office and proceed to map the remaining photos and label the soil units.

12. Establish as many soil series as occur and develop description and interpretation of the series.

13. Write up the mapping unit description.

14. Use the vertical sketchmaster to take out photo distortion and put the soils map at exactly 1;25,000 scale on a transfer sheet of paper. Be sure to transfer the UTM grid coordinate intersects and their number. Also trace the drainage channels, roads, and watershed boundaries -- each in a different color. Be sure the same areas match between photos.

15. Cut the 1:25,000 scale transfer sheets out and attach them together. This map is placed over and registered to a 100 square kilometer grid in clear acetate, by matching as many coordinates to the grid as possible.

16. Place a clean sheet of clear acetate over the paper constructed map and trace the soils, drainage channels, roads, watershed boundaries, and other important information. The map is ready for reproduction.

17. Be sure the soils classifications are consistent between adjoining watersheds.

18. Measure the watershed and each of the soil areas.

19. Complete the report including the site descriptions, the soil series descriptions, the soils interpretations, the mapping unit discriptions, list of mapping units, list of soils series encountered and their classification.

20. Make a reduced, convenient map for general distribution and correct the national map accordingly. Photos #28 through #31 illustrate some soils of the Dey Dey region.

The full report on the soils of the Dey Dey and Damerjog watersheds may be found in Appendix K of this report.

3.3.5 Large Scale Land Ownership Mapping

Due to the small size of the agricultural fields in Djibouti, it is necessary to establish a mapping capability at 1:5,000 scale which is five times larger than the largest scale photography available and twenty times larger than the only serviceable topographic map.

Therefore, Beverly Rollins, a volunteer with the Agricultural Services, learned how to locate detail from the 1:100,000 topographic map to the 1:25,000 aerial photos. She then located the farm agricultural areas (See Figure 29). The information of the black-and-white photos were enlarged and compared to some hand-held 35 mm color slides of the present condition in these two areas (see Photos #32 and #33). The distortion was removed and a 1:5,000 scale map was established

Photo #28: The EEC's agricultural project of Atar on the coastal soil called Atar

Photo #29: Hills in foreground are Dita soil

Photo #30: Guistir soil with Eulma soils where the people and trees are nonexistent

Photo #31: Due to rock cover, we flew in with pilot to describe the Guistir soil

Esquisse de Carte des Propiétés
Region de Douda Weyn

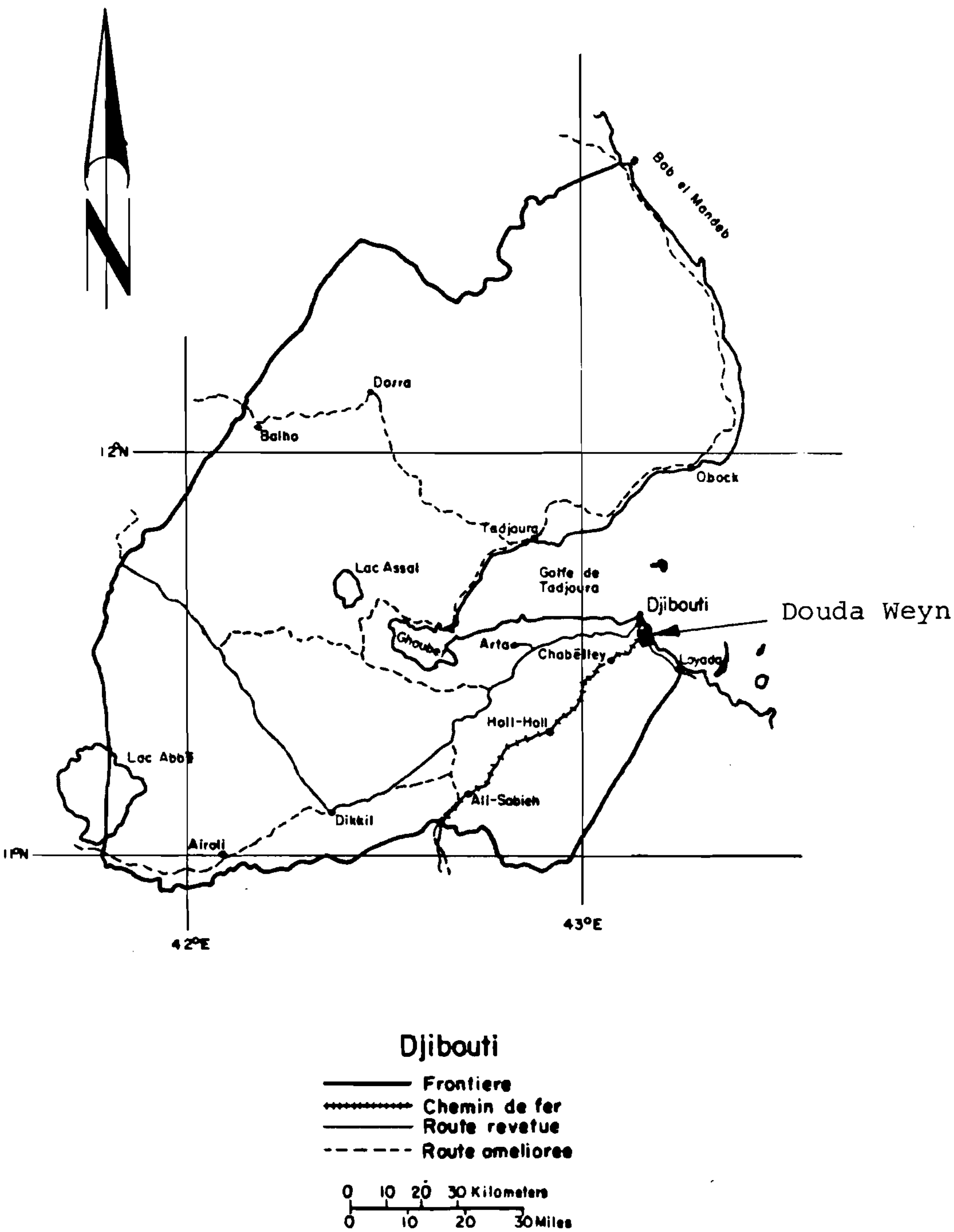


Figure 29: Location Map, Douda Weyn

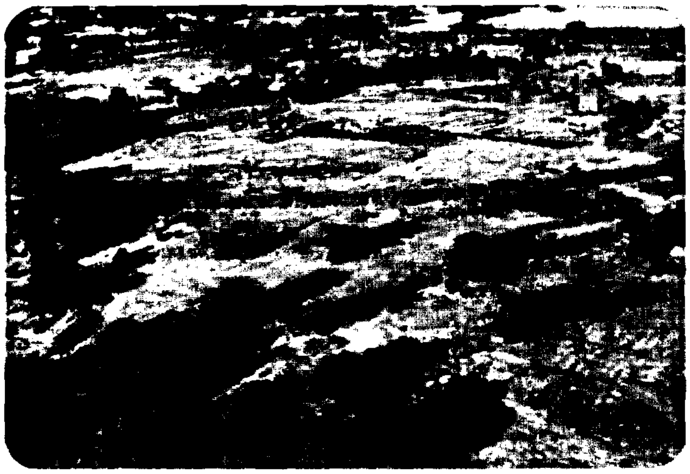


Photo #32: New Garden expansion in 1982

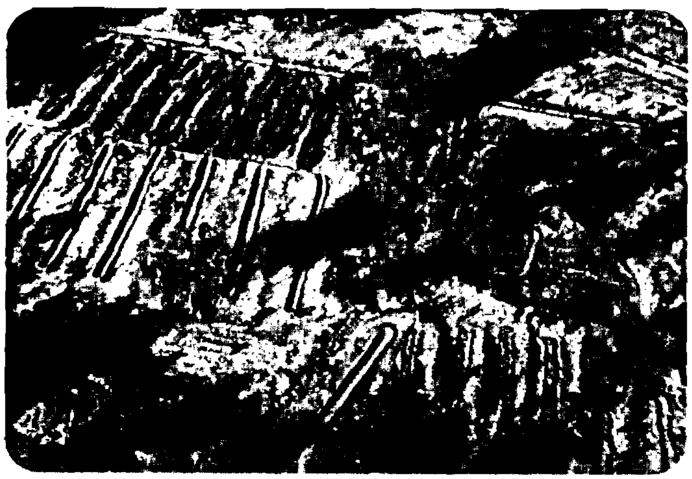


Photo #33: Two garden sites included in Houmbouli inventory and mapping of gardens using the Universal Transverse Mercator (UTM) kilometer grid as a base for placing and locating. This presents a large enough scale to begin to locate the agricultural inventory on the map. It is expected that this procedure can be expanded to other areas such as Asala, Hanle, Tadjorah, Obock, etc.

In making a map it is important to have a base map which establishes the location of features to be identified on the ground. Since Djibouti has few roads, fences and channels as well as large-scale maps, the best maps available are the 1:100,000 scale topographic map. Since there is no large-scale that covers the country, this project has used the UTM, one-kilometer grid base of the 1:100,000 map as the specific base map. The intersection of the north-south lines with the east-west ones need only then to be established for each larger scale and a serviceable map can be made.

Therefore, in this project, we compared the features of the 1:100,000 scale map to those of the 1:25,000, 1973, aerial photographs. Several UTM grid locations are placed on an acetate overlay, punch registered to the aerial photo. The scale is established and a full grid made by scratching the acetate to avoid obliterating the photo.

At this time the selected features are traced on separate overlays to facilite updating. This map is then transferred, using vertical sketchmaster to grid at exactly 1:25,000. Figure 30 shows the resultant 1:25,000 base map.

We also took 35 mm slides of the present agriculture in Houmbli and Bouda from about 500 meters elevation. Care was taken in this step to hold the camera vertical to the ground to acquire overlap on all sides.

At this point the 1:25,000 map of 1973 features are merged with the 1982 slides. The aerial photos enable one to locate the features on the 1:100,000 scale map in sufficient detail to recognize its placement on the 1:5,000 scale map (in this case the color slides). To facilitate this transfer a perpendicular is established between those points recognized on both the 1:25,000 scale map and the color slide. The 1:25,000 scale map is then placed on a board and moved to/from the projector to accomplish scale and it is filtered to compensate for distortion. Then the new features are traced on a sheet of paper placed over the 1:25,000 scale map.

The new map, with the placement of fences, channels, roads and buildings is then enlarged to 1:5,000 scale. The final map is comprised of a sheet for each square kilometer of the UTM grid (10 cm X 10 cm). Figure 31 shows a representative 1:5,000 scale map. The mylar sheets are punched and the grid is divided into 100 parts. Each type of feature is placed on a separate sheet of mylar.

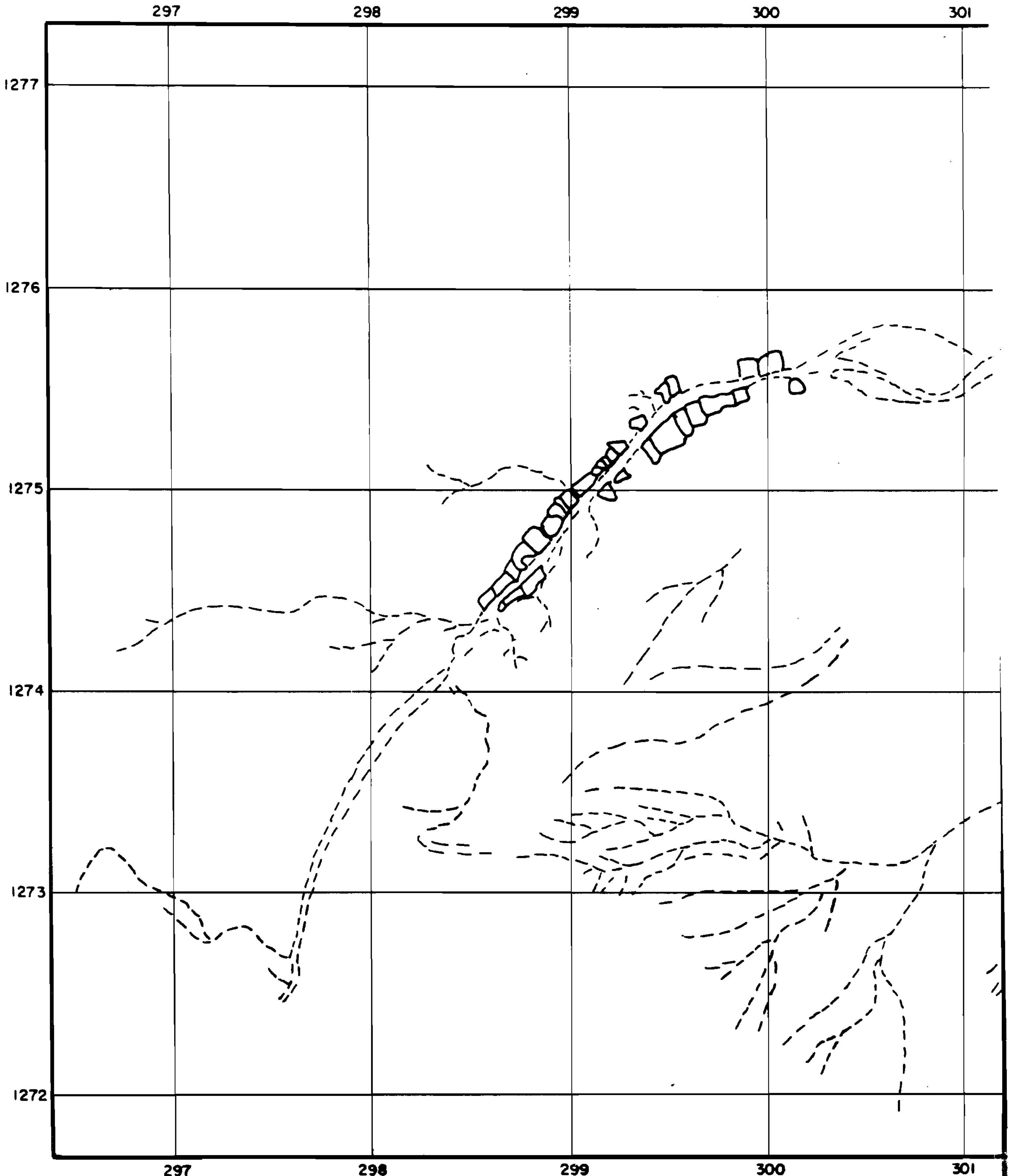
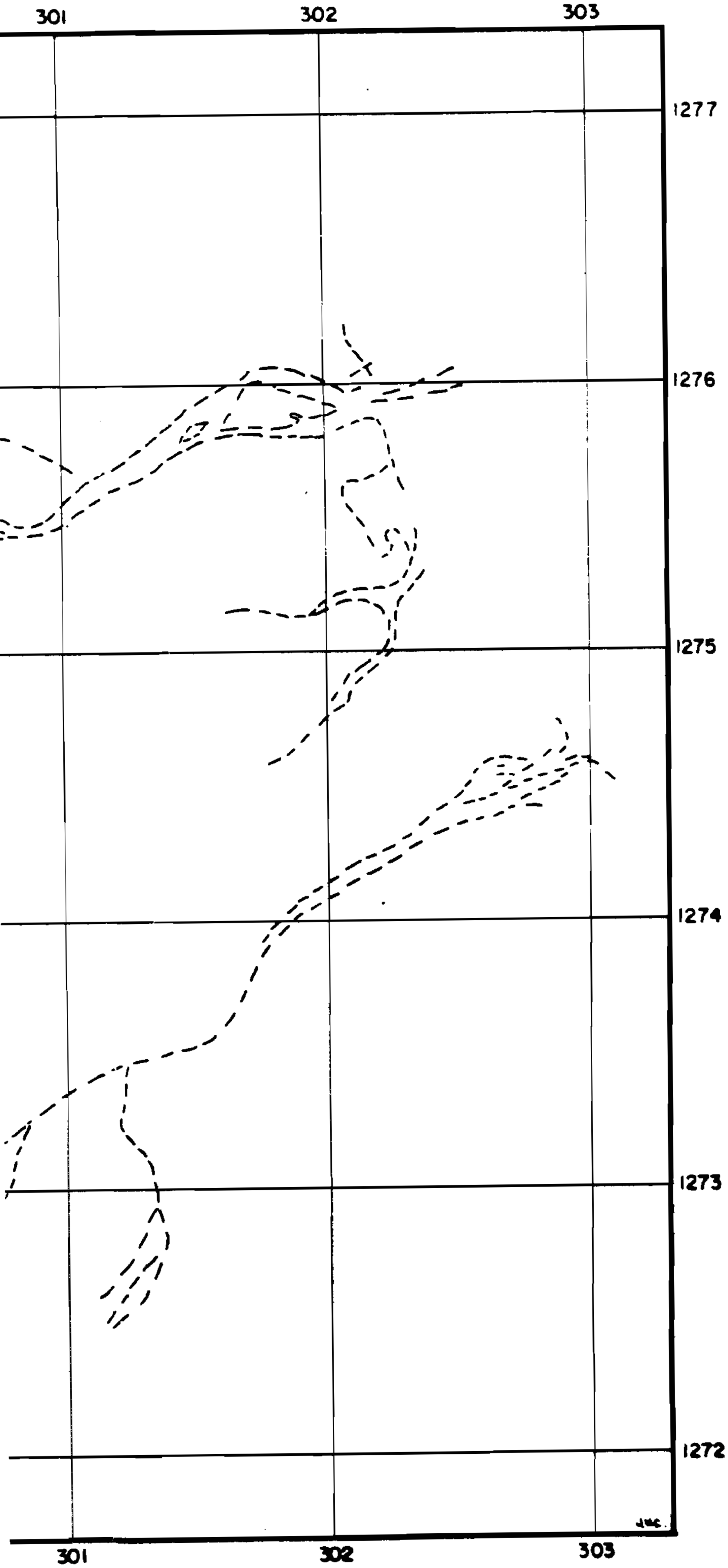


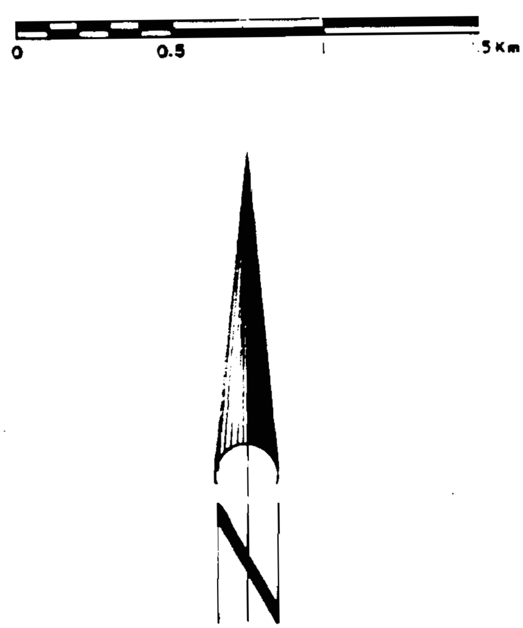
Figure 30: Land Ownership Base Map



Propriétés de la Region de Douda Weyn

Fait par Foto Arien de 1973

Eschelle = 1:25,000



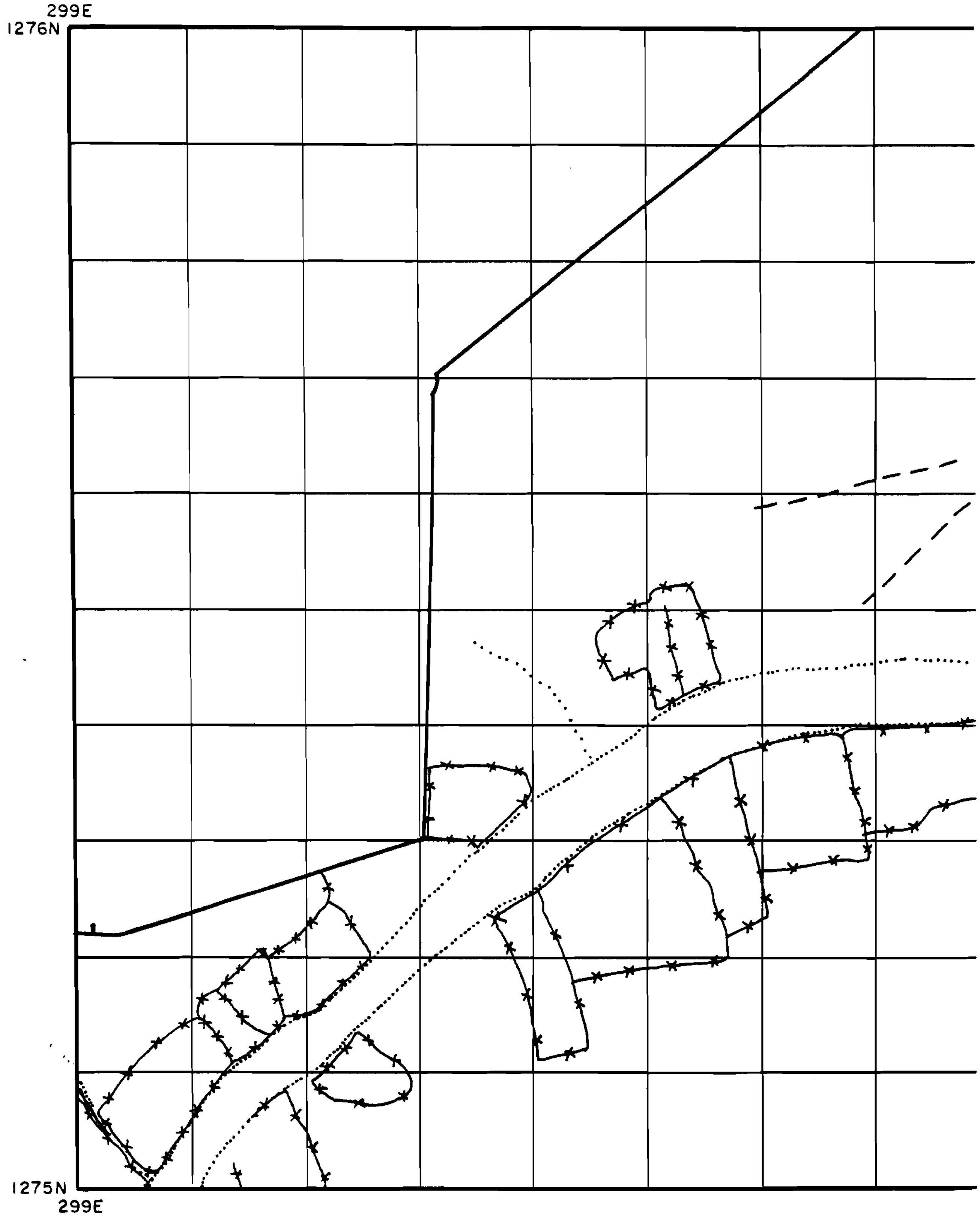
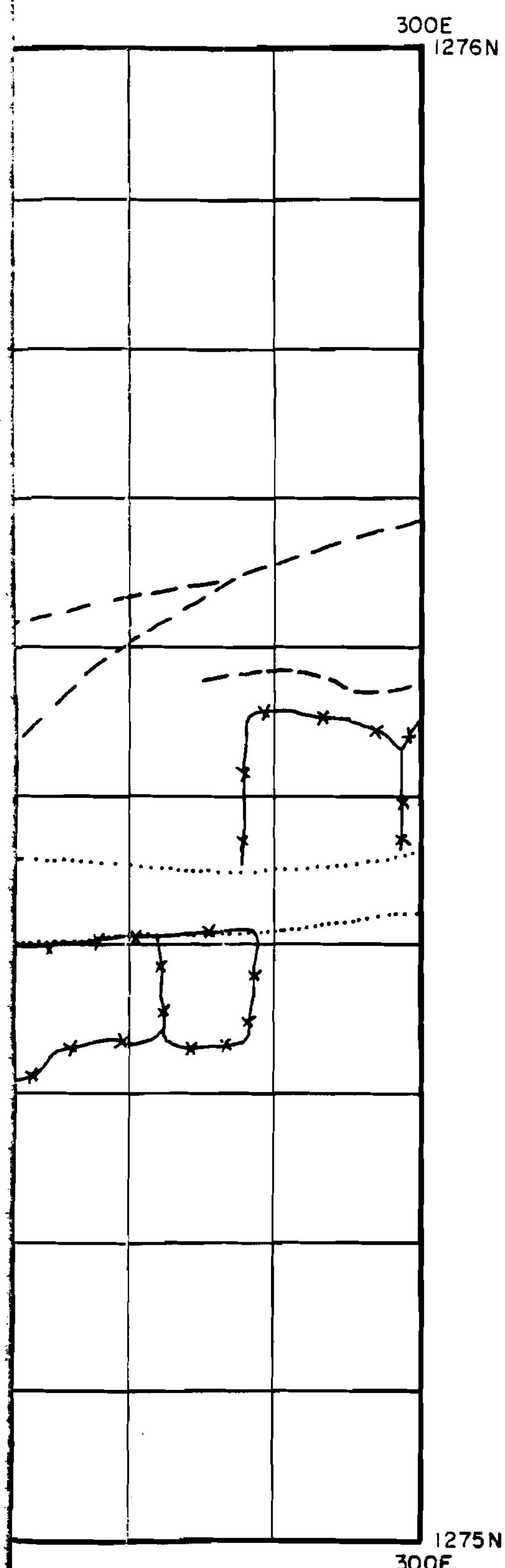
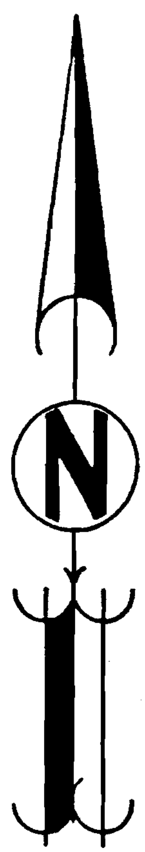


Figure 31: Land Ownership Map



Propriétés de la Region de Douda Weyn

Eschelle = 1: 5,000



qoa

A single photocopy is made and taken to the field for adjustment, verification and logging ownership. The fields are measured with a planimeter and the size of the fields are assigned to the appropriate proprietor.

The entire Land Ownership Mapping Report is to be found in Appendix L.

3.3.6 Supplementary Mapping

An assortment of maps are needed to properly plan and execute an agricultural development plan for Djibouti. Knowledge about the extent of watersheds, slope conditions, climate, elevation and physiography will permit computations to determine how much water is available and where this water may be deployed to suitable soils.

Numerous maps were prepared for this project. They include modifications of topographic and base maps, slope maps, physiography, watershed maps, detailed soils maps, generalized soils maps, soil climate maps, zones of agriculture classes, land capability maps, irrigation suitability maps, and range suitability maps.

3.3.6.1 Base Maps

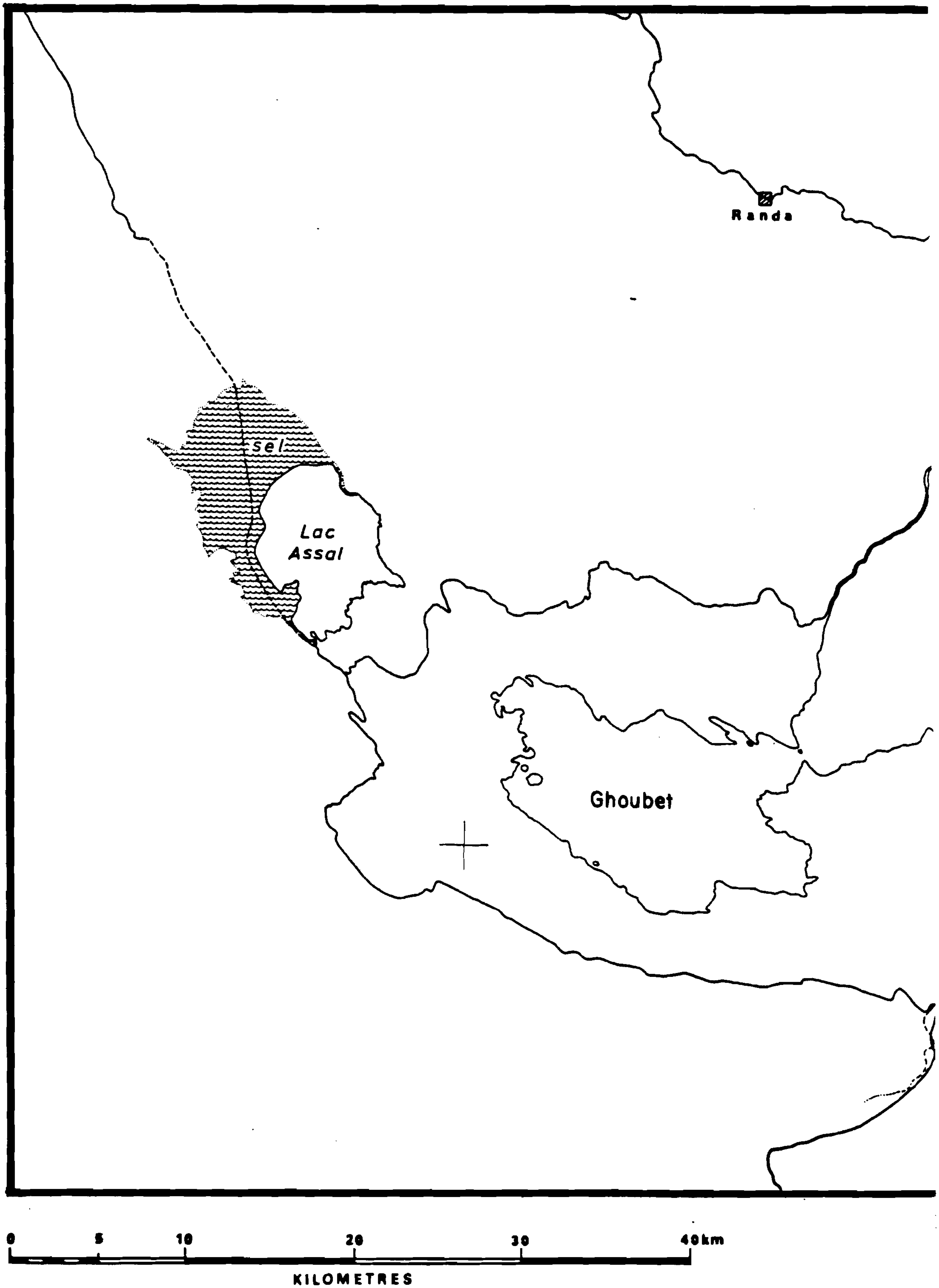
The topographic control used in this study was based on the 1:100,000 scale maps of the Institut Geographique National of France. The maps produced were also at that scale and at a scale of 1:300,000 for the interpretive maps. Figures 32 through 34 show portions of the 1:300,000 base maps for the project and include UTM grid system and topography.

3.3.6.2 Slope Maps

Slope maps have been prepared for this project. The slope classes used are those of the USDA. The different classes of the slope are:

Class	Slope
A'	0 - 1%
A	0 - 3%
B	5 - 8%
C	10-16%
D	20-30%
E	45-65%
F	>65%

The first three classes of slope are usually suitable for agriculture. The others constitute sites which need further investigation concerning surface water run-off. The stronger slopes also need particular care in selection of equipment. Photos #34 through #37 show examples of these slopes. An example of a 1:100,000 scale slope map is found in Figure 35. An example of the 1:300,000 scale slope map is illustrated in Figure 36. An example of a physiographic map is found in Figure 37.


Randa
sel
Lac
Assal
Ghoubet
0
5
10
20
30
40km
KILOMETRES

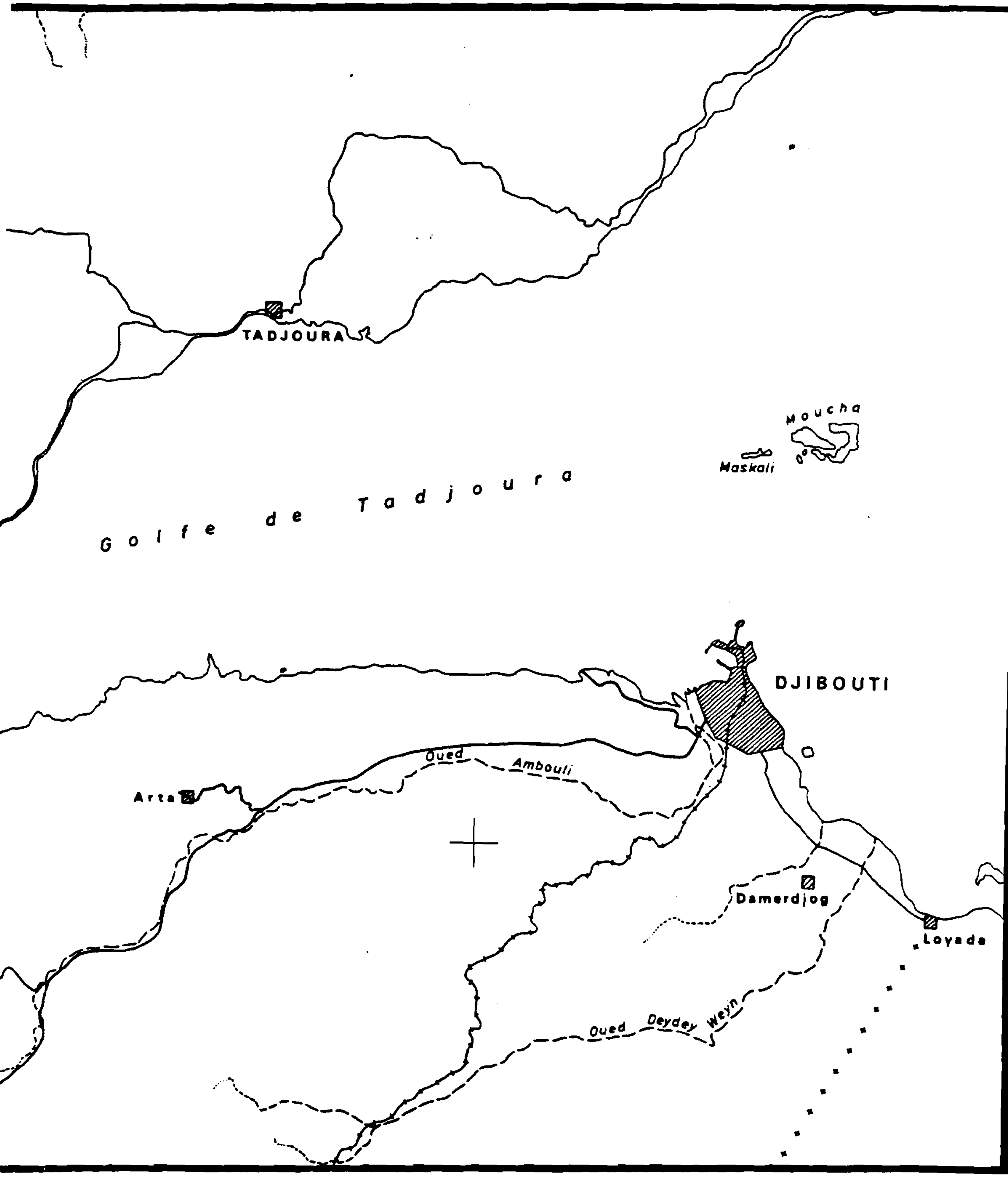
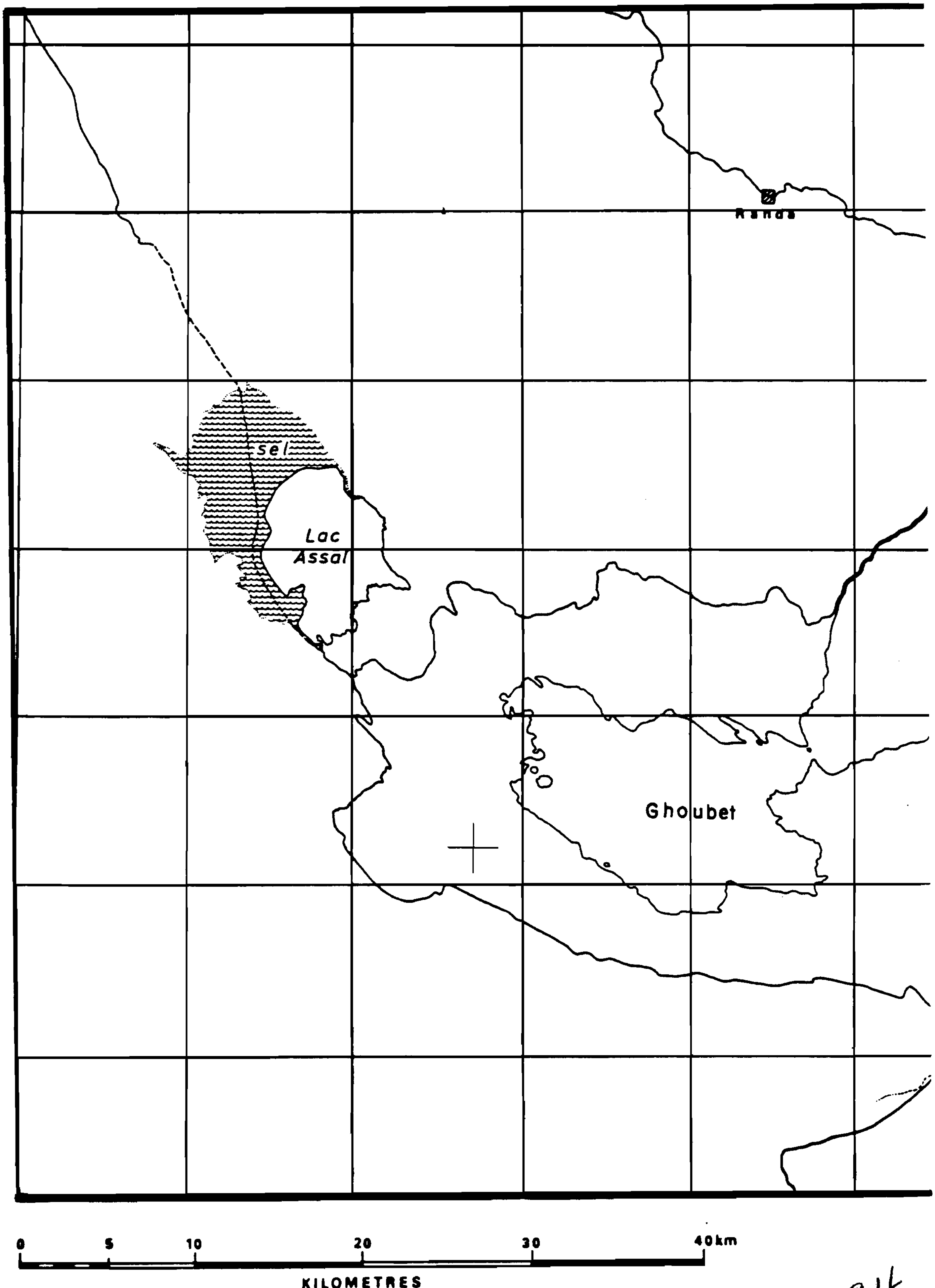


Figure 32: République de Djibouti
Scale 1:300,000


Randa
sel
Lac
Assal
Ghoubet
0
5
10
20
30
40km
KILOMETRES

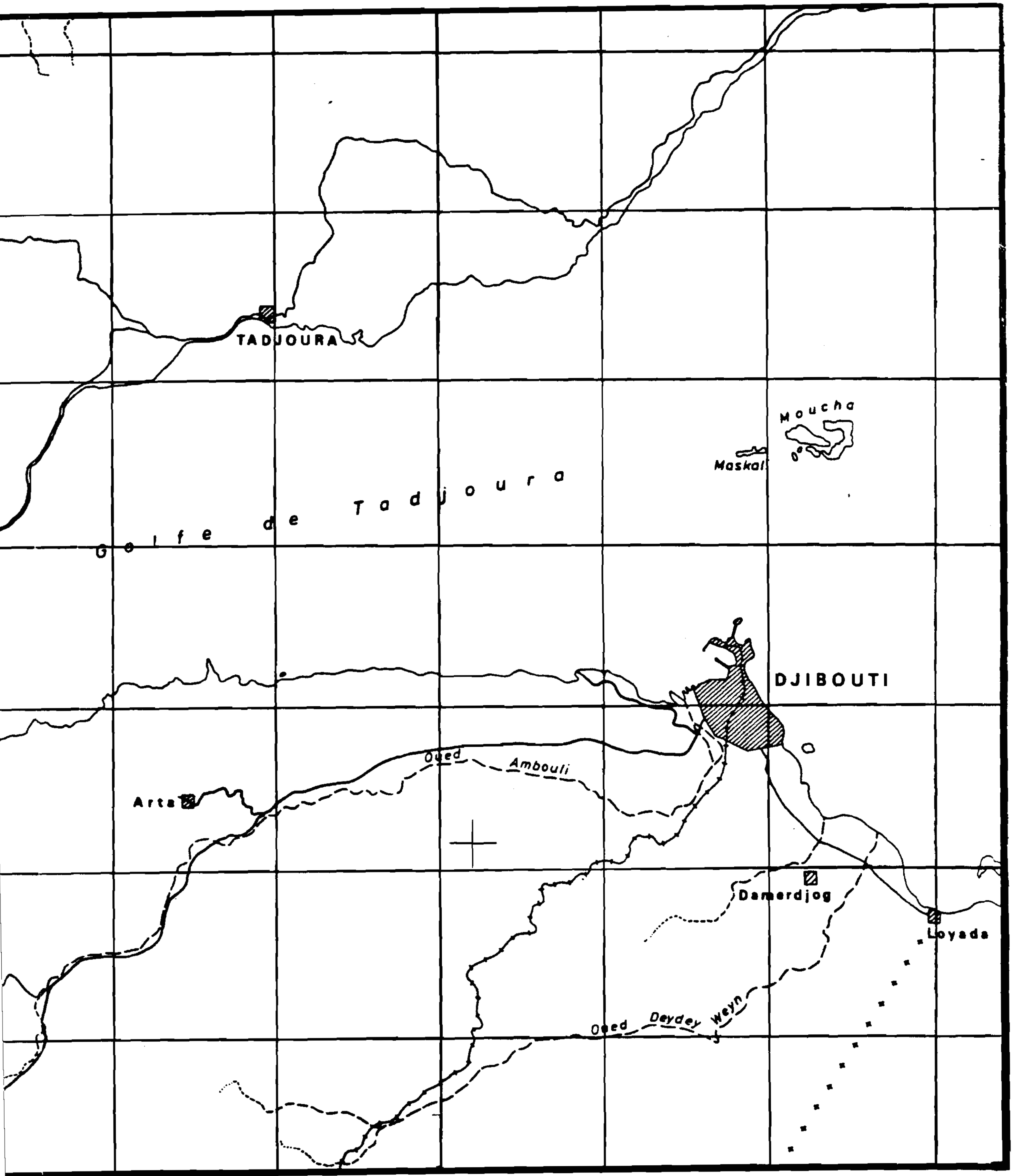
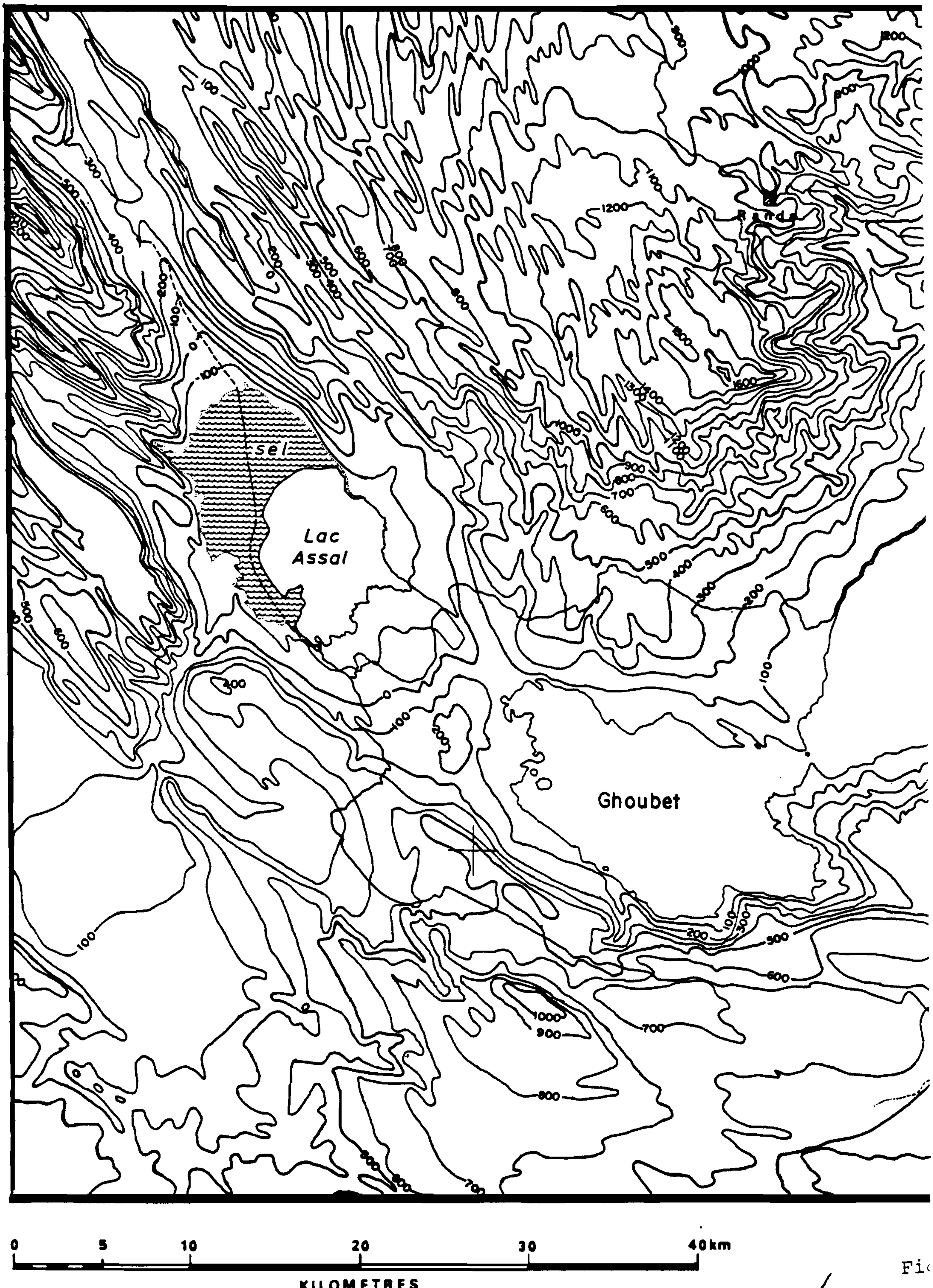


Figure 33: Carte de Projection ou Mercator Transverse Universelle
Universal Transverse Mercator Grid



Fi

95

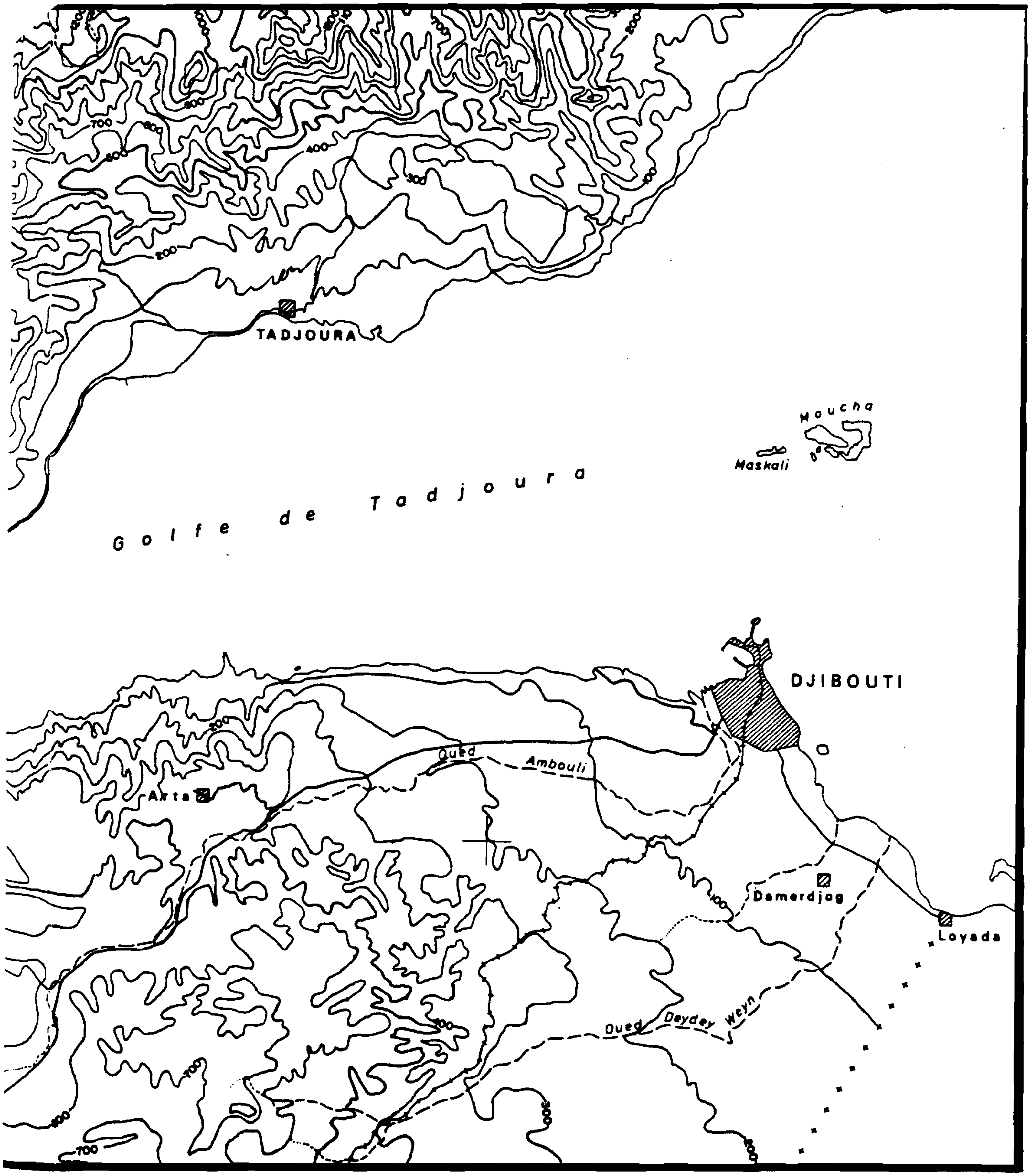


Figure 34: Carte Avec Courbes de Niveau au dessus du la Mer
Topographic Map (Contour Interval - 100 meters)

ʾhoto #34: D-slopes on left and and F-slopes on right and A-slope in the channel shows how important slope is on this Oueah soil

Photo #35: F-slope on left and B-slope in the valley fill confined by distant constricture

ıoto #36: Grass on Aada. A-slope in a Playa near Eas Eyla

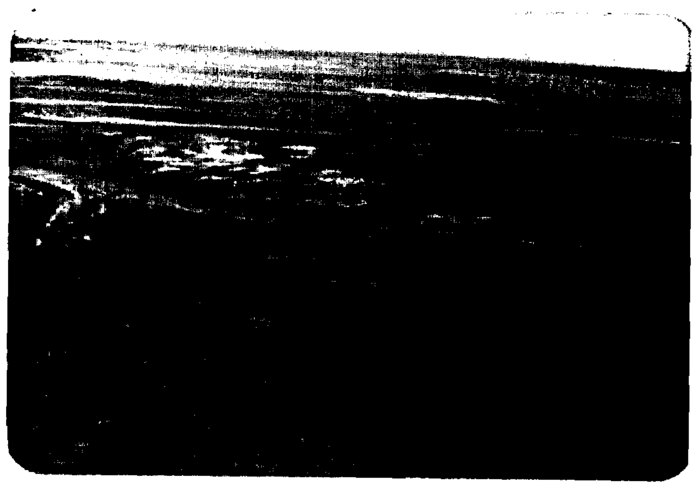
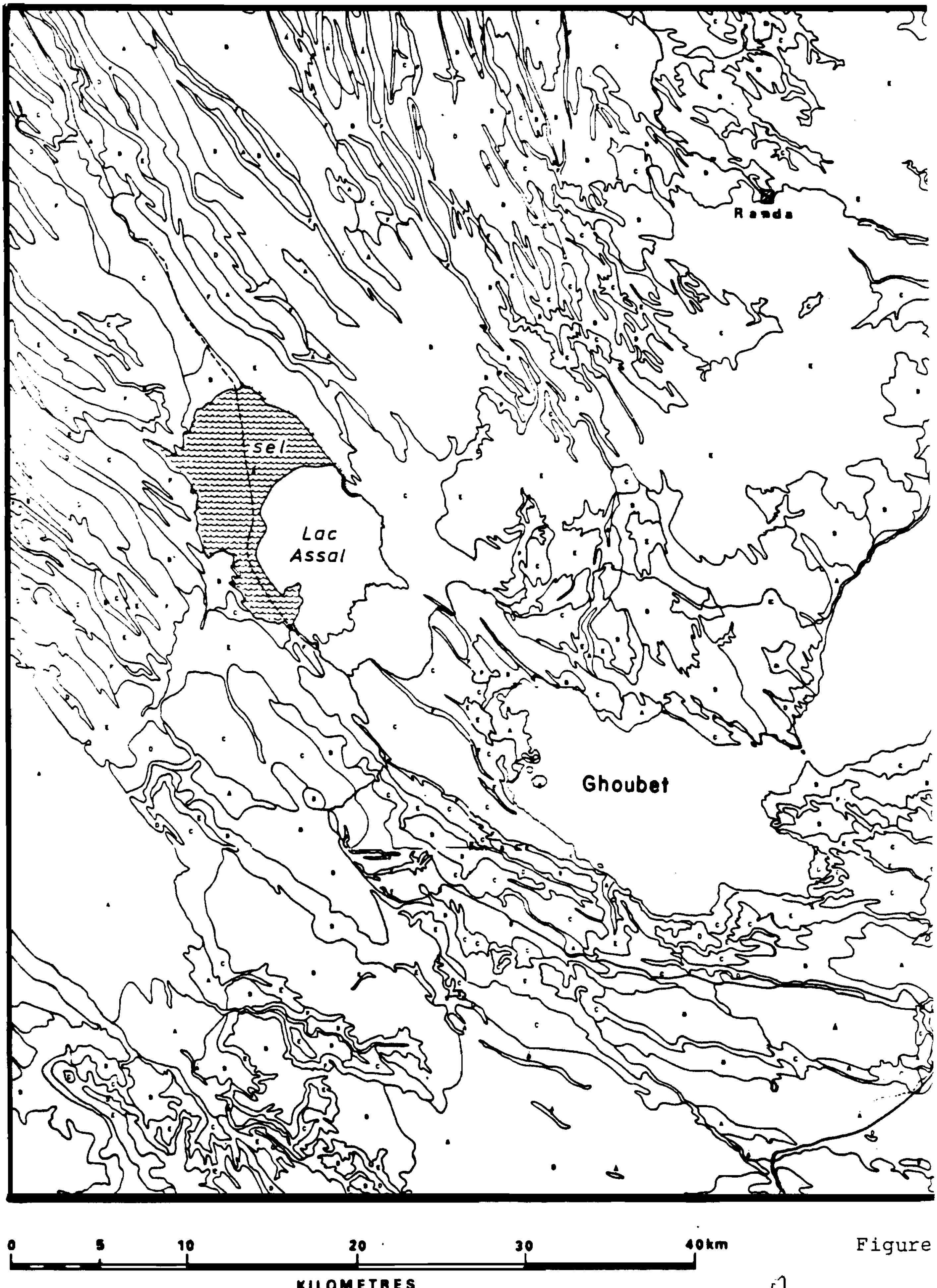


Photo #37: A-slope of Dabagalale soil along the coast. This soil is very salty

Figure 35: Example of Slope Map, Scale 1:100,000, Sadai Region



Figure

98

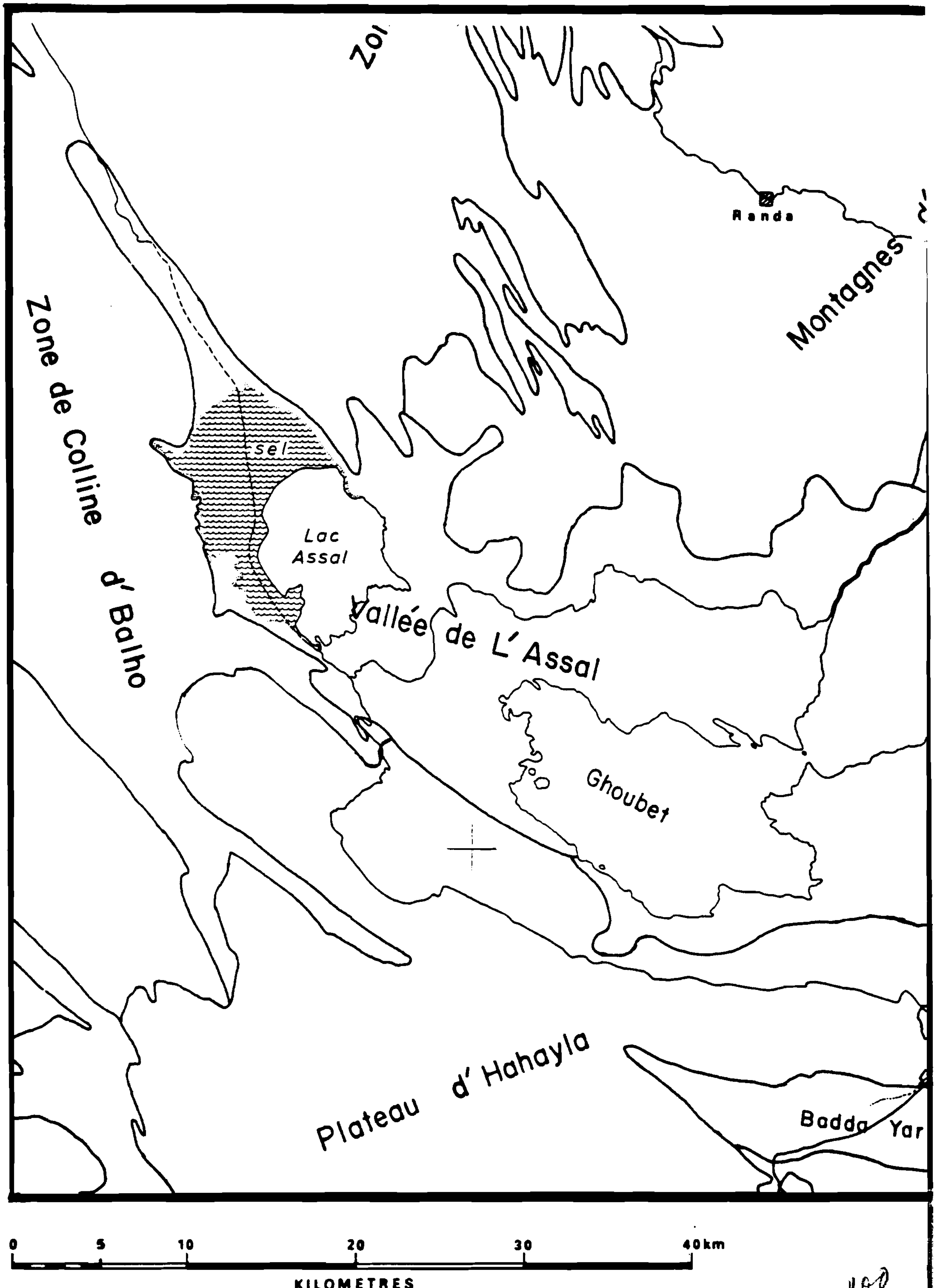
igure 36: Carte de Pente Topographique Réduction de L'Eschelle 1:100,000
Slope Map

Carte de Pente
Topographique
Réduction de L'Eschelle
1:100,000

EXPLICATION

A'	pente de 0 - 1%
A	pente de 0 - 3%
B	pente de 5 - 8%
C	pente de 10 - 16%
D	pente de 20 - 30%
E	pente de 45 - 65%
F	pente de > 65%

Figure 36: Continued


Zoi
Randa
Montagnes
Zone de Colline d' Balho
sel
Lac Assal
Vallée de L' Assal
Ghoubet
Plateau d' Hahayla
Badda Yar
0
5
10
20
30
40km
KILOMETRES

100

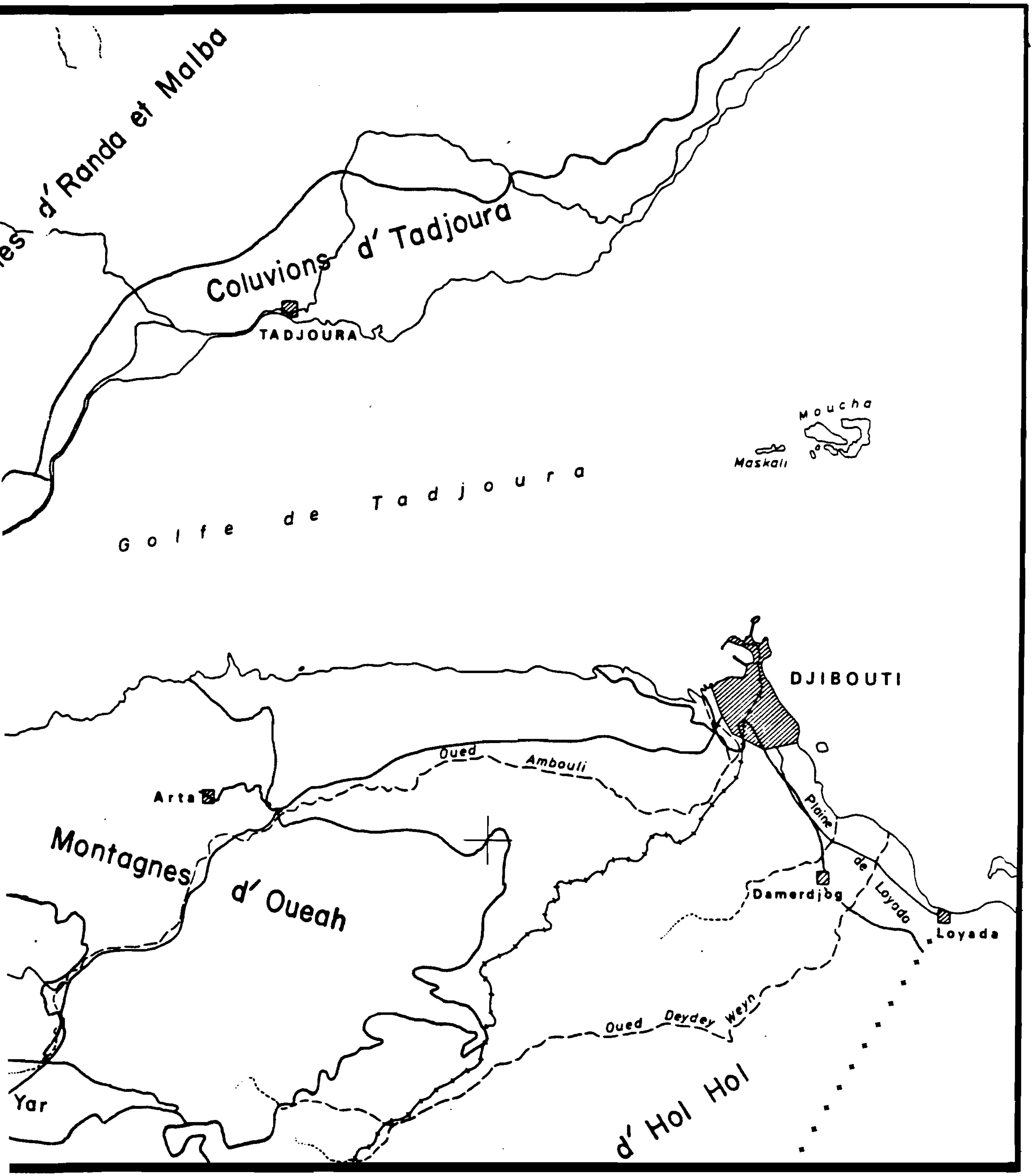


Figure 37: Carte des Zones Physiographique de Djibouti
Physiographic Provinces

List of Physiographic Zones in Djibouti

Coulée de Lave de Ouloueto
Badda Adwaea
Zone d' Coteau d' Balho
Plaine d' Habsou
Plateau d' Gaum Baro
Montagnes d' Yoboki
Plaine d' Gaggade
Plaine d' Hanlé
Plateau d' Dakka
Plaine d' Gobaead
Vallée de L'Assal
Plateau d' Hahayla
Badda Weyn
Montagnes d' Dikhil
Badda Yar
Montagnes d' Ali Sabieh
Montagnes d' Boura
Plateau d' Hol Hol
Montagnes d' Oueah
Coluvions d' Tadjoura
Montagnes d' Randa et Màlba
Coluvions d' Sadai
Zone d' Marée de Degad
Plateau d' Deseyna
Montagnes d' Moydato
Montagnes d' Cokkogofto
Plateau d' Assa Gueyla
Montagne d' Alaili Dadda
Coluvions d' Moulhoule
Zone d' Marée de Doumeira
Coluvions d' Khor Angar
Plaine d' Loyada

FIGURE 37 (Continued)

3.3.6.3 Watershed Mapping

The team identified 61 watersheds and named them. The following Tables 1 through 12 give the name of the watershed, the different classes of slope and the total area of each for each map sheet. Table 13 gives the names of the watersheds, the total for all classes for each slope class and the total area for each watershed. Table 14 shows the distribution of soil mapping units by watershed. Figure 38 and Figure 39 show examples of watershed maps.

TABLE 1: TOTAL AREA FOR THE MAP SHEET OF LOYADA

NAME OF WATERSHED	Ā	A	B	C	D	E	F	TOTAL
Barisle	10	96		1	1			108
Houmbouli	2	40		12	2			56
Douda	39	13			2			54
Damerdjog	13	42						55
Deydey	39	29			3			171
Beyya Eadday	29	190						219
Beyya Dader	30	64						94
Total:	162	574		13	8			757

TABLE 2: TOTAL AREA FOR THE MAP SHEET OF EALI SABIEH

NAME OF WATERSHED	Ā	A	B	C	D	E	F	TOTAL
Ghoubbat al Kharab	15.3	55.5	42.5	64	26.1	36.4		240
Mengala			4	11	1			16
Sangorti				3	23			26
Bada Yar	22	3.5	32.4	44.1	20			122
Houmbouli	55.8	33.3	47.7	115.1	122.1			374
Douda		3			5			8
Bada Weyn	292.2		163	103.9	179.9			739
Deydey	4.7	38.5	39	25	46.3		1.5	155
Beyya Eady	20.6	146.7	140.3	160.2	194.3	8.9		671
Beyya Dader	27	141.2	21.2	23.5	192.1	8		413
Hanle			4.2	11.1	4.7			20
Total:	437.6	421.7	494.3	560.9	814.5	53.3	1.5	2784

TABLE 3: TOTAL AREA FOR THE MAP SHEET OF DIKHIL

NAME OF WATERSHED	$\bar{A}$	A	B	C	D	E	F	TOTAL
Gobaead	168.4	44.9	34	40.3	6.5		13.9	308
Koutabbouyya	55	88	45	12.5	4.9		2.6	208
Wayielou		154.1	62	20	1.9	13		251
Hanle	262	460.6	220.5	136	81.6	70.3	49	1280
Bada Weyn	60	63.4	9.5	6.5	10.4	1.2		151
Bada Yar		1	24	1.8	22	4.2		53
Mengala			10.3	4.4	7.2	3.3	3.8	29
Gaggade	100.6	161.7	308.6	101.9	102.9	72.9	14.4	863
Leeado			7					7
Abhe Bad			6					6
Total:	646	973.7	726.9	323.4	237.4	164.9	83.7	3156

TABLE 4: TOTAL AREA FOR THE MAP SHEET OF ABHE BAD

NAME OF WATERSHED	$\bar{A}$	A	B	C	D	E	F	TOTAL
Bieida	21.3	73.9	55.5	36.9	1.9	21.8	21.7	233
Hanle	16	50.8	12.7	16.9	6.8		39.8	143
Wayielou		62.5	40	6.6	8.4		1.5	119
Leeado	22.5	88	86.4	1.3	4	4.8		207
Koutabbouyya	50.8	6.2	8	3				68
Abhe Bad	29.4	107.3	81.8	54.6	20.7	15.9	2.3	312
Gobaead	165.5		9.5	5.1	13		12.9	206
Total:	305.5	388.7	293.9	124.4	54.8	42.5	78.2	1288

TABLE 5: TOTAL AREA FOR THE MAP SHEET OF DJIBOUTI

NAME OF MAP SHEET	$\bar{A}$	A	B	C	D	E	F	TOTAL
Eambada	10		41					51
Houmbouli	35	60	15.5	1.9	4.6			117
Douda	58							58
Damerdjog	3							3
Deydey	2							2
Afadi	4.6	4.6		4.5	1		3.3	18
Dalleyi	5.4	8.2	4.2	20.5	15.5	37.5	2.7	94
Galato	4.8			14	13.8	4.4		37
Orobor	2.8	0.5	9.7	14.8	32.7	3.7	2.8	67
Tagarre	5.5	2.8		6	14.5	22.3	0.9	52
Arkaile	5.1	21.6		7	10.5	6.8		51
Sadai	14.3	8.1	1.9	14.8	2.9			42
Debergade	9.9	4.3		2.8				17
Alayla	19.1			2.9				22
Iles	7							7
Total	186.5	110.1	72.3	89.2	95.5	74.7	9.7	638

TABLE 6: TOTAL AREA FOR THE MAP SHEET OF TADJOURA

NAME OF WATERSHED	$\bar{A}$	A	B	C	D	E	F	TOTAL
Ghoubbat al Kharab		7	2	24.1	15	5.2	7.7	61
Sangorti	5.1			29.3	91.2	13.9	5.5	145
Houmbouli			24.4	30.1	10.5			75
Eambada	4.7	18.8	40	7.2		7.3		78
Afay		6.9	13.8	18.4	19.3	15.6		74
Easa Foeo		9.2	2.8	51.9	24.1	61		149
Leile		4.6		10.5	14.6	23.3		53
Easaleyi		14.4	18.7	6.9	28.7	87.3		156
Oylali				39.7	4.7	61.1	2.5	108
Earoyra				0.5	4		0.5	5
Asalalal					26.6	5.5	2.9	35
Dariyyou		17	13	12	42	105		189
Adweea	2.8		39.6	113.8	126.7	42.5	12.6	338
Madandayada		2.1	3.9	12.7	7.3			26
Weeima		2.6	25.9	53.8	23.8	64.9		171
Mengale		17.3	18.8	7.9	89.2	110.8		244
Sadai				12.7	73	65.3		151
Marsaki Ababollayi		5.5		54.9		21.6		82
Afadi		10	29.2	32.9	18.3	81.8	2.8	175
Dalleyi						17		17
Total	12.6	115.1	242.1	519.3	619	789.1	43.5	2332

TABLE 7: TOTAL AREA FOR THE MAP SHEET OF EASAL

NAME OF WATERSHED	$\bar{A}$	A	B	C	D	E	F	TOTAL
Eounda Dobi	6.2	7	16.5	38.4	13.9		3	105
Hanle	12.9	37	23.7	15.1	50	47.3		186
Gaggade	79	28.5	2.1	16.9	16.4	48.1		191
Bada Yar		7.6	13.5	10.9	3.7	2.3		38
Ghoubbat al Kharab				5	0.5	0.5	1	7
Dereela	50.4	36.1		202	71.6	17.9	50	428
Kalou			2.2	21.3	7.3	29.4	16.8	77
Fanti Garrayto			5.5	58.8	2.7	24.2	2.8	94
Habsou	48.7	2.7	69.8	86	27.9	2.6	104.3	342
Earoya				24.5	34.5		4	63
Oylali				52		5	2	59
Easal	70.7	22.8	24.2	54.5	133.4	58.2	180.2	544
Harraloli	40.4	13.3			106	2.4	31.9	194
Asalalal	14.2	14.2		21.2	103.6		24.8	178
Iddile			7	69		4	4	84
Yawli			36.6	8.1		1.5	9.8	56
Adwaea	17.2			44	89.8		36	187
Daba Babdri				6.4	1.2	4.8	1.6	14
Mengala			18.9	26.2	0.5	2.9	0.5	49
Total:	339.7	169.2	220	760.3	663	251.1	492.7	2896

TABLE 8: TOTAL AREA FOR THE MAP SHEET OF GAMARRI

NAME OF WATERSHED	$\bar{A}$	A	B	C	D	E	F	TOTAL
Bieida		2.9	13.9		2	9.2		28
Hanle	68.5	35.8	26.4	42.9	50.8	24	26.6	275
Eounda Dobi	35.2	5.7	5.9	29.2	53.7	22.6	4.7	157
Habsou		3.5	40.7	39.2	84.4	3.6	42.6	214
Total	103.7	47.9	86.9	111.3	190.9	59.4	73.9	674

TABLE 9: TOTAL AREA FOR THE MAP SHEET OF KHOR ANGAR

NAME OF WATERSHED	$\bar{A}$	A	B	C	D	E	F	TOTAL
Tagarre					7.5	11.5		19
Sadai	64.5	16	42	127.5	90.3	90.7		431
Debergade	73			1				74
Sorha	329.6		14		15.1	7.3		366
Alayla	40			1				41
Eaygou	238		2.9	22.1	46.9	53.1		363
Kabieli Sarig	388.8		40.6	63.5	89.4	71.7		654
Gorroyli	54	33	35.3	60.3	62.9	42.5		288
Kadda Hayyoukali	34.1	1	4	1	19.9	3		63
Total:	1222	50	138.8	276.4	322	279.8		2299

TABLE 10: TOTAL AREA FOR THE MAP SHEET OF DADDAETO

NAME OF WATERSHED	$\bar{A}$	A	B	C	D	E	F	TOTAL
Adweea					19			19
Madandayada	6.5	29	1	19.2	90.3		1	147
Wabbeyta	47.9	369.5	89.3	32.9	31.4			570
Weeima	15.5	276	275.7	162.3	346	278.1	6.4	1360
Kadda Hayyoukali			1.9		17	34.1		53
Gorroyli		1	6.4	12	60	35.6		115
Sadai		40.1	36.6	121.7	117.8	126.8	11	454
Total:	69.9	714.6	410.9	348.1	681.2	474.6	18.4	2718

TABLE 11: TOTAL AREA FOR THE MAP SHEET OF DORRA

NAME OF WATERSHED	$\bar{A}$	A	B	C	D	E	F	TOTAL
Yawli				48		5		53
Daba Babdri		11		2.6	3.8	5	18.2	64
Harraloli	0.5			7.4	14.3		4.8	27
Adweea	130.4	225.6	74.3	155.7	56.2	11.2	15.6	699
Madandayada	18	88	103.4	102.5	59	39.8	7.3	418
Asalalal	2.8	30.3	14.2	5.2	23.2	5.3	13	94
Wabbeyta	19.4		44.4	43.1	41	15.1		163
Total:	171.1	354.9	236.3	387.9	197.5	81.4	58.9	1488

TABLE 12: TOTAL AREA FOR THE MAP SHEET OF DOUMERA

NAME OF WATERSHED	$\bar{A}$	A	B	C	D	E	F	TOTAL
Kabieldo Sarig	5			2				7
Gorroyli	96			1				97
Kadda Hayyoukali	231				15.1	26.3	1.6	274
Sosawli Daear	167			4.8	41	8.3	3.9	225
Weeima	51.3	12.8			20.3	19.6		104
Total:	550.3	12.8		7.8	76.4	54.2	5.5	707

NAME OF WATERSHED	/A	A	B	C	D	E	F	MAP SHEET NAMES	TOTAL BY NAMED MAP SHEET	TOTAL AREA FOR THE WATERSHED
ABHE BAD	29.4	107.3	87.8	54.6	20.7	15.9	2.3	DIKHIL ABHE BAD	6 312	318
ADWEEA	150.4	225.6	113.9	313.5	291.7	53.7	64.2	EASAL TADJOURA DORRA DADDAETO	187 338 669	1.213
AFADI	4.6	14.6	29.2	37.4	19.3	81.8	6.1	DJIBOUTI TADJOURA	18 175 19	193
AFAY			6.9	13.8	18.4	19.3	15.6	TADJOURA	74	74
ALAYLA	59.1	59.1			3.9			DJIBOUTI KHOR ANGAR	22 41	63
ARRAILE	5.1	21.6		7	10.5	6.8		DJIBOUTI	51	51
ASALALAL	17	44.5	14.2	26.4	153.4	10.8	40.7	EASAL TADJOURA DORRA	178 35 94	307
BADA WEYN	352.2	63.4	172.5	110.4	190.3	1.2		EALI SABIEH DIKHIL	739 151	890
BADA YAR	22	12.1	69.9	56.8	45.7	6.5		EASAL DIKHIL EALI SABIEH	38 53 122	213
BARISLE	10	96		1	1			LOYADA	108	108
BEYYA EAD	49.6	336.7	140.3	160.2	194.3	8.9		LOYADA EALI SABIEH	219 671	890
BEYYA DADER	57	205.2	21.2	23.5	192.1	8		LOYADA EALI SABIEH	94 413	507
BIEIDA	21.3	76.8	69.4	36.9	3.9	31	21.7	ABHE BAD GAMARRI	233 28	261
DABA BABDRI		11		32.4	5	9.8	19.8	EASAL DORRA	14 64	78
DALLEYI	5.4	8.2	4.2	20.5	15.5	54.4	2.7	DJIBOUTI TADJOURA	94 17	111
DAMERDJOG	16	42						DJIBOUTI LOYADA	3 55	58
DARRIYOU		17	13	12	42	105		TADJOURA	189	189
DEBERGADE	82.9	4.3		3.8				KHOR ANGAR DJIBOUTI	74 17	91
DEREELA	50.4	36.1		202	71.6	17.9	50	EASAL	428	428

TABLE 13: Slope Class by Watershed

NAME OF WATERSHED	/A	A	B	C	D	E	F	MAP SHEET NAMES	TOTAL BY NAMED MAP SHEET	TOTAL AREA FOR THE WATERSHED
DEYDEY	45.7	167.5	39	25	49.3		1.5	LOYADA DJIBOUTI EALI SABIEH	171 2 151	328
DOUDA	97	16			7			LOYADA DJIBOUTI EALI SABIEH	54 58 8	120
EAMBADA	14.7	18.8	81	7.2		7.3		DJIBOUTI TADJOURA	51 78	129
EAROYRA				25	38.5		4.5	EASAL TADJOURA	63 5	68
EASA FOEO		9.2	2.8	51.9	24.1	61		TADJOURA	149	149
EASAL	70.7	22.8	24.2	54.5	133.4	58.2	180.2	EASAL	544	544
EASALEYI		14.4	18.7	6.9	28.7	87.3		TADJOURA	156	156
EAYGOU	238		2.9	22.1	46.9	53.1		KHOR ANGAR	363	363
EOUNDA DOBI	41.4	12.9	22.4	67.6	67.6	22.6	27.7	GAMARRI EASAL	157 105	262
FANTI GARRAYTO			5.5	58.8	2.7	24.2	2.8	EASAL	94	94
GAGADDE	179.6	190.2	310.7	118.8	119.3	121	14.4	EASAL DIKHIL	191 863	1054
GALATO	4.8			14	13.8	4.4		DJIBOUTI	37	37
GHOUBBAT AL KHARAB	15.3	2.5	44.5	93.1	41.6	42.1	8.7	TADJOURA EASAL EALI SABIEH	61 7 240	308
GOBAEAD	333.9	44.9	43.5	45.5	19.5		26.8	DIKHIL ABHE BAD	308 206	514
GORROYLI	150	34	41.7	73.3	122.9	78.1		DOUMERA KHOR ANGAR DADDATO	97 288 115	500
HABSOU	48.7	6.2	110.5	125.2	112.3	6.2	146.9	GAMARRI EASAL	214 342	556
HANLE	359.4	584.2	287.5	222	193.9	141.6	115.4	DIKHIL EASAL GAMARRI ABHE BAD EALI SABIEH	1280 186 275 143 20	1.904
HARRALOLI	40.9	13.3		7.4	120.3	2.4	36.7	EASAL DORRA	194 27	221
HOUMBOULI	92.8	113.3	97.6	159.1	139.2			EALI SABIEH DJIBOUTI LOYADA TADJOURA	374 117 56 75	622

TABLE 13 (Continued)
Slope Class by Watershed

NAME OF WATERSHED	/A	A	B	C	D	E	F	MAP SHEET NAMES	TOTAL BY NAMED MAP SHEET	TOTAL AREA FOR THE WATERSHED
IDDLE			7	69		4	4	EASAL	84	84
ILES	7							DJIBOUTI	7	7
KABIELI SARIG	393.8		40.6	65.5	89.4	71.7		KHOR ANGAR DOUMERA	654	661
								DADDA TO	53	390
KADDA HAYYOUKALI	265.1	1	5.9	1	52.0	63.4	1.6	KHOR ANGAR DOUMERA	63 274	
KALOU			2.2	21.3	7.3	29.4	16.8	EASAL	77	77
KOUTAB-BOUYYA	105.8	94.2	53	15.5	4.9		2.6	DIKHIL ABHE BAD	208 68	276
LEEADO	22.5	88	93.4	1.3	4	4.8		ABHE BAD DIKHIL	207 7	214
LEILE		4.6		10.5	14.6	23.3		TADJOURA	53	53
MADANDAYADA	24.5	19.1	108.3	134.4	156.6	39.8	8.3	TADJOURA DORRA DADDAETO	26 418 147	591
MAGALE		17.3	18.8	7.9	89.2	110.8		TADJOURA	244	244
MARSAKI ABOBOLLAYI		5.5		54.9		21.6		TADJOURA	83	82
MENGALA			33.2	41.6	8.7	6.2	4.3	EALI SABIEH DIKHIL EASAL	16 29 49	94
OROBOR	2.8	0.5	9.7	14.8	32.7	3.7	2.8	DJIBOUTI	67	67
OYLALI				91.7	4.7	66.7	4.5	EASAL TADJOURA	59 108	167
SADAI	78.8	4.2	0.5	276.7	284	282.8	11	TADJOURA DJIBOUTI DADDA TO KHOR ANGAR	151 42 454 431	1.078
SANGORTI	5.1			32.3	114.6	13.9	5.5	EALI SABIEH TADJOURA	26 145	171
SORHA	329.6		14		15.1	7.3		KHOR ANGAR	366	366
SOSAWLI DAEAR	167			4.8	41	8.3	3.9	DOUMERA	255	255
TAGARRE	5.5	.8		6	22	33.8	.9	KHOR ANGAR DJIBOUTI	19 52	71

TABLE 13 (Continued)
Slope Class by Watershed

TABLE 14

AMOUNT OF EACH SOIL MAPPING UNIT BY W

MAPPING UNIT SYMBOL

NAME OF WATERSHED	AZ 15	AD 9	AK 33	AR 9	AT 1	AW 6	BA 16	DA 16	DG 1	DD 10	DA 9	DI 5	DB 9	DT 10	EG 12	EA 31	EO 4	GA 16	GB 12	HA 10	
ABHE BAD							90	18											6		
ADWEEA	87		115	89				70			1	19	127						35		1
AFADI							47				53	9									
AFAY				5									3					18		17	
ALAYLA									16						16	31					
ARKAILE														4							
ASALALAL	2	65		14			17						70						22		
BADA WEYN	157			31	24	16	146	80	15		63	19							252		
BADA YAR	13						66	35			14								46		
BARISLE					2																
BEYYA EADDEY		78		22			73	58	8	30	136		20							62	
BEYYA DADER		119						9			85										
BIEIDA	23			43			39	93													
DABA BABDRI							44					2							10		
DALLEYI							11				53										
DAMERDJOG					9				2			7									
TOTAL:	286	262	115	204	35	16	533	363	41	30	406	56	220	4	16	31	-0-	18	371	79	4

BY WATERSHED

HA 10	HH 27	JA 16	KL 4	LD 9	MA 16	OU 9	RD 12	WD	17	19	20	25	28	TOTAL FOR WATERSHED
	19					6			30		51	98		318
	168			39	48	13			401					1213
	32	10	19			21			2					193
17			5			10			14	2				74
														63
	26		11				10							51
	19			6		36	32	10	14					307
						64	15			8				890
	4					23			10	2				213
	6	100												108
62	52		294							25		32		890
	78	179	[illegible]							29	8			507
	9				6		20		28					261
	5					9		8						78
	17		6	10	14									111
	19	21												58
79	454	604	41	55	58	192	67	18	502	66	8	83	98	5335

TABLE 14 (Continued)

AMOUNT OF EACH SOIL MAPPING UNIT BY WA

MAPPING UNIT SYMBOL

NAME OF WATERSHED	AZ 15	AD 9	AK 33	AR 9	AT 1	AW 6	BA 16	DA 16	DG 1	DD 10	DA 9	DI 5	DB 9	DT 10	EG 12	EA 31	EO 4	GA 16	GB 12	HA 10
DARRIYOU				69							3			3						
DEBERGADE														6		4	76			
DEREELA		33	23				58	79			33	8	38						59	
DEY DEY				15	13	1	8		1		12									
DOUDA						17	3		18			3								
EAMBADA																				1
EAROYRA			11						5			1								
EASA FOEO				35														5	65	
EASAL			58	136			33	69				3	53						27	
EASALEYI				41																
EAYGOU						48			56		36			71		30	14	8		
EOUNDA DOBI				24			2	50					45		4				17	
FANTI GARRAYTO							4												2	3
GAGADDE	55		2				416	44		26	13		19	9					69	
GALATO											6									
GHOUBBAT AL KHARAB							91				46							3	2	
TOTAL:	55	33	94	320	13	66	615	242	80	26	149	15	155	89	4	34	90	16	244	1

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BEST AVAILABLE COPY

Y WATERSHED

HA 10	HH 27	JA 16	KL 4	LD 9	MA 16	OU 9	RD 12	WD 13	17	19	20	25	28	22	29	TOTAL FOR WATERSHED
	5		17		18	74										189
			5													91
	13						29	55								428
	49	207					22									328
	20	57					2									120
1	25	92							2	1		8				129
						7		30	14							68
	15		13		5	11										149
						34	11		59					61		544
	26		20			69										156
						44	56									363
						46	24	47					3			262
3	8					25	14		28				10			94
	10					199	43	104	39				6			1054
	15		5			11										37
	35					80			4	44						308
1	224	356	60	-0-	23	600	201	236	146	44	-0-	8	19	61	-0-	4320

115a

TABLE 14 (Continued

AMOUNT OF EACH SOIL MAPPING UNIT BY

MAPPING UNIT SYMBOL

NAME OF WATERSHED	AZ 15	AD 9	AK 33	AR 9	AT 1	AW 6	BA 16	DA 16	DG 1	DD 10	DA 9	DI 5	DB 9	DT 10	EG 12	EA 31	EO 4	GA 16	GB 12
GOBAEAD				10			100					9			108				201
GORROYLI		135							4		33			81		12		38	2
HABSOU				26			141	157				8	15						62
HANLE	14	4	28	191			313	120		10	103	89			340				84
HARRALOLI			98				11				7	9							20
HOUMBOULI	19			65	18	57	28		8		2	42							14
IDDILE				19			11	2											1
ILES																			
KABIELI SARIG		42				290			45		77	11		67		16		10	10
KADDA HAYYOUKALI		94							49			6		16		43			
KALOU							4	6					10	3					1
KOUTABBOUYYA							29					2			29				161
LEEADO	3						166												30
LEILE				20															20
MADAND-AYADA	51			3			109	20					123						27
MENGALA	59			54			57						10						3
TOTAL:	146	275	126	388	18	347	969	305	106	10	322	176	158	167	477	71	-0-	48	636

tinued)

UNIT BY WATERSHED

OL

A 6	GB 12	HA 10	HH 27	JA 16	KL 4	LD 9	MA 16	OU 9	RD 12	WD 13	17	19	20	25	28	22	29	TOTAL FOR WATERSHED
	201	5	7					30				9		35				514
8	2				124	40		2				29						500
	62		19					89		39								556
	84		30				29	197	63	264		25						1904
	20							50	20	6								221
	14		57	139				101	62			10						622
	1											51						84
																	7	7
0	10							80				13						661
					179							3						390
	1							38	15									77
	161		4								9	2		10	30			276
	30		12					3										214
	20				5			8										53
	27		52					11			195							591
	3		66						18		26							293
8	636	5	247	139	308	40	29	609	178	309	230	142	-0-	45	30	-0-	7	6963

TABLE 14 (Continued)

AMOUNT OF EACH SOIL MAPPING UNIT BY WA

MAPPING UNIT SYMBOL

NAME OF WATERSHED	AZ 15	AD 9	AK 33	AR 9	AT 1	AW 6	BA 16	DA 16	DG 1	DD 10	DA 9	DI 5	DB 9	DT 10	EG 12	EA 31	EO 4	GA 16	GB 12
MARSAKI-ABOBOLLAYI											19								
MENGALA				4			44				10								3
OROBOR				5			6				12								
OYLALI				23					2				4					4	4
SADAI				25							67			298	7	5			52
SANGORTI							5				43							2	
SORHA									48							21	273		
SOSAWLI DAEAR		58														5			6
TAGARRE		2									24					2		3	
WABBEYTA			36		24		349	163											69
WAYDIELOU						13	144	39			11								114
WEEIMA		177		123			107	226			211	51	6	183				218	57
YAWLI				8				43			45								
TOTAL:	-0-	237	36	188	24	13	655	471	50	-0-	442	51	10	481	7	33	273	227	305
GRAND TOTAL	483	807	371	1100	90	442	2772	1381	277	66	1219	298	543	741	504	169	363	309	1562

d)

Y WATERSHED

GB 12	HA 10	HH 27	JA 16	KL 4	LD 9	MA 16	OU 9	RD 12	WD 13	17	19	20	25	28	22	29	TOTAL FOR WATERSHED
		27		8	9		19										82
3		4					3			26							94
				2	2	6	34										67
4		5				3	44			58				20			167
52					193	25	280				124			2			1078
		42		6				71			2						171
							24										366
6				148							8						225
		2		8	9		21										71
69		44					4			44							733
114		25								24							370
57	71	34		9	39						123						1635
							10		3								109
305	71	183	-0-	173	152	34	439	71	3	152	257	-0-	-0-	22	-0-	-0-	2918
1562	156	1108	1099	582	347	144	1840	517	566	1030	510	8	136	169	61	7	21786

117a

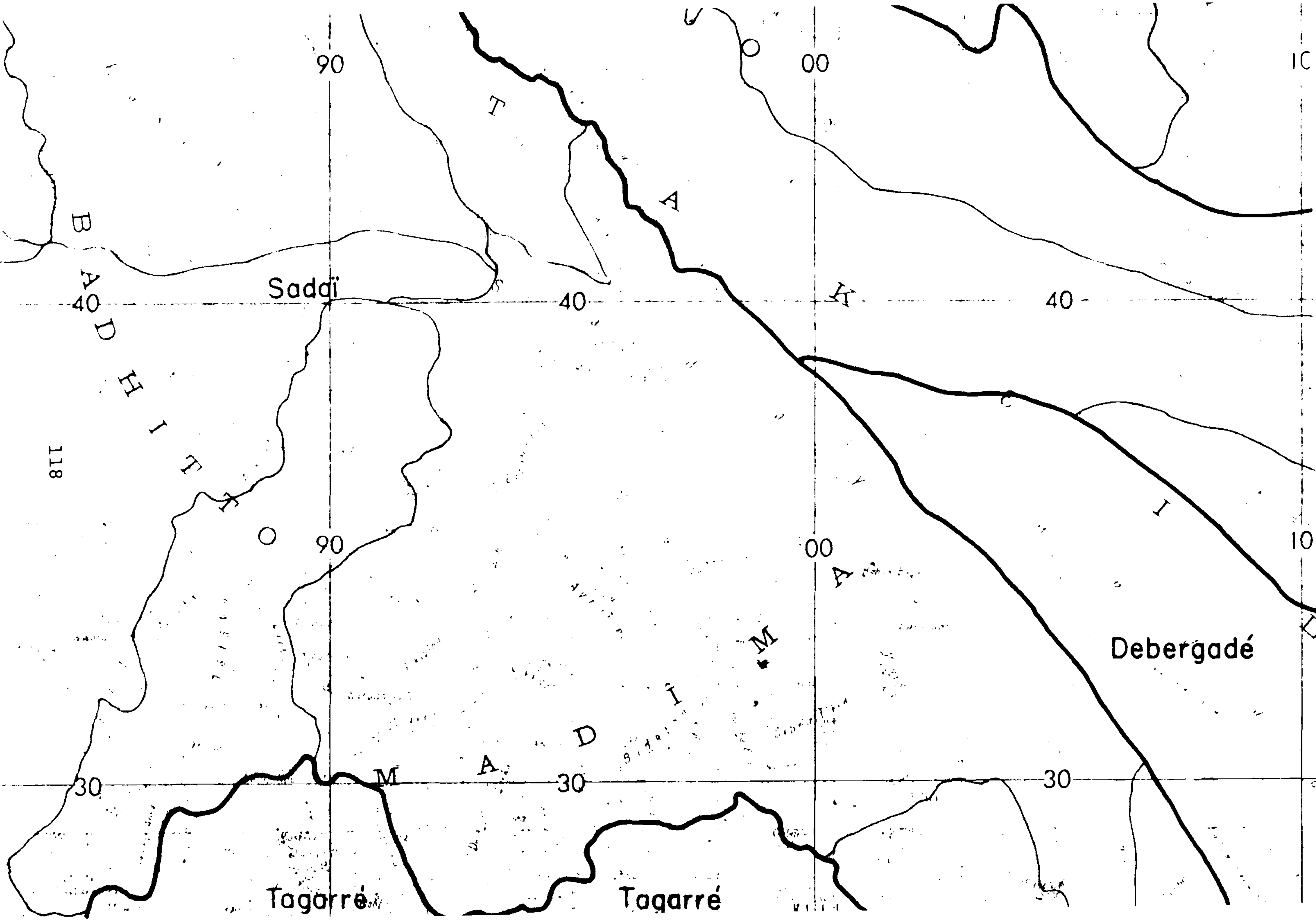
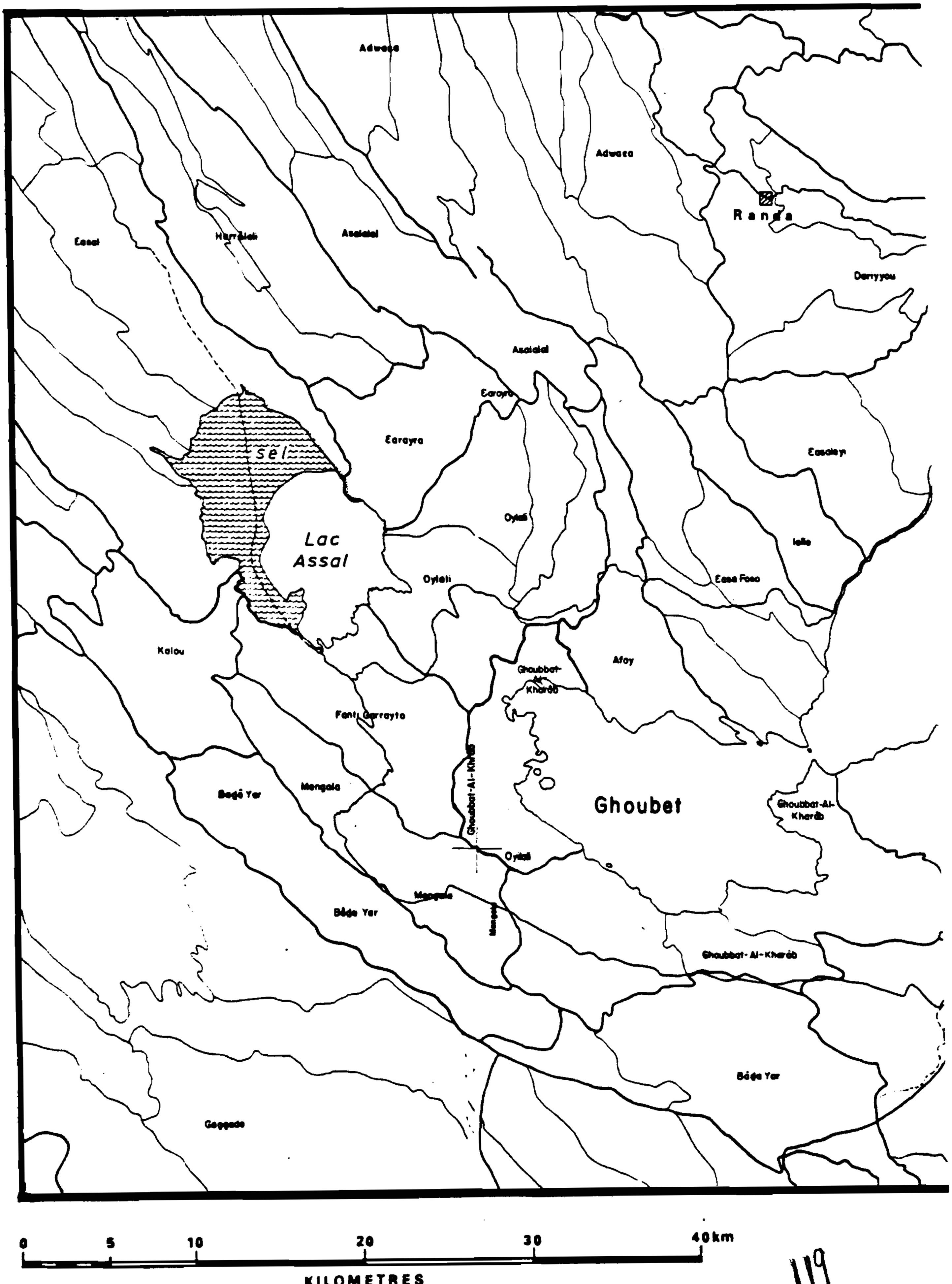


Figure 33: Example of Watershed Map, Scale 1:100,000, Sadai Region


Adwaca
Adwaca
Randa
Ɛasal
Asalalal
Dammyou
Asalalal
Ɛarayra
sel
Ɛarayra
Ɛasalayi
Lac
Assal
Oylali
Oylali
Ialla
Ɛasa Foso
Kalou
Ghoubbat-
Al-
Kharâb
Afay
Fanti Garrayto
Ghoubbat-Al-Kharâb
Bagâ Yar
Mangala
Ghoubet
Ghoubbat-Al-
Kharâb
Oylali
Bâda Yar
Ghoubbat-Al-Kharâb
Bâda Yar
Gaggade
0
5
10
20
30
40km
KILOMETRES

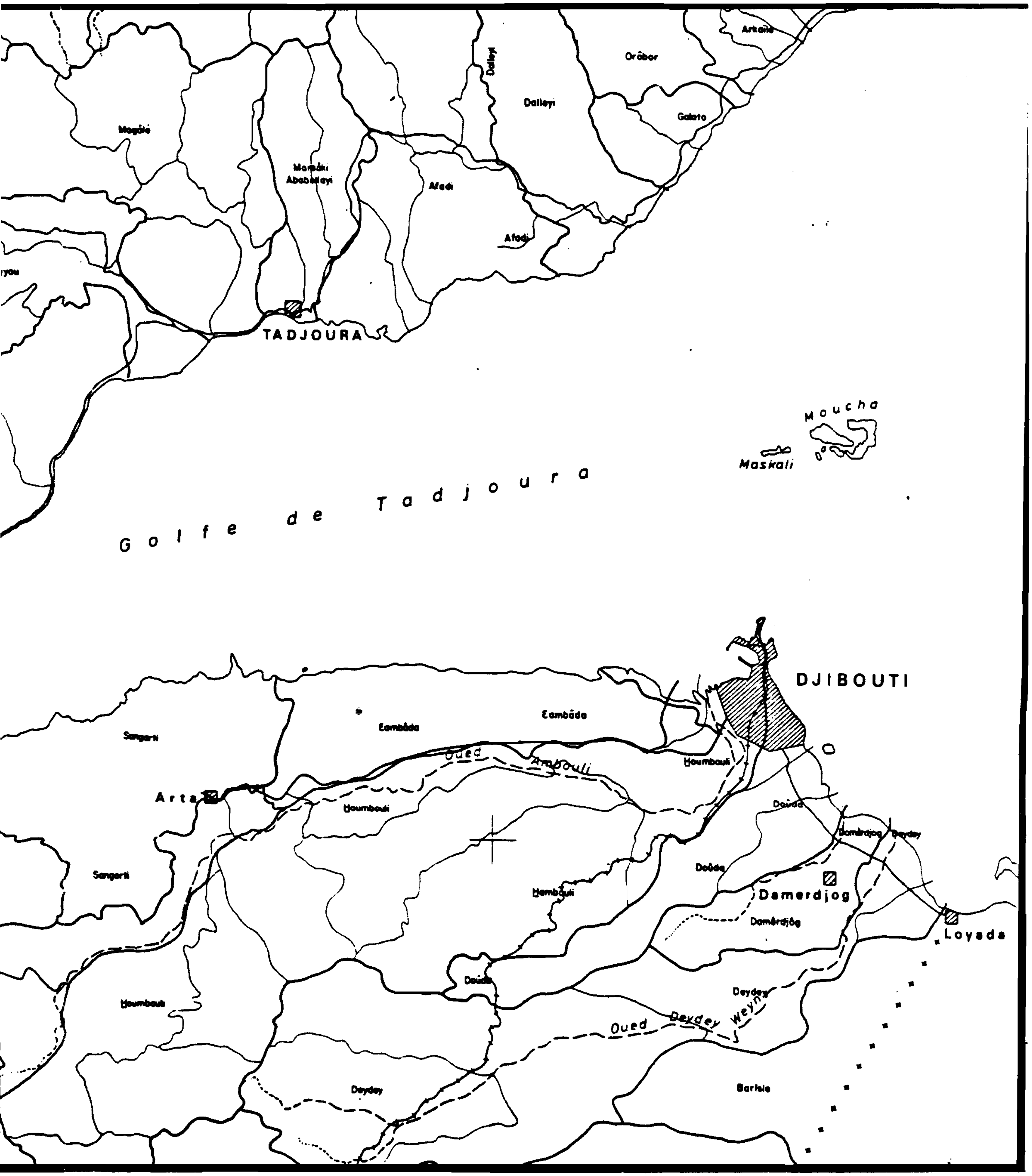


Figure 39: Carte des las Bassin Versant de Djibouti Réduction de L'Eschelle 1:100,000
Watershed Map

3.3.6.4 Soils Mapping

Both detailed and generalized soils maps were prepared for the project. Figures 40 and 41 show examples of these maps reduced to a scale of 1:300,000.

3.3.6.5 Soil Climate Map

A soil climate map, an example of which is seen in Figure 42, was also prepared. Ten climatic regions were differentiated. The characteristics of these ten regions are as follows:

Zone 1: Lac Easal Climatic region

This zone occupies an inland basin over 100 meters below sea level.

Average annual rainfall	123 mm/yr
Ranges	50-200 mm/yr
July relative humidity	6 AM 55-65% 12 PM 40-50%
January relative humidity	6 AM 80-85% 12 PM 65-70%
January Temperature	Max. 40-42 Deg. C Min. 30-32 Deg. C
July Temperature	Max. 27-29 Deg. C Min. 22-25 Deg. C

Rainwater run-off for storms of 20 mm: 3 mm = 3000 m3/Km2

Rainwater run-off for storms of 50 mm: 11 mm = 11,000 m3/Km2

Total average run-off for all storms: 15 mm = 15,000 m3/Km2

Zone 2: Obock - Khor Angar Climatic region:

This zone occupies the northeast coastal plain below 100 meters elevation.

Average annual rainfall	72 mm/yr
Ranges	30-200 mm/yr
July relative humidity	6 AM 50-60% 12 PM 35-45%

January relative humidity	6 AM 80-85% 12 PM 35-45%
July Temperature	Max. 39-40 Deg. C Min. 29-32 Deg. C
January Temperature	Max. 27-29 Deg. C Min. 20-23 Deg. C
Water run-off for storms of 20 mm:	1 mm = 1,000 m2/Km2
Water run-off for storms of 50 mm:	3 mm = 3,000 m3/Km2
Total average annual run-off for all storms:	4 mm = 4,000 m3/Km2

Zone 3: Djibouti-Tadjoura Climatic Region

This zone occurs southeast of coastal mountains on coastal plains 100 meters above sea level.

Average annual rain	165 mm/yr
Range	100-350 mm/yr
July relative humidity	6 AM 80-85% 12 PM 35-45%
January relative humidity	6 AM 80-85% 12 PM 60-70%
July temperature	Max. 39-42 Deg. C Min. 29-32 Deg. C
January temperature	Max. 27-29 Deg. C Min. 20-23 Deg. C
Water run-off for storms of 20 mm	3 mm/yr = 3,000 m3/Km2
Water run-off for storms of 50 mm	11 mm/yr = 11,000 m3/Km2
Total average annual run-off for all storms	14 mm/yr = 14,000 m3/Km2

Zone 4: Chabelley - Bissidrou Climatic Region

This zone occurs on coastal plains between 100 and 350 meters elevation.

Average annual rainfall	175 mm/yr
Range	100 - 250 mm/yr
July relative humidity	6 AM 80-85% 12 PM 35-45%
January relative humidity	6 AM 80-85% 12 PM 60-70%
July temperature	Max. 38-40 Deg. C Min. 28-30 Deg. C
January temperature	Max. 27-29 Deg. C Min. 20-22 Deg. C

Water run-off for storms of 20 mm is 4 mm =	4,000 m3/Km2
Water run-off for storms of 50 mm is 16 mm =	16,000 mm3/Km2
Average annual run-off for all storms is 23 mm =	23,000 mm3/Km2

<u>Zone 5:</u> <u>Dorra - Asa Eala Climatic Region</u>

This zone occurs in interior basins and valleys between 0 and 350 meters elevation.

Average annual rainfall	160 mm/yr
Range	125 - 275 mm/yr
July relative humidity	6 AM 50-60% 12 PM 35-45%
January relative humidity	6 AM 80-90% 12 PM 65-75%
July temperature	Max. 38-40 Deg. C Min. 28-30 Deg. C
January temperature	Max. 27-29 Deg. C Min. 20-22 Deg. C
Water run-off for storms of 20 mm is 4 mm =	4,000 mm3/Km2
Water run-off for storms of 50 mm is 16 mm =	16,000 mm3/Km2
Average annual run-off for all storms is 23 mm =	23,000 mm3/Km2

<u>Zone 6:</u> <u>Dikhil - Paddgeto Climatic Region</u>

This zone occurs in low interior mountains between 350 and 600 meters elevation.

Average annual rainfall	150 mm/yr
Range	95-245 mm/yr
July relative humidity	6 AM 82-87% 12 PM 55-65%
January relative humidity	6 AM 50-60% 12 PM 28-38%

July temperature	Max. 38-40 Deg. C Min. 27-29 Deg. C
January temperature	Max. 26-28 Deg. C Min. 18-21 Deg. C
Water run-off for storms of 20 mm is 4 mm =	4,000 mm3/yr
Water run-off for storms of 55 mm is 20 mm =	20,000 mm3/yr
Average annual run-off for storms is 35 mm =	35,000 mm3/yr

Zone 7: Hol Hol - Arda Daba Climatic Region

This zone occurs on the coastal mountain slopes and foothills between 350 and 600 meters elevation.

Average annual rainfall	210 mm
Range	130 - 500 mm/yr
July relative humidity	6 AM 50-60% 12 PM 37-43%
January relative humidity	6 AM 88-92% 12 PM 70-75%
July temperature	Max. 37-39 Deg. C Min. 25-27 Deg. C
January temperature	Max. 23-25 Deg. C Min. 18-20 Deg. C
Water run-off for storms of 20 mm is 5 mm =	5,000 mm3/Km2
Water run-off for storms of 50 mm is 25 mm =	25,000 mm3/Km2
Average annual run-off for all storms is 35 mm =	35,000 mm3/Km2

Zone 8: Arta Climatic Region

This zone occurs on coastal mountains between 600 and 900 meters elevation.

Annual average rainfall	290 mm
Range	150 - 600 mm/yr

July relative humidity	6 AM 50-60% 12 PM 28-35%
January relative humidity	6 AM 90-99% 12 PM 65-75%
July temperature	Max. 36-38 Deg. C Min. 24-26 Deg. C
January temperature	Max. 26-28 Deg. C Min. 14-16 Deg. C
Water run-off for storms of 20 mm is 6 mm =	6,000 mm3/Km2
Water run-off for storms of 50 mm is 29 mm =	29,000 mm3/Km2
Average annual run-off for all storms is 65 mm =	65,000 mm3/Km2

Zone 9: Assa Gueyla - Eli Sabieh Climatic Region

This zone occupies the interior mountains between 600 and 900 meters elevation.

Average annual rainfall	147 mm/yr
Range	100 - 270 mm/yr
July relative humidity	6 AM 50-60% 12 PM 30-40%
January relative humidity	6 AM 90-95% 12 PM 65-75%
July temperature	Max. 38-40 Deg. C Min. 25-27 Deg. C
January temperature	Max. 25-27 Deg. C Min. 16-18 Deg. C
Water run-off for storms of 20 mm is 5 mm/yr =	5,000 mm3/Yr
Water run-off for storms of 50 mm is 25 mm/yr =	25,000 mm3/Yr
Average annual run-off for all storms is 53 mm/yr =	53,000 mm3/Yr

Zone 10: Randa Climatic Region

This zone occupies mountains above 900 meters elevation.

Average annual rainfall	300 mm/yr
Range	180 - 700 mm/yr
July relative humidity	6 AM 53% 12 PM 27%
January relative humidity	6 AM 100% 12 PM 71%
July temperature	6 AM 35 Deg. C 12 PM 23 Deg. C
January temperature	6 AM 26 Deg. C 12 PM 13 Deg. C
Water run-off for storms of 20 mm is 7 mm/year	7,000 mm3/Km2/yr
Water run-off for storms of 50 mm is 34 mm/year	34,000 mm3/Km2/yr
Average annual run-off for all storms is 84 mm/year	84,000 mm3/Km2/yr

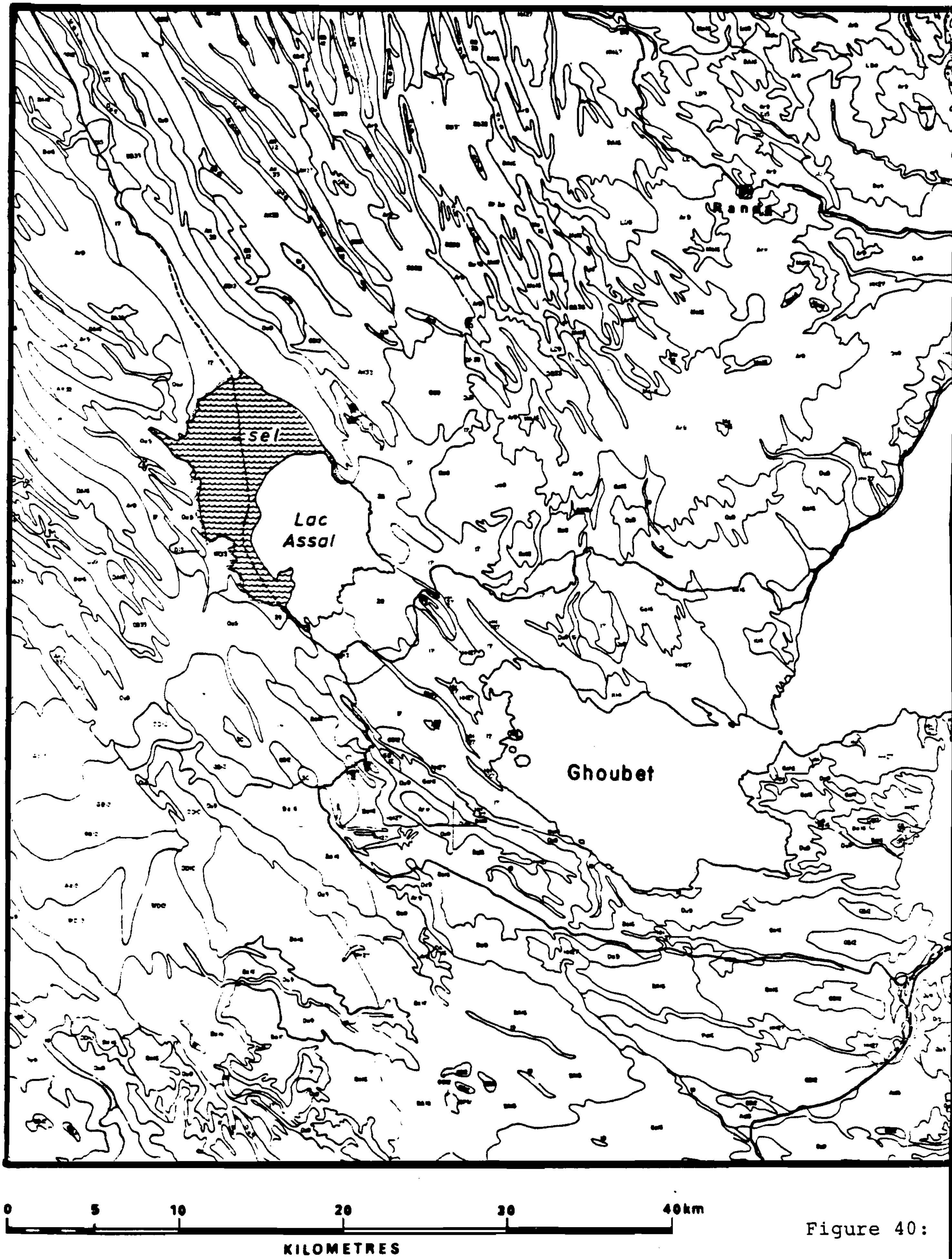
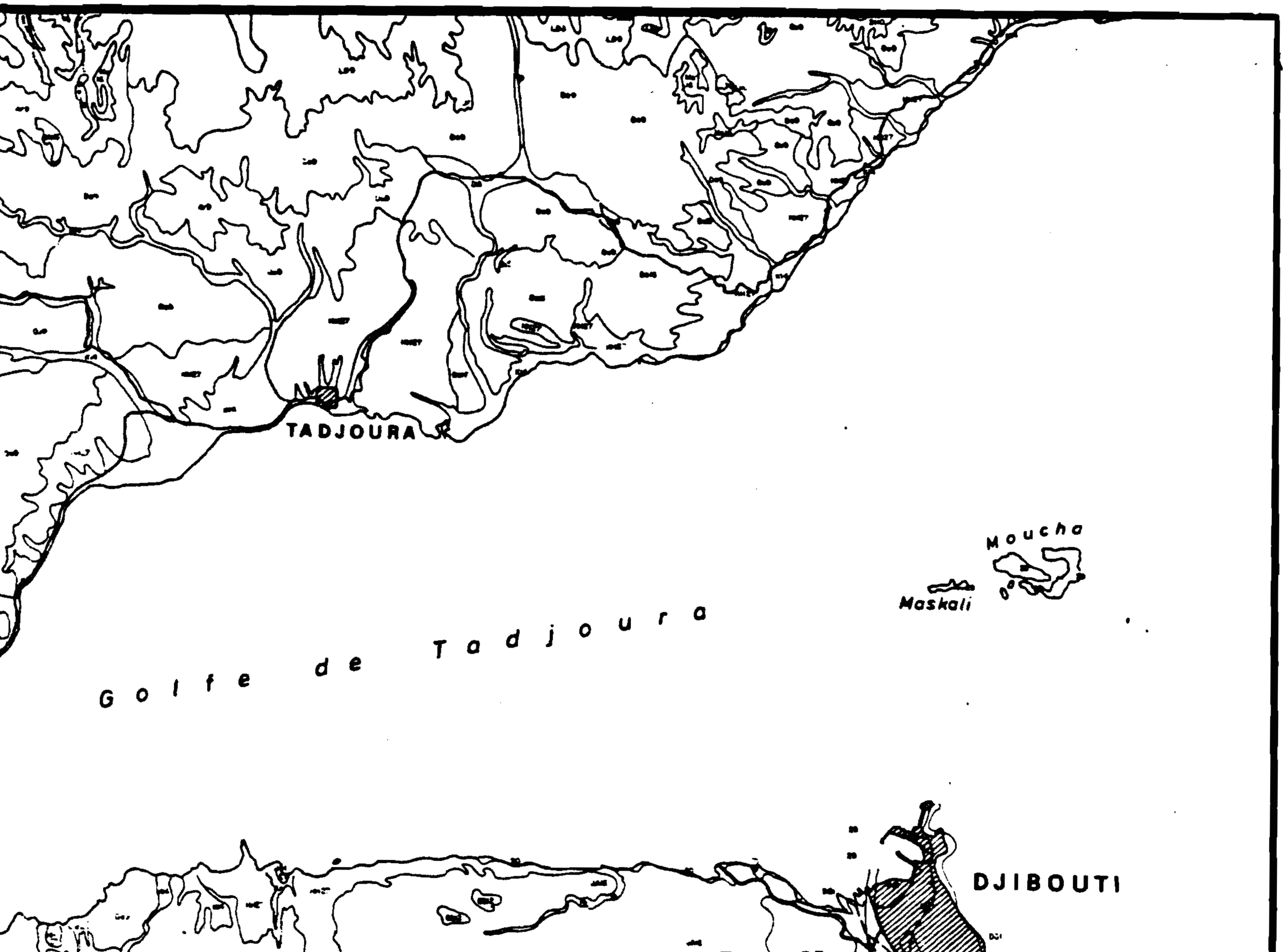
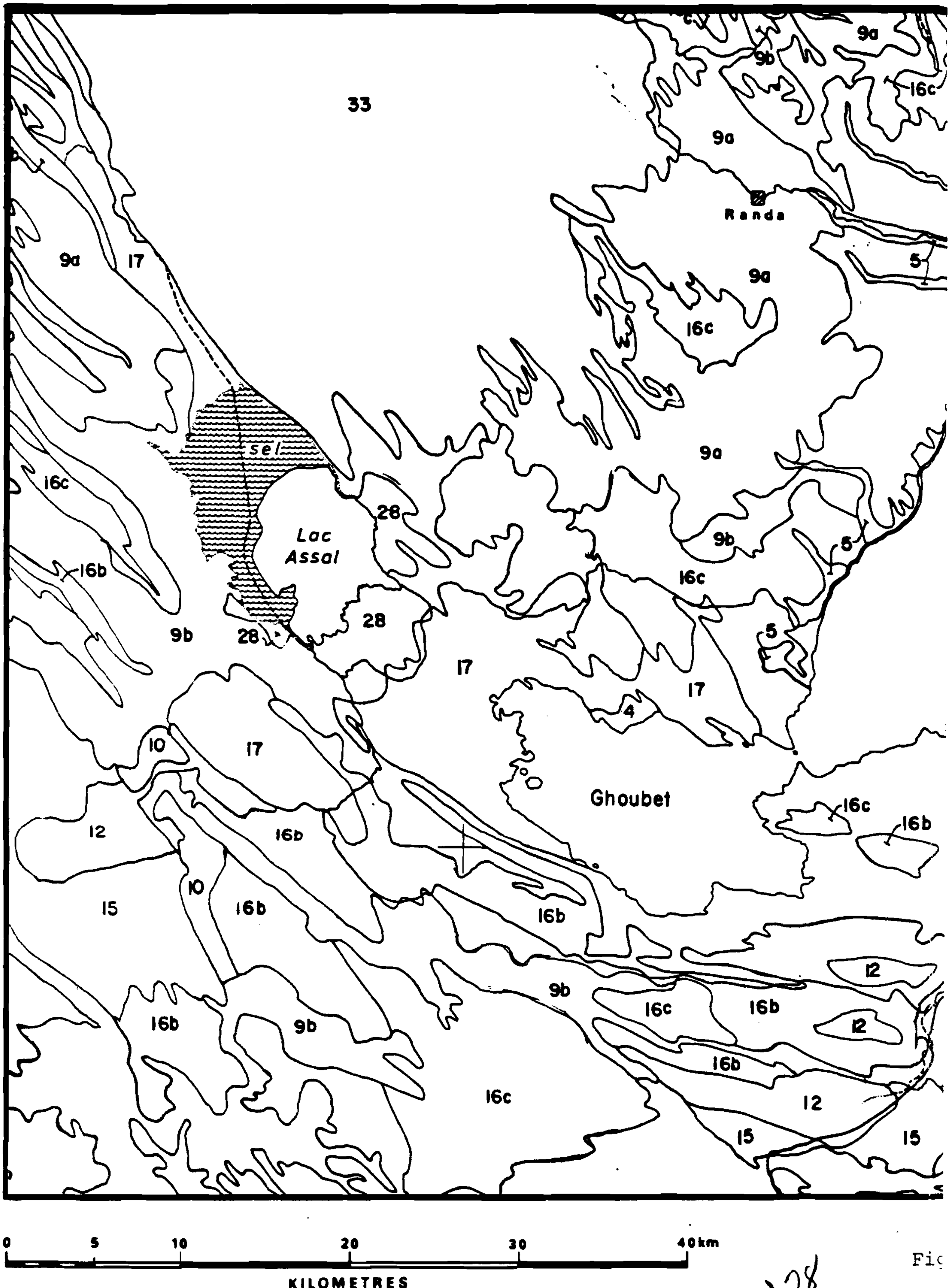


Figure 40:

127



40: Carte des Sols de Djibouti Réduction de L'Echelle 1:100,000
Detailed Soils Map



33
9a
9b
16c
Randa
5
17
sel
Lac Assal
28
16b
9b
28
17
4
10
17
Ghoubet
12
16b
10
15
16b
9b
16c
12
16b
9b
16b
16c
16b
12
15
15
0 5 10 20 30 40km
KILOMETRES

Fi

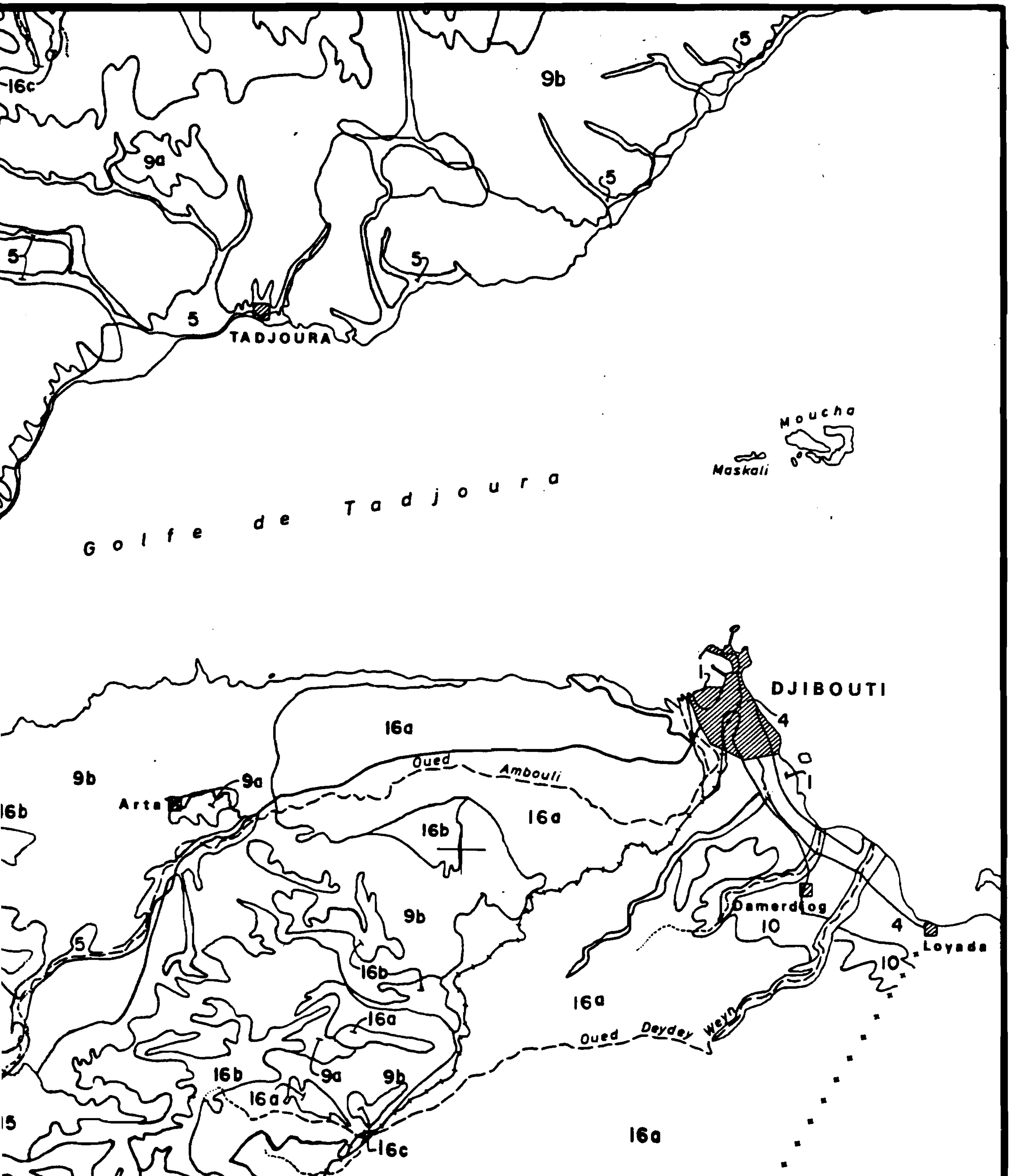


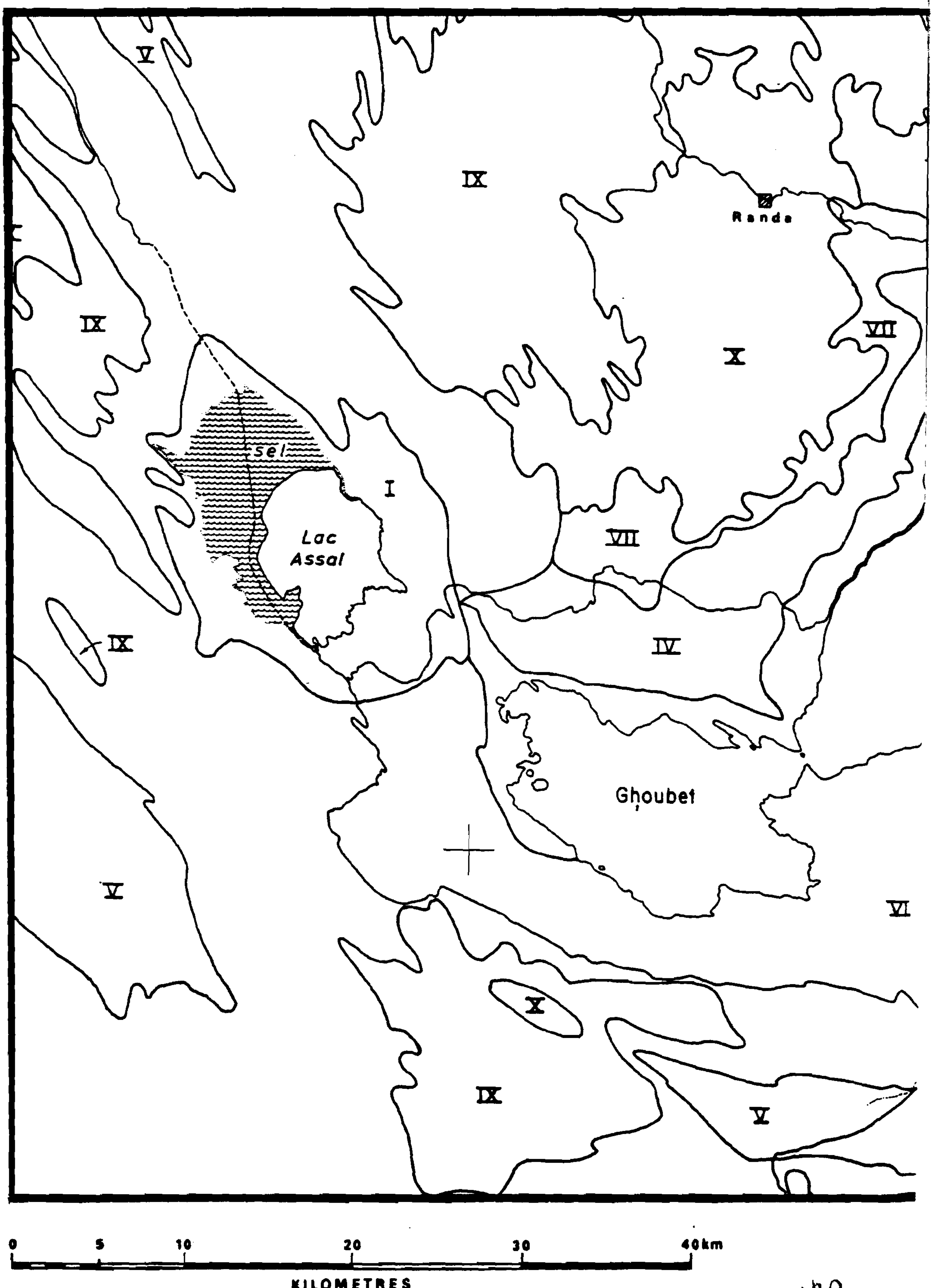
Figure 41: Carte des Sols en Plan de Djibouti
Generalized Soils Map

Carte des Sols en Plan de Djibouti

EXPLICATION

1. Sol Dabagalaley
4. Sols Kallolou - Kenannaba
5. Sol Didjan Der et lit de Oued
9a. Sols Arta - Dagah Dere - Lahi Daddaeo - Afnaba Daba
9b. Sols Oueah - Degamenkal - Damerkaddae - Afnaba Daba
10. Sols Dita - Dagah Dere - Goendale Madobe
12. Sols Grand Bara - Riffor Damoun
15. Sols Ada - Wanni Daer - Malhadlow - Eado Gafan
16a. Sol Jaban As
16b. Sol Balambal - Dero Koma
16c. Sols Daba Eabdalle - Garrayto
17. Lave
25. Boue
28. Boue Calcaire
31. Sol Eangalalo
32. Éboulis
33. Al Kibo - Esa Galow - Dimo le Boda

Figure 41 (Continued)


V
IX
Rande
IX
VII
X
sel
I
Lac
Assal
VII
IV
IX
Ghoubet
V
VI
X
IX
V
0
5
10
20
30
40km
KILOMETRES

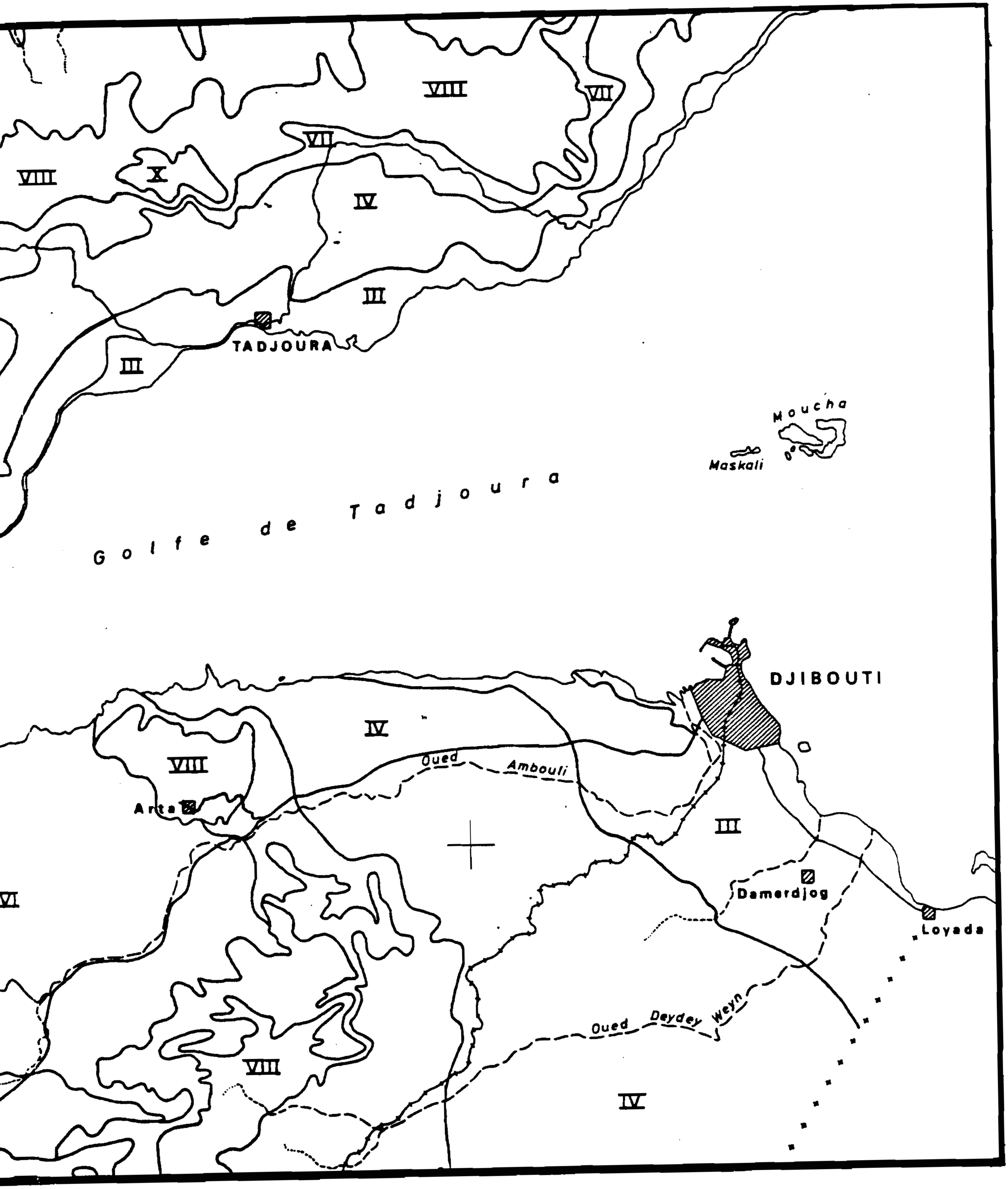


Figure 42: Carte Climatique Pédologique
Soils Climatic Map

Carte Pédo-Climatique

EXPLICATION

I. Région climatique du Lac Assal

II. Région climatique d'Obock - Khor Angar

III. Région climatique de Djibouti - Tadjoura

IV. Région climatique de Chabelley - Bissidirou

V. Région climatique de Dorra - Asa Eala

VI. Région climatique de Dikhil - Paddgeto

VII. Région climatique de Hol Hol - Arda Daba

VIII. Région climatique de Arta

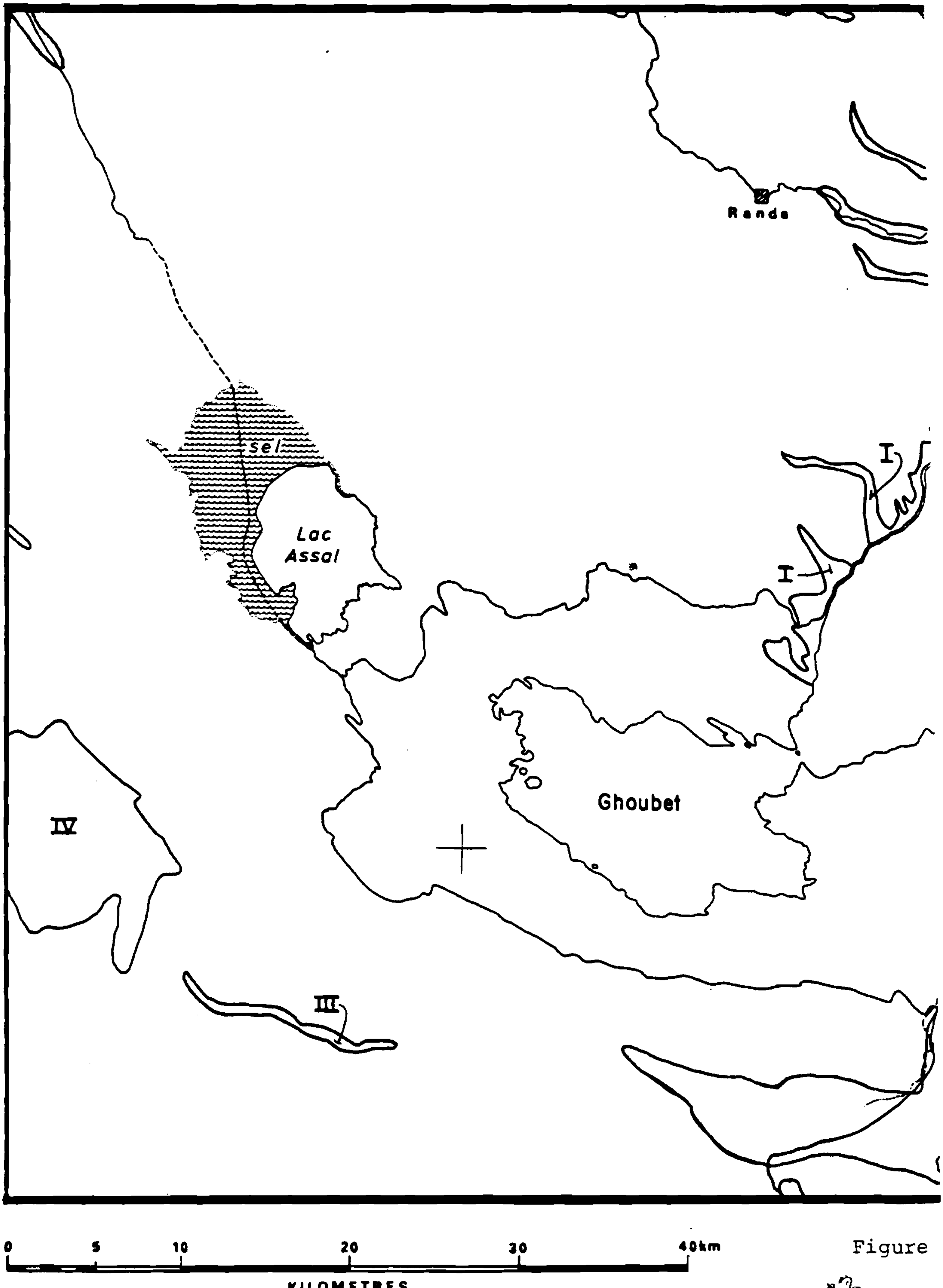
IX. Région climatique d'Assa Gueyla - Eli Sabieh

X. Région climatique de Randa

Figure 42 (Continued)

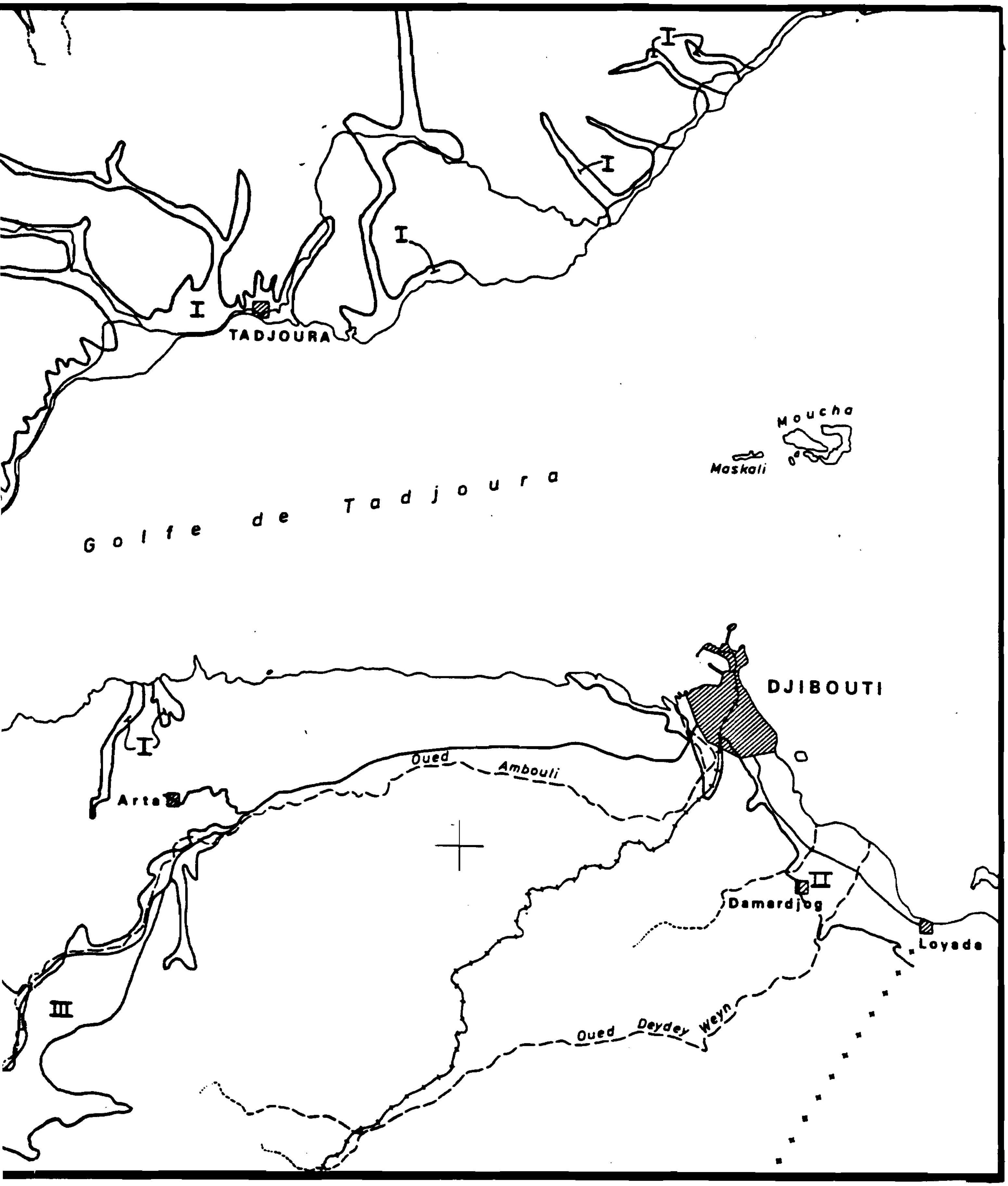
3.3.6.6 Interpretive Maps

Various interpretations of the preceeding map data allowed production of four additional maps. These maps, examples of which are found in Figures 43 through 46, illustrate recommendations regarding classes of agriculture, land capability, zones of irrigation, and range suitability.


Rande
sel
Lac
Assal
I
I
Ghoubet
IV
III
0
5
10
20
30
40km
KILOMETRES

Figure

133



:e 43: Cartes des Zones Recommandées Pour Certaines Catégories de Cultures
Agricultural Class

~~132~~

133a

Carte des Zones Recommandées pour

Certaines Catégories de Cultures

EXPLICATION

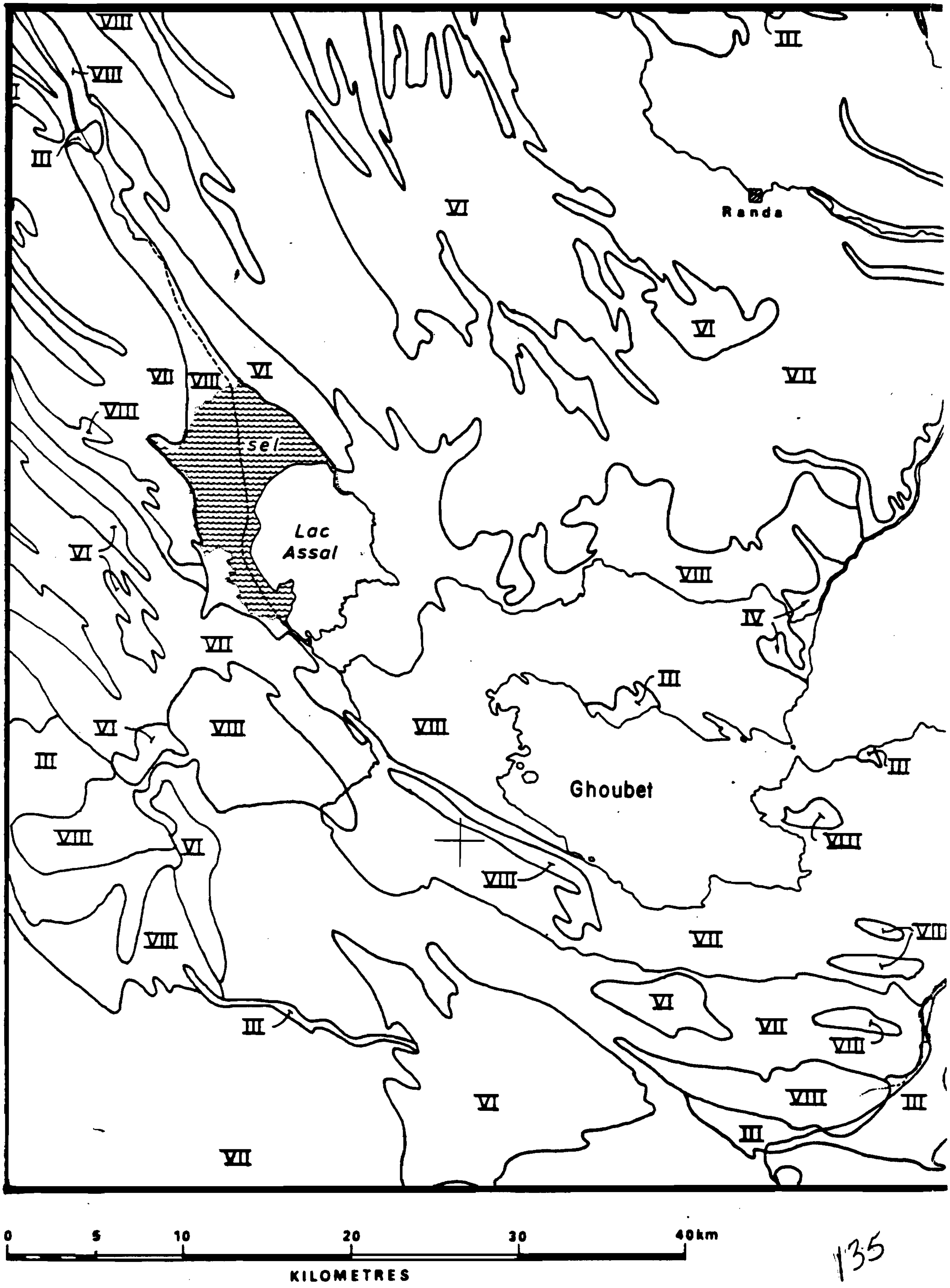
I. Zones disponsibles pour vergers

II. Zones disponsibles pour legumes et céréales

III. Zones disponsibles pour céréales et foin

IV. Zones disponsibles pour foin

Figure 43 (Continued)


VIII
VIII
III
III
VI
Randa
VI
VII
VII
VIII
VI
VIII
sel
Lac
Assal
VI
VIII
IV
VII
III
VI
VIII
VIII
III
Ghoubet
III
VIII
VI
VIII
VIII
VIII
VII
VII
VI
VII
III
VIII
VIII
III
VI
III
VII
0
5
10
20
30
40km
KILOMETRES

135

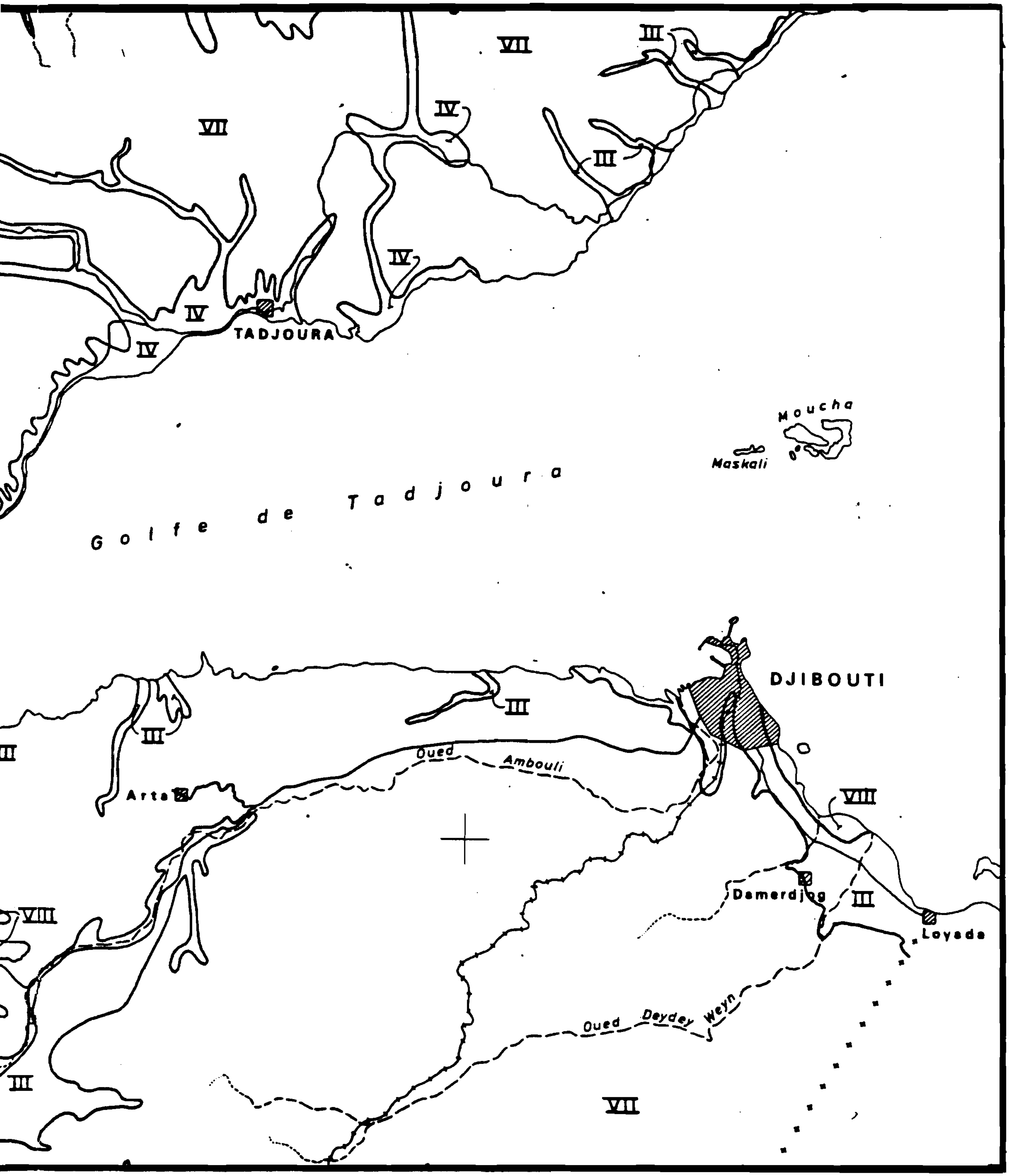


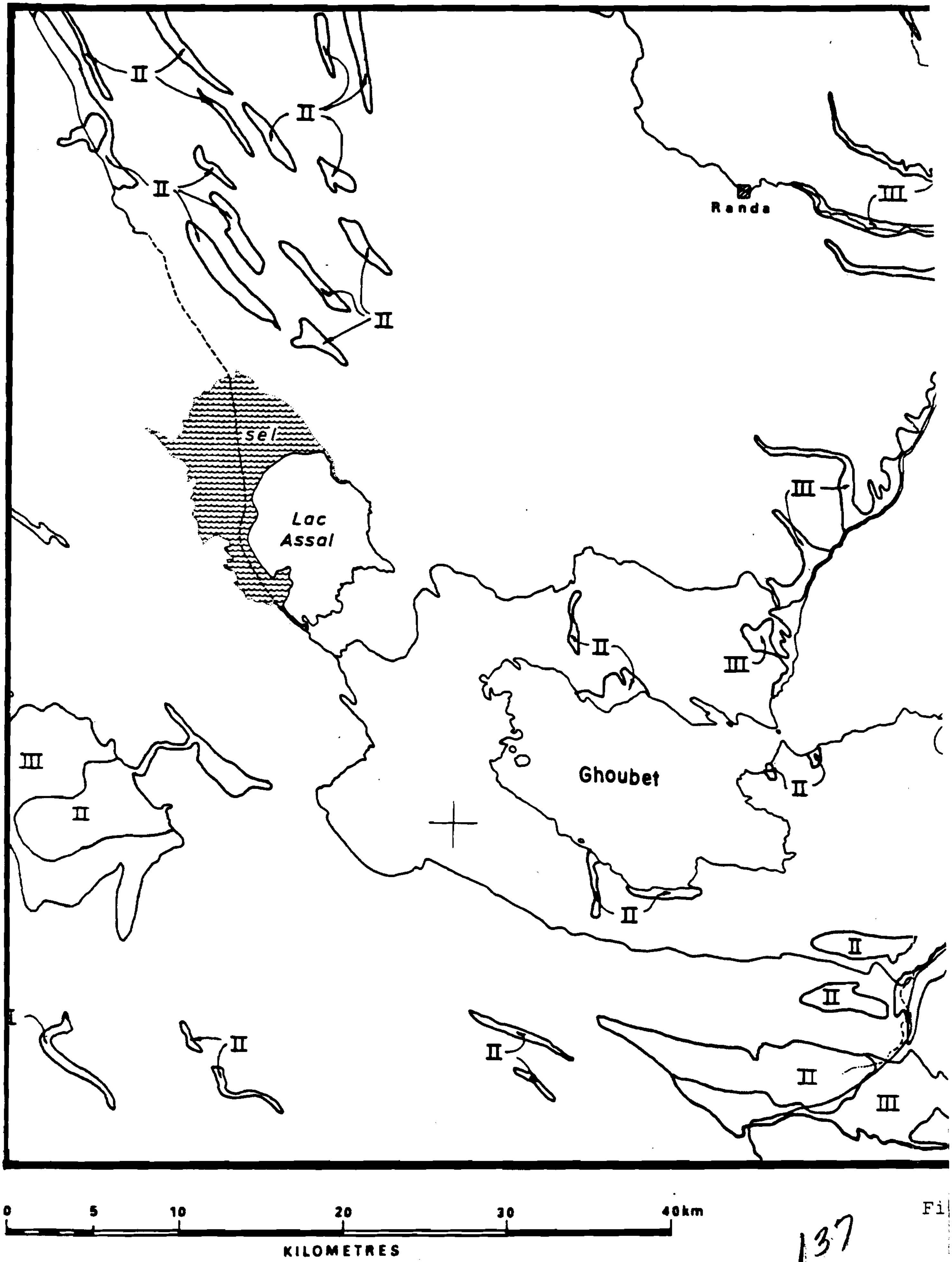
Figure 44: Carte de la Capacité de la Terre
Land Capability

Carte de la Capacité de la Terre

EXPLICATION

I - II	Il n'y a pas de ces catégories dans Djibouti
III	Il y a obstacles corrigibles pour l'agriculture intensive
IV	Il y a obstacles corrigibles pour l'agriculture généràl
V	Il ya obstacles difficilement corrigibles pour l'agriculture généràle
VI	C'est disponible pour le pàturage
VII	C'est disponible pour le pàturage ét le bassin
VIII	C'est disponible pour le bassin versant seulement

Figure 44 (Continued)


II
III
Randa
sel
Lac
Assal
Ghoubet
0
5
10
20
30
40km
KILOMETRES

Fi

137

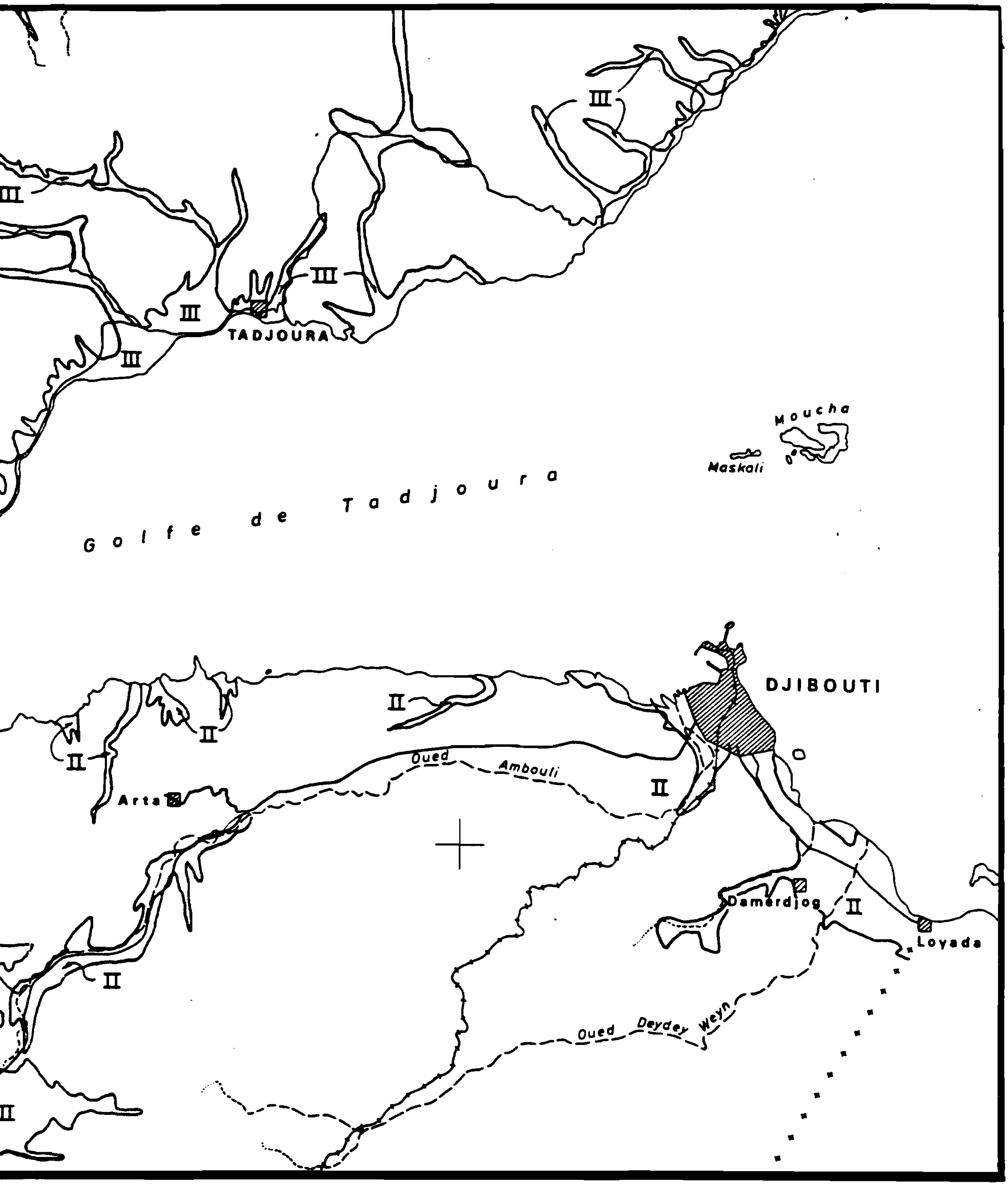


Figure 45: Carte des Zones Appropriées Pour L'Irrigation
Irrigation Suitability

Carte des Zones Appropriées Pour L'Irrigation

EXPLICATION

I. Pas de cette classe en Djibouti

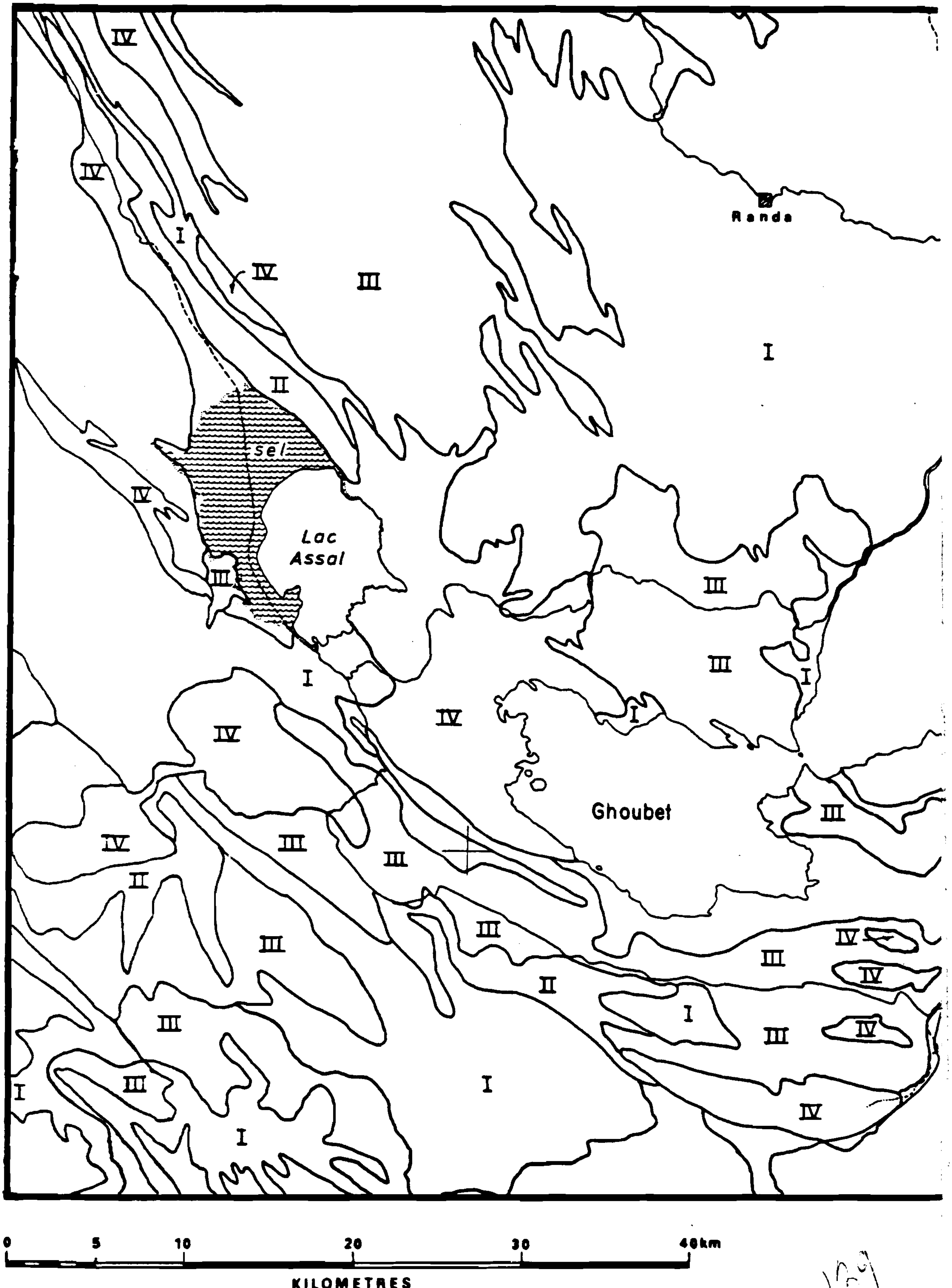
II. Sols avec peu de limites agricoles

III. Sols appropriés a l'irrigation mais nicessitant des modifications

IV; Sols convenant à l'irrigation avec beaucoup de modifications

Sans nombre. Les sols ne sont pas appropriés à l'irrigation

Figure 45 (Continued)


Randa
sel
Lac
Assal
Ghoubet
I
II
III
IV
0
5
10
20
30
40km
KILOMETRES

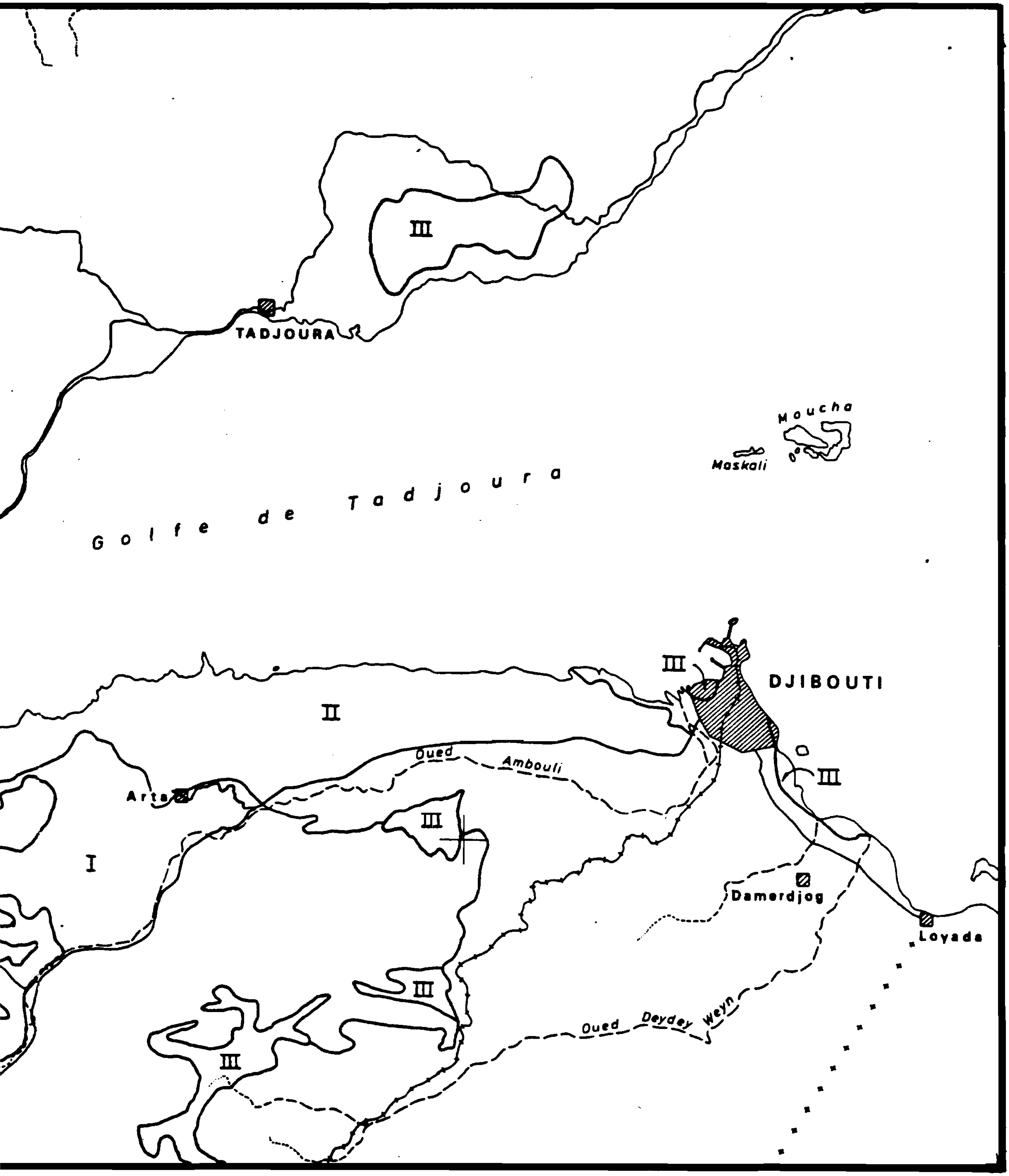


Figure 46: Carte des Zones de Pâturage
Range Suitability

Carte des Zones de Pâturage

EXPLICATION

I.	Production Bonne	200 - 500 K/Ha/An.
II.	Production Modéré	50 - 200 K/Ha/An.
III.	Production Basse	0 - 50 K/Ha/An.
IV.	Dépouillé	

Figure 46 (Continued)

3.3.7 The Soils and Water Laboratory Library

Many books in both French and English have been received by the laboratory thereby building up a repository of reference material to serve as back-up for the technicians. The titles have been selected carefully to include basic information on more than just laboratory references.

Since the Djiboutian technicians will have no access to a major library, the subject matter of the library deals will all facets of soils and agronomic investigations, agricultural practices and implementation as well as related fields in chemistry, geology, engineering, etc. (see Photos #38 through #41). Appendix M lists books and literature presently on file at the laboratory library.

3.3.8 Specific Accomplishments

A complete listing of all specific accomplishments of this phase of the project follows:

Soil Inventory

A. Identify the natural soil bodies.
B. Describe the soil characteristics.
C. Classify the soils for comparison with similar soils elsewhere.
D. Write official soils description.
E. Describe the soil mapping unit.
F. Map the extent of similar soils at small and medium scales.
G. Write a report on the soils and include the map descriptions and interpretations.
H. Interpret the soils for Agricultural uses for land-use options, irrigation, and runoff agriculture, selected crops, cropping practices and production potential.
I. Make a national soils map at 1:100,000 scale.
J. Make a national slope map at 1:100,000.
K. Make a national watershed map at 1:100,000.
L. Make a regional watershed map at 1:25,000 accomplished (three regions).
M. Make land ownership map 1:5,000.
N. Make a national soils map 1:300,000.
O. Make a general soils map at 1:500,000 scale.
P. Make appropriate interpretive maps.
Q. Make large-scale maps of potential agricultural areas, i.e., Atar, Moulud, Doudubba, Grand Bara, Gobaad, Tadjoura, Hanle, etc., -- accomplished for areas in the Gobbad and Hanle, Dey Dey and Damerjog watersheds.

Photo #38: Irrigated garden in Houmbouli

Photo #39: Vegetation of Arta Soil

The library has technical information on these subjects and many more

oto #40: Geology and geologic processes of La Easal and recent lava flow in foreground with salt in background

Photo #41: Range and grazing will always be important in Djibouti. Adaptability and productivity of goats is extradordinary

R. Make individual soils reports for cooperative laboratory clientele to be used in land-use decisions.
S. Provide guidance for subsequent soil and water analyses in the field.

Land-Use Planning

A. Make a random sample for National Resource Inventory.
B. Describe all of the natural resources in detail for each sample plot.
C. Summarize the results of the inventory.
D. Design the inventory for planning assistance.
E. Design the inventory for land-use monitoring.
F. Make rangeland interpretations.
G. Make irrigated agricultural land interpretations.
H. Contact farmers.
I. Assist individuals in planning.

Remote Sensing

A. Collect remote sensing imagery.
B. Teach remote sensing techniques.
C. Develop procedure for land-use monitoring. Developed 1:5,000 land ownership maps in cooperation with agricultural service.
D. Use remote sensing to make resources evaluation.
E. Establish ground truth for remote sensing.
F. Recommend future uses of remote sensing. A black and white panchromatic or infrared 1:50,000 scale aerial photograph should be obtained around 1987 for better resources inventories and agricultural land update.

Training Functions

Provide training in the following fields:

A. Laboratory analyses of soil and water.
B. Laboratory management.
C. Laboratory reporting.
D. Soil survey and reporting.
E. Soil Interpretation.
F. Soil and water resource evaluation.
G. Remote sensing interpretation and application.
H. Cartography.
I. Library management.
J. Cataloguing and data management -- pending the receipt of computer materials. A programmer is scheduled within a year.
K. Identify short-term training needs for two people. Also two assistants will receive one year of training each.

L. Evaluation of laboratory personnel.

Technical Library

A. Establish a library of technical information on soils, water, hydrology, geology and agronomy.
B. Order texts, books, journals and reports.
C. Establich cataloguing and checking procedures.
D. Catalogue past and present reports.

User Services

A. Determine who is intimately concerned with land-use.
B. Establish communication with land users.
C. Establish servicing procedures for land users. This is the assigned responsibility of Agricultural Service.
D. Test a means and format for information dissemination. Information is disseminated by meeting farmer groups, word of mouth, from visits, radio and television.

4.0 PERSONNEL AND TRAINING REQUIREMENTS

The laboratory requires personnel to meet the following minimum needs.

1. A pedologist for the soils inventory and survey, who must also supervise the laboratory analyses and make recommendations.

2. A laboratory technician who conducts the soil and water analyses and maintains the laboratory facilities.

3. Two laboratory assistants who will expedite routine procedures and related equipment maintenance.

4. A secretary who will be capable of some accounting, have experience in general communications and materials inventory and who will maintain the technical library.

5. Other services: a janitor, a chauffeur-mechanic and a guardian. Two laborers are also required for digging of profiles.

4.1 Evaluation of Present Staff

The pedologist, Aboubaker Douale, and the laboratory technician, Farah Omar, were both assigned to the laboratory early in the project. They have both responded well to training. They are both capable of handling their respective responsibilities. They will need regular training and practice to give them more self-assurance in their jobs.

No other personnel have been assigned or worked long enough with the laboratory to warrant evaluation.

4.2 Training

4.2.1 Training Provided

4.2.1.1 Pedologist

The pedologist received training in the following areas during his course of work. He learned how to:

- describe the characteristics and morphology of soils;
- classify soils according to the comprehensive Soil Taxonomy of USDA;
- make soil maps so that the location of similar soils can be ascertained;
- conduct chemical analyses of soil and water;
- interpret soil characteristics to identify their limitations for specific land-uses such as irrigation, crops, pasture and construction; and
- make technical soils reports and reports on laboratory results.

4.2.1.2 Laboratory Technician

The laboratory technician received training in the following areas during his course of work. He learned:

- Procedures to analyze some of the constituents of water listed under water quality testing. Training will continue in this area;
- procedures for some of the chemical tests of soil listed under soil analyses. Training will continue in this area;
- procedures for testing the physical characteristics of soils listed earlier;
- proper laboratory methods and techniques;
- systematic procedures to insure the smooth flow of water samples through the laboratory during their analyses;

- methods for developing soil descriptions, classification and cartography; and

- methods for map measurement and measurement-reporting.

4.2.2 Formal Training Requirements

Short-term training of 1 to 6 months.

Laboratory Assistant - Farah Omar

Approximately three months refresher training in water and soils laboratories in the U.S. (U.S. Geological Survey Water Laboratory and National Soil Survey Laboratory).

Water Chemist (not selected yet

Depends on candidate selected.

Graduate Study of 1 to 2 years.

Pedologist - Aboubaker Douale Waiss

Aboubaker is expected to pursue a Master's program in soil chemistry with academic work to begin approximately in the fall of 1983 with work on thesis project to commence about one year later.

Hydrogeologist (not selected yet

Depends on the candidate selected.

Undergraduate Study of 4 to 5 years.

Pedologist

Candidate should be selected within the next two years so that academic training can be completed within about five years. The Soils and Water Laboratory needs additional trained staff to be prepared to work in the laboratory or soil survey phases of the program.

Chemist

Same as above.

Hydrologist

Same as above.

5.0 CONTINUATION OF TECHNICAL ASSISTANCE

5.1 Scenario

July 1982 -

Prepared and submitted Final Report - Summary Version. This version of the Final Report was due July 31, 1982. It consisted of approximately fifty pages excluding exhibits. Dr. Goebel and Aboubaker Douale Waiss jointly prepared this report.

August 1982 -

Phase-down of contractor involvement in project; Dr. Goebel departed on 30 July 1982. USDA TDY Soil Scientist to Djibouti for six person-weeks (PW) with two weeks to overlap with Dr. Goebel. This TDY was essential to ensure a smoother transition phase-over to USDA intervention and its short-term periodic technical support.

July thru September 1982 -

Aboubaker Douale Waiss to the United States for USDA short course (two months). During his trip to the U.S., Aboubaker will select a university for his graduate study. He will select his course of study in consultation with major professors and determine what his thesis project is to be. On his return to Djibouti, it is expected that Aboubaker will begin work on his thesis project. It is expected that his thesis project will be completed by the time he returns to the U.S. for the academic protion of his Master's study program.

March, 1983 -

The expanded version of the Final Report from the contractor is due 31 March 1983.

A USDA TDY Soil Scientist will concurrently arrive in Djibouti in March 1983 to overlap with Dr. Goebel and will remain for two additional weeks to complete the final evaluation of the project.

April 1983 thru January 1985 -

Two weeks TDY of USDA Soil Scientist to Djibouti once every four months. This is essential to provide technical back-up for Djiboutian staff at the Soils and Water Laboratory responsible for operation of the laboratory and conducting the soil survey of Djibouti.

Summer 1983 -

Farah Omar to U.S. for three months of refresher training in U. S. Soils laboratories. The laboratories will probably be the U.S. Geological Survey Water Laboratory in Denver, Colorado and the Soil Conservation Services National Soil Survey Laboratory in Lincoln, Nebraska.

Fall 1983 -

Aboubaker Douale Waiss to United States to complete Master's program. It is expected that this will take about sixteen (16) months.

It is expected that the GROD will engage someone to temporarily handle Mr. Farah's tasks as he assumes those of Mr. Aboubaker.

5.2 Equipment

All the equipment and supplies needed for the proper functioning of the laboratory have been furnished through American assistance and has been received. Any further equipment or material acquisitions will be made by the laboratory with funds established in the budget resulting from the establishment of the laboratory as a unit under the Minister of Agriculture. An adequate budget for the maintenance and operation of the laboratory has been approved by the National Assembly and the President.

Catalogues and addresses have been supplied to facilitate future acquisitions. French and American laboratories have been recommended for expensive unique analyses that may be required.

6.0 SUMMARY - THE DEVELOPMENT OF AGRICULTURE IN THE REPUBLIC OF DJIBOUTI

In Djibouti, a limited agricultural capability is confined to specific parts of the terrain where water is available. Ground water is not suitable for agriculture due to toxic levels of boron and also toxic levels of other salts in many cases. Ground water yield is too little for agricultural irrigation. Therefore, the water source for Djibouti agricultural development will be limited to rain-fed systems which occur where the water naturally accumulates. These occur along the wadi channels, at deltas of colluvial fans and on foot-slopes. In these areas, water can be collected and crops grown. The soils in these areas are not limiting factors for agricultural development. There are adequate water and soil resources to produce enough foodstuffs for the present population of Djibouti. Photos #42 through #49 illustrate some of the present agricultural practices in Djibouti and the potential for agricultural development in the country.

6.1 Agricultural Needs

Let us begin with the probable or estimated requirement for agricultural production in Djibouti. These figures are an approximation based on the per capita American consumption for these products, multiplied by the number of people in Djibouti. They consider one crop production per hectare or per areas per year and do not include double cropping.

One can estimate that this population of 300,000 will annually require in the neighborhood of 8,000 mt of poultry, 3,000 mt of cheese, 17,000 mt of processed vegetables, 2,500 mt of fish, 8,000 mt of fat and oils, 21,000 mt of sugar, 22,000 mt of meat, 15,000 mt of processed fruit, 10,000 mt of flour, 20,000 mt of fresh vegetables, 11,000 mt of frest fruit, 36,000 mt of milk 3,000 mt of eggs and 1,000 mt of coffee.

For estimating the probable production in Djibouti of these crops by crop item, we can convert these to the number of hectares necessary for each crop. If all the meat requirements of Djibouti were to be met on irrigated land, it would require 11,000 hectares or about 110 square kilometers. If the meat were to be produced on the range, considering about 100 kilos per hectare forage production, we could expect a required 22,000 square kilometers of range. If the milk needed were produced on irrigated land, it would require 41 square kilometers. If milk were produced on the range, with the use of goats and camels, it would require an additional 8,000 square kilometers.

In grain, the country can expect to use 73 square kilometers for irrigated corn and 34 square kilometers for irrigated wheat. The country needs about 43 square kilometers dedicated to fruit. Fats and oils would require 42 square kilometers. Fish can be considered a direct substitute for meat. If all the crops were irrigated, including those needed for

hoto #42: This Houmbouli garden shows the kind of intensive agriculture possible in Djibouti

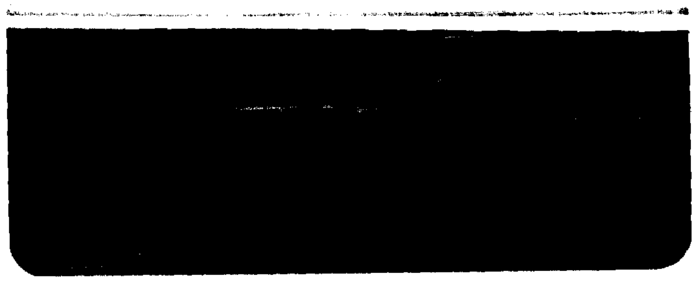
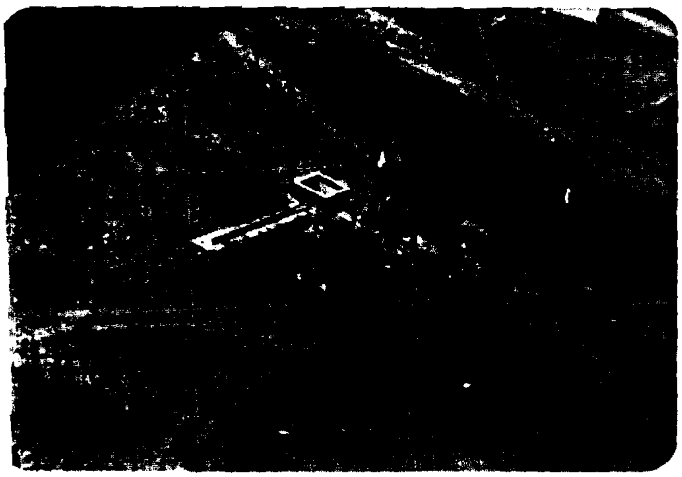


Photo #43: Water in the Grand Bara is wasted and could be used in the nearby Aada soils



oto #44: Well at Esa Galow. It is located on a natural dam. Didjan Der soil in the terrace would support agriculture

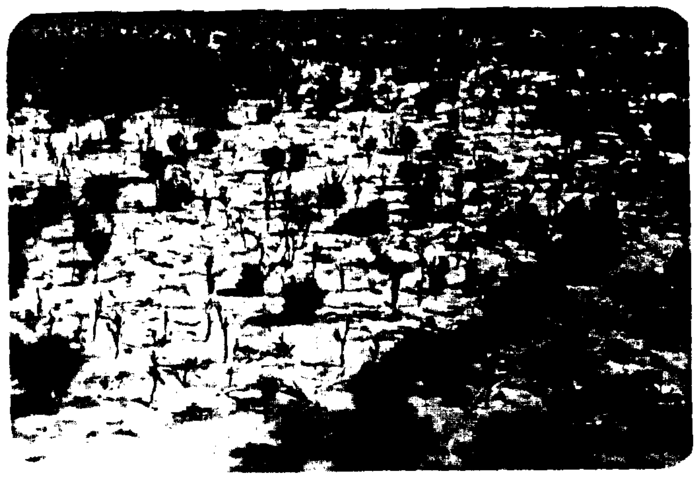


Photo #45: This forest in a playa west of Dorra is being defoliated for livestock feed. Trees are supported by flooding

Photo #46: Vegetable gardens like this can be located in Houmbouli, Douda, Subalou and Bissidirou

Photo #47: Range will always be important to those dedicated to animals descendants of nomads

ıoto #48: Fruit trees can be grown on deltas and terraces of streams flowing from mountains of Randa to the left

Photo #49: During floods this channel will store water for grain production in the gray Didjan Der soils on the banks roughage production for milk and meat, 370 square kilometers can be expected to produce the amount of food for the population of approximately 300,000. If one eliminated the forage production, 219 square kilometers can supply the needs of the country.

According to the United Nations estimate for food requirements for Djibouti (see Figure 47), the country would need 60,225 mt of cerals, 4,818 mt dairy products, 2,404 mt fruits, 4,818 mt vegetables, 6,022 mt meat and fish, and 2,409 mt edible oil. This is the same as 220 square km of land for cereals; 40 square km for meat; 7 square km for fruit; 13 square km for vegetables; 38 square km for edible oils. We can see the two estimates are approximately the same for the total amount of land needed. There is some question about diet and therefore emphasis on one crop over another. Considering these food requirements for the country it is now necessary to look at the potential for their production.

6.2 Crops

First, let us consider the kinds of crops that are required from an agricultural standpoint. We can consider fruit and vegetables for high intensity crops, or the nutritional crops. There are the fats, another kind of crop requiring a distinct management. There are sugar and cereal grain. There is the production of dry forages. There is also range production. Each of these crops have to be reviewed for their specific soil and water requirements.

As a general rule, fruits are produced on perennial vegetation which requires a constant supply of high quality water, since most fruit plants are adaptable to higher rainfall areas. As a result, the fruit trees should be established in the area with the most dependable water supply. Since they are deep rooted it may not be necessary to have as fine a textured soil or as level a terrain for their management.

Vegetables, in the same category, are usually annuals. Once the crop is established, it should have a reasonably dependable water supply. A short period of drought would not eliminate the normal production capability in vegetables as would be the case with fruit. Twenty to thirty year old trees may be lost in a drought.

In the case of oil, most fat producing plants are rather drought tolerant. They can take a lower amount of water and as a result, would be satisfactory in water plans where there is a limited supply of water available or the water is available for only short periods of time.

In the case of cereal grains, this is also usually true. Cereal grains are basically a semi-arid crop. They have some tolerance for water that is a bit salty. These crops also have some drought tolerance for short periods of time. They also produce relatively quickly.

..ORLD FOOD PROGRAMME
PROGRAMME ALIMENTAIRE MONDIAL
برنامج الأغذية العالمي
PROGRAMA MUNDIAL DE ALIMENTOS

Telegramme UNDEVPRO DJIBOUTI
Telex PNUD 5850 DJ
Tel: 353371-72

Bureau de Representant

Boite Postal 2001
Djibouti

Ref: ORG 80/USAID
P-179/82

Date: 9 May 1982

Dear Dr. Goebbels,

Subject : Annual food requirements in Djibouti

Further to our discussion of 5 May 1982 on the above subject, please find below the estimated food requirements and commercial import statistics.

Please note that the calculation of the annual tonnage required assumes a population of 330,000, and is based on the recommended daily intake of 2,500 calories per person.

Commodity	gm. per day	annual requirement (MT)
Cereal	500	60,225
Dairy products	40	4,818
Fruits	20	2,409
Vegetables	40	4,818
Meat/Fish	50	6,022
Edible Oil	20	2,409

As compared to import statistics, it is evident that the average Djiboutian does not consume the recommended daily food intake. Based on local food habits, the following estimate of average daily intake can be made with regard to the urban populations :

Commodity	Gm per day
Rice	150
Bread	250 (one loaf)
Vegetables	35
Meat	40
Edible Oil	20

The above does not apply to the nomadic groups, who basically consume dairy products (goat and camel milk) produced by their herds and some cereals (sorghom, maize) obtained in trade with Ethiopia. It should be noted that as much as 1500 tons of these cereals are imported annually by the nomads under uncontrolled conditions.

Trusting that the above will be of some use to you.

Yours sincerely,

Khaled Adly

Dr. J. Goebbels
Adviser, USAID/Ministry of Agriculture

Figure 47: 155

ANNUAL COMMERCIAL FOOD IMPORTS

COMMODITY		TONNAGE
A.	Cereals *	
	1) Wheat Flour	10,000
	2) Rice	14,000
	3) Coarse grains	5,000
B.	Dairy and Poultry products **	6,000
C.	Fresh and dried fruits **	1,100
D.	Fresh and Dried Vegetables **	1,900
E.	Meat and Fish Products **	600
F.	Edible Oils **	4,700

* Source ONAC

** Source port statistics 1980, does not reflect imports fruits, vegetables and meat from Ethiopia

Figure 47 (Continued)

6.3 Water

Water is unquestionably the most important factor for agricultural production in Djibouti. Large quantities are required over few to several months and the quality must be very high to prevent rapid salt accumulation in the soils. As a result one must look seriously at where the water occurs, the quality of water available, and how to manage the water in agricultural production.

The locations of accumulated water are basically four in nature in the country. One area is where the rainfall occurs on the mountains which have an elevation over 900 meters. The rain occurs more frequently throughout the year in these areas. Floods of these areas replenish the water within the wadies of Weima Sadai, Gobbaad, and Hanle. This area is the source of water for all the wadis from Sablali, along the coast all the way around the Goubbhet to Khor Eambado.

The second place is the wadi channels in the interior of the country. Wadi channels from time to time flood. The wadi water infiltrates rapidly into the channel, and if the alluvium is thick enough, a temporery reservoir is established which can be used for some period of time to irrigate crops, depending on local wadi conditions.

A third position suitable for collecting water is the foot-slopes of the mountains and the hills where sheet erosion and even gully erosion are presently active. This water can be channeled and directed to accumulate on lesser areas, as a consequence, increasing the moisture availability for crop production.

A fourth place is the water that accumulates in playa basins. Oftentimes the short slopes, and the narrow watersheds around the playas do supply run-off water into the playas. If this is redirected and ponded, it can be concentrated on select areas to increase water availability and thus crop production.

It must be remembered that the water available and stored by the present active system is about as efficient as can be expected. When the rainfall is high and the run off is high, the water flows down the channels which are extremely permeable permitting the water to infiltrate the channels, recharge the ground water, and recharge the aluvium. It also permits the accumulation in playas, which have a silt cover and are semi-impermeable to the water. As a result, very little water in the channels evaporates after a rain, compared to the amount that falls. At present, this system is generating the maximum amount of ground water recharge and any kind of engineering would probably eventually inhibit this recharge rather than improve it. Therefore, agriculture must adapt itself to the natural flow and availability of water rather than attempting to dominate it.

Throughout the country, highest quality water occurs in the wadi channels where it is recharged regularly with fresh clean rain water. After leaving these channels, it encounters bedrock and sedimentary rock, which are impregnated with salts. The salt content rises and the toxicity of some elements increases. At this point, it seems that we can consider the deep groundwater from deep aquifers to contain toxic levels of boron, which inhibits full healthy plant development. As a result, one should look to utilize the water as soon after it rains as is feasible.

6.4 Soils

Soils are the next most significant factor in crop development. The soils in Djibouti near the geomorphic positions associated with water accumulation and availability are normally suitable. Except on the coastal plains near the sea, the soils are not salty. All the soils though are calcareous. Must soils are coarse textured and will have moderate to high permeability. The soils suitable for agriculture occur on the first and second terraces along the wadis. They also occur on the colluvial deltas and second terraces along the wadis, and the footslopes and pediments. The soils in the playas are also suitable for cultivation. There are other areas which are suitable to cultivation but which don't have water available. Most of the other areas are suitable for range and also as watersheds for accumulating water.

6.5 Strategies for the Development of Soils and Water

Any agricultural system in Djibouti will depend on rainfall as rain is the only source of salt-free water. Because agriculture requires water on an intermediate to long-term basis, two months to a year, the rainwater must be stored. At least, it must be available at the time of the crops' requirement. Water storage is a rate of time function. The rain water accumulates in the wadi during floods. It infiltrates into the channel and flows along inside the channel sediment slowly. Here, the rainwater is protected from evaporation by the channel sediments. It is made available over several months or several days in the channel by this retarded movement. Otherwise, several years later, it may reappear as ground water in deep aquifers.

On the other hand, the rainwater on the pediment slopes, running off as sheet erosion, distributes water that infiltrates into the soil where it is stored for one to two months. Water may be stored in channel sediments, in ground water aquifers or in the soil itself until it is used by the crop. It need not be stored in reservoirs. The concept of water availability in Djibouti is knowing how much water is flowing through the system during a given period of time, so that one can know when and how much water is available to the crop at that period. This is related to the time between a rain and the time at which the sediment has too little water for crop production.

Knowing this, one can calculate the kind of crop and type of water retrieval system needed to grow that crop.

The following is a strategy for crop production. The longest-lived most valuable crops must have the highest quality and most dependable water source. The lowest-quality and the fastest-growing crops should be relegated to the most unreliable water source. The water from the high mountains represents the most dependable, high quality water supply. Tree, bush, and vine crops are the most valuable, long lived plants. Thus, they should be planted in association with water from the high mountains. Deltas and colluviums from Tadjoura west around the Goubbhet should be planted in fruits.

Vegetables, on the other hand, represent a high return crop with lesser longevity. These should be planted in association with dependable, high quality water from the mountains in an area where the source may be a bit more intermittant. Thus, the water from the Sadai wadi is probably the most suitable for commercial vegetable production.

Cereal grains and oil crops represent intermediate growth crops requiring extensive areas and water supplies from three to nine months. These crops should be planted along any of the other wadis on the first and second terraces anywhere in the country. They can be planted after the rain has established how much water is available in the alluvium to plant the crop. The wadis of Weima, Hanle and Gobbaad are particularly suited to grain production. Frequently, other smaller watersheds near Eli Sabieh, Dorra, Khor Anghar, etc. may have water available for grain production.

Finally, the short-lived forages should be planted where the water has the least durability, the lowest quality, and thus, the highest risk factor. That is, it should be planted on extra land by the wadis or in the areas where the water is concentrated along pediments, and in playas. They should be short-lived cereals and grasses which are harvested as soon as they show drought stress.

6.6 Environmental Impact

This strategy and these concepts will, of course, have some environmental impact. There will be an increase in the number of birds and insects and wild animals due to the increase in vegetation.There will be an increase in domestic livestock with added occupancy and grazing in areas near to livestock concentrations. This could tend to encourage overgrazing near the farm site. Because of the agricultural settlement there will be a general increase in the cutting of bushes for fencing.

Further, since the rainwater is the source of groundwater recharge, the use of water for irrigation will directly effect the recharge rates and lower the water availability from the deep wells. Water availability at some of the permanent well sites will be reduced or eliminated as the water is used up stream in the alluvium.

The use of the remaining water sites for longer periods without flushing the water holes and also bringing the livestock to permanent water sources will increase the diseases of the livestock to some extent. Finally because of water diversion structures, natural erosion and gully and sheet erosion, will be diverted and reduced.

6.7 Preliminary Needs

The Ministry of Agriculture and the Government of Djibouti have some initial requirements to meet before agriculture can begin. One of the things that should be initiated early is a more active contact and assistance by the Ministry of Agriculture with present farmers, principally to develop a program for assisting the farmers later when development is completed. There also needs to be a more active Agricultural Service functioning in a direct association with the farmers and farmer organizations.

The country needs to establish clear land ownership policies and laws with the legal statutes to acquire a deed by the land user. The country's most valuable resource is its land. Its land can be considered as capital to the potential land user for certain number of years of man-labor which could be performed in public service to assist the country in achieving many of its public works programs.

Further, the country must now begin to establish legal rights to water, for the livestock, for industry, for urban needs as well as for agricultural needs. Then programs can be designed to meet the water needs and allow the farmer to enter his project knowing he has assurance of continued water supply.

Following is a list of short-term specialists that are required: agricultural economists, a cadastral expert, an agricultural engineer, an irrigation engineer, a water rights and distribution specialist, a cooperative expert, an animal husbandry specialist, agronomists and horticulturists, an agricultural extentionist and a social scientist (who can look at the impact of the agricultural developments on the attitude of the people and monitor the change).

6.8 Development Policies

The government should now begin to discuss the priorities for the developmental sequence. This calls for long involved discussion and the integration of the opinions of many and various poeple. Some specific projects that can begin as high priorities follow: First, providing wadi channel water to a specific drainage for the Houmbouli, Douda and Atar projects since these projects are already established and they will supply fresh vegetables to the Djibouti market. Second, the Saadi river watershed should be evaluated. The vegetable production from this water should begin somewhere in the vicinity of Sublali. Third, fruit production should be initiated on the many various wadis along the Gulf of Tadjoura and the Goubbhet. Fourth, cereal production can then be initiated, followed by establishing family vegetable gardens and local market vegetable production along the Goubbhad and Chekheti wadis as well as the Weima wadi. Fifth, this can be followed by cereal production along the lesser wadis on any small areas a man chooses to develop. Sixth, assistance can be given to forage production in the Dikhil and As Eala areas and the frontal plains from Obock to Khor Angar and the Badda Weyn and the Badda Yar. Seventh, the following crop assistance will be necessary: The government needs to look for sources of nitrogen, potassium, and phosphorus. Principally, it should look to producing its own nitrogen with wind energy. Second, it needs to find a good source of phosphorous since calcareous soils tend to firmly tie up the phosphorous. Potassium, on the other hand, would be less necessary and should have third priority in terms of availability. Seeds and pesticides should be made available by the Agricultural Service. Agricultural Service should have responsibility for seed distribution to control varieties and seed sources. Thus, they may limit the amount of seeds available for a species so there are not overages in terms of acreages planted to single crops. Thus, a balance can be established in terms of vegetable and fruit production. Agricultural Service should control pesticides due to the highly technical nature of application of pesticides. Agricultural Service can train its personnel properly in the identification of the needs and the application of the pesticides. Finally, it might be remembered that in Djibouti, the best farmers, the most productive farmers, and the farms with the greatest longevity are located nearest the wadis and take their water as much as possible directly from the channel. Further, where the family lives on the farm, the farms are considerably better managed and have higher production rates that those where there is adsentee ownership. This might be taken into consideration in an agricultural, development plan. The size of the unit should be commensurate with producing on adequate living for the farmer. One should at least consider that the people who establish themselves on the land will be able to remain there for a long time.

6.9 Conclusions

Djibouti is no longer a nomadic state. It has farmers. It has agricultural production. It has agronomists. It has governmental and private agricultural institutions and it has agricultural experience. It has more agricultural resources than had previously been identified. If it dedicates its effort to the established objectives, and is willing to commit itself fully, it should be able to produce enough crops to adequately feed at least its present population.

Overall, there are four distinct developmental strategies that the government can use to convert the land resource into an agricultural resource. All of these systems can not be applied at one time, at least not in one sector of the agriculture but any one of them probably has as much chance of success and will have about as many complications and difficulties as the other.

First, it would be possible to write a pamphlet and give instructions on the radio and television as to how to identify the soil and water resource in the land. Those people and organizations interested in beginning farming could go in search of their own parcel of land, establish their land boundaries and initiate the agriculture on their own recognizance. This would mean they would have no further technical support and if their judgement was bad they, in fact, would fail and would then choose to abandon the parcel or relocate. This they would do on their own. In the meantime, the technical capability in the country would go on developing its data resource so that when settlement had subsided in four to five years, they could begin to work with those farmers who appeared to be successful.

A second alternative would be to hire a contract firm from a more developed country with agricultural experience who would be interested in developing the resource. This would include a contract which would permit a return of the developed resource to Djibouti or to the landusers after a specified period of time when the company had been paid back for its investment. This might be more acceptable for fruit and vegetable development, where food preservation, food quality and timing of yields are very significant factors.

Third, the Djibouti government may decide to take charge of all the agricultural development itself and hire the people that are going to do the work and have an organized agricultural system. It would be under the control of the agricultural experts and the planning policy of the state.

Fourth, the government could establish a set of priorities for development. It could pace development so one thing begins first followed by another. This has to do with the development of specific regions and specific crops so that development continues squentially and therefore technical support can enter before development and can follow along with the development and can help people maximize the resource. In this way, the technical capability of the country would be brought to bear early in the development and would share in the responsibility for negative consequences. This calls for more restraint on the part of the government and individuals and private enterprise. This is far more demanding on the technical expertise, but produces a far more systematic and controlled development in the end. Given this review of the circumstances in Djibouti, it should be possible for the Ministry of Agriculture and other governmental agencies, including the legal institutions, to initiate programs now so that their work is done by the time that the needs of the agricultural community grow large enough to demand support. This report will serve as guidance toward the organizing of whatever agricultural development program is decided upon.

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Djibouti Water Resources
and
Soils Analysis

FINAL REPORT

Volume II: Appendices A, B, C

Prepared for the Agency
For International Development
Contract No: AID/afr-C-1673

Prepared By:

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February 1983

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DJIBOUTI WATER RESOURCES

AND SOILS ANALYSIS

VOLUME II: APPENDICES A, B, C

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VOLUME II: PROJECT DOCUMENTATION

This volume of the report contains the documents which, together, have formulated and shaped the design and execution of the project. This inclusion will help those not intimately involved with all that has happened to understand some of the "where," "why," and "how," in order to better understand the resulting Soils and Water Analyses Laboratory. It helps one to better assess the project and appreciate what it is and what it can be.

Of special note, the reports contained herein are not reproduced in their entirety. They are excerpts from the original reports. Certain material not relevant to this specific project has been deleted from each of the reports.

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REPORT

on

SURVEY OF DJIBOUTI'S AGRICULTURAL DEVELOPMENT

by

Madison Broadnax, Team Leader

Dr. James K. McDermott, Agronomist/Economist

Dr. Claudio Shuftans, Nutritionist

October 4-18, 1977

SUMMARY AND CONCLUSIONS

Purpose

Purpose of this trip was to develop alternatives and recommendations for specific AID action in the newly-created Republic of Djibouti, based on a reconnaissance of the country's natural, human, and institutional resources.

This report will present a background and summary of the findings of the team which will be followed by recommendations. After that will come detailed findings and the itinerary of the trip along with an identification of the persons contacted.

Conclusions

If agricultural development could be considered in isolation, our task would be much simpler. Unfortunately, it cannot be. Such general purpose capabilities as total water management, taxation and public finance, and technical manpower, which currently do not exist, will be essential for agricultural development, and they cannot be assumed away in designing an AID strategy or project. No source appears likely for help in these areas other than AID.

Currently, water seems to be the most serious primary or first-order limiting factor. Since money and people are important in solving water problems, they too become limiting factors even if by derivation. A logical development strategy must figure to economize on the scarcest resouce. Inefficient use of relatively abundant resources is not serious and may even be wise, as long as that resource is not being destroyed. To be specific, yield per cubic meter of water is a more important performance criterion than yield per acre of land (if the land is not being lost). However, the water management problem is far more inclusive. A water management capability will include such sophisticated elements as monitoring the re-charge of underground reservoirs and the establishment and enforcement of both rates of extraction and rights to water when it becomes necessary. It will also include such mundane elements as keeping pumps in operation, as well as such general elements as an efficient procurement mechanism for essential imported supplies and equipment, which currently are very costly.

There seems to be no way that agricultural development can be initiated in Djibouti without subsidy, and for a country with few financial resources, an uncertain tax mechanism, and lack of skills in public financial management, this issue has to be faced. (The budgeting of $600,000 for the development of a 15-hectare agricultural development site dramatizes the financial management problem.) In the short to intermediate run, it can be expected that there will be external budget support assistance, but there is no basis for expecting it to provide much investment capital over any long run. Since it seems clear that the government will have to play a major role in agricultural development, the questions of where financial resources are found and the efficiency with which they are used become critical.

Neither the water problem nor the financial problem can be addressed without both (1) a stock of well-trained people and (2) an institutional framework that allows the people to be productive.

There are many indications that, given all the above, Djibouti stands exposed to a situation in which donor activity can do more harm than good. The absence of a capability to plan, to understand what is feasible; i.e., complete dependence on foreigners, exacerbates the danger. The more harm than good could flow from three types of eventualities. One is that donors will provide goods that either are not worth their cost to the country or provide such a small return that a capital starved country cannot afford them. This could come from a desire of a donor country to export goods or from a beleaguered bureaucrat under pressure to move money or forced to operate beyond his area of competence. The impact on Djibouti would be the same.

The second problem, and Djibouti may be facing it, is that with only a few external resources conditions would be created that would result in new life styles dependent on the flow of external resources, and thus highly vulnerable to an interruption of that flow over which the country has little control. Djibouti is more vulnerable than most countries because its resources in their natural states will not sustain any more than the current level of activity, and perhaps not as much. Further, the resource combination is such that it is difficult to see how the growth process can sustain itself, once initiated, in some sort of autonomous fashion. Agricultural growth is going to be dependent on investment in wells that only the government can be expected to make.

The upshot is that any significant agricultural development must depend on a relatively sophisticated institutional structure to guide, nurture, and finance it. That structure will take some time to develop, and Djibouti will have to have assistance to accomplish it. Slopiness in design and implementation of development projects could result in serious consequences if the assistance or the process were interrupted. If an economy depends on wells, the pumps have to be kept working. They don't work naturally.

The third danger of harm exceeding good stems from the damage that could come to the fragile econogy from development activities. The team can only recognize the danger, not evaluate it. It is possible that the Djibouti ecology has stabilized at such a low productive state that further degradation is not likely.

RECOMMENDATIONS

Assumptions

Some clarification is necessary of the assumptions that are relevant to the recommendations.

1. We assume that for perhaps as long as a decade, the international community, mostly France, will provide budget support to the Djibouti government. We assume that this support will not provide for

developmental activities and that it will not be accompanied with significant technical assistance in efficient budgeting and administration.

2. We assume that other donors will provide some financial assistance that will be determined on the basis of a project analysis, not a global or institutional analysis. Judging from observations of donors in some other countries, we assume that at times there will be more money available that can be efficiently used in Djibouti and that there will be short run improvisations in project management to compensate for the lack of Djibouti institutional capability.

3. We assume that there will be projects and instances of interest in specific technical areas on the part of other donors.

4. We assume that no other donor will be specifically interested in the institutional and human resource development area on the comprehensive scale that our analysis indicates to us is needed.

5. We assume that the government will not be able to maintain adequate surveillance, let alone management, of the various donor activities. Donor activity will, in effect, be out of control, but donor competition for the attention of the scarce Djibouti manpower will be substantial.

6. We assume there will be a severe shortage of resources of all kinds over which the government has discretion.

7. We assume that the needs for economic efficiency may well be in conflict with cultural traditions, but economic development is a rigorous task master and it demands efficiency. Program design must reflect the conflict and seek a resolution.

8. We assume political stability but recognize the need to maintain some protection against instability.

Recommendations

1. That AID develop a program for Djibouti that emphasizes helping Djibouti know and understand its natural resource situation and helping develop the human and institutional resources. The program should be guided by the following criteria.

a. We must face the Djiboutians with the facts of the difficult development task that the country faces and guard carefully against masking over the problem, either intentionally or inadvertently.

b. The program should attempt to keep recurrent financial requirements as nearly as feasible in line with Djibouti's capacity to produce financial resources (by economic activity) and to mobilize them (by taxation or other anticipated means).

c. It should aim to conserve capital to the maximum extent feasible.

d. It should look to non-financial forms of capital both in use and formation. For example, if boulders can be removed from land by use of the otherwise unemployed labor of those who will benefit, scarce financial resources can be saved, and capital will be formed.

e. It should aim to achieve net cumulation of benefits as opposed to relying on future (or continuing) investments to make past investments productive.

f. It should seek efficiency in the use of all resources, either internal or external, not just the inputs provided by AID.

2. That AID assign one office to Djibouti. At this time it is difficult to justify more than one, either as a function of the indicated program or of the availability of AID officers. On the other hand, it is important that one be assigned. The Embassy is not staffed to handle an AID effort.

3. That immediate steps be taken to procure a new well drilling rig for Djibouti, according to criteria recommended by experts available to AID/W. It is essential that appropriate spare parts accompany the rig and that liberal training in operation, maintenance, and repair be provided before the rig begins to operate. The need is urgent and AID should seek the most expeditious means to provide the rig.

4. That the Djibouti program be implemented in the Title XII style, given Title XII emphasis on knowledge, technology, human resource development, and institutional development, which is precisely what is most needed. The arrangement needs to be made immediately because of the great need for technical expertise in program development, and the advantages that would be gained from early involvement of the university. The program should depend heavily on TDY help, with no more than one person being in residence. Either the Consortium for International Development or one of its member universities is indicated as the logical collaborator. A team consisting of one AID officer and one contract person with TDY access to the resources of a major university operating over a decade would stand a relatively good chance of making an impact in Djibouti. If the two-man team cost $200,000 to $225,000 a year, and one assumed a million dollar annual budget, ample funds would be left for TDY, training of Djibouti personnel, and even some modest commodity procurement. One could expect some technical input, not simply administrative services, from the two-man team in residence. The Embassy plans four rooms for AID in its new facilities. If two were used for this team and one for the secretary, a room would be available for TDY personnel.

5. Three resource inventory and evaluation tasks need immediate attention, dealing with water, soil, and environment. The Title XII collaborator should be involved in this effort. We offer these considerations.

Full advantage needs to be taken of the work of Pierre Pouchan, University of Bordeaux hydrologist. His data and analysis on the water situation may be adequate for immediate needs. It would be useful in planning the inventory. Dealing as he does in geology, his information may also be useful to the soils people. AID and/or the Title XII collaborator should procure his services on a consulting basis to help determine what we know and what needs to be done to develop further information.

In the soils area, a survey is needed, but the extent and nature is in question. The first task that we see needed is to evaluate the soils in the spots where there is currently some water available for irrigation. The second priority need is for surveys in those areas in which Djibouti is interested in drilling more wells, or in helping determine future well sites. Some study should be made of the Gobaad and Hanle Plains.

We recommend providing some soil testing laboratory equipment and supplies along with the survey, but do not know what is needed.

We have no recommendation for specific action in the environmental field -- only that our program not ignore it.

6. Given the urgent needs for efficient use of resources and the nature of the culture, we recommend that both economic and social expertise be made available by the university.

7. We recommend that every activity take all feasible steps to build Djibouti capacity. For example, the soil survey should supply some equipment and involve the native agronomist. Solving the water drilling rig problem should immediately address the need for a maintenance and repair capability, <u>plus</u> the need for an efficient procurement mechanism. Stated in another way, we recommend that human resource and institutional development constitute the central thrust of the AID program, but that in <u>every case</u> the activities should be oriented to real problems, strictly resisting any temptation to build institutions in the abstract.

8. We cannot be precise at this time on recommendations for initiating the agricultural development program. Currently, the French, with two line officers in high Ministry of Agriculture positions dominate this activity. We do recommend a strategic position; i.e., that activities be designed to achieve agricultural development in a gradual, steady fashion. The alternative is to attempt quantum jumps which would necessitate large capital investments in ditch construction, and wells, and with little experience, technology and knowledge on which to base decisions. The gradual steady course would involve taking advantage of "surplus" water at current wells or wells drilled to serve other needs, and natural springs over the next three to five years. During this time, technicians could be trained, farmers could be recruited and trained, essential experimentation both in agronomy and in farm development could be done, program experience on the part of the public officials could be gained, and we would have many insights as well as questions which we cannot foresee today. The capital costs would be relatively

modest, and the inevitable errors would be small in consequence. Finally, at any time it were justified, the alternative strategy could be adopted.

The alternative is to establish big projects. Prelimninary data indicate that good water and good soil can both be found in the Gobaad and Hanle Plains, and that is a temptation to move in immediately. With no farmers, no public servants experienced, no technical training or training facilities, and no indigenous technology, the large project seems too great a risk. In Djibouti, it will not take a very big project to be too large.

It is difficult for us to visualize the course of agricultural development when the process starts at zero, but if 100 acres were under crops on 20 going-concern farms in five year, it would probably be a notable achievement. That could be done at four or five sites, and experimental work could be handled at another four or five sites.

This presumes that the current site at Petit Bara would be developed at a rate to be determined by the success in bringing costs under control. It is not counted as a going-concern farm.

FINDINGS

Water

Water is the critical element in any of Djibouti's development alternatives. We did no detailed study of precipitation, but in consultation with Pierre Pouchan, hydrologist from the University of Bordeaux, we understand that average rainfall ranges from about ten inches a year down. Timing of the rainfall is so variable that it cannot be predicted. Shortly after completion of the field visit, five inches fell on the capitol and parts of the interior, creating near disaster conditions. There has been no experience with surface water impoundment. The evidence is mixed regarding the ability of the soil to contain surface impoundments. The earth's crust is leaky in many spots, but there is also evidence that clay settling out of runoff water will seal the soil.

Currently, aquifers about 100 meters deep are the important source of water and are likely to be for the next several years. Fortunately, considerable information on groundwater has been collected, all by Pouchan who has been studying the country's water situation for some 15 years and has determined the locaion of the wells drilled until now. This report depends completely on his studies in its discussion of water. He also provided geologic input for the soil analysis and general information on areas we did not see.

Our tentative conclusion is that the total supply of groundwater, replenished from rain, is adequate for a substantially higher level of economic activity, including agricultural development. The evidence follows.

Djibouti has an unusual geology. It is formed largely by volcanic action over long periods of time, and has undergone uplifting in some areas and collapse and settling in others. There has been significant geologic erosion and transfer of soil and its parent material in many areas. Two important characteristics have resulted. One is that there is a large area of soil along the coast north of Obock that is formed by an uplift of coral from the sea. Some of this is covered with volcanic outwash. The other characteristic is that some of the watersheds have no drainage to the sea. Some are below sea level. Water escapes by percolation and evaporation of this type is associated with salinization.

1. More information about the water supply is needed, particularly with respect to the annual yield capacity of the major aquifers and to water quality, especially in those reservoirs in which the danger of salt is recognized. The Pouchan data would yield considerable information, but he claims that adequate information will require more test borings. The team's judgment is that the water supply potential is adequate to support some agriculture and thus it justifies further attention. Water expertise is needed to help determine both study needs and exploitation needs.

2. Temperature of the well water ranges from 39 to 50^{o} Celsius (105 - 122 F.), and we do not know how to evaluate this phenomenon in either its direct effects or its implications.

3. Major limiting factors are represented by the lack of trained manpower and the lack of an institutional framework to deal with the water problem. One problem, for example, is the exceptionally high cost of equipment and supplies associated with water, all of which are imported, chiefly due to weakness in the importing institution.

Soils

Little is known about Djibouti soils. Some non-technical briefing material listed the soil as sand. In one of our interviews it was indicated that there had been so little weathering that the parent material has not been broken down to form a soil base adequate for agriculture. Our observations did not square with either of these bits of evidence.

Our judgment is that the soil base is adequate to support a significant agriculture. We base that judgment on the fact that volcanic soils are usually relatively fertile and that soils under arid conditions have not been extensively leached. In addition, the soil is of a color normally associated with relatively good soils, and the parent material is essentially basalt. Finally, our observations were that the parent material has been weathered and that there is a high clay content. In fact, in some areas a major problem may be associated with a high clay content.

While we saw snow-white surface in only one area, and that from the air, our hypothesis is that salinization has occurred on a major scale and is the explanation of the so-called "sterile clays." We inspected only one of these areas on the ground, that of the Grand Bara, but we saw much more from the air. The "sterile clay" areas are almost always found on the plains formed by alluvium which filled in the collapsed faults associated with the aquifers. Our hypothesis is that these sterile areas were formed in the low spots of the closed surface drainage systems, that the heavier material had settled out before the water reached these spots, that the clays settled out in the spots, that the clays sealed off the surface so that there was almost no percolation, and that the ensuing evaporation has allowed enough salt to accumulate to prevent plant growth but still not enough to produce the pure salt cover. Admittedly, this is layman reasoning, but it does seem to fit observations made from the surface. We did not see areas in which the entire plan was "sterile clay." Much of the surface is covered with basalt rocks and boulders, but these "sterile clay" areas were clean, as if the boulders had been covered by the sedimentation.

At any rate, a study by soils experts is needed, and our judgments are that there is enough good soil to justify such a study. We saw a wide variety of crops growing at several well sites, but given the size of the plots, and the lack of information on technology used, the evidence of the care and attention they had received, we could draw little conclusion from them.

We recognize these problems or possibilities of problems.

1. One is the lack of knowledge and understanding of the soils. We do have from Pouchan some fairly good geologic maps. While some soil survey is justified at present, the extent of the survey must be determined in consultation with experts.

2. Of special concern is the danger of salinization, as a function of both water and soil quality.

3. Djibouti has only the beginnings of an institutional structure to deal with this problem, but virtually all the expertise is embodied in one person with a B.S. in agriculture, and he has virtually no equipment and no library or literature facilities.

Climate

This is a harsh country. In addition to the ancient volcanic activity, the faults and sinking of huge areas of land, the country is still subject to earthquakes and floods that cannot be anticipated. On the other hand, the sun and the wind are constant. Data on evaporation was not available, but the sun shines on most days, and in the month of July the mean high temperature is above 100 degrees Farenheit in the capitol. It is claimed that the climate is humid, but we saw no data on this. The wind was mentioned often as a problem. In several of the areas, the growing of windbreaks was of as much interest as the growing of crops. The wind and sun may also constitute energy resources, but there has been no experience with them in Djibouti, and we were not able to evaluate them.

APPENDIX A-2

TRIP REPORT

February 21, 1978

NAME: Dean F. Peterson, Chief, SWM, DS/AGR

PURPOSE: To confer with USAID Mission, REDSO representatives, and Djibouti representatives in company with Professor Pouchan, Hydrogeologist, University of Bourdeaux regarding hydrological aspects of an AID Agricultural Development Project.

DISTRIBUTION: DS/AA, C. MCGRAW
DS/AG, L. Hesser, K. McDermott, Division Chiefs (circulate) SWM Staff (circulate)
AAO/Djibouti, Karl Mahler

INTRODUCTION

This report consists of two parts. Part I is a Summary. Part II goes into more technial details and is supplementary to the reference material and to Prof. Pouchan's report, Attachment 4. This part will be more meaningful if the reader has already read Reference 1 and Attachment 4.

Part II contains the following sections:

- Dug Wells
- Drilled Wells
- Water Quality
- Other Possibilities
- Drilling
- Land Tenure

PART I

NARRATIVE

The period January 31-February 6 was spent in Djibouti in company with Prof. Pierre Pouchan of the University of Bourdeaux, a hydrogeologist, who has some 15 years experience in Djibouti, Madison Broadnax of REDSO and Karl Mahler, AID/Djibouti, along with representatives, entirely French except for one Somali, of the Djibouti Republic's Agricultural Department.

Because of the political situtation between the Issas and Afars, our field visits did not extend into areas north of the Gulf of Tadjoura.

Principal sites visited were Petit Bara, (6), Grand Bara (5), and Henle (2), and Gobaad Plains (1) and in and around Djibouti town (Ambouli Basin) (7). These are decribed by Broadnax et al (Ref 1) p. 11-12 and by Pouchan, (Attach 1) p. 5-11. Numbers in parenthesis refer to the map and description in Ref. 1. Three other general areas are of interest but were not visited. These are Aibole-Magale Wadi, Tadjoura area (8). Saddai Wadi, Obock Area and Eoulma (10), and Weima Wadi, Bisidaurou Area (11). Based on water quality information and considering geology, Obock/Eoulma does not look very promising; and Ambouli is dedicated to water supply for Djibouti town. This reduces the number of interesting aquifers for drilled well development to six. Water has not yet been proved at Petit Bara, and supplies there and at Grand Bara cannot be very extensive. Thus the need for further groundwater studies for drilled well supplies seems to be focused pretty much in the above areas and there are existing exploratory wells which have been pump-tested in all except Petit Bara. Prof. Pouchan also has considerable geophysical information based on resistivity measurement. There is an Institute of Geology in Djibouti maintained by the University of Bourdeaux. Geological maps have been prepared on a scale of 1:200,000. These are being revised to a scale of 1:100,000 and descriptive portfolios are being prepared.

Small gardens irrigated from dug wells were also inspected in the Hanle and Gabood Plains areas and near Djibouti. These are limited in extent. Each well may have from 0.1-0.5 hectare. Some are reasonably well managed, but the potential for this type of development is thought to be low because of saline water underlying the shallow groundwaters accessible to dug wells. Nevertheless, these could serve for experimentation and training.

The Minister of Agriculture was visited twice. Once on our first day, once on our last.

Discussion and Conclusions

There are limited groundwater resources that could support some cropping in Djibouti. Salinity is a problem but appears manageable. It will be a limiting factor in the use of these resources.

There is evidence that there are some satisfactory soils contiguous to water supplies. The extent of soil and water resources is unknown and indeed depends upon the mode and technology used in developing them. Whether or not Djibouti people could become interested in cropped agriculture is also unknown as is whether or not the activity would be economical. It is doubtful if these questions can be answered except through trial in the field.

Modest training programs pointed toward farming, concurrent with limited new agricultural developments could begin to test the human interest, the economics and cropping patterns. Concurrently the exploration of the more important soil and water resources could proceed. There seems to be no overwhelming reason to make a complete assessment of resource potential immediately, but soil reconnaissance in the most promising areas of water supply potential should be checked out before a decision is made to proceed.

The implications of tribal land tenure customs and the Djibouti Goverment's policies in relation to them needs to be checked out also.

Besides irrigated agriculture, livestock, which is already established, is important, and there are possibilities for runoff farming and water harvesting that might be looked at. If the U. S. gets involved, the venture should be tested intermittently, with a commitment to withdraw if things do not work out.

One issue that should be settled early is whether or not there is water at Petit Bara. This means extending the present boring discontinued at depth 144 meters another 50 or 60 meters.

The government very much desires the U. S. to provide them with a well-drilling rig. This should be contingent on agreement to a rational program based on the known hydrogeology and most promising agricultural areas, and upon a plan for adequate training and management of a drilling program with the potential for evolving a general hydrographic and water development capacity.

All told, developing agriculture in Djibouti looks like a high risk, expensive and slow activity. It will not involve a large segment of the population nor have a major impact on the economy. On the other hand, it is probably the most attractive development opportunity there and even it will strain the capacity of the evolving Djibouti Government.

PART II - MORE DETAILED COMMENTS

Dug Wells and Gardens

All of the irrigated agriculture I saw, except within Djibouti town where gardens may receive some municipal water from drilled wells, was irrigated using dug wells. These were inspected at the following locations: Taeou and Cheikile Wadi in and tributary to the Hanle Plain, as Eyla in the Gabood Valley and Atar and Ambouli Wadis near and in Djibouti Town. Similar gardens exist at other sites where water tables are within 3 or 4 meters.

Wells are 3-4 meters in diameter and 4-6 meters deep. They appear to irrigate from 0.1 to 0.5 ha each and probably can produce only 25 to 50 cubic meters per day or less. (1 cubic meter per day will irrigate about 0.01 hectare.)

Usually the water is pumped using a centrifugal pump driven by a small internal combustion engine but human or animal-powered lifts like buckets on endless chains are also used.

I do not have informtion about how many such gardens there are, but the total in southern Djibouti is probably numbered in dozens rather than hundreds. So this agriculture is not extensive. It might be useful to make an inventory of the number of wells in the country using remote sensing imagery.

Crops include leafy vegetables, tomatoes, maize, sorghum, melon, dates, and mangos. Crop quality is variable from marginal to good.

Shallow groundwaters in the Hendle and Gobaad Plains overly saline water residual from Pliestocene/Holocene lakes. The upper surface, which is replenished by rainfall is relatively fresh; but the dug wells, were reported by Pouchan to become salty if they are pumped very heavily or if drought prevails. A similar hazard but under different circumstances exists in the gardens near Djibouti, which are located in the residual soils overlying the coral conglomerates along the coast. Here the conglomerates have not been leached so that increasing salinity is associated with overdrafts and droughts. Dug wells are located near wadis where the groundwater is fresher.

The Agricultural Department is giving its attention to gardens irrigated by dug wells, but it does not seem that there is a large potential for expanding this kind of agriculture though there may be some. Gardens irrigated by dug wells could be useful for training and adaptive experimentation, however, and this is anticiapted in the program proposed by the PID.

Other Possibilities

A fairly substantial stand of phreatophytic shrubs occurs in the Henle and Gobaad basins. These apparently tap the upper, fresher waters of the aquifers. It might be possible to replace some of these with more economic crops. For example, could alfalfa be maintained by the water table if it could be started using irrigation? This could be checked out on some of the gardens near Teaou or Es Eyla. This suggestion needs to be checked with a crops specialist. There may be more promising crops.

Forage crops might have a special appeal because of the nomadic livestock activities in the country. This is something the Project Paper team may wish to look into.

Other interesting potentials are runoff farming and water harvesting. Runoff farming has been successful in areas having as little as 100 mm annual rainfall. The rainwater from a larger catchment is concentrated on a cultivated field to produce a crop. Rainfall harvesting stores runoff water from catchment areas in tanks or reservoirs for stock watering or other purposes. The red soils and topography between Djibouti and Arta appear favorable for runoff farming. This might be competitive for runoff now replenishing Djibouti's aquifer, but limited activity would probably not be serious.

There likely are many potential sites for runoff farming and this seems like a possibility deserving experimentation. Rainfall harvesting should be considered for livestock supplies. This would be more economical than drilling wells in many parts of the country. (See "More Water for Arid Lands" National Academy of Sciences chapters 1 and 2 for detailed information on rainfall harvesting and runoff farming.)

Hydrogeology of Djibouti

By Professor Pierre Pouchan

February 6, 1978

CLIMATE

The climate is of arid type. In Djibouti, the average air temperature is 29.7 Deg. C. Rainfall is very irregular, and maximum continuous rainfall is not more than six days. Dry periods can exist of more than six consecutive months.

In Djibouti airport (Z = + 8m) average rainfall on 20 years is 151 mm and 210 mm in Arta (Z = + 700m).

In winter time, east winds are dominant and cold fronts descend along the Red Sea. Exceptionally, hurricanes and tropical depressions coming from Indian Ocean arrive in Tadjoura Gulf. Winter rains are generally located at the east of a line passing from Ali Sabieh to Assa-Gayla.

In the summer time, storms produce rain along western margins of the Republic.

METEOROLOGICAL RECORDS

Rainfall and temperature were recorded in Djibouti town since more than 50 years. Later in the airport, a meteorological station gives complete information since more than twenty years.

Second order stations were created in some other places in the country by National Meteorology Service. The Plan is given in Annex. Duration of records is variable, and there are gaps for some stations.

The meteorological net seems in fact good but the records are not always representative due to numerous effects of relief. Data is in Annex.

Evaporation is continuously recorded in Djibouti airport using Colorado tanks and other kinds of evaporometers. Average evaporation rate is in order of 0.8 cm/day.

Short-time evaporation measurements were made in some other places.

They show rates from 0.8 cm/day to 1.5 cm/day in lake Assal area (Z = 156 m) which is considered as the hotest point of the country. At this place, maximum day temperatures were measured up to 40o C.

Wind is common in the Republic. Continuous measurements are made at the airport station and at some localities as Ali Sabieh and Dikhil. Main winds are coming from E/S.E. in winter time and from N.W. in summer time. The last wind commonly called "Khamsing" in the country is continual. It is dry and hot with dust affecting the visibility.

Air humidity is also recorded in Djibouti station. In fact, it seems humidity is high in autumn especially in Djibouti and coastal areas. Inland, humidity decreased with altitude and distance of the sea.

GENERAL HYDROLOGY

There is no perennial stream in the Republic of Djibouti. All the rivers are "Wadi." Defining the importance of a Wadi as related to its drainage basin, we can infer there are six important wadis in the total area of the Republic. According to the tectonic scheme, some of them are flowing into or to closed basins (endoreic systems). The others run to the sea (open systems).

- Open systems:

  - Ambouli wadi - Djibouti area
  - Alboli-Magale wadi - Tadjoura area
  - Saddai wadi - Obock area
  - Weima wadi - Bisidirou area

- Endoreic systems:

  - Hanle (or Henleh) wadi - Dikhil area
  - Gobaad wadi - As Eyla area

Lakes

There are two main lakes. First one is Lake Assal. Lake water is a sodium chloride brine at -156m below the sea level. By evaporation, the brine genertes halite as a white flat bank, in the N. W. corner of the depression. The halite bank is sub-horizontal at some tenth centimeters above water. Halite bank is fed by overflowing brine of the lake, in a very irregular manner. Inside the lake, we can observe gypsum crystals banks.

The balance of the lake is supplied by inflowing underground sea water coming from Gubbet-Al-Kharab through faults and fractures which affect intensively this volcanic area. Surface of open lake is approximately 50 Km2, surface of halite is 60 Km2.

Second lake is Lake Abbe. Lake water is sodium carbonate and chloride brine at 234m above sea level. Lake Abbe is the evaporative terminus of Awash river coming from highlands of Ethiopia and Gobaad Wadi coming also from Ethiopian mountains. The last course of Gobaad Wadi occurs in Gobaad Plain.

PALEOHYDROLOGY

These two large lakes are in fact the relics of a large lake system, well-developed in all the closed basins of the southern front of the country, during the holocene time, with a paraxysmic phase at 8,000-9,000 years B.P. as shown by C.14 datations on molluscs shells. At this time, it is inferred a high Rainfall/Evaporation ratio and we can observe old lakes extensions in several depressions:

Old Lake Levels:	+ 400 m in Gobaad (Lake Abbe)
	+ 300 m in Hanle Plain
	+ 150 m in
	+ 150 m in Assal depression

Climatic inversion seems to begin about 4,000 years B.P. tending to lower the Rainfall/Evaporation ratio and to lower progressively lake levels with increasing salinity of the waters by evaporation. Present aspect correspond generally to playa systems in closed basins with corresponding paragenesis and salinity gradients in the soils. In a such way, salinity is increasing from the border to the lower point of the playa. This scheme is evident in Gobaad and Hanle Plains. In fact, this general rule is disturbed by leaching and spreading effect related to the wadi flows. It has some important consequences in Hydrogeology and Pedology.

RUN-OFF

The analysis of the drainage net shows that the whole system is not in equilibrium with present arid conditins but with the ancient (holocene) conditions. This adaptation to high ancient rainfall intensities is important in the study of run-ff hydrographs which show generally high peak discharge with short duration of flow, high solid transportation, and run-off coefficients for such a country.

Some available run-off measurements made in Ambouli basin tend to confirm this general view (see detailed hydrology)

DETAILED HYDROLOGY

Measurements in surface hydrology have been made only in Ambouli basin. Difficulties appeared in getting observers and/or automatic records for non-perennial streams measurements in other main basins.

SPECIFIC RECOMMENDATIONS

On Hydrology

Surface hydrology measurements are to be developed in places. Perhaps Hanle-Cheikoitti Wadi floods and Gobaad floods could be used at time.

1. Gauging places must be chosen on the stream courses and quicky equipped.

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2. Necessary equipment must be quite convenient for desert measurements.

It would be interesting to find a compromise between best theoretical place for measures and possibility in getting observers (villages or military posts). For Hanle Wadi, Gourabous would be such a place. A short survey on the Wadi bed can reveal an available cross section.

Equipment mut be simple: scale of heights on wadi wall. Velocity measurements are more difficult and the simplest way is to use floaters, like fluorescent painted bottles for night observations.

Training of observers is necessary in some office in Djibouti (C.E.G.D.)(Teal Institute)

3. Good places for Gobaad wadi measurements are not frequent. They will be found in the upper course up to Saballou. So it will be a problem for observers. We have to find a solutiuon.

4. Accurate hydroclimatic stations must be installed in:

- Mouloud Area
- Gobaad Area
- Gourabous Area

This is not a restrictive list.

Are to be measured:

- Evaporation by tanks
- Rainfall
- Temperature
- Wind and Humidity

Installations and measurements are to be in place as soon as possible.

Ground Water Hydrology

Ground water studies must be made especially in:

- Grand Bara
- Gobaad Plain
- Hanle Plain

Plans must be made in geophysical prospecting (resistivity) to complete existing data.

In second time, exploration wells must be drilled and pumping tests made with water analysis.

Scheme concerning aquifer boundaries, transmissivities, storage, water table contours, relations with surface water must be the final purpose in sub-surface ground water investigations.

If possible, deep exploration is to be tried by two or three drills in:

- Grand Bara Area
- Gobaad Area

Objective could be sedimentary reservoirs probably lying at depth.

On Drilling

Present rigs are quite insufficient for determining ground and P.E.B. will provide an available equipment in some areas, or recommended to the P.E.B. specialist some main characteristics:

- Rotary and hammerdrill capacitors

- Possibility drilling 0 12"1/4 until 400 m and 5" until 1,000 m.

- Education and training of a couple of young drillers, not only in drilling techniques but also in management and maintenance.

GENERAL RECOMMENDATINS

We keep in mind there is an immediate necessity to begin some agricultural experimentation. The alone possibility is to use at first ground water. In this way, first agricultural soils must be chosen taking account of water quality and not reverse. We are not in favor in autonom garden system with one well for each agriculturer. Water supply system must be collective and managed by authority.

- Surfaces must be adapted to discharge and climate and not reverse.

- During this experimental time, we can hope for a better progressive knowledge of surface flow and whole ground water.

At this time, development extension could be envisaged ... Inch'Allah

- Good places of first experimentation are in our advice

- Atar zone: some hectares irrigated by appropriated bore-holes. This clear for education and/or demonstration. Intensive development is supply.

- Grand Bara margins: some wells sixty to eighty meters deep.

- Hanle basin: specially between Lilly Ya Bourri and Cheikeitti.

- Gobaad: using ground water from Sabbalou zone.
- Petit Bara has to proof ground water possibilities.

Djibouti, February 6, 1978

Pierre Pouchan

APPENDIX A-3

Report on the Visit to Djibouti

Raymond H. Tremblay, Agricultural Economist

March 3, 1978

II. Conclusions

There are several alternatives for USAID projects in Djibouti. One should consider the greatest economic benefit for the least cost. Three alternatives which can be considered are:

1. Have no project and do nothing
2. Support a laboratory for a water and soil survey
3. Develop a full-scale agricultural project. This would include demonstration farms, an agricultural perimeter, agricultural extension agtents, marketing, credit, and needed support for a viable agriculture.

The first alternative is rejected as there appears to be potential for agricultural development. There exists a number of small gardens in various parts of the country. Currently three percent (3%) of the food requirements is being produced within the country. The major crops grown include tomatoes, melons, canteloupes, egg plants, and a variety of other vegetables. Food prices are extremely high. There is a tremendous amount of unemployment and underemployment. There is no industry other than a few service-oriented businesses. Practically no grain is grown so nearly the entire amount consumed is imported. The livestock industry is carried on by nomads. The estimated 600,000 goats and sheep provide milk for the nomads and a little meat. Other livestock include approximately 20,000 camels and nearly as many cattle of the zebu breed. However, imports of live animals are at least three times the number of domestically grown ones. In addition, there is a large amount of imported prepared meats.

It is obvious that this country of 250,000 inhabitants needs help. This is an undeveloped country and just giving them food and money is not the recommended way to help them get started. It was estimated by the "Caisse Centrale de Cooperation Economique" that one half of the GDP is earned by the 10,000 Europeans and the other half by the people of the country. On a per capita basis, this would be less than 100 for most of the people. Obviously, they do not have the resources, with few exceptions, to get started in farming and credit to them is not available.

Alternative three is premature. Before agriculture is developed to any great extent, water must be available. The soil quality mut also be known. Very little is known of the chemical qualities of the soil, drainage, fertility and if it can be used profitably for agriculture. It would appear that in most areas the soil quality could be improved for agricultural purposes if the water available was of reasonably satisfactory chemical quality. There is one salt deposit. Salinity has been reported in some shallow wells. The salt content, if any, in the soil of various areas is now known.

In other words, it would appear that the third alternative might be premature. The most promising areas of water supply must be determined and the general capacity of soil resources for agriculture and their geographic location must be determined. Much of the little agriculture currently found is government-owned and maintained. The terrain is hilly with some mountains and much faulting especially in the northwest. There is a substantial number of refugees from the Ogaden war. The number at present is approximately 25,000 and increasing gradually. A few of these refugees do have an agricultural tradition even though it is in a more humid region. The continuing war in Ethiopia has disrupted rail service and food deliveries into Djibouti.

Alternative two is high endorsed. Its cost-effectiveness is very high. It is the logical step to follow in development. Instead of going full flight into agricultural development in an area where little knowledge exists, the needed knowledge will be obtained. Personnel of the country will be trained to take over and carry on. In alternative two the existing laboratory, which is in the process of further being developed, will be supported. This is imperative as conjunctive soil and water surveys are badly needed. A systematic organization and some sort of central availability of data are high priority requirements. A little information already exists but is found in various places such as in France and different ministries in Djibouti. There is a need for Djibouti to properly assess its water and soil resources. The country must know its water resources to develop it urban and possible industrial potential. Its national policy gives the cities the first priority for the use of water. Currently the port, when servicing ships, sells them water at four times the rate paid by the people of Djibouti. There is certainly a need for water for development of any kind. Some water records have been carefully collected, but there has been no central reporting and no central authority.

Little equipment is currently being used and additional equipment is urgently needed for soil and water analysis. Sending soil samples half-way around the world to Hawaii for analysis is costly and not the best use of funds. But of even greater concern is the amount of time lost. Thus, soil and water analyses ought to be done in Djibouti as a basis for further development.

Training of local personnel is an excellent and highly recommended use of funds. The USAID staff should train the local personnel while doing the soil and water inventory and analysis.

In short, alternative two should be done before alternative three. Full flight agriculture, although needed, must wait until knowledge has been gained. There are many other components such as teaching people how to farm, providing them with tools and equipment, know-how, etc., but these will come in a later phase.

As for research, and teaching, the return will be a "hundredfold." Any development can then be in line with the water and soil resources of the country. It certainly is the least expensive alternative with the greatest potential for economic benefit.

This alternative can be accomplished in the short-term (18-24 months) and would reinforce other agricultural programs.

II. <u>The Agricultural Situation - Problems</u>

1. Statistical information - very poor with great range in estimates from various sources.

2. Food imports account for 97% of consumption.

3. Little agricultural tradition as the rural people are nomads. About 100 hectares have been or are in agriculture.

4. Little if any range management. Even though sheep and goats eat very close to the ground, soil erosion does not appear to be a problem.

5. Practically no fertilizer ued -- some manure especially by the Yemeni farmers.

6. Inadequate transportation will hinder agricultural development especially in the north.

7. High temperatures especially in the summer limits variety of crops that can be grown.

8. Credit -- a lack of institutions to provide low-cost credit for farmers.

9. Shortage of readily available water and of future sources as well as the high cost of obtaining it.

10. Little knowledge of the soil resources.

11. Land tenure changes could cause problems in the long run. Appears unclear at present.

III. Possible Approaches to Improve the Agricultural Sector in the Future

1. Development of skilled farmers.

2. Training of a local staff of agricultural advisors.

3. Establishment of an agricultural credit agency.

4. Establishment of agricultural cooperatives.

5. Better utilization of present water supplies and garden plots.

6. Better utilization of available manpower.

7. Rehabilitation of former garden plots within existing perimeters.

8. Creation of new perimeters, where water exists, for example at Garrasou.

9. Introduction of improved varieties of crops currently grown and the introduction of new crops.

10. As population increases, an attempt should be made to at least maintain the present proportion of food production which is three percent (3%) of consumption.

11. Decrease unemployment.

12. Bring in experienced personnel and develop agriculture in an area of at least 100 hectares inclusing the marketing of the agricultural products in Djibouti.

IV. Suggested Approaches for the Future

1. Send some promising young students to agricultural schools in the southwestern part of the U. S.

2. Establish an AID agricultural advisor to work as a "country agricultural agent" with the farmers of Djibouti.

3. Conduct "short-course" training programs to develop a local staff of agricultural advisors. A first priority should be the training of local people to take over.

4. Help the Djibouti Government establish an agricultural bank to provide low-cost loans to farmers.

5. Make available to farmers, on a trial basis, some improved seed varieties from the U.S. and also

fertilizer, spray materials, and new crops not now being grown but which could be grown.

6. Help the Djibouti Government establish a farmers' cooperative to get supplies and market produce on an orderly basis.

7. Provide an agricultural engineer to help the farmers design better and more efficient irrigation systems and teach them the recommended care and repair of engines, pumps, and equipment.

8. Support a laboratory for a water and soil survey.

9. Develop a full-scale agricultural project of sufficient size to make an impact.

V. Observations

1. Agricultural production at current prices is profitable. Even with the reopening of the railroad, efficient producers should be able to compete with the imports from Ethiopia, Somalia and Kenya.

2. One reason for agriculture in mountain valleys is that cooler climate allows a greater range of crops especially during the summer when prices are high. Consideration should be given to developing gardens in the northern half of the country.

3. Soil base, in many areas, appears to sustain a reasonable level of agricultural activity. Without water and improved human resources it is likely being used at its optimum level now.

4. Towns have first priority for water in the long run but sufficient water exists for limited agricultural development.

5. Land is owned by the tribe. There is no problem if land is rented. Tribal custom permits the continuous holding of land by individuals but does not permit its tranfer outside of the tribe or family. Also there are customary rights to access by nomadic herdsmen. Government also claims ownership.

6. There is a need for well-trained people for agricultural development, as traditionally a man's livestock is his heritage and food supply.

7. Wells are 3 to 4 meters in diameter, and 4 to 6 meters deep. They appear to irrigate from 0.1 to 0.5 hectares each and probably can produce only 25 to 50 cubic meters of water per day.

8. A constraint to greatly increased agricultural production in coastal areas might be increased salinity.

9. Without additional water and soil information, one cannot identify the areas with the greatest agricultural potential. However, the most promising areas appear to include the Hanle Plain, the Gobaad Plain, and Mouloud.

10. The two wells at Mouloud at present have sufficient water for the needs of Ali Sabieh and to irrigate 300 hectares. Several thousand acres in the plain around Mouloud appear suitable for agricultural development. The existing garden would indicate so. Additional wells in the area are a possibility. Hydrologists need to make an evaluation. Pedologists should check the soil.

VI. The Country

The Republic of Djibouti is about the size of Vermont and has no permanent rivers. Rainfall is low with the most in the highlands and the least on the coast. One report states that the average is only about 128mm per year with lows of 58mm and highs of 171mm. There are two lakes. Lake Assal, which consists of sodium chloride brine at 156m below sea level and neighboring to a salt flat. Lake Abbe is sodium carbonate and chloride brine at 234m above sea level. It is the evaporative terminus of the Awash river and Gobaad Wadi, both from Ethiopia.

A few hundred hectares have been cultivated at times. Djibouti has very little agricultural tradition and much of that resulted from the activities of expatriate Yemeni farmers. Agriculture consists of scatter gardens and some date plantations. These are usually at shallow wells or at the few springs. In the winter, it is estimated that between 50 and 60 hectares are in cultivation but in summer less than 5 percent (5%) of this small area is cultivated. For the most part, these gardens are government operated by salaried employees. The cultivated perimeters are primarily in the Djibouti town region and at As Eyla. There has been a small steady increase in agricultural output. However, the production proportion has remained constant over the past dozen years at about three percent (3%). During the winter tomatoes are the leading crop with production of 75 tons. Turnips follow with 60 tons and egg plants with 50 tons. Date production is 15 tons. Summer production is mostly melons and cateloupes of which 55 tons are produced.* (*Source: Bulletin Statistique.)

For years most agricultural imports were from Ethiopia by way of railroad. When the Ogaden war stopped the railroad operation, food prices greatly increased.

Food imports in 1975 consisted of approximately 12,000 tons of fruit and vegetables, 4,000 tons of rice, 1,500 tons of sorghum, and 136 tons of miscellaneous cereals. In addition in recent years between 7,000 and 8,000 tons of flour has been imported annually.

The FED reports that of the 280,000 inhabitants in the Republic, between 150,000 and 180,000 live in Djibouti town and the rest in the country. With the exception of the people in the small administrative centres of Dikhil, Ali Sabieh, Goboki, Tadjoura, and Obock, these 100,000 people are nomads traveling not only within the country but also in neighboring countries as it is a tribal right. Among the nomads there is no harvesting and storage of forage. They essentially live from the milk production of their animals. There is no distinct rainy season. However, they tend to receive the most precipitation from June to September. The vegetation on the pastureland is represented by the foliage and bunches of small thorny shrubs to which are added, following the rains, small grass-like plants.

The herds move from one grazing area to another according to the rainfall and seasons regardless of borders.

The rural sector certainly lives at the subsistence level being without doubt among the "poorest of the poor." Those in the urban sector are, for the most part, either unemployed or underemployed being sustained and supported by a strong extended family system.

VII. Livestock

Livestock numbers vary as they move in and out of the country and also through the country. Estimates as to numbers vary considerably.

	Estimate by Mr. Gasc	Ag. Minist.* 1977 Report	FED 1977 French Estimate	FAO in 1974-75 Annual Report
Goats	300,000	150,000	350,000	95,000
Sheep	275,000	50,000	250,000	561,000
Camels	25,000	8,000	20,000	23,000
Cattle	10,000	10,000	------	18,000
Donkeys	------	------	50,000	3,000

The estimated milk production is:

120 liters per cow
60 liters per goat
30 liters per sheep
180 liters per camel

*Service de L'Elevage et des Peches (1977)

During 1976 the slaughter houses reported the following figures:

Cattle	7,289
Goats	76,966
Sheep	93,719
Camels	133

During the first six months of 1977 the following number of animals were dressed:

Cattle	3,354
Goats	43,889
Sheep	26,695

Of cattle imported, 80% are from Ethiopia, and 20% are from Somalia.

<u>1976 Number of Livestock Reported at Slaughter Houses</u>

Cattle	7,289
Goats	76,966
Sheep	93,719
Camels	133

From 1955

<u>Domestic Production in 1976</u>

		TONS		
	Number	Carcass	Offal*	Total
Cattle	1,200	132	35	167
Sheep	15,000	210	31	241
Goats	45,000	540	81	621
Camels	720	115	17	132
			TOTAL	1,161

*Offal: Heart, liver, tongue, and organ meat.

<u>Imports of Live Animals in 1976</u>

	TONS (dressed)		
	Carcass	Offal	Total
Cattle	789	197	986
Sheep	1,174	176	1,350
Goats	667	100	767
		TOTAL	3,103

Source: F.E.D. Diagnostique Economique et Perspectives de Developpement a moyen et plus long terme.

Total Meat Consumption

	Tons
Domestic Production	1,161
Live Imports	3,103
Imports/Prepared Meats	386
TOTAL	4,650

Meat consumption per capita for all = 22.1 Kg
Meat consumption per capita excluding Europeans = 21.3 Kg

Domestic Milk Production in 1976

Cows	400
Goats	5,100
Sheep	870
Camels	750
TOTAL	7,120
Imports	1,880
Total Consumed	9,000 tons

Consumption per capita 42,8 liters, or 120g per day per capita.
Imported canned milk = 380 tons

Average Retail Meat Prices in 1977 per kilo

Beef	500 FD
Goat and Sheep	700 FD
Camel	500 FD

Visit at abattoir (slaughter house) in Djibouti on 7/30/78. The manager reported the following statistics:

Slaughtered Per Day at Present

Sheep	300 per day
Goats	200 per day
Camels	2 per week
Cattle	15 per day

The fee to kill a goat or sheep is 100 F each. The abattoir was built in 1950 and is too small. It runs a deficit financially. None of the three cold rooms are operating due to breakdown of refrigerators. It is opened 365 days per year, but by 10 AM all activity for the day is over. It was built for a 1,000 ton capacity but is currently operating at 4,500 tons per year. The hides are exported to Italy. This is one of the few exports or re-exports from the country. The abattoir should be replaced by a new modern, larger facility outside the city. The present location is not satisfactory. Sanitation is extremely poor.

VII. Cropping

Labor requirements for the growing of vegetables during winter are as follows:

	Hrs. per hectare
Tomatoes	1,900
Onions	1,300
Carrots	900
Potatoes	650
Pimentos, peppers, and egg plants ..	1,260

This gives an average of 1,300 hours of man labor of 160 days of eight hours. Labor requirements for vegetables grown during summer (melons and cateloupes) are 700 hours per hectare or 90 days of work.

For grains and forage labor requirements are:

Corn and sorghum cut green for livestock takes 650 hours per hectare of man labor or 70 days. Sorghum grains require 4.5 days of labor for hand harvesting.

FED has estimated that sufficient water probably is available for the production of:

20,000 to 30,000 tons of winter vegetables
2,500 tons of grain, and 6,400,000 forage units or 15,000 tons of summer vegetables instead of forage crops.

The above estimates are provided that 2,000 hectares of good soil is available with sufficient water and 2,000 workers under skilled management.

Potential crop yields are as follows:

Winter Crops	Tons per hectare
Tomatoes	35
Pimentos, peppers, egg plants	15
Onion	20
Carrots	17
Potatoes	20

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Summer Crops	Tons per hectare
Canteloupes	22
Melons	12
Grain and Forage	
Sorghum grain	2.5
Sorghum or corn forage	6,400 forage units

According to M. Gasc, one hectare of irrigated land in the Djibouti town area produces:

12,000 Kg of tomatoes in 5 months @ 100 F =	1,200,000
2,000 Kg of sorghum in 3 months @ 50 F =	100,000
30,000 Kg of canteloupes in summer @ 30 F =	900,000
Returns	2,200,000 FD
Cost of Water	128,275 FD
Seeds and Misc.	71,725 FD
NET	2,000,000 FD

or 11,838 per hectare for labor at present prices.

Electricity costs about 10 cents per kilowatt in town. That is, 1Kw of electricity costs 20 DF for large users and 25 DF for small users. The actual cost of production is 18 DF. Seven for fuel and 11 for all other costs plus 2-7 DF.

One liter of diesel fuel costs 40-45 DF. Other costs include the cost of water which is about four times higher than in the U.S. In U.S. one uses about 36" to grow one crop and in Djibouti one uses 39" to grow three crops. The cost of 3Hp pumps is 130,000 DF with an output of 30-35 cubic meters per hours. The output of water per well limits the size of the garden. In the Djibouti area, if pumped too much, the water becomes salty. Seeds per kilo cost 4,000 DF, and per hectare costs are 25,000 DF.

IX. Imports

Imports 1972

Animals on the hoof	649 tons
Fruit and vegetables	9,409 tons
Frozen meat and fish	538 tons
Dairy products and eggs	2,445 tons
Flour and derivative products	5,522 tons
Rice	3,359 tons
Sorghum	3,104 tons
Sugar	3,534 tons
Salt	227 tons
Non-alcoholic beverages	3,188 tons
Wine	2,755 tons
Beer	1,027 tons
Whiskey	736 tons
Khat	1,293 tons

Retail Prices at the Local Market on 7/28/78

Meat (goat)	600 F/Kilo
Fish	300
Potatoes (Ethiopia)	200
Onions	200
Oranges (Somalia)	300
Tomatoes (Somalia)	400
Canteloupes (Djibouti)	150
Bananas (Somalia)	300
Carrots	350
Mangoes	300

Prices at the nearby supermarket (Prisunic) were about twice as high. For example, most fruit was 750 F per kilo (oranges, bananas, etc.)

Imports 1976 and other data

Rice, sorghums	9,552 tons
Flour and derivatives	7,050 tons
Meat	1,059 tons
Dairy Products	4,334 tons
Alcoholic beverages	4,031 tons
Canned goods	1,719 tons
Sugar and salt	6,521 tons

Note: Salt is imported from Yemen for the most part.

Re-Exports 1976

Rice and sorghums	774 tons
Flour and derivatives	1,000 tons
Meat	20 tons
Dairy Products	20 tons
Alcoholic beverages	2,82 tons
Canned goods	17 tons

Source: Bulletin Statistique.
Note: Apparently there has been a substantial increase in reported imports from 1972 to 1976.

Employment 1976

	Number	Percent
Production Sector (Agriculture, fisheries, industry, etc.)	991	5.5
Energy, construction, armed forces	2,991	16.8
Transportation and distribution	5,576	31.3
Commerce and services (private administration)	3,853	21.6
Public Administration	4,421	24.8
(from page 284)	17,832	100

Djibouti water consumption is 20,200-21,000 cubic meters/day

Cubic meters per month	cost per cubic meter
Less than 60	45 DF
60 - 120	60 DF
More than 120	70 DF

Note: 70DF is equivalent to 40 cents per cubic meter.

The use of windmills for pumping at shallow wells seems to be an alternative as the country has almost constant winds. However, there is no one trained to maintain and repair them. Both windmills in the country have broken down.

Wages now (during 1979) paid to workers at the gardens range from 15,000 to 20,000 DF (average $100 per month).

Budget per hectare for a 100 hectare project:

<u>Costs</u>

Water cost per hectare		1,000
Labor cost (domestic)		625
Seeds and all other		375
	TOTAL	2,000

<u>Returns</u>

Tomatoes 30 T @ 500		15,000
Sorghum 2 T @ 200		400
Canteloupes and melons 20T @ 100		2,000
	TOTAL	17,400
Marketing Expenses		400
Returns above costs per hectare		15,000

At present the number of employed wage earners is only a small fraction of the total available. Unemployment is estimated at 80-90 percent. Practically none of the refugees are working. Wages are low. Food prices are high. Even the most conservative budget shows a large profit.

Irrigated agriculture can compete with food imports. The Government claims control fo the land. So with available land, sufficient water, good soil, ample labor, a market for total output, one can conclude that farming will be profitable. USAID ought to help Djibouti evaluate its resources (water, soil) so as to then be able to develop its human resources.

<u>Sources of Many of the Statistics</u>

Diagnostic Economique et Perspectives de Developpement a moyen et plus long terme.

Etude preparatoire a la planification commission des communautes Europeennes F.E.D.

APPENDIX A-4

POTENTIAL AGRICULTURAL STUDIES IN DJIBOUTI

By

Frederick E. Beckett, P.E.Ph.D.

13 August 1978

I. Recommendations for Djiboutian Agriculture

Existing farms prove that agriculture is possible in Djibouti. Optimistic assessments of potential based on not enough information predict that the country might someday be self-sufficient in food. The true potential cannot be determined until the extent of soil and water resources is known. Based on our study, I make the following recommendations:

1. Develop personnel and a laboratory with the ability to inventory soil and water resources in the country.

2. Begin the inventory by studying soils and water in and around areas being cultivated now.

3. As soon as salt, drainage, soil texture and plant nutrient conditions are known, assist the monitours in the Ministry of Agriculture to work out optimum cropping and soil treatment sequences for each garden area and give this information to present farmers.

4. Plan for and encourage expansion of agriculture around the present gardens based on the inventory.

5. Develop a catchment basin cropping experiment in two locations. Perhaps Arta and Day.

6. Locate, translate and publish information on agricultural resources and farming procedures for Djibouti. This could become a handbook for Djiboutian agriculture.

7. Develop plans for exploiting all of Djiboutian agricultural resources.

II. Summary

A profitable agriculture appears to be physically and economically possible in Djibouti. Nine areas were examined through visitation, study of written information or both. It appears that from 100,000 to 200,000 hectares of land are reasonably level, have native vegetation growing and have some hope for at least a small amount of groundwater for irrigation.

Water will be the limiting factor in all locations. Even rough estimates of water are more difficult but a "wild" guess is that there might be enough groundwater to irrigate between 200 and 10,000 hectares.

There appears to be some potential for conserving water with dams and groundwater recharge through spreading water from the Wadis during runoff.

Catchment basin agriculture may be possible and if it is the potential could be in the range of 20,000 to 50,000 hectares of cultivated area.

The best chance for success appears to be during the winter season and then there will be chances for crop failure because of drought. I concur in the recommendation to inventory soil and water as a beginning point.

I recommend that this inventory begin at current garden locations and that this information be immediately made available to present farmers.

The most feasible method of pumping water appears to be with diesel engine prime movers. If the cost of windmills could be reduced they could be used in the same area. Information about Djiboutian agriculture is found in different places and is written mostly in French. I recommend that this information be assembled, edited and translated into English. This information should be made widely available through some kind of publication, it might be eventually assembled into a handbook of Djiboutian agriculture. It would contain information about what crops might be grown as well as how to grow them in addition to information on soil, water and human resources.

III. <u>Procedure and Sequence for Developing Farms in Djibouti</u>

A. Alternative I - use conventional extension to:

1. Improve present farms
2. Expand present farms
3. Develop new farms near present farms using present pattern
4. Develop irrigation projects based on drilled wells
5. Develop project at Mouloud
6. Develop project near Loyada
7. At all other points possible.

B. Alternative II - a contract organization:

1. Hire an organization, group, or person who is experienced in desert agriculture to develop designated areas. Pay would be based on agricultural production and knowledge native farmers gain.

C. Alternative III - a land and water concession:

1. Give an experienced outside organization a land and water concession for 20 years with the proviso that this organization would develop agriculture in specified areas and then gradually sell their development to their laborers - farmers over a finite period -- say 15 to 25 years.

D. Catchment Basin Agriculture:

1. Study and experimentation determine the feasibility of catchment basin agriculture.

2. Expand this type of agriculture to its limits.

On the previous page three alternatives are listed for the development of farms in Djibouti. I recommend the first one, although the second or third might produce faster results, the first one probably fits more easily into the thinking of most agricultural workers who came from the U.S. and also the officials in Djibouti. This alternative can be accomplished in steps.

1. The first step would be to provide technical information to the people who are now farming. They need to know:

   a. How to manage their water and soil to reduce salt problems and maximize profit.

   b. What crops or varieties to plant for the best yield.

   c. The fertilizer, insect and disease control procedures to follow for the most profitable agriculture.

   d. Harvesting and handling procedures which will result in a quality product being delivered to market.

In addition to information, a government subsidized and operated market cooperative which guaranteed a market and minimum price would be very desirable. As the farmers gain experience they could take over the operation of the cooperative. Hopefully, the subsidy and price supports provided initially by the government could be removed as the farmers became more skilled in agricultural production and marketing procedure.

All of the above objectives cannot be attained within the budget of $500,000 envisioned for a Djibouti project. Therefore, I recommend the following steps:

a) Have the soil and water laboratory analyze the soil and water of the present gardens.

b) Based on the salt content of the water and soil, needs of the plant, and the abilities of the farmer, develop a program of crops, irrigation frequency and amount, planting procedures, leaching and drainage which would allow the farmer to make the most money.

This activity program would be developed and carried to the farmers by the soil and water team along with the agricultural extension (moniteur system in the Ministry of Agrioculture). TDY personnel could help here.

c) Because there is a garden at Mouloud now, it will be included in steps one and two. At the same time this is being done the soil in the uncultivated part of the fenced area at Mouloud should be analyzed in preparation for the development of an irrigation project there.

Perhaps another donor might finance a farming project here. Although M. Gasc suggeted tht the Ministry of Agriculture felt that a new well and new diesel electric power unit should be provided to irrigate the four hectares now under fence at Mouloud, it appears to me that the present wells can easily provide the water and still meet the water needs of Ali Sabieh. Repair of the two electric generators which are out of order would provide needed back-up power in case the generator now in use should fail.

At the time soil and water quality are being studied at all of the garden locations, the water producing capacity of the aquifers being used should be determined with as much precision as possible. For example, the well at Mouloud has been pumped for 5 years. Measurement of present static water level along with a pumping test could give some information about how much water the aquifer can produce over the long term.

2. Based on the soil and water tests of land adjacent to present farms, the Ministry of Agriculture should suggest that those farmers who have unused labor resources expand their farms. Water will be critical. More water can be obtained in many locations by using present power units to pump from more than one well. Family labor may be used to dig additional wells and these keep cost down. The small diesel pumps now being used could be used for pumping because, except at As Sela the productivity of the well is the limiting factor rather than the pump.

Fencing might be stone or thorn bush. See the write-up on fencing. The water distribution system could be the stone flumes which are used at most gardens now, or plastic pipe whichever is cheaper. The stone flume requires the purchase of cement for making mortar whereas pipe distribution requires the purchase of plastic pipe.

3. Develop new farms near present farms

This part of the effort would be a follow-on project beginning after the first or second year of the efforts listed in parts a) and b).

Elsewhere in the report there is a table with the cost for pumping water, with diesel fuel, and another with the costs for pumping water with windmills. These costs should be checked, but they indicate that for a dug well with a yield of 8.66 m3/hr will produce water to irrigate one hectare year-round at a cost of FD 174,000 (approximatley $1,000). A diesel engine pump on the same well will produce the same water at a cost of FD 148,000 (approximately $846).

Well and pump cost were taken from Ministry of Agriculture data. Windmill costs were derived from 1976 published costs by adding inflation and transportation. All cost data should be checked again. The well costs seem high to me. A well, 2 meters in diameter and 10 meters deep required removal of 32 m3 of dirt, building tanks to hold 10-15 m3 of water and lining part of the well with stone. The cost figure given by the Ministry of Agriculture is FD 1,583,000 or $9,046.00.

For drilled wells of various depths and yields the cost per hectare per year for water ranges from $298.00 to $1,538.00.

These numbers indicate that dug wells are probably the most economical source of water if the yield is good. To reduce cost of dug well watr when yield is poor, 4 wells may be connected to a single pump. Providing information will be the extent of USAID activity on expansion activity during the initial project.

If information developed during the initial period is favorable, then a follow-on project could be developed to provide credit and technical expertise to encourage expansion.

4. Develop Irrigation Project Based on Drilled Wells

Wells drilled into deeper aquifers are likely to provide a more reliable water supply than shallow dug wells. These aquifers are resources which can be developed in addition to the shallow aquifers.

The wells at Mouloud are in place along with a fenced area, it should be easy to develop this area. If water can be dedicated to agriculture near Djibouti, transportation difficulties would be much less.

5. During the initial 6 to 18 months of the project, develop a follow-on plan for more complete development of Djiboutian agricultural resources.

6. Catchment Basin Agriculture

There is not nearly enough water in Djibouti to irrigate all the land having suitable terrain and soil. No doubt most of this land will continue to be used for grazing but there may be the potential for a considerable increase in agriculture through catchment basin agriculture.

The U.S. national academy of sciences has published a book "More Water for Arid Lands," which describes the procedure. Peterson, in his report suggested that this procedure might be applicable to Djibouti. I agree with this suggestion. In catchment basin agriculture, land is separated into plots by levees. On the downhill side of each plot a basin is dug. The water from the remainder of the plot runs off and collects in the basin and in effect multiplies the rainfall for that area. An ideal soil would be deep and have a large field capacity (water holding ability). Crops to be grown will depend on the amount and distribution of rainfall. If rainfall is well-distributed through the year, tree crops such as mangoes and dates may be grown. If it is concentrated in a short time period, crops such as tomatoes or dura must be grown. Some Djibouti rainfall data is attached to this paper.

IV. Potential Areas and Procedures for Agricultural Development

A. Petit Bara

The central part of the Petit Bara is a level plain and has topography which is ideal for agricultural operations. There are some stones on the land but the removal problem will not be great. Judging from the topographic map I estimate that between 5,000 and 10,000 hectares of land is ideally suited for cultivation and that an additional 4,000 to 8,000 hectares of land is available on the fringes which is steeper and more rocky but could be cultivated. There is vegetation on all of this plain which indicates that some kind of agriculture is possible as far as soil is concerned.

Furthermore, this plan is on a paved road leading to Djibouti approximately 60-70 kilometers away. Before any large agricultural development is started soil test should be made in order to determine salt and plant nutrient content.

The elevation of the Petit Bara is 575 m.a.s.l. and thus should have somewhat cooler temperatures than those recorded in the city of Djibouti. If water were available this plain would have great agricultural potential.

The dry holes found in the search for water are discouraging but the search should be continued under the direction of an expert. I would place this area third in priority for development.

If irrigated agriculture is not possible for any part of the plain, catchment basin agriculture might be possible. In fact, if exploration for groundwater is to be delayed for a few years, I would suggest that the 15 hectare plot which has been cleared of stones be used as an area for catchment basin experiment. If the whole plain were used as a catchment basin area and if the cultivated area runoff area were 1-8, the cropping area would be 1,7000 hectares. If yields were 10 tons of tomatoes per hectare, the food tonnage available to the Djibouti market would be 17,000 tons. Of course, other fruits and vegetables might be grown.

The limiting factor for developing irrigated agriculture on the Petit Bara is water. If satisfactory groundwater supplies can be located and developed, the Petit Bara can make large contributions to the agriculture of Djibouti. If irrigation agriculture is not possible, then the contributions made by catchment basin agriculture will not be inconsequential.

Development Procedure - Irrigated Agriculture

1. Find and evaluate quantity and quality of water.

2. Test the soil.

3. Plan the system and determine costs.

4. Determine the land tenure system and procedure for governing the project.

5. Determine training procedures.

6. Recruit farmers.

7. Install the project.

Development Procedure for Catchment Basin Agriculture

1. Run a 2-3 year experiment that begins with .1 hectare of cropped land the first year and increases to 1 hectare in third year.

2. As soon as possible set up a small weather station to record temperature, rainfall, wind speed and humidity.

3. When data is available compare the benefits of catchment basin agriculture with grazing by animals. If the benefits favor catchment basin agriculture, expand to cover the entire plan.

Summary

Possible area for irrigated agriculture 14,000 hectares if water can be located. If there is no groundwater, the cultivated area under catchment basin agriculture would be 1,700.

Cautions

1. Areas were estimated by driving across the basin and a rough measurement of distances on a topographic map. The scale of the map was 1-200,000.

2. Discovery of fossil water could allow irrigation of the whole basin, however, this is unlikely. Aquifers replenished by rain would support a much smaller irrigated area on a perpetual basis.

3. The feasibility of catchment basin agriculture will be determined by the amount and time distribution of rainfall, depth and moisture holding capacity of the soil as well as human factors and market conditions.

Human Benefits

Allowing 2 hectares of land for each family, run-off agriculture could benefit 800 to 1,000 families. If a very large water supply were discovered and developed irrigated agriculture in this basin could benefit 8,000 to 10,000 families if they were allowed 1 hectare each.

Statements about the Petit Bara made by Pouchon, Broadnax and Peterson should be studied in relation to this area.

B. Grand Bara

The central part of the Grand Bara is covered by what the French call a sterile clay. No vegetation grows here. This clay covers an area of from 15 to 20 kilometers by 3 to 5 kilometers. This means that 45 to 100 square kilometerhas no vegetation. Because land is not a limiting factor in agriculture one would not normally consider doing anything to this sterile area. However, because this area collects water on its surface from the rest of the basin after each run-off producing rain it is a natural water harvest area. If some inexpensive treatment could make this land grow crops it could be used for producing food. For this reason the soil here should be analyzed with the thought that some treatment might reclaim it for agriculture.

Pouchon stated that the Grand Bara basin encompasses a total of 800 square kilometer I estimate that the area between the sterile clay and the mountains to be 100 to 200 square kilometer. This land could be cultivated with fairly easy land preparation if water were available.

The Grand Bara which is about 100 kilometers from Djibouti is unlike the Petit Bara in that significant amounts of water have been discovered. There are 2 wells about 15 meters apart. Depth given by government data is 80 meters with static level of 55 meters below ground surface. Pouchon says the specific discharge is 50 cubic meters per hour per meter of drawdown. This indicates a possible yield of 1,000 cubic meters/hr with a 20 meter drawdown.

These wells furnish water to Ali Sabieh. Evidently, the amount furnished is about 700 to 1,000 m3/day. If this aquifer could stand continuous pumping, the remaining water could irrigate about 300 hectares. It would seem that the potential of this aquifer should be studied with a high priority because of the agricultural potential.

The land around the well is fairly level and could be easily prepared for agriculture. In fact, some land (4 hectares according to the man doing the farming) is already under fence and about 1/4 hectare was farmed last year and is in water melons now.

The farmer said he grew tomatoes and egg plants during the winter. He also was growing a few trees consisting of oranges, lemons and a legume which produced edible beans. He had been farming 2 years. At one time he had been on the police force in Djibouti and had learned to farm by watching the gardeners there.

The land and water was free for this operation and he got to keep all the money collected. He said that there would be 400 water melons on the plot this year. I estimated that he had .16 hectares in cultivation. If the water melons weighed 3 kilos each he would get 1,200 kilos. He said he received FD 70 (18 cents per pound) per kilo. His melon income would be FD 8,400 ($480). As I understand it the most lucrative crop is tomatoes. He said that he grew tomatoes and egg plant in winter. All the above weights and areas are estimates and could be in error in either direction but illustrate that an inexperienced person with a profit motive can learn to farm in some manner and make fair crops. With proper guidance and experience he will very likely improve his skills. This man had a very possessive feeling toward the land he was working. With a profit motive many people in Djibouti might become farmers.

It was stated above that under the most optimistic set of circumstances that the wells at Mouloud might irrigate 300 hectares in addition to furnishing water to Ali Sabieh. The number of acres could be far less. These wells have been pumped since 1973. Measurement of static level and drawdown now would give a better idea of well potential. Additional drilling at nearby sites would give a better estimate of the aquifer potential. The production potential of this aquifehould be evaluated as soon as possible.

M. Gasc of the Minister of Agriculture's Office said the government would allow a 4 hectare experimental irrigation plot to be developed at Mouloud. Judging from the above information there may be enough water to irrigate far more in this location. Because of the proximity to the road, the availability of land, and previous successes the exploration of the Grand Bara for water should continue under the guidance of experts knowledgeable in groundwater development.

The land which is not irrigated might be farmed with catchment basin agriculture if the procedure should prove to be feasible. The cultivated area under catchment basin agriculture would be in the range of 1,000 to 2,000 hectares.

Development Procedure - Irrigated Agriculture

1. Set up an irrigation project at Mouloud using 7 families (let the present farmer keep 1/2 hectare). This would take care of the 4 hectares now under fence.

2. Have a competent expert study the present wells and, based on his study, plan an expansion of Mouloud farming area.

3. Drill additional exploratory wells.

4. Test the soil.

5. Plan the irrigation system and determine costs.

6. Determine land tenure system and how the project will be governed.

7. Install the project.

Development Procedure for Catchment Basin Agriculture

1. Set up a small weather station to record maximum and minimum temperature daily, rainfall, wind speed and humidity. Operate this station continuously.

2. Await the results of the Petit Bara catchment basin study.

3. If these results are positive, begin to develop catchment basin agriculture in the Grand Bara and expand it until all suitable land is utilized. This could range from 1,000 to 3,000 hectares of cultivated area.

Summary

Possible area for irrigated agriculture is 10,000 to 20,000 hectares. Possible cropped area under catchment basin agriculture 1,000 to 2,000 hectares.

Cautions

See cautions under Petit Bara. All these cautions apply here.

Human Benefits

Allowing 2 hectares of cultivated land under run-off agriculture 500 to 1,500 families could benefit.

If water were available, 10 to 20 thousand families could benefit by allowing one hectare of land per family.

Statements about the Grand Bara made by Pouchon, Peterson and Broadnax should be studied.

C. Hanle Plain and Cheikeitti Basin

Much of this plain was covered by bushes which were 1 to 2 meters high, and they were spaced a few meters apart. The bushes had collected blowing soil and sand and thus were on mounds. It had rained the night before we visited the plain and one of our vehicles was stuck as it tried to cross a small wadi. We did not reach the garden which was our objective but it was reported to be successfully producing fruits and vegetables. Wind may be a problem here.

Pouchon reports the plain as having an area of 400 square kilimetersand the total basin as 1,700 square kilometers. The Cheikeitti basin wadi flows into the Hanle plain. Pouchon reports the total area for the Cheikeitti basin as 1,100 square kilometers. On the map the level area in the Cheikeitti appears to be much smaller than the level area in the Hanle. Perhaps the area is 50 to 100 square kilometers.

The center of the Hanle plain is approximately 200 kilometers from the city of Djibouti. Much of the road is not paved. For this reason it seems advisable to grow crops which are easy to transport. Peterson suggests that the shallow water table here might be reached by plant roots. This procedure would involve irrigation until the crop was established then when the plant roots reached the water table irrigation would no longer be needed. If alfalfa could be used, livestock production in the area could be increased.

Another crop that might be managed in the same way is dates. Dates servive in dry areas with brackish water better than other crops. Dates would have the advantage of being easily transported to market.

The amount of flat land in these plains is estimated to be 400 to 600 square kilometers or 40,000 to 60,000 hectares. According to Pouchon, there is very shallow groundwater along the3 wadi. He also gives data from one well at Lilli va Bourri. This well produced 40 cubic meters/hr of water with 2 meters of drawdown. Static level of the water is 8.2 meters below ground level with 60 meters of saturated aquifer below static level. Pouchon said the storage capacity of the aquifer seemed to be high.

Development Procedure - Irrigated and Run-off Agriculture

See this same topic under Petit Bara. The same procedure is recommended except Peterson's suggestion for trying to get plants which will tap groundwater without irrigation should be tried.

Summary

There appears to be 400 to 600 square kilometers of land which might be irrigated (see Pouchon's comments on salt content). If enough water were available this basin would have 40,000 to 60,000 hectares which could be cropped. Under run-off agriculture this number would be 4,000 to 10,000 hectares.

Cautions

See this topic under Petit Bara. Also, wind may be more of a problem. The same is true for transportation.

Human Benefits

Allowing 2 hectares of cultivated land per family catchment basin agriculture in this area could benefit 2,000 to 3,000 families. If an unlimited water supply were available irrigated agriculture could benefit 40,000 to 60,000 families if they had one hectare each. Comments by Pouchon, Broadnax and Peterson should be studied.

D. Gobaad Plain

As with the other areas flat lands were estimated from a topographic map. The area appeared to be in the 20,000 to 40,000 hectare range.

Pouchon has indicated that there is potential for good groundwater in this plain. Some of it has been proven. He also states that approximately 20 million cubic meters of water flows out of this plain into Lake Abbe. If this water could be saved through groundwater recharge almost 1,000 hectares could be irrigated with it.

Pouchon gives the results of a bore hole in the Saballou area of this plain. Static level was 9.5 meters below the soil surface. There was 90 meters of saturated bed. Discharge was 75 cubic meters/hr with 11 meters drawdown. This well might irrigate between 100 and 200 hectares if it could sustain continuous pumping.

It is sufficient to say that there is enough flat land in this basin to allow use of all of the water supply which might be found. If catchment basin agriculture were practical, there is a potential for 2,000 to 4,000 hectares of cultivated land.

Development Procedure

See this same topic under Petit Bara. The limiting factor in developing will be as in all other locations, water.

Cautions

See this same topic under Petit Bara.

Human Benefits

Allowing 2 hectares of cultivated land per family catchment basin agriculture could benefit 1,000 to 2,000 families. If unlimited water supply were available, the number would be 20,000 to 40,000.

E. Ambouli Basin

This basin is adjacent to Djibouti. It contains a number of gardens of .1 to 1 hectare, each in the area of Atat, Ambouli and other places. We visited 4 of these gardens. Three were privately owned. Two were cultivated by the owners who reported that they were making a profit. The groundwater basin has been explored here in more detail than in other places in the country.

The city of Djibouti is using 20,000 cubic meters of water from this basin each day. The estimated maximum yield is 28,000 cubic meters per day. Leo Heindl, the hydrologist on the team, thinks that this estimate is on the low side.

There are several options open to the city. One would be to dedicate the remaining 8,000 cubic meters/day to agriculture. This would irrigate about 115 hectares of land. With this option it would be necessary to reduce per capita consumption of water as the city grows or get water from other sources. Measures for reducing water consumptions might include increasing the price of water and/or requiring all new and replacement water using appliances to be of the water conservation type. Another option would be to build a dam across the Ambouli wadi near the Arta road and save water that would run into the sea.

It is probable that this reservoir would be filled up fairly rapidly with rocks and other material brought in by the flowing water. Even if this happened 30 to 40 percent of the volume behind the dam would be available for storage in the pore spaces of the detritus. This filling would reduce evaporation. Of course, the system would have to be designed to release the water from the detritus. Perhaps water from this dam could be delivered to Djibouti by gravity through a pipeline.

Another option would be to use water from the city's sewage treatment system. We were informed that most of the water coming into the sewer system is lost through leaks. There are many trees in Djibouti. Perhaps some are watered by the leaky sewer system. Some are irrigated by the owners and around Ambouli some palms are evidently using water from the water table. A public effort to replace these trees with date palms would increase the food supply if the campaign were successful. Such an effort might be initiated by planting date palms at the Presidential Palace and the American Embassy with full media coverage. Giving date palms to those who wished to plant them would probably increase the chance of success.

Run-off agriculture might be successful in this area. Study of the rainfall records in the Hauguin thesis indicates that crops might be produced in the winter during some years.

There appears to be 10,000 to 20,000 hectares of level land in this area. Land is available for any irrigation water that might be dedicated to agriculture. From 1,000 to 2,000 acres will be available for run-off agriculture.

Development Procedure - Irrigated Agriculture

1. Decide to dedicate part of the available water to agriculture.

2. Offer part of this water to those who are already farming. Let them use it to expand their production.

3. Plan for additional irrigated acres.

4. Follow 4 through 7 under this topic for the Petit Bara.

Development of Catchment Basin Agriculture

1. Study weather records carefully.

2. If the prospects look promising follow the procedure under this topic for the Petit Bara.

Summary

The amount of level land available is estimated to be 10,000 to 20,000 hectares. There will probably not be water available for irrigated agriculture for very long unless water is imported from other areas, or a dam is built, or water consumption in Djibouti is reduced.

Cautions

1. See caution 1 under the Petit Bara.

Human Benefits

If water were available for 100 irrigated hectares, 200 families could be benefited.

Comments by Peterson, Pouchon and Broadnax should be studied.

F. Aibole and Magale Wadis

This land is located north of the Gulf of Tadjourah. Judging from the topographic map the amount of land available for irrigated agriculture in this area would be from 10 to 20 square kilometers, or 1,000 to 2,000 hectares.

The wells around Tadjourah are numbers 68, 71 and 75. These wells appear to be very productive. Specific yields range from 14 to 36 m3/hour per meter of drawdown. Pumpting lifts generally are less than 40 meters. Possible water supply from these wells could be from 7,000 to 10,000 m3/day. This would irrigate from 100 to 125 hectares. There is some doubt that these wells could stand heavy pumping without salt water intrusion. See the comments by Pouchon and Peterson. Heindl felt that large quantities of water might be available here.

Water transportation to Djibouti is possible therefore this area should be considered as having considerable agricultural potential. According to Peterson, inland from Tadjourah pumping costs would be high because of pumping lifts which are at least 100 meters. This would require about 6,000 liters of diesel fuel per hectare at a cost of FD 40 per liter. This would be FD 240,000 per hectare per year at the well head. High value vegetable crops could probably justify this energy cost. Hopefully further investigation will find useable water with less pumping lift.

Catchment basin agriculture could be considered for this area also.

Development of Agriculture and Summary

1. Follow the steps outlined under Petit Bara.

Cautions

See Petit Bara.

Human Benefits

If irrigated agriculture were developed on all land the number of families which could be helped would be 2,000 to 4,000 range. This is assuming that there would be enough water to irrigate all available land. If catchment basin agriculture were developed the cultivated ara would be from 50 to 100 hectares, and the number of families helped would range from 25 to 50.

Statements about this area by Pouchon and Peterson should be studied.

G. Saddai Basin

This wadi is in the vicinity of Obock. We did not visit the area. It is relatively remote and available water appears to be somewhat salty. It probably could be used for growing dates and Pouchon is optimistic about the quantity of water available. Dates would be relatively easy to transport. Judging from the map the amount of level land is between 40 and 80 Km2. Lack of information on rainfall makes statements about catchment basin makes already speculative statements even more speculative.

If rainfall is available, then 400 to 800 hectres might be developed for catchment basin agriculture. If water supply were not limiting 4,000 to 8,000 hectares might be developed for irrigated agriculture.

Development Procedure -- Summary -- Cautions

See Petit Bara.

Human Benefits

Allowing 1 hectare of dates per family irrigated agriculture could help 4,000 to 8,000 families. For catchment basin agriculture these numbers would be 400 to 800.

H. Weima Wadi (Bisidouro Area)

The wadi is in the north part of the country near Ethiopia. We did not visit it. Pouchon said the drainage area was 2,000 Km2. Estimating from the map there appears to be 30,000 to 40,000 hectares of land level enough to cultivate easily. The Weima wadi is the boundary between Ethiopia and Djibouti for a considerable distance. It is beyond a mountain range from Djibouti City and is thus very remote. Pouchon said that a well drilled in Bisidouro had a large storage capacity and contained good fresh water.

Although this area appears to have considerable agricultural promise it probably will not be developed until transportation facilities are provided to the area.

I. High Land Areas Having Soil, Water and a Cool Climate

These areas are very productive and will produce almost any crop year-round. Such areas are not plentiful but those which can be developed will improve the diet of the local population when they are remote from roads. When they are near roads the produce may be taken to market.

The outstanding example of such areas is Randa where several gardens are in production. Another is Bankoouale. There appeared to be enough water in the Bankoouale area for considerable agricultural expansion.

We saw another area at Garrousou. It was difficult to see all the land, but that available to agriculture might be in the range of 2 to 20 hectares. There was water on the surface. After seeing the dry desert for many miles this was truly a beautiful place. We were told that we were the first white men to visit this location.

Leo Heindl the hydrologist, said the amount of water might be less than you think although he did not estimate how much. He said the best collection system would be galleries as far downstream as possible. There were large palm and other trees growing here. Many of the trees did not have small limbs because they had been removed for firewood. The tools the people have cannot cut large timber. At this place we heard and saw some blond baboons on a cliff about 200 yards away. The land could be used for both tree crops and vegetables.

Because transportation in and out will be very difficult, food should probably be grown for local consumption and the source of power might be windmills.

It is probable that the results would be very similar to those at Randa. Water is probably available in other areas also. Although the amount of water available in the aquifers found at high altitudes is likely to be less than one would want, quality of water and climate will justify higher than normal investments in these areas.

J. Information and Personnel

A. American Agricultural Advisor

The ideal person for the U.S. work in Djibouti agriculture would have agricultural experience in the southwestern part of the U.S. The climate, soil and water conditions there are most like those in Djibouti. At least one person who has had production agriculture experience in irrigated desert agriculture and who is familiar with the information and research system in the U. S. should be obtained to work with Djibouti ministry personnel and farmers. This should be done for the second project. Before coming to Djibouti he should visit the Salinity laboratory in Riverside, California, meet the people, get their publications and look at their research.

It is unlikely that someone who speaks French can be found for this job. Providing an interpreter or teaching the individual French would be the solution to this problem. During the first project, the experiments on fencing, catchment basin agriculture, and initial work with crop production in Djibouti could be done by TDY personnel or by the soils man, or both.

B. Compilation and Publication of Information

The work of everyone concerned with Djibouti agriculture would be easier if all material were available in one place and in English. All germane information should be easily available to teams working here. This same information should be available to all concerned -- other donors, ministry personnel, marmetc, etc. Such information would reduce duplication of effort and save a great deal of time in the search for information.

I recommend that all available information on soils, water, crops, present farms production imports and markets be gathered, translated into English, and made freely available to all libraries, information centres, Agriculture Ministry, AID team personnel, TDY consultants and back-up people in Washington.

C. Outline of Publications

HISTORY

Gather as much history as possible from FED reports and French reports. Interview Michell Ferry on his efforts and experience. If possible locate the French army people who founded here in 1930's and 1940's. Find out more about the Yemeni efforts of the past.

PRESENT AGRICULTURE

Inventory the present gardens by visits, interviews and over-flights. Get statistics and information for FED reports and other documents.

WATER RESOURCES

Translate the French work on water and abstract that germane to agriculture. Add any material developed by the American team.

SOILS

Translate and abstract material from French. Include material developed by U. S. team.

CROPPING PROCEDURES, PRESENT AND NEEDED

Observe and interview present farmers. Read team and French reports. Study agriculture of other areas of similar climate. Compile technical information on how to grow crops, use windmills, build fences, etc.

MARKETING PRACTICES

Analyze agricultural marketing practices and needs in Djibouti.

ANNOTATED BIBLIOGRAPHY

Sources containing technical information relevant to Djibouti should be listed and described.

V. PUMPING METHODS AND COSTS

These costs are for direct connected diesel engines and for windmills. Wells with 7.8 lift are dug wells. The others are drilled. Costs are based on data collected in Djibouti, published windmill costs, and estimates based on U. S. experience.

A. Discussion of Power Sources

The costs of water pumping is a substantial part of any irrigation project. As pumping lifts increase, the pumping costs become larger until at some point the enterprise is no longer economical. Costs for pumping water from dug wells and drilled wells are given here. Pumps for the dug wells are small diesel engine-driven pumps. For drilled wells diesel generators driving submerged pumps were used. Yield of the well and pumping lifts are crucial in all cases. Generally speaking, these costs indicate that pumping from dug wells will cost less than pumping from drilled wells.

Windmill pumping costs are also given. It may be practical to pump water from dug wells with windmills. Costs for diesel pumping range from DF 65,000 per hectare (25,000 m3) for a dug well yielding 24 m3/hr to DF 2,230,000 per hectare for a 300 meter lift from a drilled well yielding 24 m3/hr.

Presently available windmills appear to be practical only for shallow wells. Windmill-powered pumping costs range from DF 174,000/hectare for a well yielding 8.66 m3/hr and having 7.8 meter pumping lift to DF 525,000/hectare for a pumping lift of 26.8 feet and a yield of 3.25 m3/hr. These windmill costs are based on the operating 80% of the time, 365 days per year, 24 hours per day. This may be overly optimistic based on wind records available, at any rate, pumping water with windmills is higher than pumping with diesel engines. If the purchase and installation costs of windmills could be reduced to one-half of the costs used in the paper, they would be an attractive alternative for power at some locations in Djibouti. Many small engines are already in use here and the technology is understood by a fair number of people.

Source and Reliability of Cost Figures

Well costs used were taken directly from or extrapolated from Ministry of Agriculture figures. It appears to me that these costs may be too high. This is particularly true for dug wells. If an opportunity arises this cost should be checked. Power unit and pump costs were taken from or estimated from Ministry figures. Fuel costs were taken as DF 43/liter of diesel fuel and fuel consumption was estimated based on tyupical engines.

Windmill costs were taken from 1976 quoted prices in the U.S. and increased for inflation, transport and Djibouti installation.

B. TABLE

COSTS FOR PUMPING WATER WITH WINDMILLS IN DJIBOUTI
(costs are 1000's of Djibouti francs)

Windmill	8' Baker 40' Tower	12' Baker 40' Tower	12' Baker 40' Tower
Yield - m3/hr	3.25	8.66	3.25
Pumping Lift - m	7.8	7.8	26.8
Cost of Plant			
Well + Tank	1,583	1,583	2,175
*Tower & Pump + Windmill	1,068	1,750	1,750 100
TOTAL	2,651	3,333	3,925
Annual Fixed Charges			
Int. @ 10%	133	167	196
Taxes	0	0	0
Mill Deprec. 5%	53	88	88
Well + Tank 5%	79	79	133
TOTAL	265	334	398
Annual Operating Cost			
Lubricating Oil	9	9	9
Repairs	32	52	52
Labor-1/hr/day	40	40	40
TOTAL	81	101	101
Fixed + Operating			
Costs	346	435	499
Cost m3	1,015	1,007	10,021
Cost/hc/yr	364	174	525
Area Irrigated	.95 hect.	2.5 hect.	.95 hect

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*Tower pump and windmill costs were taken from the 1976 edition of Energy for Rural Development. These costs were increased by 5% for sales taxes, by 40% for inflation since 1976, by 40% for shipping from U.S.A., by 25% for tariff into Djibouti, and by 40% for installation.

These increases were compounded. Baker mill and pumps were used and aero motor towers. Tower, pump and windmill are depreciated over a 20-year period.

VI. INFORMATION ON DJIBOUTIAN AGRICULTURE

A. Comparison of Djibouti Agriculture With California Agriculture

The cost of water delivered to farmers in the central vally of California ranges from $40 to $90 per acre/foot. This is equivalent to FD 156,000 to FD 334,000 for 25,000 m3, the amount of water the Ministry fo Agriculture assumes will be needed to irrigate one hectare for one year. Even with water prices like this, California farmers are able to grow and ship fruit and vegetable crops 2,000 miles in competition with rain-fed agriculture in the eastern part of the U. S.

Some Djibouti waters are as chemically desirable as California water. If a Djibouti farmer is able to produce 2 vegetable crops per year per hectare of 10 tons each and sell them at FD 75 (a quarter current retail market value) his gross income will be FD1.5 million. This yield estimate si very low. The FED report estimates yields of tomatoes to be 35 tons per hectare and water melons at 20 tons per hectare. Perhaps the 10 ton estimate should be doubled.

B. Motivation

How power and income is distributed will have a profound effect on the outcome of any effort to establish agriculture in Djibouti. There are many models for agricultural effort in the world. The feudal system of some countries, the Chinese commune, the Israeli Kibbutz, the American and European independent land-holder, the Soviet Collective and the American Corporation Farm -- it appears to me that to be most successful any system should have as many of the following features as possible:

1. There should be a direct relationship between the income of the farmer and the goods which he produces. And he should be responsible for the inputs and outputs of the enterprise. If the farm is productive he should have a high income. If it is not productive he should have a low or no income.

2. The farmer should run his own land. He should be able to sell or keep the land or buy other land.

3. He should have reliable markets for the goods which he produces.

4. Agricultural information should be easily available and free.

5. Farming units should be large enough initially to potentially provide the farmer and his family a higher income than they could earn elsewhere.

Looking over world agriculture it appears to me that some reward systems are consistently less effective than others. Among these are government ownership and management of farm enterprises, corporate ownership and management and absentee landowner systems. Although viable farms using these systems exist, it appears to me that owner-operated farms are in general most productive. For example, I was in agricultural education at the college level many years. Most colleges owned farms. I know many people over the U.S. involved with thse college farms, and I never heard of one which was operated at a profit.

In my community there are both absentee-owned farms and owner-operated farms. The owner-operated farms are nearly always more productive than absentee-owned farms. Djibouti might follow the homestead procedure which was used in the U.S. beginning with the administration of Abraham Lincoln. Farmers were allowed to move on a tract of land. They were given full title of the land after they had lived on it for the required number of years and made required improvements. In later years when there were more homesteaders than land, people were chosen by lot.

It would seem wise to study land-tenure-reward systems over the world, and select the one which offers the most promise of meeting the Republic's objectives.

C. Pumping Water vs Hauling Vegetables

There is a proposed project to pump water from the Hanle and Gobaad plains to the Djibouti area. The hypothesis is that it is cheaper to pump the water and irrigate land near Djibouti than it would be to haul vegetables. Cost data is not available but this hypothesis seems to me to be false. Most of the water for agriculture appear to be in the Hanle and Gobaad plains. There is a proposal to pump the water to areas near Djibouti and to use part of it for agriculture. There is a hypothesis that it is cheaper to pump water 120 kilometers than to haul vegetables produced by that water the same distance.

One set of numbers than I saw placed the cost of the pipeline and pumping stations at $15.2 million. Amortized over a 20-year period this would be $1.4 million per year for interest (at 6-1/2%), and depreciation without considering energy, repair and labor costs for pumping water.

The amortization costs per cubic meter would be $.075 per cubic meter. It requires about 1,000 cubic meters of water to produce a ton of vegetables. This would put the amortization costs at $75 per ton. Added to this would be the other costs listed above which would probably more than double the $75 number.

In the U.S. the cost of hauling on good roads with trucks of 20 tons capacity is $.06 per metric ton mile.

The distance the vegetables need to be hauled is about 85 miles. The cost of hauling a ton of vegetables 85 miles in the U.S. would be about $5. The cost in Djibouti would be 2.5 times U.S. costs for the same equipment and roads.

Because perhaps 5 ton trucks must be used here, the costs would be doubled to 5 times U.S. costs and perhaps because of poor roads, the costs should be doubled again. This would bring the cost of hauling to $50 per metric ton which is about one third the cost of pumping water to Djibouti.

D. Fencing

Because herds have the right to roam free in this country, it is necessary to fence cultivated areas to keep out animals. Fences can be constructed with imported wire and posts, native thorn bushes, and stones. Sometimes native thorn bushes must be transported a considerable distance. I do not know how long such fences will last in this dry climate. Perhaps they would be effective for 2-5 years. If this is the case, this is perhaps the most economical fence in the country when the material is available nearby.

1. Stone Fences

The other native material is stone and there is an over-abundance of this in most places. The nomads use stone to build small houses and corrals for their animals. The local AID Mission thinks goats can climb such fences. I suggest an experiment in which a rock fence is built vertical by using a moveable plywood guide. The vertical fence would be inside the experimental area and goats would be placed inside the corral and allowed to climb out if they could. The second experimental corral would have the vertical wall filled with mud.

The cost of a 5-foot tall wire fence would probably be between DF 3,000 and DF 7,000 per meter installed in Djibouti. The minimum wage here is DF 15,000 per month. Most of the cost for a stone fence would be labor. Obviously one man can build more than 3 meters of stone fence in one month.

2. Area Fenced - Variation in Cost

The larger the area fenced, the less fencing costs are per unit area. If one hectare is fenced, 400 meters of fencing is needed, at DF 6,000 per meter, the cost would be DF 2,400,000 per hectare.

Of 100 hectares to be fenced, 4,000 meters of fencing is needed. In this case, the cost per hectare will only be one tenth that for an area of one hectare fenced or DF 240,000 per hectare.

I estimate where stone is readily available that fencing with stone will cost only one quarter to one fifth the cost for imported wire. Obviously regardless of the kind of materials used, fencing one large area is more economical than fencing many small ones.

E. Animal Control

At several locations water melons have been partially eaten. We were told that the "porc-u-peek" had done this. Evidently this is a porcupine. In two places the gardeners had set traps. We heard of rabbits eating gardens at other places.

Control of these animals is a problem. Possible alternatives are:

1. Relatively small mesh wire fence anchored in concrete.

2. Stone fences which have the spaces between rocks filled with adobe.

3. Keeping a dog inside the garden.

4. Hunting the animals with a gun and light at night.

5. Poison bait. (Strichnine or other material.)

6. A trapping program developed by a biologist trained in trapping.

All of these alternatives have some disadvantages. For example, many people and perhaps all who would farm have a religious taboo against dogs. Well-built wire fences would solve the problem but this uses imported materials and is expenbsive.

Stone fences might be the solution. It is not known whether or not the animals could climb these fences.

This problem should be considered in fence design and construction. Other procedures should be investigated for control inside brush fence enclosures.

WIND IN DJIBOUTI

In considering wind power historical data on velocity of wind, hours of wind and periods of calm are essential.

I understand that such data has been kept for 20 years or more for the Djibouti Airport. I was able to get a few months data from the Minister of Agriculture. Observations are made four times daily at the Djibouti Airport and three times at other locations. They are summarized here:

SOME WIND VELOCITY OBSERVATIONS IN DJIBOUTI

	JULY 1977						AUGUST 1977					
Velocity m/s	C	0-1	2-4	5-6	7-14	Over	C	0-1	2-4	5-6	7-14	Over
Djibouti Air.	0	1	45	39	39	0						
Arta	11	24	46	17	6	0						
Dikhil	Average wind speed less than 1m/s											
Obock	Average about 5m/s											

	SEPTEMBER 1977						OCTOBER 1977					
Velocity m/s	C	0-1	2-4	5-6	7-14	Over	C	0-1	2-4	5-6	7-14	Over
Djibouti Air.	8	14	75	27	4		12	21	75	26	2	0
Arta	7	27	56	7	0		9	34	55	4	0	0
Dikhil	Av	2	m/s	-------			Av	4	m/s	---------		
Obock	Av	4	m/s	-------			Av	4	m/s	---------		

	NOVEMBER 1977						DECEMBER 1977					
Velocity	C	0-1	2-4	5-6	7-14	Over	C	0-1	2-4	5-6	7-14	Over
Djib. Air.	17	31	65	24	0	0	0	4	68	37	5	0
Arta	15	23	44	19	4	0	0	0	55	36	2	0
Dikhil	Av	3	m/s	-----------			Av	3	m/s	-------------		
Obock	Av	3	m/s	-----------			Av	4	m/s	-------------		

Four observations per day at Djibouti airport. Three observations per day at other places. One meter per second = 2.2 miles per hour.

F. Wells in Djibouti

Information from diagrams furnished by "Sce Genie Rural"

NAME	Yield m^3/hr	Draw-Down m	Dynamic Level m	Static Level m	Total Depth m
	CERCLE D'OBOCK				
Soublali No. 1 1-71	21	8	46	38	120
Soublali No. 2 2-74					
Oulma 74	16	2	64	62	90
Orobor 74	20	1	17	16	25
Lahassa 74	1.3	68	108	40	120
Ras-sian	1.3	9	27	19	33
Assa-Guinetta 65	0.5	35	60	25	66
	CERCLE TADJOURAH				
Tadjourah 68	36	1	22	21	34
Tadjourah 71	44	2	25	23	34
Tadjourah 75	28	2	31	29	37
Magale 76	25	11	79	68	101
Adaillou 77	6	2	10	8	25
PK 9-73	28				92
Dorra No. 1 64	2.8				156
Dorra No. 2 68	7				
Dorra No. 3 69	5	6	117	111	155
Assa-Gueyla No. 1 68	3.5	71	80	9	80
Assa-Gueyla No. 1 68	3.3	44	63	19	80
Andaba 73	3.6	15	188	173	188
Madgoul No. 1 67	0				138
Madgoul No. 2 68	0				138
Adoila 77	0				60

Irrigation Costs (Ministry of Agriculture - Djibouti)

The costs were taken from a budget made by Michelle Ferry and then corrected in pencil by M. Gasc. Gasc generally raised Ferry's estimate for dug wells and lowered them for drilled wells.

I suspect the costs are somewhere in-between.

Costs for Irrigation in Djibouti (Costs in Djibouti francs)

These costs were taken from material furnished by M. Gasc from the Ministry of Agriculture. The dug well is proposed for 1.5 hectares and 3 families. The drilled well is for 10 hectares and 30 families.

INVESTMENT COSTS	DUG WELL	DRILLED WELL
Wells, tanks, housing, water distribution, pump, power, etc.	3,473,000	33,604,000
Cost per family	1,158,000	1,121,000
Annual costs (irrigation costs)		
Amortization (mostly 10-20 years but pump in one year)		3,000,000
Per family (annual amortization)	95,000	100,000
Operating costs annual		
Operating costs per family		70,000
Other charges per family (tractors, work, tools, fertilizer, hauling, etc.)	170,000	361,000
TOTAL PER FAMILY - DF	575,000	DF 531,000

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Costs for Irrigation in Djibouti

These costs were for projects proposed by the Ministry of Agriculture

(They appear to be high to me.)

Costs are in DF.

INVESTMENT	DUG WELL	DRILLED WELL
Well	1,583,000	5,600,000
Pump and Power Unit, tanks, etc.	220,000	18,000,000
Water distribution system, fencing, etc.	1,670,000	10,004,000
TOTAL - DF	3,473,000	33,604,000
Cost per farm family (10 hectares and 30 families for the drilled well and 1.5 hectares and 3 families for the well)	1,158,000	1,121,000

APPENDIX A-5

ACTION MEMORANDUM

12 January 1979

To: Mr. Karl H. Mahler, A.I.D. Affairs Officer, Djibouti

Subject: Project Paper - Djibouti - Water Resources and Soils Analysis Project (603-001)

A. RECOMMENDATIONS

Based on the approval by AID/W of the Project Identification Document (PID) and a source and origin waiver for a project vehicle, authorization of this project is recommended:

-FY 1979 Grant	$497,000
Total New AID Obligation	$497,000

B. Summary Description of the Project

The Government of the Republic of Djibouti (GROD) has requested AID assistance in determining the long-term potential of agricultural development. By analyzing data on soils and water resources, GROD officials will be able to make rational economic decisions regarding Djibouti's future development in food production and water and soil conservation.

A paucity of accurate and detailed information for providing a sound data base is a primary justification for AID assistance to the GROD at this time. The nature and timing of AID assistance is predicated on the belief that agricultural potential exists in Djibouti and that U. S. technical assistance, even if modest, can have a significant impact if concentrated on the most basic resource needs, i.e., water and soils.

The project will institutionalize, through training in the Ministry of Agriculture and Rural Development (MOA), the capacity to undertake studies supportive of long-term agricultural sector development, that is, the capacity to do basic applied research which has immediate practical benefits to the Djiboutian farmer. The key assumption is that initial results will indicate the agricultural inputs (seeds, fertilizers, etc.) in which farmers should invest and the extent to which that investment is economically and socially justifiable.

Over the two-year life of the project, AID will provide resources totalling $497,000, to finance the long-term services of a hydrogeologist who has had experience in soil sampling. This advisor will work with and train Djiboutian counterparts in exploring for aquifers, analyzing water samples, taking soil samples, directing soils analyses and interpreting the results to the farmers who work those soils. He will also assist in the establishment of a water and soils analyses laboratory which is being built and partially equipped by the GROD. Short-term consultant services in soils and water resources planning will also be provided to assist the long-term advisor in preparing soils and water inventories. Both long-term U. S. and short-term Third Country participant training will be offered to Djiboutian staff of the water/soils laboratory. This staff will make available applied research to the existing agricultural extension service, and its agents, giving information of practical value and benefit to the farmers. In addition, supplementary equipment and supplies will be purchased for the laboratory, as well as a project vehicle and camping equipment to assure maximum mobility for the long and short-term technical advisors. Funds will also be provided for aircraft rental, communications, vehicle operation and maintenance, temporary lodging and miscellaneous operating expenses.

In support of this project, the GROD is prepared to finance the equivalent of $198,000, to provide complete access to and use of a water and soils laboratory, including equipment and supplies, plus the services of the following Djiboutian laboratory personnel: one hydrologist, one water quality chemist, one or two soils scientists, one librarian, one lab assistant and non-professionals, as required. These technicians and facilities will backstop the 10-man agricultural extension service, which will bring soils and water samples to the laboratory and take the practical advice derived from laboratory findings to the farmers.

The estimated total cost of the project is $695,000, of which AID will contribute $497,000 and the GROD will contribute $198,000. AID life-of-project financing will be provided in FY 1979.

This project will be the first of several projects in a modest, bilateral assistance program in Djibouti. The GROD is keenly interested in implementing this project as soon as possible to coincide with completion of the water and soils analysis laboratory in August 1979. The GROD official request for assistance is attached as Annex A.

C. The Project Paper (PP) Design Team

The team responsible for the preparation of this Project Paper included two soil scientists, a hydrologist, an irrigation engineer, an agricultural economist, a rural sociologist, and a design consultant. The team was thoroughly briefed by the AID Affairs Officer in Djibouti (AAO/Djibouti) and at meetings arranged with the U. S. Charge d'Affaires and various local agricultural experts and GROD officials. Site visits were undertaken in three of the four administrative regions (Cercles) of the country. The fourth region could not be visited due to limitations of time and transport.

Members of the team were taken on a chartered air flight for an aerial over-view of the country at low altitude. Numerous discussions and interviews were held with Djiboutians at all levels of society, from nomadic herdsmen to government ministers.

As the work of the PP team progressed, two facts become clear. On the one hand, team investigation established that certain small areas of the country (quasi-oases) appeared to have the necessary soil and water requirements for successful agriculture. On the other hand, the amount of time available to the team and their need to make judgments based only on observation rather than thorough accepted laboratory procedures combined to make the determination of specific interventions difficult. The physical characteristics of the country and the financial and organizational difficulties to be expected in a newly independent nation suggested that agricultural sector development should be approached with caution to prevent AID and GROD commitment to unwieldy, expensive programs. This approach has been agreed to by the MOA. The lack of necessary data concerning the agricultural situation and the resulting lack of a coherent national policy with clear goals suggested that an intensive effort to promote agricultural extension would be premature, and, if poorly prepared, potentially detrimental to future agricultural development.

With the above in mind, the search began for a practical initiative that would build on the positive information collected by the team. During this process, the team learned that the GROD had committed funds for the construction and the establishment of a water and soils laboratory for investigation of Djibouti's agricultural production potential. Discussions between team members and government officials indicated two conditions:

(1) The equipment already ordered for the laboratory was inadequate for the preparation of the necessary water and soil inventories, and

(2) while some local expertise existed, there was a need for professional technical assistance in support of the laboratory. GROD officials concurred in this assessment, but there were insufficient funds available for a significant expansion of their project. It was the judgment of the team that the laboratory effort was an appropriate response to the situation and worthy of support, as it would lay a necessary foundation of information for future activities in the agricultural sector and would permit a step-by-step practical extension of agricultural support services to existing farmers.

Each member of the PP team prepared a technical report, including analyses of sources of data on water and soils resources, observations and recommendations for AID assistance. The technical reports are available on file in REDSO/EA and AAO/Djibouti.

II. BACKGROUND AND DETAILED DESCRIPTION

A. Background

1. Project Setting

The former Territory of the Afars and Issas only recently became the Republic of Djibouti, gaining its independence from France in 1977. No AID relationship had previously existed with the Territory. Other than the distribution of P.L. 480 foods and other assistance to the refugee communities resulting from the war in the Ogaden, AID/Djibouti projects and activities are presently in the planning and development stages.

With an estimated population of 300,000, Djibouti is a small country in one of the world's driest inhabited areas. Rainfall averages about 200 mm per year. A large proportion of Djibouti's population is active in nomadic husbandry, herding primarily goats and sheep, with smaller numbers of cattle and camels. Djibouti's present center of economic activity and the primary reason for the original French colonization are found in the operation of the port located at the capital city. This port and the railroad connecting it to Ethiopia provide the population's major source of employment and income.

Ninety-seven percent of Djibouti's food is imported, including all of its food grains. Traditionally, the majority of this food was imported by rail from neighboring Ethiopia. However, the recent fignting in the Ogaden has severely disrupted rail service and resulted in increased food imports from Kenya and France. The additional expense involved in this importation has led to steep increases in food prices and shortages. The disruption of rail service has also created unemployment for a large segment of Djibouti's salaried labor force. The drop in income, rise in prices and influx of refugees have combined to create severe economic difficulties. Although occasional day-time rail service has resumed, the long-term prognosis remains unclear.

The lack of agricultural growth in the local economy may be attributed to insufficient expertise among the local nomadic inhabitants and a scarcity of known sources of suitable soil and water. Since the early 1940's, the French have undertaken agricultural schemes, but with limited success. Yemeni farmers had established gardens in recent years, but were generally unble to obtain sufficient income to continue farming. While adequate soil and water for agriculture are thought to exist in parts of Djibouti, there is no systematic, centralized collection of scientifically acceptable water and soil information currently available for agricultural planning and for dissemination to farmers through the agricultural extension service.

2. The Importance of Water Resources and Soils for Development

a) Water Resources

As is true of all nations, water is essential to the physical well-being of the people of Djibouti and to the future economic development of the nation. The highest priority for water use is for domestic consumption. The rapid increase in recent years of Djibouti's population (average annual growth rate, including refugees, is estimated at close to 5%) has severely increased national requirements for water in an area that is one of the world's most arid and where water has traditionally been at a premium. Beyond domestic purposes, water will also be needed in the event of increased agricultural and/or industrial development which will bring even greater strains to bear upon existing and presently foreseeable water supplies. Proper planning will be required for the efficient use of water in the future. A clear understanding, insofar as this is possible, of total water resources, both surface and groundwater, will be essential to this planning.

Present information regarding Djibouti's water resources is insufficient to determine acceptable initiatives for AID's consideration in the area of large-scale increased agricultural production. Prior to the proposal of water-related projects, it is essential that a full water resources inventory be undertaken in Djibouti under the direction of technically competent individuals and supported with the necessary equipment and labortory facilities. Such an inventory would also provide significant benefits to the GROD in its concern with the problems associated with population growth and industrial development.

b) Soils

It is not feasible, at this time, to state definitely the relationship of Djibouti's soils to the potential for national agricultural development. As Djibouti lacks a tradition of farm cultivation, this relationship cannot be determined by past experience. For the present, the influence of soils on future production can only be estimated. Howevere, it can be said, based on the analysis of the limited data available and following discussions with local experts and officials, that it appears that arable soils exist in sufficient quantity in various regions of Djibouti to justify professional interest and certainly to justify laboratory and extension facilities to inventory those soils which are being worked in order to identify what treatment they require to yield optimum, sustainable crops.

Both the immediate and the eventual development of arable land could be of significant economic and social benefit to Djibouti. The present diet of many Djiboutians, particularly in rural areas, is comprised in large part of milk, boiled sorghum and some meat from one or more of various livestock sources: goats, sheep, cattle, and/or camels. This diet does provide sufficient nutrients, assuming a sufficient quantity is consumed. Observations of the current situation and investigation of the literature suggests that, whereas nutritional deficiencies do exist as might be expected in a low-income developing nation, the general nutritional status of the population is not alarming. However, as the estimated population growth rate is in excess of 4% annually, it is doubtful that (a) the herds of livestock can also increase sufficiently in the coming years to meet future needs, and/or (b) Djibouti's ecology can support such an increase without danger of over-grazing. This is particularly a problem for the rapidly growing urban center of Djibouti city. If the serious gap persists between food requirements and food supplies (as represented by livestock), a gap presently overcome by French subsidies, then an alternative source of protein/vitamins/minerals will be required. This alternative source could include grains, vegetables, and fruits grown locally for local consumption. Further, Djibouti presently imports an estimated 97% of its food requirements. Thee importations from areas as distant as France and Kenya represent a major expense to the country, requiring the use of a large proportion of Djibouti's limited (and externally supplied) financial resources and thus denying their use for other vitally important development projects. Thus, it is concluded that the investigation of Djibouti's soil resources and their potential use for cultivation is a concern warranting the attention and support of the Government of Djibouti and AID.

c) Basis for Intervention

The GROD Ministry of Agriculture and Rural Development (MOA) is responsible for all agricultural matters. The Ministry employs an average of 400 people during the course of the year, of whom approximately 100 hold professional positions at varying levels. Within the Ministry, there are three "Services": Agriculture and Forestry, Rural Engineering, and Livestock and Fisheries (see attached organization plan, Annex B). The determination of the quality of soils and water and the provision and promotion of their use for cultivation are primarily the concerns of the first two Services. Approximately 50% of the Ministry's employees work under the Rural Engineering Service, which is particularly concerned with the provision of water supplies.

Although recognizing the needs presented above, it would be premature for AID and GROD to initiate financing for large-scale cultivation programs at this time. Much more specific data on soils and water resources must be accumulated before such efforts should be undertaken. The collection of this data will require considerably more time than is available to short-term teams. Furthermore, adequate laboratory facilities are not currently available in Djibouti.

The MOA has begun the construction of a variety of offices and a laboratory. The primary purpose of the laboratory will be to support the investigation of water resources, soils research and land classification. The effectiveness of water and soils research, however, will be greatly enhanced and the results of that research will be of greater benefit to future activities, particularly in terms of agricultural production. Specifically, additional inputs, particularly in terms of additional equipment and technical assistance, will greatly increase the benefits to be derived from the work of the laboratory.

Construction of the laboratory is expected to begin in late 1978, with completion expected by mid-1979. Within the MOA, the laboratory will be administered by a special and newly-created Laboratory Section of the Rural Engineering Service, under the general administrative overview of the Technical Advisor to the Minister (French) and, ultimately, the Minister. In order to coordinate activities with agricultural planning, the laboratory will cooperate closely with the Studies Section of the MOA Agriculture and Forestry Service. It will also, for practical purposes, be linked with the MOA Agricultural Extension Service.

B. Detailed Description

I. Sector Goal and Project Purpose

The purpose of the project is to institutiuonalize within the MOA Rural Engineering Service the capacity to (a) analyze ground and surface water quantity and quality, as well as to compile, catalogue and disseminate hydrological information, and (b) classify soils, prepare soils maps and provide evaluation concerning the proper utilization of soils. In practical terms, farmers can be advised on soil treatments to obtain optimum sustainable yields. Achievement of this project purpose should impact on the sector goal of developing an information base for use by the GROD in (a) national agricultural planning, and (b) its dessmination to farmers through the agricultural extension service.

Assumption for achieving the sector goal are that (a) data of sufficient importance and scientific validity can be accumulated, and (b) the GROD has (or can obtain) the necessary technical expertise to evaluate and make use of the data and to communicate its practical Application to farmers.

By the end of the project, the laboratory staff fo the Rural Engineering Service will have begun work on an considerable portion of a national water resource inventory, with at least preliminary specific recommendations on the potential for water and soil use for crop production in the more favorable areas of Djibouti, e.g., Plan de Goubet. The laboratory will also have undertaken a soils inventory and developed a land classifications system in those areas:

2. Project Outputs

The following outputs provide a direct linkage to and are necessary for the accomplishment of the project purpose:

(a) a water and soils analysis laboratory fully equipped and in full opration;

(b) a data collection system established and available for the use of other GROD, private and donor institutions;

(c) systemization of existing water data and information;

(d) documentation of soils and land classification; and

(e) GROD personnel trained and staffing the water and soils analysis laboratory.

Based on the above, the magnitude or quantifiable indicators of the outputs by the end of the project include:

(a) a 150m^2 laboratory/office complex equipped with supplies and instrumentation provided by both the GROD and AID;

(b) a technical library established and stocked with relevant texts, manuals and journal subscriptions (in French) in the fields of soils science, hydrology, water resource planning and development and management of land;

(c) reports (approximately 3) prepared on water resources surveys using stream gauging, well-logging and meteorological methods;

(d) selected small-scale water and soil studies (approximately 3) undertaken in areas which have the most agro-potential based on soils samples;

(e) on-the-job training completed for a hydrologist in stream gauging, well-logging interpretation and data management, for a librarian in cataloguing and data management, and for lab assistants in soils sampling and testing; and

(f) a hydrologist and water quality chemist trained to continue work on the water resources inventory.

3. Project Inputs

AID inputs will be provided over the two-year life of the project. They will consist of the following:

(a) Technical Services: The long-term services of a hydrogeologist will be provided for two years. The primary duties of this advisor will be to develop and maintain the water and soils anlysis laboratory, train local technicians, operate the laboratory and analyze samples for water and soil surveys. A position description is attached as Annex C. Required prior experience for this position includes soil sampling. Although his technical training rests in exploring for aquifers, the advisor will also take soil samples, direct soils analyses and interpret the results which will be available to the agricultural extension service and other GROD and donor organizations. Short-term consultant services will also be provided for a total of five person-months. Specialists in water resources planning and soil science will periodically assist in the laboratory, train Djiboutian lab staff in soil sampling and generally direct the soils inventory and land classification effort between visits.

(b) Participant Training: Funds will be provided for the training in the U. S. of a Djiboutian in hydrology. Upon his/her return, he/she will join the staff of the laboratory in continuing research for the water resources inventory. One Djiboutian will also receive short-term, specialized training (up to two months) in water chemistry and quality. Suitable training programs may be available in West Africa.

(c) Commodities: Equipment will be provided to supplement the work of the laboratory in regard to water inventories, soils classifications and field investigations, including necessary sounding equipment, conductivity meters, pH-meters, a colorimeter, a nitrogen analyzer and balances. An illustrative equipment list is attached (Annex D). To provide mobility on field trips throughout the rugged country a project vehicle will be procured. The vehicle must have four-wheel-drive, be capable of carrying 4-6 persons and field gear and have a self-rescue capability (front-end winch, sand tracks, etc.). A Toyota Land Cruiser is recommended. Camping equipment will also be purchased to permit lengthy field trips by the advisor, short-term consultants and Djiboutian technicians on the laboratory staff. A procurement source and origin waiver for the project vehicle is attached as Annex E.

(d) Other Costs: Funds will be provided for aircraft rental for aerial reconnaissance and transportation to relatively inaccessible regions of the country, communications (including the mailing of soil samples to international research centers and U. S. experimental stations), vehicle operation and maintenance, temporary lodging and subscriptions to professional journals and periodicals for the technical library, housing and furnishings for the American technician.

Government of Djibouti

The GROD is prepared to provide the following inputs in support of the project:

(a) Technical Services: The full-time services of a hydrologist, a librarian and at least two laboratory assistants will be provided to work with the U. S. advisor. Candidates will be made available for long-and short-term training in hydrology and water chemistry. In addition, the GROD will provide the services of a typist, accountant, driver and office cleaner.

(b) Construction: The GROD will construct a water and soils analysis laboratory/office complex, including 150m2 of floor space, chemistry benches with access to distilled and tap water and a stable electrical power source, four sinks and a wall bench with cabinets for the storage of glassware and supplies. Other facilities will include three offices, a sample preparation room, a supply and storage room and an instrument room. The building complex is scheduled for completion in late 1979.

(c) Commodities: Basic equipment for the new lab.

(d) Other Costs: Utilities and maintenance of the laboratory and offices will be financed by the GROD. In addition, temporary laboratory and office facilities will be furnished by the MOA, if the MOA-financed building is not completed prior to the arrival of the long-term USAID Advisor.

III. PROJECT ANALYSES

A. Technical Analysis

There are a number of reasons for the low state of agriculture in Djibouti, including: (1) extreme aridity, (2) high summer temperatures, (3) shortage of readily available water, (4) an inadequate transportation system, (5) uncertain demand for farm products, (6) scarcity of skilled farmers, and (7) unwillingness of nomads to undertake farming. These factors makke the prospect of food self-sufficiency extremely doubtful. Yet the GROD is very interested in reducing the country's dependency on imports through support of economically-viable agricultural programs. However, preparation of a national agricultural development plan is hindered by the lack of adequate soil and water resource inventories. This deficiency results in expression of opinions about agricultural development which range from deep-seated pessimism to moderate optimism. In no case are opinions or reports based on reliable, documented information.

Profitable agriculture may be -- and this project should help to provide an indication -- both physically and economically possible in Djibouti. Nine areas were examined by the PP team through visitation, study of written information or both. It appears that upwards of 50,000 hectares of land are reasonably level, have native vegatation growing and may have some possible supplies, albeit limited, of groundwater. Water clearly will be the limiting factor in all locations. Even rough estimates of water quantities are difficult to project, but very preliminary estimates indicate that there might be enough groundwater to irrigate between 100 and 2,000 hectares.

There appears to be some potential for conserving water with dams and groundwater recharge through spreading water from the wadis during runoff. Thus, basin agriculture may be possible. This would increase the potentially cultivteable area.

With respect to its soils, Djibouti has no adequate soil resources inventory. This is needed to plan proper agricultural development. Also, crop production in the immediate future will only be possible where irrigation water, pumped from deep wells, will be available. Soils and water quality are extremely variable. The high cost of irrigation agriculture infrastructure requires careful selection of sites in order to make optimum use of scarce water resources.

The Government of Djibouti does not have the capacity to carry out a critical evaluation of the potential of the soils and water resources for crop production. In the past, some surveys have been undertaken by the French technicians on a short assignment basis. Only two govewrnment officers have training in soil science but little experience. One hydrologist has been trained in Romania, and one hydrologist is now in training in France and will return within a year.

Djibouti has recognized the need to develop the agricultural sector. Present-day agricultural activities consist of small garden plots (approximately 1,000 sq. meters) that surround existing wells. It is reported that a total of only 20 to 40 irrigated hectares is under cultivation. Most of this is in citrus and vegetables. However, water resource surveys and previous experience indicate that the agricultural area could be markedly increased, provided crops, water and soils are well-managed.

Irrigation agriculture is not the only activity which lacks basic information for planning. The large majority of the population in the country is nomadic and lives from the products of herds of goats and sheep. Many areas around wells have been over-grazed, and hunger, not thirst, has devastated a considerable number of communities in the past. Land and water evaluation and mapping at appropriate scale could assist in determining the carrying capacity of the soil, the selection of sites and the spacing of drilled and hand-dug wells, and thereby maintain a balance between amount of range and sizes of herds.

There are three major objectives which the water and soils analysis laboratory will serve:

(1) Immediate needs of existing garden areas where management, irrigation techniques, reclamation procedures, crops, and drainage will be adapted to soil conditions and water quality;

(2) Medium scale (1:50,000) surveys of major plains and valleys, in order to plan further development of irrigation areas; and

(3) A large-scale survey (1:200,000) of the country, which would provide basic information on uplands and stratify soil environments according to their potential for grazing, carrying capacity, etc.

The three objectives are listed in sequence, adapted to local circumstances and development needs.

The field work undertaken during the project will focus on the collection of ground and surface water samples and soil samples from wadis, well-sites, present spring sites and potential "run-off" agricultural sites. Samples will be analyzed in the laboratory. Soils samples which cannot be analyzed in the lab will be mailed to international research centers or U. S. agricultural stations (at Cornell University and the University of Hawaii, for example) for interpretatin. In-depth field studies will be published as a result of the accumulation of data on particular areas. The area focus of these studies will be at sites selected by the GROD and other donor agencies. For example, German aid agencies are considering some assistance to the Plan de Goubet area, and water and soils analyses will be used in determining the extent of such assistance. In addition, the technical reports of the hydrologist, irrigation engineer and soils scientists on the PP team recommend specific locations for study.

B. Social Analysis

The principal beneficiaries of the project are the portion of the population which makes its living off the land. The data base generated through the project and the complementary and follow-on extension activities will provide the scope for a more rational, efficient use of soil and water by both farmers and herders. Regular communication between laboratory staff and other MOA personnel, especially agricultural extension agents, should enable farmers to benefit by providing them with information to make decisions on using their scarce soil and water resources more scientifically. Identification and use of water resources may also significantly decrease the time and energy expended by both herders and their animals in the search for good grazing and water.

Systematic knowledge of productive soils and water supplies will be especially important to rural people in the event of drought and/or other disasters, such as locusts. It will also be important as the GROD increases its attempts to intervene in the ongoing traditional subsistence systems. A systematic knowledge of reliable soil and water resources is imperative to avoid serious negative effects in the mid-and long-term.

There are two issues related to the success of the project in social terms which must be monitored. One is the departure of trained Djiboutians from their positions once they have been trained. The provision of well-equipped laboratory facilities, high-level technical assistance and participant training opportunities is expected to improve the professional opportunities available in Djibouti for nationals interested in soil and water-related sciences and will thus serve as an incentive to their continued presence in Djibouti.

The second issue is the degree to which project linkages between MOA personnel, such as extension agents, and related instituitions, such as the proposed Commission for Planning (see Section III.E.), can be firmly established. This will guarantee a continued flow of information vertically -- down to the farmer and herder and up to the level of national planning -- as well as horizontally to other GROD ministries. The short timeframe of the project must be recognized, and linkages must be established quickly so that the goal of the project can be achieved in the mid-and long-term. A facilitating factor which merits emphasis in this regard is the relatively small-scale nature of the environment in which the project will be implemented. Djibouti is a very small country, and the MOA and other ministries are comparably small. In such an environment, frequent interaction among interested parties is the norm, not the exception.

Additional information on the cultural mores of the Afars and Issas, the principal tribal groups in Djibouti, is included in the report of the rural sociologist member of the PP team.

C. Cost-Effectiveness Analysis

The "product" of this project will be information on soils and water which is necessary in the design of subsequent farmer and nomad-oriented projects. This information is a precondition to such projects. In this case, economic analysis focuses on the cost-effectiveness of alternative means to produce soil and water information. Cost-benefit and internal rate of return approaches are unsuitable as no direct, discrete, quantifiable flow of benefits will be forthcoming.

The alternative to an indigenous soil testing capability is dependence upon expatriate technical assistance in every instance. Such a dependence will mean Djibouti will either have to use foreign exchange to hire skils or secure donor assistance whenever soils studies are required. This is clearly a less-effective and more costly approach than using comparatively low-cost indigenous soils anslysts in a national laboratory.

In the case of water resources inventories, the alternative are to (1) continue existing practices of drilling in likely sites in an ad hoc manner, and to exploit the resulting new wells with little regard to the effect upon aquifers, and/or (2) depend upon expatriate assistance along the lines discussed above for soils analysts. Focussing drilling efforts in specific areas on the basis of accumulated and analyzed water data should allow for an increase in the number of successful drillings. Prevention of over-pumping, estimations of the costs of water and allocation of scarce water resources among various claimants will be less expensive in social and financial costs than has been the case in recent history.

The project costs, including the GROD contribution are clear. The flow of benefits to the beneficiaries is much less clear and depends upon many assumptions and variables. Additional other donor projects will have to be implemented before the economic benefits of this project can impact directly on the poor majority. No projects however, can do this effectively without adequate knowledge of water and soils.

D. Financial Analysis and Plan

1. Project Funding Summary

As shown below, the estimated total cost of the project is $695,000. It is proposed that AID will provide $497,000. The GROD will contribute the equivalent of $198,000 over the two-year period of the project.

TABLE 1: PROJECT FUNDING SUMMARY

SOURCE	FOREIGN EXCHANGE	LOCAL CURRENCY	TOTAL
AID	$432,000	$ 65,000	$497,000
GROD	59,000	139,000	198,000
TOTAL:	$491,000	$204,000	$695,000

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2. Summary Cost and Financial Plan

The project costs and financial plan are summarized in the table below. All of the foreign exchange requirements are to be met by AID. Of the AID contribution, 95% represents dollar costs, and the equivalent of 5% represents local costs. The latter consists mainly of administrative support costs.

TABLE 2: SUMMARY COST ESTIMATES AND FINANCIAL PLAN
(1000)

SOURCES	AID		GROD		TOTAL		TOTAL
USE	FX	LC	FX	LC	FX	LC	
Techncial Services	250	---	---	84	250	84	334
Participant Training	14	---	---	---	14	---	14
Commodities	96	---	12	---	96	12	108
Construction	---	---	37	27	37	27	64
Other Costs	---	55	---	6	---	61	61
Inflation (10%)	36	5	5	11	41	16	57
Contingency (10%)	36	5	5	11	41	16	57
TOTAL	432	65	59	139	491	204	695

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TABLE 3: AID OBLIGATION BY COMPONENT (U.S. $)

Component		Amount	Totals
Technical Services			$250,000
Long-Term			
Hydrogeologist (24 pm)		$200,000	
Short-Term			
Soils Scientist (3)		30,000	
Water Resources Planner (2)		20,000	
Participant Training			13,500
U. S.			
Hydrology (6)		8,500	
Short-Term			
Water Chemistry (2 pm)		5,000	
Commodities			96,000
Equipment for water and soils analysis laboratory		80,000	
Vehicles (1)		15,000	
Camping equipment		1,000	
Other Costs			55,500
Aircraft rental		2,000	
Communications, incl. external analyses of soils samples		3,000	
Vehicle operation & maintenance		5,000	
Temporary lodging		6,000	
Subscriptions for technical library		3,000	
Housing and furnishings		36,500	
	SUB-TOTAL	415,000	415,000
Inflation (10%)		41,000	41,000
Contingency (10%)		41,000	41,000
	GRAND TOTAL	$497,000	$497,000

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4. Cost Analysis

The cost of the long-term technician's services are estimated at $100,000 per man-year, including base salary and benefits, allowances, transportatin of effects, round-trip transportation, etc. This assumes a contract with some firm or institution. $6,000 has been included in the budget for temprary lodging in case the housing is not available upon the technician's arrival in Djibouti. Short-term consultant services have been budgeted at $10,000 per man-month, including salary, per diem and round-trip transportation.

Participant training costs have been estimated at $8,500 for six months of academic training in the U.S., and $2,500 per month for short-term technical training in Africa. Estimates are based on the following budgets:

(a) Training In U.S. - Six Months

$ 600	OIT costs
612	Misc. (books, typing, etc.)
238	U. S. travel
2,050	Maintenance and per diem
3,000	Tuition
6,500	
2,000	Round-trip international air fare
$8,500	TOTAL

(b) Short-term Technical - Africa - Per Month

$ 400	Tuition
1,050	Per diem ($35.00 per day)
50	Misc. (books, etc.)
$1,500	
1,000	Round-trip international air fare
$2,500	TOTAL

The $80,000 estimate for equipment for the water and soils analysis laboratory was included in the technical reports of the hydrologist and soils science members of the PP team. The illustrative equipment list is found in Annex D.

5. Project Expenditures

The table below indicates estimated annual expenditures for AID and GROD:

TABLE 4: ESTIMATED ANNUAL EXPENDITURES AND PROJECT COSTS

(U.S. $000)

	1979	1980	1981	TOTAL
AID				
Technical Services	34	106	110	250
Participant Training	----	12	2	14
Commodities	26	60	10	96
Other Costs	26	18	11	55
SUB-TOTAL	86	196	135	417
Inflation (10%)	8	19	13	40
Contingency (10%)	8	19	13	40
TOTAL	102	234	161	497
GROD				
Technical Services	21	42	21	84
Commodities	12	----	----	12
Construction	64	----	----	64
Other Costs	2	2	2	6
SUB-TOTAL	101	44	21	168
Inflation (10%)	9	4	2	15
Contingency (10%)	9	4	2	15
TOTAL	119	52	27	198
COMBINED TOTAL	221	286	188	695

It is assumed that the long-term U.S. advisor will arrive no later than August 1979. The Djiboutian candidate for U. S. long-term training should be scheduled to begin the academic year in September 1980.

E. Administrative Feasibility

The Djiboutian hydrologist in the MOA Rural Engineering Service and the French technical advisor in the MOA are somewhat concerned about the existing, fragmented and random approach to soils analyses and water resources development. To correct this situation, a Commission for Planning will be established within the coming

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months. The Commission will include ministerial representation and will have its own planning staff. Sub-commissions will be established for water, power and renewable energies. This mechanism will provide for liaison and guidance to water-using agencies, such as the MOA Rural Engineering Service. Also under this proposed organization plan, the French-supported Center for Geological Studies and Development will be integrated into the plannint structure, while maintaining iontacts with the University of Bordeaux and other European research institutions. This arrangement will strengthen the capability of the water and soils analysis laboratory to relate academic hydrological studies to applied water and soils investigations. The outlook, then, is hopeful that the outputs of the project will be beneficial to the GROD's overall agricultural planning efforts.

F. Environmental Concerns

An initial Environmental Examination is attached as Annex F. The following statement discussing the environmental impacts of water development is taken from the report of the hydrologist member of the PP team.

At present, the level of water use in Djibouti has had practically no impact on what might be considered its natural hydrological regimes. Even the intensive development of the city of Djibouti has not had any visible impact. Of course, one might look at a place like Randa, with its intensive small-scale agriculture in a narrow canyon, and say that the microclimate has been affected. This is probably true, but is extremely minor.

The key is the extent to which the existing regime is modified. If local areas along channels are over-pumped, some of the scant vegetation will die. However, in most areas, the amount of arable land is so limited that the amount of water pumped for agricultural purposes will have little or no effect on the local environment. Continuously increasing pumpage in the urban areas will no doubt tend to raise the salt water level; but at the same time, as the salt water concentration rises, the well becomes less useful and pumpage is slowed. Gradually, the salt water level drops back to near its former elevation.

In general, the small-scale agricultural developments that are under discussion should have little impact on the water tables. However, large-scale diversions of water, such as that proposed to move water from near Dikhil to Djibouti, may have localized effects on vegetation, result in minor subsidence, and possibly drop the water level below the bottom of some dug wells.

Until large-scale developments are affected, the impact of agricultural and municipal development will have little more than minimal impact on local and regional environments.

IV. IMPLEMENTATION ARRANGEMENTS

A. Administrative Arrangements

I. AID

Upon approval of this Project Paper, a Project Agreement will be negotiated with the GROD Ministry of Foreign Affairs. Upon signature, a sub-obligating PIOT/T will be issued by REDSO/EA authorizing AID/W to contract for the long-term technical services. Possible contractors include water resources engineering firms or, under a PASA, the U. S. Soil Conservtion Service of the U. S. Geological Service. If necessary, a second sub-obligation PIO/T will be issued for the short-term consultant services in water resources planning and soils science. Once the U. S. hydrogeologist is identified, he/she can finalize the required equipment lists for the water and soils analyses laboratory and camping equipment. A subobligation PIO/C(s) will be issued by REDSO/EA for this procurement. Project monitoring and administrative support for the project will be provided by the AAO/Djibouti. REDSO/EA services will be provided as required, throughout the 30-month project period.

2. GROD

The Ministry of Agriculture will be the GROD implementing agency. The U. S. hydrogeologist and short-term consultants will work under the general direction of the Director of the MOA Rural Engineering Service. The MOA will be responsible for identifying Djiboutian candidates for long- and short-term training and for providing the services of other trained water and soils technicians and laboratory assistants. The GROD will also provide suitable h ousing in the city of Djibouti for the technician and his/her family. In the event that the MOA-provided laboratory is not completed prior to the arrival of the technician, suitable office space will be provided by the MOA.

B. Implementation Plan

CY	Month	Action	Responsibility
79	January	PP approved	AAO/D; REDSO/EA
	January	Signature of proj. agreement	AAO/D; REDSO/EA; AID/W
	January	PIO/T issued; contracting begins	AID/W; REDSO/EA
	February	Country clearances obtn'd	AAO/D; GROD
	June	Housing for tech. obtn'd	GROD
	June	(temporary contract)	
	July	Contract technician arrives	AID/W; Contr'tr
	July	Equipment arrives, installation begins	GROD; Contr'tr
	August	Lab layout completed	GROD
	August	Equip. arrives, staff on site	GROD; Contr'tr
	September	Contractor Work Plan finalized & approved	Contractor, AAO/D; GROD
	September	Lab begins operation	GROD; Contr'tr
	September	Field work begins	GROD; Contr'tr
	November	Library functioning	GROD
80	January	Progress report	Contractor
	March	Small-scale, in-depth field studies begin	GROD; Contr'tr
	July	Mid-term evaluation	GROD; AAO/D; REDSO/EA
	July	Progress report	Contractor
	September	Djiboutian departs for long-term training	GROD; AAO/D; AID/W
81	January	Special evaluation	Contr'tr; USAID GROD; AID/W; REDSO/EA
	April	Survey, tests, OJT completed	Contractor
	May/June	Maps completed; reports drafted	Contractor
	June	Djiboutian return from Int. training	
	June	Final progress report	Contractor
	June	Data, maps, final reports finished w/copies submitted to AID & GROD	Contractor; AAO/D; GROD
	June	Technician departs	Contractor; AAO/D; GROD

C. Evaluation Arrangements

A formative evaluation is scheduled for July 1980, approximately one year after the arrival of the U. S. hydrogeologist. The purpose of this evaluation will be to (a) provide an indication of progress achieved towards the project outputs, (b) determine any need for project redirection and (c) establish the timing and frame of reference for a "special evaluation," which should follow six months later. A "special evaluation" (January 1981) will be made 6-8 months prior to completion of the project to determine if there is sufficient justification for AID consideration of a follow-on effort. As has been previously mentioned, it is not anticipated that a complete water resources inventory and soils classification will be accomplished within the 30-month period of the project. If, in the judgment of the "special evaluation" team, continued assistance is warranted, a rationale will be presented in the evaluation report for AID consideration (an inclusion in a follow-on PID). Members of the evaluation team should include a hydrogeologist, a water resources planner and a soils scientist, as well as the REDSO/EA Evaluation Officer. Given the in-depth analyses which will be conducted during the "special evaluation," the summative evaluation, scheduled for July 1981 prior to the departure of the U. S. hydrogeologist, can be undertaken by REDSO/EA and AAO/D, in collaboration with the GROD.

APPENDIX A-6

ATTACHMENT NO. 3

WATER AND SOILS PROJECT

STATEMENT OF WORK

PIO/T

A. OBJECTIVE

To institutionalize within the MOA Rural Engineering Service the capacity to (1) analyze ground and surface water quality as well as to compile, catalogue and disseminate hydrological information, and (2) classify soils, prepare soils maps and provide evaluation concerning the proper utilization of soils.

In practical terms, farmers can be advised on soil treatments to obtain sustainable yields. Achievement of this project purpose should impact on the sector goal of developing an information base for use by the GROD in national agricultural planning, and its dissemination to farmers through the agricultural extension service.

By the end of the project, the laboratory staff of the Rural Engineering Service will:

- possess equipment and technical expertise to independently analyze all water and soils types in Djibouti;
- have necessary data upon which to base recommendations for water/soil use for crop production and provide guidance for subsequent soils/water resource analyses in the field;
- have undertaken a soil inventory and developed a land classifications system in selected priority areas.

B. STATEMENT OF WORK

1. Specifically to accomplish the above, the contractor will:

   a) Establish a water and soils data collection system as well as a system for the data's dissemination and use by other GROD, private and donor institutions;

   b) collate existing and past water and soils data and to extent possible other donor data collection activities;

   c) provide training to GROD personnel in water quality testing and soils data collection and analyses;

   d) undertake soils studies and analyses supportive to ongoing donor studies and independent of other donor efforts in several MOA-USAID targeted areas;

e) given data obtained, provide estimate of further requirements needed to undertake a national overview of soils resources.

2. Indication that the contractor has satisfactorily attained the above will be evidenced by the following:

a) Re soils: has developed field survey and testing methods, such that the country or at least areas showing greatest potential may be methodically covered (duly classified) in the ensuing 5-6 years. Survey and analysis should follow normal "ground truth" practices so that it will complement existing or planned satellite or aerial imagery. Further, has developed map units with appropriate soils classifications, relying on field data, lab reports and other information sources. Also, has developed laboratory (equiped) to point that soil testing requirements can be independently handled therein.

b) Re water resources: coordinates equipping of laboratory and established practices for water quality testing and recording. (Certain commodities deemed critical to functioning soils/water lab are funded under this project, others will be forthcoming from GROD and other donors);

c) A "user service" will be established which will list institutions, GROD, and other donors, which are intimately involved and concerned with Djibouti's land-use. A means and format for dissemination will be tested and implemented;

d) A technical library established and stocked with relevant texts, manuals and journal subscriptions, (in French) in fields of soil science, hydrology, geology and water resource, planning and land-use management. All past and present information (maps, studies, reports) re soils and water will be catalogued;

e) "On-the-job" training provided:

1) A GROD-designated degree lab assistant will be trained in water quality testing soil analyses procedures. He will be under the direction of both the contract assisted Djiboutian pedologist and a trained Djiboutian hydrologist who will be assisted/trained by West German technical assistance team in well-logging interpretation aquifer reconnaissance, stream gauging, meteorological and general hydrogeological techniques and data management to extent that he can fully assume and direct ongoing activities at time West German technical assistance team's departure,

2) A GROD-designated Djiboutian will receive "OJT" in cataloguing and data management.

3) A GROD-contractor designated degree-trained Djiboutian soil scientist will receive "OJT" in soil sampling and analysis, mapping and reporting.

f) Identified two candidates for specialized U. S. or Third Country short-term training in areas: related to soil analyses, and water quality testing. (Eight person-months of training is funded under the project);

g) Based upon project soils and water activities and other existing data, developed comprehensive soils reports. Geographical areas studies by other donors and the Contractor/MOA lab personnel will be analyzed in terms of soil depth, structure (salinity), texture, infiltration and drainage with subsequent recommendations regarding viability of various land-use options, i.e., intensive irrigated vs run-off agriculture for selected crops, cropping patterns, pasturage potential. Water resource component will address water quality, i.e., chemical composition and be supportive to other donors efforts to determine quantity of ground-surface water in order to develop recommendations for its potential application for human, animal and agriculture use.

2) To extent data available, recommend if further investment in this sector is warranted based upon project findings, as well as address the question of further U.S.G. investment vis-a-vis upgrading capabilities within the soils and water laboratory.

C. PERSONNEL

1. In order to implement the above tasks, the contractor will be required to supply the following long-term resident services.

Twenty-four person-months of an experienced BS degree-trained soils scientist. It is expected that this individual will be responsible for attaining project "soils" objectives stated earlier.

In summary he will:

- facilitate equipping soils laboratory, using project, GROD, and other donor funds;

- develop initial annual work plan for GROD-USAID approval within one month arrival and subsequent plans within one year thereof and one month prior to his departure;

- conduct field surveys in following order of priority:

  a) family unit and detail scale (1:100,000) surveys of existing or potential garden areas where management, irrigation techniques, reclammation procedures, crops and drainage have to be adapted to soil conditions and water quality/availability. Areas by order of priority and magnitude are tentatively first year:

     - Moulud (100 ha)
     - Doudubbala "
     - Forrage Grand Bara (200 ha)

  b) In medium-scale (1:50,000) surveys of major plains and valleys, in order to plan further development of potential irrigation areas. Areas by order of priority and magnitude are tentatively second year:

     - Gobaad (10,000 ha)
     - Hanle (5,000 ha)
     - Tadjourah (5,000 ha)

  c) For both a) and b) above see attached map and proposed keyed implementation phases.

  d) developed plan for small-scale survey (1:200,000) of country, which would provide basic information on uplands and stratify soil environments according to their potential for grazing, carrying capacity, etc.

- prepare reports on above surveys with accompanying land-use recommendations. Also included will be following field maps:

a) large-scale mapping of gardens (existing or potential) at a scale less than 1:100,000. Terminology should be in agreement with USDA system and will need to be at the family level.

b) Reconnaissance mapping at 1:50,000 in valleys and plains. Phases of sub-group will probably be the units to be recognized during mapping.

c) Developing plan for eventual exploratory survey of whole country at 1:200,000. Units will be mostly natural regions, in which great soil groups would be described.

- develop land-use recommendations vis-a-vis above areas surveyed relying principally upon: field tests to determine permeability, infiltration in areas where irrigation is planned, lab analyses to determine texture, pH, organic carbon, electric conductivity, cations, cation exchange, water availability, bulk density, boron;

- as early as possible, determine extent to which MOA soils lab can satisfy above requirements, and, where determined unable, to develop system/relationship for analysis outside Djibouti;

  - provide "OJT" for one MOA degree-trained Djiboutian pedologist assigned as Director of Rural Engineering Soils section and one lab assistant charged with lab analyses;

  - provide "OJT" training to lab assistant in soils analyses and reporting;

  - given existent or planned satellite or aerial photos to develop information such that it will serve as baseline "ground truth" data, upon which time-lapse analysis may ultimately be developed;

  - be ultimately responsible for establishing within MOA/Rural Engineering Service, a technical library and user service;

  - be tasked to coordinate soils collection analyses activities with other donors or per GROD designated priorities whichever takes precedence;

  - as Chief of Party be charged with informing GROD, MOA, and USAID on quarterly progress of project activities and bringing to GROD-USAID attention any problems/shortfalls, expected as result of, for example, insufficient manpower, training, commodities, donor coordination, etc.

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Moreover, will be responsible for coordinating TDY visits, synthesizing contractor's results. In the absence of hydrologist, he will be expected to provide guidance to water chemist. Hence, it is desirable to fill this position with someone who has had some water quality testing experience.

2. Short-term contractor services, 8 person months will be required as follows:

a) five person months of an experienced MS degree-trained hydrologist. It is expected that this individual will be responsible for attaining project water resource objectives stated above.

In summary he will:

- facilitate equipping laboratory using project, GROD, and other donor funds;

- be charged with providing "OJT" to MOA hydrogeologist and/or lab assistant counterpart in water quality testing and reporting.

It is expected hydrologist will make three two-month TDY's. Two in the first year, one in the second year of project to monitor and provide direction for activities previously scheduled during his stay here. The last trip will require his/her preparing final reports;

b) Remote sensing expert (1 person month) who will make recommendations concerning satellite/aerial reconnaissance as supplementary effort to this project;

c) To be identified (2 person months), possibly water resources planner or senior hydrogeologist who will arrive at beginning of third year and be specifically charged with assisting in final development of reports especially with respect to summarizing long-term GROD agricultural development potential and policies based upon other donor activities/results in water sector. It should be noted that a different technical service mix might be required other than that described above. Subsequent contractor reports and evaluation will serve as source for identifying such requirements, e.g., agronomist.

D. TIMING

It is requested that the contractor's designated soils scientist and hydrologist arrive in October. Upon arrival the resident team will undertake general field/air reconnaissance; develop detailed annual work plan to be submitted by November 1979. Given that USAID intends to order bulk of project equipment, no later than May, 1979, it is reasonable to assume that majority of lab and field commodities, including vehicle will be on-site by November, 1979. Hence it will be expected that resident team will spend majority of time, November-

December, in equipping laboratory, and familiarizing itself with existing material on water and soils in Djibouti. Hydrologists will depart in CY 1979.

First quarter of CY 1980 soils scientist will continue to provide instruction to designated lab assistant(s) in water quality testing and soils lab analyses.

Contractor will set in motion establishment of library, system for cataloguing past, present and future data and developing "user service."

Second quarter will see soils scientist continue lab "OJT" and begin field analysis in major prioritized areas; e.g., Moulud, Grand Bara.

Third/fourth quarters will have soil scientist continuing above and to extent feasible initiating larger scale survey of plain sites where GROD, other donors agricultural projects are planned, e.g., Gobaad. Toward end CY, soil scientist will develop second annual work plan, which will include additional TDY assistance foreseen. During this period remote sensing expert will arrive make recommendations regarding satellite/aerial recon requirements, and hydrologist for two months TDY assistance in support of lab operations.

During early CY 1981 a joint USAID/AID/W annual evaluation will be undertaken. Primary purpose of this evaluation will be to ascertain project contractor's progress toward meeting specified objectives and based upon findings to possibly recommend additional follow-on activity. Furthermore, during this period, the hydrologist will return to do follow-up work in water quality testing procedures. Soils scientist will have finalized reports on Moulud, Grand Bara areas.

Second quarter of 1981 will see soils scientist finalizing soil reports based upon follow-up gardens, plain/mountain studies undertaken in Gobaad and initiating further studies in priority plain/mountain areas, e.g., Hanle and Tadjourah.

This quarter will be devoted to completing field work and drafting reports on Hanle, Tadjourah as well as developing plan for national soils survey.

Fourth quarter soils scientist will depart.

In early 1982, soil scientist and senior hydrogeologist (water resource planner) will return for one person-month each to observe ongoing activities, update studies/reports. To extent possible, USAID final evaluation will be conducted concurrent with their visit. Final reports will be submitted to USAID, GROD and AID/W no later than two and one-half (2-1/2) years from the time of contract team's arrival.

The above represents USAID expected contractor scenario which, however, is subject to amendment based upon USAID approval/review of contractor recommendations and/or USAID/AID/W formal evaluation.

It should be noted that the contractor is expected to provide continuing "OJT" throughout resident tenure and subsequent TDY's. For that reason, the contractor will be expected to periodically report on counterpart and staff's progress toward grasping instruction/guidance provided and hence, institutionalization of project activities.

It is hoped that USAID will be able to identify and send water chemist for training so that he will have returned by time resident team arrives. To extent USAID is unable to fulfill this objective, it will be expected that the contractor will do so.

E. REPORTS

1. Annual Work Plan.

2. Quarterly progress regarding lab activities, outputs in support institutionalization.

3. Specific area reports (to be determined) which discuss objective of study, methods used, results and recommendations. In case of soils work this should be accompanied by maps referred to earlier.

4. Final report, synthesizing comprehensive soils analyses and water quality testing reports which would cover all areas addressed during life of project and provide preliminary recommendations regarding future U.S.G. assistance in this area.

F. ADMINISTRATIVE & OTHER DONOR COORDINATION

(Contractor Working Relationships)

It is understood that GROD presently perceives the Rural Engineering Service within MOA as the institution responsible for surveying, analyzing Djibouti's soil/water potential and recommending preferable land-use options, as well as providing for utilization of water in rural areas.

1. In support of the above objectives, the Rural Engineering Service is organized into the following sections under the present Chief of Service Mr. Mohamed Wabari.

a) Administration/Accounting

b) Maintenance - charged to provide support and maintenance to all facets of services operation

c) Public Works/Drilling - charged to:

1) develop identified water sources in rural areas for agriculture/human use, i.e., water points, barrages, etc.

2) provide test drilling using Saudi-Arabian well rigs (2) in order to identify possible water sources.

d) Research comprised:

1. Water analyses - charged to:

a) undertake well-logging, well net monitoring to determine quantity of groundwater.

b) (provisional) do stream (wadi) gauging to determine run-off for purposes identifying surface water potential.

c) Use indigenous lab facility for testing quality of water for human/agricultural use and furnishing technical reports concerning results.

d) develop comprehensive plan, synthesize above for making specific recommendations for water potential/usage.

2) Soils analyses - charged to:

a) undertake field analysis, develop classification system and maps in order to determine agricultural potential for irrigated versus run-off agriculture.

develop lab into unit capable of independently conducting necessary soils type analysis and furnishing technical reports on analyses.

develop comprehensive plan for effecting analyses in potential agricultural areas, i.e., plains, maountains and national in that order of priority.

3) Library - charged with compiling, collating data, reports, maps, photos, all material produced supportiive to Rural Engineering Service.

2. At present GROD staffing requirements remain to be further defined with respect to the Soils and Water section; however, it is tentatively planned that the water secion will have as its head a degree-trained hydrogeologist assisted by a water chemist in the laboratory, who will most probably double as the soils lab analyst. It is expected that within a year additional hydrologist positions will be added. The soils section will have as its head a degree-trained pedologist, specializing in arid/saline soils and assisted by one lab assistant (see preceding sentence).

A library will be staffed by a clerk who will receive subsequent training in cataloguing and will have a secretary who will support soils and water, plus libary section tasks. All sections will be housed in a new laboratory/office complex, which includes 150 m2 of floor space, chemistry benches, with access to distilled and tap water and a stable electrical power source, four sinks and a wall bench with cabinets for the storage of glassware and supplies. Other facilities will include three offices, a sample preparation room, a supply and storage and an instrument room. Estimated completion date is November 1979.

3. Other donor assistance will be supportive in following manner:

a) French technical assistance in hydraulics-general engineering (2 persons) will be expected to assist Public Works section in carrying out its objectives and specifically provide operational support for rigs, "OJT" and special training to selected drill crews. Assistance expected before end CY 1979.

b) West German technical assistance (2-year project beginning in CY 1979 providing 48 full-time person months of hydrogeologist and technician) who will develop plan for intensive hydrological survey of Djibouti. Attached to the water section, they will be initially expected to do well-logging, and stream gauging; to determine water quantity via pump testing, gauging static, dynamic charge in already agreed upon priority areas, e.g., Grand Bara, Gobaad, Hanle and Tadjourah. They will provide TDY assistance to assist in identifying prospective sites for Public Works section test drilling. They will establish well nets to determine aquifer volume, precise locations and as part of all above provide "OJT" to section chief hydrogeologist, provisional hydrologist and to drill crews in logging procedures. They will provide field samples to the water lab chemist who will be expected to test its quality. Based upon field and lab results, the hydrogeologist will prepare reports with recommendations.

c) French expertise (nature undefined) will be provided to the Chief of Service. It is expected that assistance in administration and land-use science will be provided full-time beginning in late 1979. The land-use scientist will be principally charged with synthesizing results from water (W. German assisted) and soils (U.S. assisted) sections in terms of agricultural potential of areas jointly studied, and developing, in coordination with those sections and their advisors, a National Resource inventory plan for subsequent implementation.

4. As previously stated and further detailed in organigram the contractor will be responsible for:

a) developing the laboratories of the water/soils sections;

b) providing operational and advisory support to the soils section in toto;

c) confine activities in water section to training water quality chemist;

d) developing library and training librarian.

5. Given that the contractor will work across organizational lines he will be expected to report to the Chief of Service only, but also coordinate field tasks closely with head of West German hydrological assistance team (English speaking).

APPENDIX A-7

Resources Development Associates - Contract

COST REIMBURSEMENT TYPE CONTRACT

Agency for International Development
Negotiated Contract No. AID/afr-C-1673

Contract Type
Cost Plus Fixed Fee

CONTRACT FOR:

Djibouti Water Resources and Soils Analysis

Project No: 603-0001

ISSUING OFFICE (Name and Address)

Contracting Officer
Regional Operations Division, Africa
Office of Contract Management
Agency for International Development
Washington, D.C. 20523

CONTRACTOR (Name & Address)

Resources Development Associates
P.O. Box 407
Diamond Springs, CA 95619

ACCOUNTING & APPROPRIATION DATA:
PIO/T NO. 603-0001-3-90002

Appropriation No:
72-1191021.3

Allotment No:
943-54-603-00-69-91

NAME OF CONTRACTOR

Resources Development Associates

s/Kenneth B. Craib, Partner

Date: 10/3/80

UNITED STATES OF AMERICA
AGENCY FOR INTERNATIONAL DEVELOPMENT

s/Michael H. Snyder, Contracting Officer

Date: October 3, 1980

CONTRACT NO. AID/afr-C-1673

SCHEDULE

COST REIMBURSEMENT TYPE CONTRACT

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SCHEDULE

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ARTICLE I - STATEMENT OF WORK

A. Objective

The purpose of this contract is to institutionalize within the Ministry of Agriculture (MOA) Rural Engineering Service the capabity to (1) analyze ground and surface water quality as well as to compile, catalogue and disseminate hydrological information, and (2) classify soils, prepare soils maps and provide evaluation concerning the proper utilization of soils.

In practical terms, farmers can be advised on soil treatments to obtain sustainable yields. Achievement of this contract purpose should impact the sector goal of developing an information base for use by the Government of the Republic of Djibouti (GROD) in national agricultural planning, and its dissemination to farmers through the agricultural extension service.

By the end of the contract, the laboratory staff of the Rural Engineering Service will:

- possess equipment and technical expertise to independently analyze all water and soils types in Djibouti;
- have necessary data upon which to base recommendations for water/soil use for crop production and provide guidance for subsequent soils/water resource analyses in the field;
- have undertaken a soil inventory and developed a land classifications system in selected priority areas.

B. Statement of Work

1. Specifically to accomplish the above, the contractor will:

a. Establish a water and soils data collection system as well as a system for the data's dissemination and use by other GROD, private and donor institutions;

b. Collate existing and past water and soils data and to extent possible other donor data collection activities;

c. Provide training to GROD personnel in water quality testing and soils data collection and analyses;

d. Undertake soils studies and analyses supportive to ongoing donor studies and independent of other donor efforts in several MOA-USAID targeted areas;

e. Given data obtained, provide estimate of further requirements needed to undertake a national overview of soils resources.

2. Indication that the contractor has satisfactorily attained the above will be evidenced by the following:

a. Re soils: has developed field survey and testing methods, such that the country or at least areas showing greatest potential may be methodically covered (dually classified) in the ensuing 5-6 years. Survey and analysis should follow normal "ground truth" practices so that it will complement existing or planned satellite or aerial imagery. Further, has developed map units with appropriate soils classifications, relying on field data, lab reports and other information sources. Also, has developed laboratory (equipped) to point that soil testing requirements can be independently handled therein.

b. Re water resources: coordinates equipping of laboratory and established practices for water quality testing and recording. (Certain commodities deemed critical to functioning soils/water lab are funded under this project; others will be forthcoming from GROD and other donors);

c. A "user service" will be established which will list institutions, GROD, and other donors, which are intimately involved and concerned with Djibouti's land-use.

A means and format for dissemination will be tested and implemented.

d. A technical library established and stocked with relevant texts, manuals and journal subscriptions, (in French) in fields of soil science, hydrology, geology and water resource, planning and land-use management. All past and present information (maps, studies, reports) re soils and water will be catalogued;

e. "On-the-job" training provided:

1. A GROD-designated degree lab assistant will be trained in water quality testing soil analyses procedures. He will be under the direction of both the contract assisted Djiboutian pedologist and a trained Djiboutian hydrologist who will be assisted/trained by West Geraman technical Assistance team in well-logging interpretation, aquifer reconnaissance, stream gauging, meteorological and general hydrogeological techniques and data management to extent that he can fully assume and direct ongoing activities at time West German technical assistance team's departure.

2. A GROD designated Djiboutian will receive on-the-job training (OJT) in cataloguing and data management.

3. A GROD-contractor designated degree-trained Djiboutian soil scientist will receive "OJT" in soil sampling and analysis, mapping and reporting.

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f. Identified two candidates for specialized U. S. or third country short-term training in areas: related to soil analyses, and water quality testing.

g. Based upon project soils and water activities and other existing data:

1. Developed comprehensive soils reports. Geographical areas studied by other donors and the Contractor/MOA lab personnel will be analyzed in terms of soil depth, structure (salinity), texture, infiltration and drainage with subsequent recommendations regarding viability of various land-use options, i.e., intensive irrigated vs. run-off agriculture for selected crops, cropping patterns, pasturage potential. Water resource component will address water quality, i.e., chemical composition and be supportive to other donor's efforts to determine quatity of ground-surface water in order to develop recommendations for its potential application for human, animal and agricultural use.

2. To extent data available, recommended if further investment in this sector is warranted based upon project findings, as well as address the question of further U.S.G. investment vis-a-vis upgrading capabilities within the soils and water laboratory.

C. PERSONNEL

1. In order to implement the above tasks, the contractor will supply the following long-term resident services:

Twenty-four person months of an experienced BS degree-trained soils scientist. It is expected that this individual will be responsible for attaining project "soils" objectives stated earlier.

In summary he will:

- facilitate equipping soils laboratory, using project, GROD, and other donor funds;

- develop initial annual work plan for GROD-USAID approval within one month of final arrival and subsequent plans within one year thereof and one month prior to his departure;

- conduct field surveys in following order of priority:

a. family unit and detail scale (1:10,000) surveys of existing or potential garden areas where management, irrigation techniques, reclamation procedures, crops and drainage have to be adapted to soil conditions and water quality/availability. Areas by order of priority and magnitude are tentatively first year:

- Moulud (100 ha)
- Doudubbala (100 ha)
- Forrage Grand Bara (200 ha)

b. in medium scale (1:50,000) surveys of major plains and vALleys, in order to plan further development of potential irrigation areas. Areas by order of priority and magnitude are tentatively second year:

-	Gobaad	(10,000 ha)
-	Hanle	(5,000 ha)
-	Tadjourah	(5,000 ha)

c. developed plan for small-scale survey (1:200,000) of country, which would provide basic information on uplands and stratify soil environments according to their potential for grazing, carrying capacity, etc.

- prepare reports on above surveys with accompanying land-use recommendations. Also included will be the following field maps:

a. large-scale mapping of gardens (existing or potential) at scale less than 1:10,000. Terminolody should be in agreement with USDA system and will need to be at the family level.

b. Reconnaissance mapping at 1:50,000 in valleys and plains. Phases of sub-group will probably be the units to be recognized during mapping.

c. Developing plan for eventual exploratory survey of whole country at 1:200,000. Units will be mostly natural regions, in which great soil groups would be described.

- develop land-use recommendations vis-a-vis above areas surveyed relying principally upon: field tests to determine permeability, infiltration in areas where irrigation is planned, lab analyses to determine texture, pH, organic carbon, electric conductivity, cations, cation exchange, water availability, bulk density, boron;

- as early as possible, determine extent to which MOA soils lab can satisfy above requirements, and, where determined unable, to develop system/relationship for anlysis outside Djibouti9;

- provide "OJT" for one MOA degree-trained Djiboutian pedologist assigned as Director of Rural Engineering Soils section and one lab assistant charged with lab analyses;

- provide "OJT" to lab assistant in soils analyses and reporting;

- given extent or planned satellite or aerial photos to develop information such that it will serve as baseline/"ground truth" data, upon which time-lapse analysis may ultimately be developed;

- be ultimately responsible for establishing within MOA/Rural Engineering Service, a technical library and user service;

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- be tasked to coordinate soils collection analyses activities with other donors or per GROD designated priorities whichever takes precedence;

- as Chief of Party, be charged with informing GROD, MOA, and USAID on quarterly progress of project activities and bringing to GROD-USAID attention any problems/shortfalls expected as result of, for example, insufficient manpower, training, commodities, donor coordination, etc.

Moreover, will be responsible for coordinating TDY visits and synthesizing contractor's results. In the absence of hydrologist, he will be expected to provide guidance to water chemist. Hence, it is desirable to fill this position with someone who has had some water quality testing experience.

2. Short-term contractor services up to eight (8) person-months will be required.

D. TIMING

It is requested that the contractor's designated soils scientist and hydrologist arrive in July, 1980. Upon arrival the resident team will undertake general field-air reconnaissance; develop detailed annual work plan to be submitted by August, 1980. Given that USAID intends to order bulk of project equipment no later than May, 1979, it is reasonable to assume that majority of lab and field commodities, including vehicle will be on site by November, 1979. It will be expected that resident team will spend majority of time, September-October, 1980, in equipping laboratory, and familiarizing itself with existing material on water and soils in Djibouti. Hydrologist will depart in CY 1980.

Fourth quarter of CY 1980 soils scientist will continue to provide instruction to designated lab assistant(s) in water quality testing and soils lab analyses.

Contractor will set in motion establishment of library, system for cataloguing past, present and future data and developing "user service."

First quarter of CY 1981 will see soils scientist continue lab "OJT" and begin field analysis in major prioritized areas; e. g., Moulud, Grand Bara.

Second/third quarters of CY 1981 will have soil scientist continuing above and to extent feasible initiating larger-scale survey of plain sites where GROD, other donors agricultural projects are planned, e. g., Gobaad. Toward middle/end CY soil scientist will develop second annual work plan, which will include additional TDY assistance foreseen. During this period remote sensing expert will arrive and make recommendations regarding satellite/aerial recon requirements, and hydrologist will arrive for two months TDY assistance in support lab operations.

During fourth quarter CY 1981 a joint USAID/AID/W annual evaluation will be undertaken. Primary purpose of this evaluation will be to ascertain project contractor's progress toward meeting specified objectives and based upon findings to possibly recommend additional follow-on activity. Furthermore, during this period, the hydrologist will return to do follow-up work in water quality testing procedures. Soils scientist will have finalized reports on Moulud, Grand Bara areas.

First quarter of CY 1982 will see soils scientist finalizing soil reports based upon follow-up in gardens, plain/mountain studies undertaken in Gobaad and initiating further studies in priority plain/mountain areas, e.g., Hanle and Tadjourah.

This quarter will be devoted to completing field work and drafting reports on Hanle, Tadjourah as well as developing plan for national soils survey.

Third quarter CY 1982 soils scientist will depart.

In late 1982, soil scientist will return for one person month each to observe ongoing activities update studies/reports. To extent possible, USAID final evaluation will be conducted concurrent with his visit. Final reports will be submitted to USAID, GROD and AID/W no later than two and one-half (2-1/2) years from time of contract team's arrival.

The above represents USAID expected contractor scenario which, however, is subject to amendment based upon USAID approval/review of contractor recommendations and/or USAID/AID/W formal evaluation.

It should be noted the the contractor is expected to provide continuing "OJT" throughout resident tenure and subsequent TDY's. For that reason the contractor will be expected to periodically report on counterpart and staff's progress towards grasping instruction/guidance provided and hence institutionalization of project activities.

It is hoped that USAID will be able to identify and send water chemist for training so that he will have returned by time resident team arrives. To extent USAID is unable to fulfill this objective, it will be expected that the contractor do so.

E. REPORTS

The Contractor shall submit the following reports:

1. Annual Work Plan.

2. Quarterly progress reports regarding lab activities, outputs in support institutionalization.

3. Specific area reports (to be determined) which discuss objective of study, methods used, results and

recommendation. In case of soils work this should be accompanied by maps referred to earlier.

4. Final report, synthesizing comprehensive soils analyses and water quality testing reports which would cover all areas addressed during life of project and provide preliminary recommendations regarding future U.S.G. Assistance in this area.

All reports, including annual work plans, shall be in French and English. The Contractor is required to submit quarterly reports as well as end-of-project report to the USAID Director and to the Minister of Agriculture. The reports to the former must be in French (3 copies) and English (3 copies); the reports to the latter in French only (3 copies). In addition, ten (10) copies in English of the end-of-project report should be sent to the Djibouti Project Officer, AFR,DR/EAP, Department of State, Washington, D.C. 20523.

F. ADMINISTRATIVE & OTHER DONOR COORDINATION (Contractor Working Relationships)

It is understood that GROD presently perceives the Rural Engineering Service within MOA as the institution responsible for surveying, analyzing Djibouti's soil/water potential and recommending preferable land-use options, as well as providing for utilization of water in rural waters.

1. In support of the above objectives, the Rural Engineering Service is organized into the following sections under the present Chief of Service, Mr. Mohamed Wabari:

   a. Administration/Accounting.

   b. Maintenance - charged to provide support and maintenance to all facets of services operation.

   c. Public Works/Drilling - charged to:

      1) Develop identified water sources in rural areas for Agriculture/human use, i.e., water points, barrages, etc.

      2) Provide test drilling using Saudi-Arabian well rigs (2) in order to identify possible sources.

   d. Research comprised:

      1) Water analyses-charged to:

         a) undertake well-logging, well net monitoring to determine quantity of groundwater,

         b) (provisional) do stream (wadi) gauging to determine run-off for purposes identifying surface water potential,

c) use indigenous lab facility for testing quality of water for human/agricultural use and furnishing technical reports concerning results,

d) develop comprehensive plan, synthesize above for making specific recommendations for water potential/usage.

2) Soils analyses-Charges:

a) undertake field analysis, develop classification system and maps in order to determine agricultural potential for irrigated vs. run-off agriculture,

b) develop lab into unit capable of independently conducting necessary soils type analysis and furnishing technical reports on analyses,

c) develop comprehensive plan for effecting analyses in potential agricultural area, i.e., plains, mountains and national in that order of priority,

3) Library-charged with compiling, collating data reports, maps, photos, all material produced supportive to Rural Engineering Service.

2. At present GROD staffing requirements remain to be further defined with respect to the Soils and Water section; however, it is tentatively planned that the Water section will have at its head a degree-trained hydrogeologist assisted by a water chemist in the laboratory, who will most probably double as the soils lab analyst. It is expected that within a year an additional hydrologist position will be added. The soils section will have at its head a degree-trained pedologist, specializing in arid/saline soils and assisted by one lab assistant (see preceding sentence). A library will be staffed by a clerk who will receive subsequent training in cataloguing and will have a secretary who will support soils and water and library section tasks. All sections will be housed in a new laboratory/office complex, which includes 150 cubie meters of floor space, chemistry benches, with access to distilled and tap water and a stable electrical power source, four sinks and a wall bench with cabinets for the storage of glassware and supplies. Other facilities will include three office, a sample preparation room, a supply and storage and an instrument room. Estimated completion date is November 1979.

3. Other donor assistance will be supportive in the following manner:

a. French technical assistance in hydraulics-general engineering (2 persons) will be expected to assist Public Works section in carrying out its objectives and specifically provide operational support for rigs, "OJT" and special training to selected drill crews. Assistance expected before end CY 1979.

b. West German technical assistance (2-year project beginning in CY 1979 providing 48 full-time person months of hydrogeologist and technician) who will develop plan for intensive hydrological survey of Djibouti. Attached to the water section, they will initially be expected to do well-logging and stream gauging; to determine water quantity via pump testing, gauging static, dynamic charge in already upon priority areas, e.g., Grand Bara, Gobaad, Hanle and Tadjourah. They will provide TDY assistance to assit in identifying prospective sites for Public Works Section test drilling. They will establish well nets to determine aquifer volume precise locations and as part of all above "OJT" to section chief hydrogeologist, provisional hydrologist and to drill crews in logging procedures. They will provide field samples to the water lab chemist who will be expected to test its quality. Based upon field and lab results, the hydrogeologist will prepare reports with recommendations.

c. French expertise (nature undefined) will be provided to the Chief of Service. It is expected that assistance in administration and land-use science will be provided full-time beginning in late 1979. The land-use scientist will be principally charged with synthesizing results from water (West German assisted) and soils (U. S. assisted) sections in terms of agricultural potential of areas jointly studied, and developing, in coordination with those sections and their advisors, a National Resource inventory plan for subsequent implementation.

4. As previously stated and further detailed in organigram the contractor will be responsible for:

a. developing the laboratories of the water/soils sections;

b. providing operational and advisory support to the soils section in toto;

c. confine activities in water section to training water quality chemist;

d. developing library and training librarian.

5. Given that the contractor will work across organizational lines he will be expected to report to the Chief of Service only, but also coordinate field tasks closely with head of West German hydrological assistance team (English speaking).

ARTICLE II - KEY PERSONNEL

A. The key personnel which the contractor shall furnish for the performance of this contract are as follows:

Key Personnel - Dr. Joseph Goebel-- Soils Scientist

B. The personnel specified above are considered to be essential to the work being performed hereunder. Prior to diverting any of the specified individuals to other programs, the Contractor shall notify the Contracting Officer reasonably in advance and shall submit justification (including proposed substitutions) in sufficient detail to permit evaluation of the impact on the program. No diversion shall be made by the Contractor without the written consent of the Contracting Officer; provided, that the Contracting Officer may ratify in writing such diversion and such ratification shall constitute the consent of the Contracting Officer required by this clause. The listing of key personnel may, with the consent of the contracting parties, be amended from time to time during the course of the contract to either add or delete personnel, as appropriate.

ARTICLE III - LEVEL OF EFFORT

The Contractor shall furnish the following technicians over a two-year period for the duration listed below in performance of the work under this contract:

Number	Specialized Field	Duration
1	Soils Scientist	24 person-months

In addition, 4 person-months of home office professional services will be furnished.

ARTICLE IV - PERIOD OF CONTRACT

The effective date of this contract is June 24, 1980, and the completion date is September 30, 1982.

ARTICLE V - ESTIMATED COST AND FIXED FEE

The total estimated cost of this contract exclusive of fixed fee is $306,338.00. The fixed fee is ________.

ARTICLE VII - LOGISTIC SUPPORT TO CONTRACTOR

1. USAID/Djibouti will furnish the Contractor the following logistic support:

a. Housing and utilities

b. Furniture

c. Household equipment (i.e., stove, refrigerator, etc.)

d. Transportation within Djibouti

2. The cooperating country will furnish the Contractor the following logistic support:

a. Office space

b. Official vehicle(s)

3. USAID/Embassy will assist the Contractor in clearing duty-free effects and consummables.

4. The Contractor shall arrange for the following logistic support using contract funds:

a. Transportation to and from country

b. Shipment of household effects (not to exceed 2,500 lbs) for long-term technician by combination surface/air from technician's U.S. residence to Djibouti and return.

c. Shipment by surface of consummables not to exceed 1,500 lbs. net.

d. Shipment to post and return of privately-owned vehicle (POV) for long-term technician.

e. Other shipping allowances as applicable.

f. Materials/supplies.

g. Vehicle operation and maintenance.

h. Laborers (approximately four) for soil survey.

i. Language training for soils chemist (up to 5 weeks)

LABORATOIRE D'ANALYSE DES SOLS ET DES EAUX

RÉPUBLIQUE DE DJIBOUTI

APPENDIX B

THE LAW ESTABLISHING THE SOILS AND WATER ANALYSIS LABORATORY

THE LAW ESTABLISHING THE SOILS AND WATER ANALYSIS LABORATORY

The following document was prepared for the President of the Republic of Djibouti and the National Congress to establish the autonomy of the Laboratory of Analysis of Soil and Water from Genie Rural to operate directly under the Ministry of Agriculture and Rural Development.

It establishes its existence, personnel positions, authority and budget. In January 1983, funding should begin for the laboratory based on this document.

R E P U B L I Q U E DE D J I B O U T I

UNITE - EGALITE - PAIX

PRESIDENCE DE LA REPUBLIQUE

LOI N° 241/AN/82

PORTANT création d'un Laboratoire d'Analyse des SOLS et des EAUX.

L'ASSEMBLEE NATIONALE A ADOPTE
LE PRESIDENT DE LA REPUBLIQUE PROMULGUE
LA LOI DONT LA TENEUR SUIT :

VU les lois constitutionnelles n°s LR/77-001 et 77-002 du 27 Juin 197

VU l'Ordonnance n° LR/77-008 en date du 30 Juin 1977,

VU le Décret n° 81-076/PR du 7 Juillet 1981 portant nomination des membres du Gouvernement,

VU l'Accord signé entre la République de DJIBOUTI et les ETATS-UNIS d'Amérique en date du 14 Avril 1979,

VU l'Avis de l'Agence des Etats-Unis pour le Développement International,

ARTICLE 1er : - Il est créé un Laboratoire d'Analyse des Sols et des Eaux au sein du Ministère de l'AGRICULTURE et du Développement Rural.

ARTICLE 2 : - Il constitue l'embryon du futur centre des recherches agronomiques du Ministère de l'Agriculture et du Développement Rural.

ARTICLE 3 : - Il a pour attributions : la prospection, l'inventaire, la recherche et la cartographie des sols et l'analyse des sols et des eaux. Il assure l'étude de tous les problèmes techniques découlant de ces attributions, procède à la prépara-

./. En particulier il est chargé :

1. Des études de pédologie générale,
2. Des études et des recherhes des ressources édaphiques,
3. De l'établissement des programmes annuels et pluriannuel d'études détaillées des sites à vocation agricole,
4. Des études spécifiques concernant l'usage des sols,
5. Du contrôle de l'évolution de la qualité des sols et des eaux des puits et des forages,
6. De l'analyse des constituants chimiques des eaux souterraines et de surface pour les besoins humains, des animaux, industriels et urbains,
7. DE l'analyse des éléments nutritifs et autres constituants minéraux et chimiques importants à la croissance des plantes,
8. De l'étude descompottement de la plante en fonction des qualités des eaux et des sols,
9. De l'élaboration de toutes les cartes des bassins versants, des pentes, de la climatologie, des sols à l'échelle appropriée et les cartes d'occupation des sols ;
10. De l'interprétation de chaque sol et échantillon d'eau et de leurs usages futurs (agricoles, industriels, urbains...) ;
11. De l'évaluation des ressources en sols de toute la République de Djibouti ;
12. De l'assistance technique nécessaire à la vulgarisation des techniciens agricoles ;
13. De la lutte contre l'érosion
14. De la détermination des sites menacés par la désertification et des moyens de lutte ;
15. Du suivi des populations phytosociologiques ;
16. D'apporter son conours technique et actif :
    - au service de l'Agricultûre et des Forpets dans le cadre des politiques de conservation des sols et du choix des types et doses d'irrigation aussi bien que dans les enquêtes auprès des Jardins administratif et privés ;

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- au Service de l'Elevage et des Pêches en ce qui concerne l'assistance technique à la gestion des pâturages, des zones à mettre en défense ;
- au Service du Génie Rural dans le cadre de l'hydraulique pastorale et des analyses des eaux ;
- à l'Institut Supérieur d'Etudes et des Recherches Scientifiques et Techniques pour les analyses de ses échantillons d'eau et de sol ;
- au Service d'Hygiène et d'Epidémiologie, à la Direction des Travaux Publics, à la Régie des Eaux aux agriculteurs privés et à tous les propriétaires fonciers qui en font la demande.

ARTICLE 4 :- Il dispose d'une bibliotèque technique et d'une collection d'articles techniques sur les ressources naturelles du Pays.

ARTICLE 5 : - Le laboratoire est placé sous la tutelle du Ministre de l'Agriculture et du Développement Rural et est dirigé par un ingénieur agropédologue assisté de personnel administratif et technique dans la limite de ses inscriptions budgétaires.

ARTICLE 6 :- Le personnel est régi par le STATUT de la Fonction Publique et les textes subséquents pour son application ou par le code du travail.

ARTICLE 7 : - Il est créé au titre du laboratoire dans le Budget National à la rubrique Ministère de l'Agriculture et du Développement Rural une ligne intitulée "Budget de fonctionnement du Laboratoire d'Analyse des Sols et des Eaux".

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ARTICLE 8 : - Pour la réalisation de ces tâches, il dispose de ses propres crédits dans le cadre du Budget National ainsi que les subventions éventuelles et les dons octroyés par les Pays amis.

ARTICLE 9 : - [illegible] contrôles des dépenses sont soumis au Ministère des Finances et de l'Economie Nationale.

ARTICLE 10 : - Le Laboratoire facture les services qu'il rend aux autres établissements gouvernementaux disposant d'un budget de fonctionnement, aux agences privées et aux organismes étrangers. Il établit des tarifs préférentiels aux agriculteurs nationaux. La fixation des tarifs des prestations sera arrêtée ultérieurement en Conseil des Ministres.

ARTICLE 11.: - Le recouvrement des recettes sera assuré par le Trésorier Payeur National sur présentation de quittance délivrée par le comptable et inscrit à la Section Recettes du Laboratoire d'Analyse des Sols et des Eaux du Budget National.

ARTICLE 12. : - La laboratoire d'Analyse des Sols et des Eaux est organisé en deux sections :

- une section administrative et comptable ;
- une section technique relevant directement du Chef du Laboratoire.

ARTICLE 13 : - Le Ministère de l'Agriculture et du Développement Rural et le Ministère des Finances et de l'Economie Nationale sont chargés de l'application de la présente LOI qui sera publiée au Journal Officiel de la République de DJIBOUTI, dès sa promulgation.

FAIT à DJIBOUTI, le 29 AVRIL 1982.

Par le Président de la République

HASSAN GOULED APTIDON

BUDGET PREVISIONNEL DE L'ANNEE 1983

Liminaire:

Le Laboratoire d'Analyse des Sols et des Eaux dont la loi portant création fut promulguée le 29 avril 1982 est né à la suite de l'accord américano-djiboutien du 14 avril 1979 et est entré en fonction en juillet 1980. Il se propose d'entreprendre tous les travaux d'enquête, de description et de cartographie du milieu en général.

Ses agents passent le tiers de leur temps sur le terrain.

Le contrat prendra fin en juillet 1982 et il appartient au gouvernement de la République de Djibouti de prévoir d'ores et déjà la relève sur le plan technique aussi bien que sur le plan administratif.

Comme moyens de déplacement, le laboratoire dispose d'une Land Rover Station Wagon(10 places)et d'une Daihatsu Jeep(6 places)qui fonctionnent toutes les deux à l'essence ordinaire et constituent par conséquent de vrais gouffres à essence. La Land Rover qui a parcouru toute la brousse nécessite de plus en plus d'entretien et nous prévoyons déjà une Toyota Land Cruiser à Chassis Court(Diesel). Comme tous les sites ne sont pas accessibles, nous faisons appel parfois aux services de l'hélicoptère de l'Armée Nationale.

Pour avancer régulièrement et assez vite en description des sols, en analyses et par conséquent en cartographie, autre le personnel technique, il disposera de deux manoeuvres permanents qui assureront le travail de fonçage des profils pédologiques.

Nous désirons sur les crédits des dépenses communes nous abonner aux publications de la "Nation" et du Journal Officiel National de la République de Djibouti.

1. Dépenses de Personnel

.1. Postes existants

Il existe actuellement le poste d'ingénieur agronome(indice 1250)et celui de conducteur des travaux agricoles(indice 700). Ces deux postes appartiennent encore au Service de l'Agriculture et des Forêts dont les titulaires sont détachés et portent respectivement les numéros suivants: 28 et 16.

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1.2. Création d'emploi

Le laboratoire entreprend des travaux de recherche et doit obligatoirement disposer d'un personnel qualifié pour donner des recommandations fructueuses basées sur des résultats précis et fiables. Ainsi pour qu'il y ait une bonne division du travail, il faudra créer les emplois suivants:

- 1 poste de chef de la section administrative et comptable (indice 900)
- 1 poste de technicien de laboratoire (indice 850) qui assurera la bonne conduite des analyses et le contrôle du matériel,
- 2 postes de laborantins hautement qualifiés (indice 700) qui assureront le travail quotidien du laboratoire,
- 1 poste de secrétaire comptable (indice 700) qui sera chargée également de la bibliothèque,
- 1 poste de chauffeur mécanicien (catégorie 3A) qui assurera l'entretien du parc automobile et la conduite en brousse,
- 1 emploi de fille de salle (catégorie 1B) qui garantira la propreté des locaux et le lavage journalier des verreries,
- 2 emplois de gardiens (catégorie 1A) qui s'occuperont de la sécurité de tout le laboratoire,
- 2 emplois de manoeuvres (catégorie 1A) qui creuseront les profils pédologiques,
- 1 emploi de planton (catégorie 1A) qui assurera la liaison avec les autres établissements publics et privés

1.3. Frais de déplacement

Plus haut nous avons vu que le personnel du laboratoire s'occupera en grande partie de la description et de la cartographie du milieu rural. Il jouera également le rôle d'intermédiaire entre le service de l'Agriculture et des Forêts et les agriculteurs. C'est pourquoi il est demandé un crédit forfaitaire de 500 000 FD justifié entr'autres par la demande des services de l'hélicoptère.

1.4. Heures supplémentaires

(Voir le Tableau ci-joint). Conformément à ce tableau, il est demandé 307 615 FD pour couvrir les heures supplémentaires. Pour ce qui est du chef du laboratoire il est demandé une indemnité de responsabilité de 350 points d'indice (45 250 FD). Il est demandé un sursalaire de 10 000 FD aux gardiens qui assureront la surveillance et la sécurité du laboratoire 24 heures sur 24 à tour de rôle.

2. Dépenses de Matériel (Fonctionnement)

2.1. Ventilation

2.1.1. Paragraphe 1. Fournitures de bureau et entretien des locaux.

Le laboratoire utilise trop de papiers et de films spéciaux. Vu les prix exhorbitants de ce matériel, il est demandé un crédit de 500 000FD.

Bien que le bâtiment soit neuf le toit et le plafond laissent passer l'eau s'il pleut beaucoup. Egalement la paillasse des salles n° 8 et 10 nécessite des travaux de réfection. Le montant total de ces travaux justifié par les devis ci-inclus s'élève à 1 362 227 FD.

Ainsi pour ce paragraphe il est demandé un crédit de 1 862 227 FD

2.1.2. Paragraphe 3: Téléphone

Il est demandé un crédit de 500 000 FD justifié par l'installation de la nouvelle ligne téléphonique et l'accroissement des prix des communications et les nombreux contacts avec les établissements scientifiques étrangers.

2.1.3. Paragraphe 4 : Habillement

Le personnel du laboratoire doit porter obligatoirement des blouses blanches pour éviter tout contact avec les réactifs chimiques. Et à raison d'une blouse par personne et par trimestre, on a besoin de vingt huit blouses dans l'année (5 techniciens + 1 fille de salle + 1 secrétaire).

Le chauffeur mécanicien et les gardiens doivent avoir 6 tenues kaki. Ainsi il est demandé un crédit de 78 400 FD justifié par le devis ci-joint.

2.1.4. Paragraphe 5: Moyens de transport

Etant donné que nous devons nous déplacer sans cesse pour avoir le maximum d'enseignement sur nos sols, disposant de deux véhicules (Land Rover Station Wagon et 1 Jeep Daihatsu) et ayant demandé 1 Jeep Toyota châssis court, il est sollicité un crédit de 500 000 FD. Nous demandons 15 600 litres d'essence ordinaire et 6 000 litres de gas-oil comme indiqué par le tableau ci-inclus.

2.1.5. Paragraphe 6: Matériel et Mobilier non renouvelables

Le laboratoire étant le nouveau né de nos services, en dehors du matériel en surplus fourni par l'USAID, il nécessite:

- 5 chaises et fauteuils
- 5 bureaux R 150X 75 2 coffres
- 2 tabourets
- 3 armoires métalliques FH 100 avec 4 étagères

- 1 machi... à écrire électrique ADLER 46 cm
- 1 machine à calculer Adler 120 P
- 1 photocopieuse RR 5080
- 1 duplicateur RR 750

Ainsi il est demandé un crédit de 2 253 500 FD justifié par la facture proforma ci-inclus et 130 000 FD pour l'achat au planton d'une mobylette Yamaha Tassola, soit 2 383 500 FD justifié également par la facture ci-jointe.

2.1.6. Paragraphe 7 : Achat des réactifs chimiques

Ce paragraphe et les suivants sont spécifiques au laboratoire. Les réactifs chimiques constituent la colonne vertébrale du laboratoire. L'année dernière l'USAID a pu commander des produits dont le montant s'élève à 25 000 $ USA. Aussi, vu l'inflation à laquelle ils sont soumis, il est demandé un crédit forfaitaire de un million de francs Djibouti (1 000 000 FD).

2.1.7. Paragraphe 8 : Acquisition des verreries et appareils usuels et entretien du matériel

Le laboratoire est équipé d'un matériel moderne et cher dont une partie peut s'avérer inutilisable ou dépassé au bout d'un an de fonctionnement. La pédologie étant une jeune science qui reçoit de plus en plus d'audiences et de performances, on assiste actuellement à un boom du matériel dont: pipettes, tarières, cylindres gradués, appareils portatifs tels que pHmètres, termomètres, clysimètres...

Donc pour que notre tâche aille de pair avec les nouveautés scientifiques, il est sollicité un crédit forfaitaire de un million de francs Djibouti (1 000 000 FD).

2.1.8. Paragraphe 9: Acquisition des livres et des revues scientifiques

Un laboratoire efficace doit être au courant des progrès réalisés dans son domaine. C'est pourquoi, il est indispensable de s'abonner à plusieurs périodiques scientifiques étrangers et acheter tous les ans les ouvrages interessant qui paraissent. Pour cela, il est sollicité un crédit forfaitaire de 200 000 FD.

Service : Laboratoire d'Analyse des Sols et des Eaux

Exercice 1983

TABLEAU N° 1

FONCTIONNAIRES (En Place)

Noms	Grade et Fonctions	Situation de famille	Indice de solde	Solde Net	P.F.	Total	Réservé à la Direction des Finances
Aboubaker Douale	Ingénieur Agronome	Célibataire	1250	145 782		145 782	
Farah Hadji Omar	Laborantin	Marié	700	84 114	2 000	86 114	
TOTAL				229 896	2 000	231 896	

.B. Ces deux postes appartiennent encore au Service de l'Agriculture et des Forêts dont les titulaires étaient initialement détachés et il y a lieu de procéder à leur transfert.

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Service : Laboratoire d'Analyse des Sols et des Eaux — Exercice 1963

TABLEAU N° 1 Bis

FONCTIONNAIRES (Création d'Emploi)

P.n.	Noms	Grade et Fonctions	Situation de Famille	Indice de Solde	Solde Net	P.F.	Total	Réservé à la Direction des Finances
		Technicien de laboratoire		850				
		Laborantin		700				
		Laborantin		700				
		Secrétaire Comptable		700				
		Chef de la Section administrative et comptable		900				
		TOTAL						

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Service : Laboratoire d'Analyse des Sols et des Eaux　　　　Exercice 1983

TABLEAU N° 2 Bis

Personnels Relevant de la Convention Collective du 28 Juin 1973

(CREATION D'EMPLOI)

N.B.	Noms	Classe-ment	Situation de famille	Salaire Net Conventionnel	Sursalaire	Indemnités Diverses	Total	Réservé à la Direction des Finances
5	Chauffeur mécanicien	3A						
6	Fille de salle	1B						
7	Gardien	1A						
8	Gardien	1A						
9	Manoeuvre	1A						
10	Manoeuvre	1A						
11	Planton	1A						
	TOTAL							

Service : Laboratoire d'Analyse des Sols et des Eaux

Exercice 1983

TABLEAU N° 5 A

HEURES SUPPLEMENTAIRES

	Noms	Salaire de Base	Nombre d'H /an	25%	50%	75%	Coût Annuel	réservé à la Direction des Finances
16	Farah Hadji Omar	90 542	300				66 788	
1	Technicien de Labor.	109 917	300				80 788	
2	Laboratoire	90 542	300				66 788	
3	Laboratoire	90 542	300				66 788	
5	Chauffeur mécanicien	59 400	300	23 783	2 680		26 463	
		Sous Total		Coût annuel pour le service 307 [illegible]				

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TABLEAU N° 6

Dépenses de Fonctionnement (MATERIEL)

LATURE	Exercice en cours	Propositions	JUSTIFICATIONS	Réservé à la Direction des Finances
iture de bureaux et retien des locaux		500 000	Le laboratoire est un service qui utilise trop de papiers et de films spéciaux.La propreté des locaux contribue à la fiabilité des résultats.Les verreries sont entretenues par de l'eau distillée ou de l'acide.Ceci justifie nos propositions susmentionnées.	
Téléphone		500 000	L'installation d'un intercom et les nombreux contacts avec les organismes scientifiques étrangers et l'augmentation des prix des communications justifient largement nos propositions.	
Habillement		78 400	L'ensemble du personnel du laboratoire doit porter des blouses pour éviter tout contact avec les réactifs.Les gardiens et les manoeuvres et les mécaniciens doivent avoir des bleus de travail.Ceci est justifié par la facture proforma ci-inclus	
ens de transport et Indemnités kilométriques		500 000	Les véhicules du laboratoire sont tout le temps en tournée en brousse et demandent des révisions et un entretien continus.Parfois nous faisons appel	

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TABLEAU N° 6 (suite)
Dépenses de Fonctionnement (MATERIEL)

NENCLATURE	Exercice en cours	Propositions	JUSTIFICATIONS	Réservé à la Direction des Finances
			aux services de l'hélicoptère de l'Armée Nationale pour les sites inaccessibles par Land-Rover.C'est pourquoi nous demandons ce montant.	
Matériel et mobilier non renouvelable		2 253 500 + 130 000 = 2 383 500	Comme le laboratoire est un nouveau service il doit être équipé en bureaux,armoires,machine à écrire et à calculer,en photocopieuse,en duplicateur,en chaise...la facture proforma ci-jointe justifie ce montant.A cela il faudra ajouter 130 000 F.D. pour l'achat d'un cyclomoteur au planton(voir facture proforma ci-jointe)	
TOTAL		3 961 900		

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TABLEAU N° 8

CARBURANTS

?	NOMBRE	Consommation aux 100 KM	KILOMETRAGE ANNUEL	BESOINS ANNUELS (litres)		Réservé à la Direction des Finances
				ESSENCE	GAS-OIL	
ROVER	1	25 l.	25 000	8400		
JEEP DAIHATSU	1	25 l.	20 000	7200		
		Total des besoins		15 600		

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TABLEAU N° 9

Travaux d'entretien et Réparations des Bâtiments

ts	Travaux (Justifications)	Coût	Réservé à la Direction des Finances
N° 8 et 9	Féfection de la paillasse: le carrelage des paillasses est mal posé et la moitié des carreaux s'enlèvent ou se cassent sous le poids des appareils. Les appareils devant reposer sur une paillasse bien horizontale pour avoir des résultats fiables nous demandons la réfection de toutes les paillasses dont le montant justifié par le devis ci-joint s'élève à 735 777 F.D.	735 777	
oits et Plafond es 4 salles du aboratoire	Les toits et les plafonds laissent passer l'eau lorsqu'il pleut en présence de vent. Nous avons constaté ceci lors des fortes pluies de mars dernier qui ont endommagé une partie des cartes que nous avons élaborées. Pour mettre le matériel à l'abri des intempéries il nous est urgent d'entreprendre les travaux de réfection le plus tôt possible. Le montant est justifié par le devis ci-inclus.	626 450	
	TOTAL	1 362 227	

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TABLEAU N° 11 A

ACQUISITIONS DE MATERIELS

I. VEHICULES

	PUISSANCE	PRIX	AFFECTATION	R ou S	Réservé à la Direction des Finances
Jeep Toyota Land Cruiser Chas.Court Diesel		2 550 000	Tournées en brousse prospection pédologique.	S	
Toyota Corolla DX		1 470 000	Services en ville	S	
	TOTAL	4 020 000			

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TABLEAU N° 11 B

ACQUISITION DE MATERIELS
MATERIEL SPECIFIQUE DES SERVICES

.l demandé	Nombre	Coût	Justifications	Réservé à la Direction des Finances
civimètre portatif WTW LF ssenschaftlich Techni sche ... D 8120 Weilheim avec lectrode LFB 101/8	1 1	50 000 FD	Cet appareil portatif résiste beaucoup aux chocs,il est simple donne des résultats précis sur la qualité de l'eau.Il est durable.	
erreries dont fioles,tubes, reusets,ballons,calcimètre ernard,thermomètres,Erlenmeyer, ïchner,et petit matériel dont hronomètre,agitateurs,papier iltre,papier Joseph,pipettes, essicateurs...		950 000 FD	Cette somme est arrêtée d'une manière un peu arbitraire car la plupart de ces matériels sont très fragiles et deviennent hors d'usage avec le temps ou se cassent facilement.En plus de ça, de nouveaux matériels plus simples et plus fiables paraissent tous les ans.	
	TOTAL	1 000 000 FD		

<u>Service</u> : Laboratoire d'Analyse des Sols et des Eaux

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TABLEAU N° 12

VEHICULES EN SERVICE

ralogique inistratif	MARQUE	PUISSANCE FISCALE	ANNEE D'ACHAT	AFFECTATION	ETAT	Réservé à la Direction des Finances
1138 B	Land-Rover		1980	Travail de terrain	Assez Bon	
1146 B	Jeep Daihatsu		1981	Conseiller Technique	Bon	

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TABLEAU N° 14

ABONNEMENTS

...e la Revue, Journal, Document	Adresse de l'Editeur	Montant Annuel	Réservé à la Direction des Finances
...etin FAO d'Irrigation et de ...ainage	Publications de la FAO Via Delle Terme Di Caracala 00-100 Rome. Italie.	6 000	
...hiers O.R.S.T.O.M. Série Pédologie	Editions de l'ORSTOM 70 -74 Route d'Aulnay 93 140 Bondy - France.	6 000	
...hiers O.R.S.T.O.M. Série Hydrologie	Editions de l'ORSTOM 70 -74 Route d'Aulnay 93 140 Bondy - France.	6 000	
...ronomie Tropicale	Institut de Recherches Agronomiques Tropicales et de Cultures Vivrières. 110, Rue de l'Université 75 340 Paris - France.	7 000	
	TOTAL	25 000	

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LABORATOIRE D'ANALYSE DES SOLS ET DES EAUX

RÉPUBLIQUE DE DJIBOUTI

APPENDIX C

MISCELLANEOUS PROJECT DOCUMENTS

APPENDIX C-1

Quarterly Progress Reports

To: Ellsworth Amundson, USAID/Djibouti

From: Joseph E. Goebel, RDA

Subject: Progress Report, Djibouti Soils/Water Project
July 1980 - January 1981 (Contract C-1673)

Date: January 20, 1981

This is the first progress report for the Soils and Water Laboratory project in Djibouti, Africa, and covers the period of July 22, 1980 to January 22, 1981. Subsequent reports will be prepared on a quarterly basis.

I. Work Originally Scheduled for the First Two Quarters

It was anticipated that, in the first quarter, the project would start with the arrival of the senior technical advisor. Plans were to be drawn to complete the construction of the laboratory facilities. The equipment, which had already arrived, was to be inventoried. Chemicals, materials, field equipment, and remote sensing imagery were to be selected and ordered through the services of USAID or RDA as appropriate. Construction was to be completed in September. Materials were to be located and ordered for the library. Field reconnaissance of the soils and agricultural resources of Djibouti was to be made to place the project into perspective.

During the second quarter, training was to begin in soil description and classification if the laboratory facilities were not completed. An "Annual Work Plan" was to be prepared. Training was to be given in soil cartography via preparation of a slope map and a watershed map. A preliminary soils map was to be prepared and a random soil sample drawn to establish a data base to permit evaluation of the agricultural resources and to assist in monitoring land-use change.

II. Work Accomplished

All of the objectives were effectively met with the exception of completion of the laboratory facilities. The senior technical advisor, Joseph Goebel, was mobilized to Djibouti on July 14, 1980, within two weeks of the company receipt of contract and notification to proceed.

On arrival, a Djiboutian degree-trained pedologist, Mr. Aboubaker Douale, was presented to the project TDY from the Agricultural Service. He is a capable and well-trained young man.

The first task was to prepare an inventory of the equipment which had already arrived some months earlier. Following this, detailed plans for the laboratory facilities layout were prepared. These plans were used to plan the work, purchase materials and contract technical services.

Next, a list was prepared of chemicals, materials, field equipment and remote sensing imagery needed to achieve the project's objectives. Some library materials were also required. Between RDA and AID/Djibouti, all of the orders were placed by November. No commodities or materials have yet arrived. Part of this delay is due to the nature of much of the commodities and materials. Chemicals defined as "hazardous" must be shipped sea freight, which is considerably slower than air shipment.

In November, it was determined that a second small, four-wheel-drive vehicle was necessary to complete the objectives of the project. Its purchase has been approved, but the vehicle is not yet in service. It was also decided that film positive color separates of the twelve sheets of the 1:100,000 series topographic maps should be purchased to assure accurate map construction and location of mapped features. This purchase has been approved, but the maps have not been received.

In September, the laboratory assistant, Farah Omar, was assigned to the project TDY from the Agricultural Service without a permanent appointment. He is eager and capable of learning the laboratory procedures, but he will need supervision in cases of unusual occurrences and demands.

In October, this three-man team made a reconnaissance of the country by vehicle and air. This was particularly useful in putting the soil and agricultural resources into perspective. It also clarified the logistics of field operations.

Soils training was initiated in the second quarter. Most of this training time was spent in describing and classifying soils to familiarize the team with soil conditions in Djibouti and how these soils occur in their natural environment. Both men responded well to training. They work well together as a team and should well understand the description and classification of soils by the end of the project. Fifteen soil series were recognized during the training. These descriptions will be used in training for soil analyses. The results of these analyses will establish the background chemistry of the soils in Djibouti.

Next, training was given in cartography. Mr. Douale was taught to make slope maps which are essential in land-use planning. Slopes are also an important soil characteristic. Mr. Omar was taught to make watershed maps. These are necessary to determine the surface water potential and will be used in conjunction with the soils maps and the slope map to determine the areas of combined soil and water potential for agriculture.

The senior advisor, Dr. Goebel, drew a random sample of 1,000 plots, each a square kilometer in size, to be used in natural resource assessment and land-use monitoring. The soil survey will sample and test these sites while characterizing and classifying the soils of Djibouti. The data base will then be used to statistically test the natural resource production as desired in the future.

III. Modifications in the Plan and Their Consequences

The most outstanding "modification" in the plan was that the laboratory facilities were not completed in September. They are now projected to be completed in March, 1981. As a consequence, priorities have been restructured and effort redirected from laboratory training to soil survey training. This should produce better background information for both the laboratory and the personnel.

As noted earlier, it was decided in November that a second four-wheel-drive vehicle was necessary to complete the objectives of the project. This vehicle will allow the laboratory and field work to continue as planned and will also facilitate servicing the laboratory clientele.

Similarly, it was decided that the film positive color separates of the twelve sheets of the 1:100,000 topographic map series should be purchased. When they arrive, these maps will facilitate accurate production and reproduction of soils maps and other auxiliary maps.

IV. Obstacles to Reaching Objectives

It is now anticipated that the laboratory facilities will be completely installed in March. If all construction has not been completed by then, the work plan will definitely be altered. One month is required for setting up the equipment after the laboratory is completed. It is imperative that maps, equipment, chemicals and imagery be here by April. At present, there are not enough of any of these to do an adequate job for any of the project objectives, with the exception of training in soil survey.

The laboratory personnel have been receiving mixed directives concerning the administrative position of the laboratory between the Ministry of Agriculture and Rural Engineering Service. Their TDY status leaves doubt as to whom they work for or report to. What is more, Mr. Omar was assigned to the laboratory in September, but did not receive his job appointment or salary until January 15. Understandably, this affected his ability to concentrate on training. TDY assignment leaves the men without the authority or responsibility to achieve the project objectives. The project would benefit from a clear statement on the issue of TDY status. The laboratory can function effectively either as a department in the Rural Engineering Service or as a service directly under the Ministry of Agriculture. Because the laboratory will service many agencies and individuals, it may be more effective directly under the Ministry of Agriculture.

The laboratory assistant has received neither short-term nor formal training in laboratory procedures and techniques for either soil or water anlysis. He will receive on-the-job training sufficient to perform routine analyses. After this project, he will need some further work and training in a long-established laboratory.

Working without equipment or materials has been difficult. Working without office space and in the middle of construction for six months has made it almost impossible to maintain a sense of order and achievement, especially in a project where there are high demands on expertise, quality and speed.

QUARTERLY REPORT

To: Ellsworth Amundson, USAID/DJIBOUTI Date: April 25, 1981

From: Dr. Joseph Goebel, Project Manager, RDA

Subject: Quarterly Report, Djibouti Soil/Water Project

This is the second progress report and it covers the period of January 23, 1981 to April 25, 1981.

I. Work Originally Scheduled for the Third Quarter

Thirty soils were to be described during this period. This data would provide baseline information for the country's soils and would allow grouping the soils based on similar characteristics in order to evaluate soil test results done in the laboratory.

The 1:100,000 scale (12 sheet series) slope maps and watershed maps were to be drawn. These will be used to assess the soil and water capabilities of Djibouti in conjunction with a preliminary soils map based on the known geology, climatic indicators, topographic maps, and satellite imagery.

A random sample of 1,000 locations of one square kilometer was to be taken to represent 5% of the natural resources area. This sample will allow correlation of detailed investigations in soils, hydology, range, agriculture, and rural economics. It will also serve to monitor resources changes and to establish ground truth for future remote sensing evaluations of the conditions in Djibouti.

Training was to be given in remote sensing covering both satellite imagery and aerial photography as they are related to soils and soils investigations. These techniques can expedite the accurate identification and location of soil types.

Construction work on the laboratory was to be completed and the laboratory equipment properly installed in preparation for training in water analyses. Materials and supplies previously requested were to be delivered by the end of this quarter.

II. Work Accomplished

Sample collection, soils identification, classification and description proceeded effectively for the soils of southern Djibouti. The staff characterized and separated the major soil areas and established a framework to distinguish the various soils. Forty soil profiles were sampled and described. The samples are stored at the laboratory for later chemical and physical testing.

One hundred random inventory sample sites were chosen from which to collect basic data for the general soils map. The forty soil profiles described were associated with forty inventory sample sites, thus beginning the detailed technical descriptions of these sites. The staff collected data on soils, vegetation, slope and geomorphology.

Training was given on remote sensing. A review was made of the basic elements of remote sensing using as a text the ASP "Manual of Remote Sensing" and other references. Specific training was given in recognizing, on satellite imagery, the features of Djibouti. Aerial photographic interpretation training was concentrated in the Mouloud areas' ground. Both counterparts have responded well to the training and are applying their new knowledge to the project.

Construction on the laboratory facilities has proceeded throughout the quarter. Work still remains to be done. The equipment has not been placed in the laboratory due to the construction activity.

The slope and watershed maps at the 1:100,000 scale, the preliminary soils map and the soils climate map are essentially completed. We have also received the film positives of the three color plates for the 12 sheets of the 1:100,000 scale topographic map.

In response to a special request by the Minister of Agriculture, the staff of the laboratory prepared a status report for the Ministry. This status report contained, not only a description of the work performed to date, but a detailed budget for operating the laboratory and some administrative recommendations on the position of the laboratory within the government and servicing responsibilities, vis-a-vis potential end-users.

The four-wheel-drive Daihatsu vehicle arrived during the quarter. In addition, field equipment, more Landsat imagery and diazo color separations off Landsat imagery arrived.

III. Modifications in the Plan and Their Consequences

The construction on the laboratory was not completed. It is essential all construction be complete before setting up the laboratory since construction activities will disrupt training and endanger the equipment, materials, and supplies. Some cabinets, painting, and electrical work are the primary jobs remaining. These are minor matters but appear to be very time-consuming due to the detailed nature of the work.

Training on the laboratory techniques cannot begin until the equipment, materials and supplies are properly installed and functional. More than a year is needed to give proper training in the procedures for the many analyses to be performed by the laboratory. Thus, construction must be completed as soon as possible. It is believed possible for construction to be completed within six weeks.

The status and budget report prepared for the Minister of Agriculture was necessary but unexpected. It delayed entry into the field to collect samples by three weeks. Later, there was a three-week interruption in field work due to heavy rain which severely damaged the trails used to travel to the sample sites. As a consequence, fourteen sites remain to be described in order to complete the soils work in the southern half of the country. These will take about a week to complete.

The bulk of the materials and supplies have not yet arrived and may not be available until the end of the year. The chemicals needed for water analyses were ordered separately by RDA and were due to be shipped April 15, 1981 and require 6-8 weeks by surface freight. Training will be restricted in scope until these supplies and materials arrive since the available supplies and materials will serve to do only basic water analyses.

V. Plans for the Coming Quarter

It is expected the construction on the laboratory will be completed shortly so that the supplies, materials and equipment can be installed as quickly as possible. Immediately training will begin in water quality testing procedures. In the meantime, semi-detailed soil mapping will begin in Domerjog and Deydey watersheds. By the end of the coming quarter, the next Annual Work Plan will be written.

QUARTERLY REPORT

To: Ellsworth Amundson, USAID/Djibouti Date: June 25, 1981

From: Dr. Joseph Goebel, Project Manager, RDA

Subject: Quarterly Report, Djibouti Soil/Water Project

This progress report covers the period of April 25, 1981 to June 26, 1981.

I. Work Originally Scheduled for the Fourth Quarter

The overdue construction of the laboratory facilities was to be completed and laboratory equipment installed during this quarter so laboratory analyses training could begin. Training and mapping for a semi-detailed soil survey, scale 1:27,000, was to be initiated for the Domerajog and Deydey wadis watersheds.

II. Work Accomplished

Semi-detailed, scale 1:27,000 soil mapping and training was begun by locating the photographs, matching them correctly to each other, making a composite base map, locating kilometer grid coordinates on each photo, and establishing the resources random inventory sites in the study area. Further field progress awaits the arrival of the stereoscope.

All of the 53 resources random sites were described except the five inaccessible ones. These sites have all been described, and classified in English and French and soil samples preserved. This information was used as ground truth to identify the soil types on the 1:250,000 scale colored Landsat photographs.

The soils of the southern half of Djibouti have now been established and mapped at the 1:250,000 scale and work was begun on the 1:100,000 scale soils map.

Final drafting of the watershed and slope maps with the completion of the Djibouti and Loyada 1:100,000 scale topographic maps.

Remote sensing training advanced with the preparation of aerial photographs for detailed soils mapping and for soils interpretation of the 1:250,000 colored Landsat photographs.

The international Desert Forest Control Organization's meeting in Djibouti and subsequent meeting in Uganda required an unexpected use of two weeks time of the principal counterpart's time.

III. Modifications in the Plan and their Consequences

Completion of the laboratory facilities are now scheduled for September, six months after scheduled completion. This calls for delaying implementation and training on laboratory procedures. Consequently effort was directed towards final drafts of the watershed and slope maps and applying more effort toward completing the 1:100,000 soils map and initiate semi-detailed mapping of Deydey and Domerajog.

Delay in the arrival of chemicals and equipment has also resulted in directing efforts to the work which is not dependent on them, such as drafting maps and matching photographs.

IV. Obstacles to Reaching the Objectives

The delay in completion of the laboratory facilities until September, six months behind schedule, will seriously limit training on laboratory analyses.

Aboubaker Douale was temporarily reassigned to assist the DLCO's international meeting in Djibouti and a management meeting in Uganda. He, therefore, was not available for two weeks of training and work. On-the-job training means the personnel must both learn and produce effectively. It is important that the trainee is available for work and working satisfactorily, as well as, studying and understanding the subject matter. Such a situation requires twice the effort on the part of the participant to take advantage of the program in the project. Reassignment elsewhere confuses the training and the Work Plan.

Mr. Douale has found it very difficult to attend to work and training during the past quarter due to the uncertainties concerning the organizational position of the laboratory and the resources he has been given to exercise his responsibilities. He has even suggested he may return to France for further schooling. The status and budget of the laboratory needs to be clarified so that men may understand how they are going to contribute to the long-term success of the laboratory. Mr. Duale has demonstrated the capability to handle both the technical and administrative requirements of the laboratory. He must be given the facilities to do both so he can accomplish the responsibilities of the laboratory.

The chemicals and equipment ordered last year have not yet arrived. Some are scheduled in a few weeks and the rest in September. Therefore, the laboratory should be able to begin training in September.

V. Plans for the Coming Quarter

During the coming quarter we expect to complete the 1:100,000 and 1:250,000 scale soil maps of the southern half of Djibouti.

The 1:100,000 watershed maps and slope maps should be completely drafted.

The Domerajog and Deydey watersheds should be mapped.

The laboratory equipment should be set up to begin training.

QUARTERLY REPORT

To: Ellsworth Amundson, USAID/Djibouti Date: October 25, 1981

From: Dr. Joseph Goebel, Project Manager RDA

Subject: Quarterly Report, Djibouti Soil/Water Project

This report covers the period June 26, 1981 to October 26, 1981.

I. Work Originally Scheduled for the Fourth Quarter

During this quarter it was expected that the 1:125,000 scale soils map of the southern half of Djibouti would be completed; the 1:100,000 scale watershed and slope maps were to be completely drafted; the Domerajog and Deyudey watersheds were to be mapped; the laboratory equipment was to be set up so laboratory training could begin; the laboratory construction was to be monitored/finished; and the equipment was to be inventoried, and a list of publications for the library completed.

II. Work Accomplished

During this quarter the soils maps at the 1:100,000 and 1:250,000 scale were largely interpreted and final checking and drafting was initiated. However, a special project for the United Nation's High Commission on Refugees requesting technical assistance on resettling refugees and the homeless on an agricultural project intervened. Nevertheless, the 1:100,000 scale watershed map and slop map and U.T.M. kilometer grid maps were completed. The watershed map and the contour maps were sent to Germany to be reduced to 1:300,000 scale to provide a more-manageable size. This base (1:300,000) map will be used to report general resource information about Djibouti. Mapping of the Deydey and Damerajog watersheds was postponed temporarily due to other work.

The equipment available was installed in the laboratory. More equipment is due next quarter. Some of the equipment received (AC's) is not functional due to deficient electrical supply. In fact, one of the AC's burned out. Laboratory training, therefore, has not been given. The inventory of current equipment is complete. The list of books to be purchased has been completed. Aboubaker Douale attended three weeks training in remote sensing at FAO in Rome. I spent two weeks on vacation. Farah Omar learned to use the planimeter and measured the slope areas and watersheds on the 1:100,000 scale maps. We attended the Ministry of Agriculture's weekly technical meeting which proved to be helpfull regarding resolving many stagnant problems. We continued to supervise the slow rehabilitation of the laboratory. We wrote the Annual Work Plan. We prepared the laboratory budget for 1982.

Two papers were developed and accepted for presentation in Cairo, Egypt, at the International Remote Sensing Symposium concerning natural water containment sites in Djibouti and remote sensing as it applies to soils resource assessment. We presented a display of the work of the laboratory at the World Food Day event. Cooperative assistance has been given the German Mission on surface water location, availability, recognition and methods of acquisition. Assistance was given to the Catholic Relief Services on selection of Soils and Water for Food for Work project in Ali Sabieh and the Petit Bara.

We assisted the Minister of Agriculture in giving a technical report to the UNHCR on two sites to resettle refugees and the homeless. Both sites were mapped at 1:25,000 scale and the irrigation potential determined for the different soils classified. Various people sought advice and information from the laboratory. Besides the German Mission's regular requests, the Arab League of Nations' representative, (a horticulturist) received technical advice. The European Economic Community representative received a day of consultation/orientation of the facility. The Atar project received routine backstopping consultation. The Minister of Agriculture received technical advice and reports as requested. We made a field visit with him to the Dikhil region and supplied him with the requested soils report for the UNHCR.

III. Modifications in the Plan and Their Consequences

Minor construction on the laboratory still has not been accomplished. Therefore, the office has not been organized and equipment installed. Consequently, the team has been working under very confined circumstances which have not been conducive to good productivity. This and the loss of the air conditioners and an improper supply of electricity has prevented the operational implementation of the laboratory equipment and, therefore, training in laboratory procedures has not begun. Without the electricity and office, the laboratory has not been completed for occupancy now over a year from initial construction.

Outside requests such as special studies or meetings or reports consumed time and/or redirected the efforts of the laboratory personnel. Often these cannot be avoided or foreseen such as the refugee resettlement or meeting with the MOA or preparation of the budget, and supporting training and meetings. As a result the soils maps are not complete.

IV. Obstacles to Meeting the Objectives

The main obstacle to meeting the objective is the deficiency of equipment all of which are on order and expected to arrive in late December. Unfortunately, outside interruptuions cause a slippage of our objectives. The lack of a budget for the laboratory has been a serious obstacle because the needs of the laboratory cannot be met. Specifically, all of the needed personnel cannot be assigned. Per diem is not paid. Without assurance of its payment, we cannot return to the field in December because the men will not be duly reimbursed. These are only some of the problems of operating without a budget. A generator which supplies 110V 60HZ current must be obtained before the laboratory equipment can be made operable. It is expected to arrive in December.

The Special Soils Reports directed effort to mapping the Deydey and Damerajog watersheds. These reports will be considered as well as the detailed studies for the Hanle and Gobahd agricultural projects per the PIO/T scope of work. The watersheds will be mapped later in the project.

V. Plans for the Coming Quarter

In the coming quarter we expect to finish the soils report for the MOA to UNHCR.

We expect to complete the measurement and report on the size of watersheds and their slope groups.

We will await the equipment and hopefully install it in the first quarter of 1982.

We will begin the field work for soil mapping the northern half of Djibouti.

We will gather the data necessary to prepare soils maps for the Deydey and Damerajog watersheds.

QUARTERLY REPORT

To: Ellsworth Amundson, USAID/Djibouti Date: January 25, 1982

From: Dr. Joseph Goebel, Project Manager RDA

Subject: Quarterly Report, Djibouti Soil/Water Project

This report covers the period October 26, 1981 to January 25, 1982.

I. Work Originally Scheduled for the Sixth Quarter

This quarter it was expected that we would finish the special soil report for the Ministry of Agriculture and Rural Development and the United Nations High Commission of Refugees. We also expected to complete the measurement and report on the size of watersheds and their slope groups.

Also, we were expecting to receive the equipment and install it in January, 1982.

We expected to begin training on water quality analysis.

We expected to begin the field work for the soils mapping in the northern half of Djibouti and collect the soils data to make the soils map.

We expected to gather the data necessary to prepare the soils map for the Deydey and Damerajog watersheds at a scale of 1:25,000.

We also expected to have training in vegetation identification in conjunction with Dr. Maureen Yates.

We also expected to deliver two professional papers in Cairo, Egypt, at the Remote Sensing Symposium for Arid Land Studies.

II. Work Accomplished

During the last quarter we accomplished the following effort:

First, we finished a soils report for the Ministry of Agriculture to the United Nations High Commission on Refugees. This report concerns the adaptability and location of soils in the areas of Chekheyti on the Hanle Plain and Sabbalou on the Gobbad Plain. The objective was to resettle refugees in agricultural projects. The work was completed, handed in on time, and submitted to Geneva. This was done in cooperation with the Agriculture Section and the German Cooperation.

We measured and established the size of the watersheds and the respective areas of the standard slope groups within each watershed. The maps are complete, and a summary report available.

We did not receive the equipment in January and therefore, training did not begin on water quality analysis as scheduled. In the meantime, the work was directed toward training in soil analysis with available equipment.

We did the field work to gather the data for soils mapping of the northern half of Djibouti, except for thirty-five (35) remote areas that could not be accessed by vehicle. A delay on the part of submitting the request, and a need for a new rotor for the helicopter, postponed this last phase of the investigation. We did develop the soils mapping units and the soils mapping legend.

The field data necessary to prepare the soils map of the Deydey and Damerajog watershed at a scale of 1:25,000 was gathered.

A project was initiated to monitor the salt content, electric conductivity and the water depth for selected wells in the Houmbouli and Douda agricultural areas. The purpose was to establish base data to decide if there was too much draw on the aquifer this year with the installation of several new farms.

During this quarter we had a technical review by the USDA Soil Conservation Service, Mr. Allen Heidelbaugh. He spent two weeks with us reviewing the project and making recommendations about future effort. The review was satisfactory.

Two hours one day were spent with the President of the Republic of Djibouti in conjunction with his Prime Minister and several other ministers explaining the complications and limitations to the development of the Grand Bara and other alternatives to development in other parts of the country. This was also assisted by Dr. Mueller.

A meeting was held with the District Commissioners to present to them the structure and purpose of the laboratory and offer them a view of some of the maps and accomplishments that have been achieved. They were all favorably impressed, and could understand the effort that has been put forward in getting a solid base for the systematic development of the agriculture.

The laboratory was visited by the United States Ambassador, Mr. North, the USAID representative, Mr. Amundson, and the Genie Rural Chief, Mr. Waberi to review the status of the laboratory. A favorable response was made.

The Project Manager spent time cooperating with the following people and agencies: Time was spent with the FAO Agricultural Specialist, Mr. Sorenti, also with the German hydrogeologist, Dr. Mueller, and with Dr. Bornhorst, geologist. He also spent time advising the Agricultural Section Chief, Mr. Awali and the Range Section Chief, Mr. Moussa, and the European Economic Community Project

Advisor, Mr. Custer. He also spent time with the Catholic Relief Services Director, Mr. Bourassa, and he spent time on several field trips with the Minister of Agriculture. The trips were to give technical information on soils, agronomy, and irrigation interpretations.

III. Modifications in the Plan and Their Consequences

Minor construction on the laboratory still has not been completed. The electricity has not been installed for 110V 60Hz current. Equipment to do so has not yet arrived. The equipment and chemicals, ordered over a year ago ahve not yet arrived. As a consequence, training in water and soil analysis will be severely delayed and due to the short time remaining in the project, training will be direct and non-repetitive. Outside requests for work on the status of the laboratory, developing a legal statute for its autonomy, the question of not resolving the employment status of the counterparts, the questions of requests for attendance by the trainees or the project consultant have taken unscheduled time from the direct objectives of the project -- thus hampering regular and systematic development of the objectives.

The delay in submitting the requests to the military for the use of the helicopter, a delay made by the Chief of Genie Rural, prohibited the approval of its use until it was too late to accomplish anything in January. This will cause an unknown amount of delay, probably six to eight weeks before the final field data can be collected. This in turn will delay the drafting, mapping, and summary of the soils data until some months after this data is collected.

IV. Obstacles to Meeting the Objectives

Again the main obstacle to meeting the objectives established is the deficiency of equipment including some field equipment that still has not arrived, therefore, training in water analysis could not begin.

Another obstacle is the lack of budget for the laboratory. As a consequence work has had to proceed in directions in which expenditures are not required. This type of effort has been exhausted.

Another obstacle to the work this quarter was the fact that the men were not assigned or officially attached to the laboratory. As a result, they were denied their per diem, and other field benefits. This is again an administrative complication which can only be resolved by the Djiboutian Government.

V. Plans for the Coming Quarter

Next quarter we hope to continue the training in soils testing.

We expect to do the semi-detailed soils maps for the Deydey and Damerajog watersheds.

We expect to develop soils use interpretations.

We expect to complete the soils sampling and do the mapping of the northern half of Djibouti.

We expect to start agricultural mapping in cooperation with the Agricultural Service by use of air photo interpretation at a scale of 1:5,000.

We expect to continue monitoring the wells of Houmbouli and Douda and we expect to start water quality analysis training.

We expect to receive and set up the equipment when it arrives.

We expect to continue to cooperate with the other agencies on behalf of agricultural development and use of the Soils and Water Laboratory.

QUARTERLY REPORT

To: Ellsworth Amundson, USAID/Djibouti Date: April 25, 1982

From: Dr. Joseph Goebel, Project Manager RDA

Subject: Quarterly Report, Djibouti Soil/Water Project

This report covers the period January 26, 1982 to April 25, 1982.

I. Work Originally Scheduled for the Seventh Quarter

During this quarter it was expected that books would be ordered for the library.

It was expected that we would begin training on water quality analysis.

We expected to contnue training in soils testing.

We expected to continue monitoring the wells of Houmbouli and Douda.

We planned to begin mapping of agricultural sites in cooperation with the Agricultural Service by the use of air photo interpretation at 1:5,000.

We planned to complete the soil sampling by helicopter and to map the northern half of Djibouti.

We also anticipated completing the semi-detailed soils maps of Deydey and Damerajog at 1:25,000 dcale.

We planned to do soil interpretations, and we also expected to continue to cooperate with other agencies.

II. Work Accomplished

During this quarter we received the equipment we had been waiting for. We inventoried it and set up most of it.

Second, we listed books for the library. The list has been sent out for purchase.

We continued training in soils testing, did testing on particle size analysis by hydrometer and by sieve methods. We learned to take pH, soil conductivity, total salt content, chloride content and total moisture.

We continued monitoring the wells of Houmbouli and Douda monthly.

We started mapping the agricultural areas in cooperation with Beverly Rollins, who works with the Agricultural Service and does air photo interpretation to establish a base map and to use some helicopter photos taken to identify the present agricultural sites. The final map will be at a scale of 1:5,000.

We completed the soil sampling of the northern half of Djibouti. The delineations and distribution of the soil units of the north half has not been addressed yet.

We also did not start water quality analysis training except for conductivity and total salts.

We collected all the data for the semi-detailed soils map of Deydey and Damerajog. But the soil delineations have not been done pending completion of the soil delineations in the northern half of Djibouti. We also have not done the soil use interpretations.

We have continued to cooperate with the other agencies, including the Minister of Agriculture on guidance for soils use and interpretations on field trips. We assisted the German Cooperation, with Dr. Mueller in discussing hydrogeology, Dr. Merkt, in discussions of the Quaternary geology and Mr. Stroebing in terms of particle size analysis in discussion of infiltration rates at the channels. We cooperated with FAO, Mr. Sorenti and Mr. Alsaue' of Tunisia on an agricultural development plan. We cooperated with Catholic Relief Services, Mr. Bourassa, on placement of wells and agricultural sites on a Food for Work Program. Finally, all of the effort toward achieving autonomy was positively achieved and the laboratory is now a legal sub-entity directly under the Ministry of Agriculture and Rural Development.

III. Modifications in the Plan and Their Consequences

The question of the accessibility of the random sample sites by vehicle proved inadequate. Thus the plans were modified to complete the soil sampling by helicopter. This was to make rpeparations for the data necessary to complete the mapping. The delay in helicopter availability caused the delay of mapping the northern half of Djibouti at 1:100,000 and finishing the map for the Deydey and Damerajog watersheds at a scale of 1:25,000. But with this information now collected, we should proceed to do soils interpretations and soils mapping soon.

IV. Obstacles to Meeting the Objectives

One of the obstacles which prevented meeting the objectives was the lack of proper 110V 60Hz electricity. Though the equipment has arrived, the facilities have not been built to install the generator. As a consequence, the other laboratory equipment that has been installed has been limited to that which has been adaptable to the invertor which I have supplied.

Another obstacle to meeting the objectives was the time used by Mr. Douale to establish autonomy. This was time taken from necessary training and also production in mapping. The results were the solution to the problem of the legal status of the laboratory and the problem of a necessary budget for the laboratory to accomplish its work after this project is over. In the meantime, this is causing more time in administrative organization which continues to detract from training and work accomplishment.

Another problem which has been encountered has been locating an electronics or electrical expert who is able to repair the equipment when there is minor malfunction. It is hoped that one is presently located and we are checking his work on one of the instruments that is malfunctioning. Also, demands for special reports and special assistance by other agencies have to be monitored carefully or they tend to detract from the pace set to accomplish the goals.

The counterpart does not always apply himself to the work and training when it is assigned, thus delaying the implementation of the next sequence of work and training. A new work schedule is attached designed to complete the objectives of this project. It is imperative that the work and training and timing of this schedule be met or surpassed as prescribed.

V. Plans for the Coming Quarter

In the coming quarter, we expect to complete the 1:100,000 scale soils map of Djibouti.

We expect to complete the 1:25,000 scale map of the Deydey and Djamerajog watersheds.

We expect to complete the agricultural maps of Houmbouli and Douda agricultural areas at a scale of 1:5,000.

We expect to measure the soils map.

We expect to do soils interpretations for agricultural and range use.

We expect to initiate water analysis training.

We expect to organize the soil and water sampling collection procedures.

We expect to continue to do soil analysis training.

We expect to compute the results of analysis made in the laboratory.

We expect to establish the laboratory reports.

We expect to continue to cooperate with other agencies.

We also plan to an Annual Work Plan for the coming year.

We expect to complete the project and submit a final report by July 25, 1982.

QUARTERLY WORK PLAN - APRIL 25 - JULY 25, 1982	TIME FRAME
Complete 1:100,000 scale soils map	
Goebel, Drafting and Correcting	Apr. 24 thru May 15
Douale, Mapping	Apr. 24 thru May 8
Omar, Measuring	May 1 thru May 29
Complete 1:25,000 soils map	
Goebel, Training and Drafting	May 15 thru May 29
Douale, Training and Mapping	May 15 thru May 22
Omar, Measuring	May 29
Set-Up Equipment	
Goebel, Douale, Omar	June 5
Complete Agricultural Maps 1:5,000	
Goebel, Training and Drafting	Apr. 24 thru May 29
Rollins, Mapping	Apr. 24 thru June 5
Final Report	
Goebel	May 8 thru May 29
Soils Interpretations	
Goebel, Douale	June 12
Water Analysis Training	
Goebel, Douale, Omar	June 12 thru June 19
Soil Analysis Training	
Goebel, Douale, Omar	June 26 thru July 3
Compute Results	
Goebel, Douale, Omar	July 10
Organize Soil and Water Sample Collection	
Goebel, Douale	1/4 - July 17
Establish Laboratory Reports	
Goebel, Douale	1/2 - July 17
Annual Work Plan	
Goebel, Douale, Omar	1/4 - July 17

QUARTERLY REPORT

To: Ellsworth Amundson, USAID/Djibouti Date: August 1, 1982

From: Dr. Joseph Goebel, Project Managewr, RDA

Subject: Quarterly Report, Djibouti Soil/Water Project

This report is the eighth and final quarter which covers the period April 25, 1982 to August 1, 1982.

I. Work Originally Scheduled for the Eighth Quarter

During this quarter we expected to complete the 1:100,000 scale soils map of Djibouti.

We expected to complete the 1:25,000 scale map of the Deydey and Damerajog watersheds.

We expected to complete the agricultural map of Houmbouli and Douda agricultural areas at a scale of 1:5,000.

We expected to measure the soils map.

We expected to do the soils interpretations for agricultural and range use.

We expected to initiate water analysis training.

We expected to organize the soil and water sample collection procedures.

We expected to continue to do soil analysis training.

We expected to compute the results of the analysis made in the laboratory.

We expected to establish the laboratory reports.

We expected to continue to cooperate with other agencies.

We also planned to do an Annual Work Plan for the coming year.

We expected to complete the project and submit the final report by July 30, 1983.

We expected to set up the equipment.

We expected to do soil interpretations for the soils series of Djibouti.

II. Work Accomplished

During this quarter we completed the 1:100,000 scale soils map of the Republic of Djibouti.

We completed the 1:25,000 maps of the Deydey and Damerajog watersheds.

We completed the agricultural ownership map of the Douda agricultural area and some work remains on the Houmbouli agricultural area at 1:5,000.

We measured the soils maps.

We did the inter-relations of the major soil series for agriculture and range use.

We initiated water analysis training at the end of the quarter with the assistance of USDA Soil Conservation Service personnel.

We worked with the USDA personnel to organize the sampling of soil and water.

We continued soil analysis training with the assistance of the Soil Conservation Service USDA personnel.

We computed the results of the anlysis that we made in the laboratory and any new analyses will be computed.

We cooperated with the following agencies: The German Mission; the European Economic Community Mission; the Agricultural Service; the Catholic Relief Services; the Ministry of Agriculture in Garden Siting at Yoboki and gave counseling for organizing the national census.

We wrote an Annual Work Plan for the coming year.

We balanced the soils and watershed areas to determine how much of each soil is present in the country.

We wrote the initial Final Report.

We set up the equipment and got the alternator at 110V, 60Hz production installed.

We made receiving forms and have filled them out for all the samples that we have received.

Training was given of remote sensing by way of photo interpretation and photo transfer and map construction for the Deydey watershed.

I made a field trip guide for the agricultural positions for developing potential agricultural sites from Djibouti to Eali Sabieh.

III. Modifications in the Plan and Their Consequences

Delay in installing the alternator to produce the necessary 110V, 60Hz cycle electricity required postponing training in soil and water analysis until July and August and another session later. This required that we develop an alternative plan to accomplish some more training in the laboratory techniques and procedures.

IV. Obstacles to Meeting the Objectives

The first obstacle is that the laboratory be autonomous from Genie Rural has still been awarded no budget. As a result, there are insufficient funds to meet the day-to-day requirements of the laboratory. The laboratory does have available the one million Djibouti Francs that were allocated last year and which are being used very judiciously.

Further, the personnel have not been assigned to the laboratory, neither the personnel which I work with which have been assigned to the Agricultural Service nor the necessary new personnel that has been requested in the new laboratory Plan and Budget.

The construction of the laboratory as well as the installation of the alternator by Genie Rural was far too slow. The alternator was not installed until four months after its arrival with constant attention to getting the men to get their work finished.

Further, there have been no books acquired yet for the library, though the books are on order. As a consequence, the consulting pedologist will leave his books behind for their use until the new books arrive.

V. Plans for the Coming Quarter

Since this is the final quarter of the contract, the next Quarterly Report will be presented by the Chief of the Laboratory, Mr. Aboubaker Douale, who has not been assigned as Chief of the Laboratory as yet. Therefore, the laboratory is without the necessary leadership.

It is anticipated during the next quarter that two weeks of assistance in the first part of August will be given by the Soil Conservation Service, USDA assistance to USAID for the laboratory.

The permanently assigned personnel at the laboratory will take at least two months of vacation during the latter part of the quarter.

There will be some training for Mr. Douale. In the meantime, the principal pedologist consultant will work on the Final Report in bringing up the data and information to make it presentable in January.

VI. Personnel Evaluation

The laboratory staff did not grow as anticipated in our budget requests. This in a large part leaves some question as to the commitment that the Government of Djibouti has toward assuming the laboratory after outside assistance. The question is not only the lack of personnel but the lack of funding of the approved budget.

Two persons on the staff can be evaluated. The first is the Chief and principal degree-trained pedologist assigned to the project, Mr. Aboubaker Douale. Mr. Douale is an intelligent man. He is pleasant and sensitive. He has been well-trained in pedology and in general education. He is a committed person. He is honest. He is dedicated to his work. He is competent. He is interested in the subject and is capable of handling his job. He does need some more training and development in supervision/management -- two skills which he will be required to use and in which he is deficient. He needs to develop a good work plan and follow the plan as he assigns the work to himself. He has to stick to his plans. He does need time and help to mature and get the perspective of the laboratory under control. He is presently able to execute all the requirements of the laboratory and the soil survey. Though advanced training on this subject at the graduate level is necessary for him to execute the added responsibilities, that will come with time. He will also need more experience and he must have time to gain control of his position. Given time, he will make the laboratory operate well.

The other person is Farah Omar. Farah is a pleasant, eager, diligent, and patient individual who receives training well. He is dedicated and réliable in his job. H is background is limited, especially in getting him trained. He anticipates what is to happen when the training is given and therefore, he requires careful instructions under close supervision to be sure that he executes the work assigned and as described. Once trained, he is a very accurate, reliable, and diligent worker. When he returns to work previously performed, he needs a good careful review on how to do the work. With careful supervision, Farah Omar will do all work needed for the laboratory analysis and soil survey assistance.

These two men complement each other and normally work well together. They have an acceptable respect for each other. From time-to-time, they will need help to rectify their personality differences. They should resolve these differences while they are small, before they get out of proportion.

Overall, I think the laboratory has the equipment, the structure, and the personnel. Given some more time it will be a successful and productive laboratory, probably the best laboratory in the horn of Africa.

APPENDIX C-2

ANNUAL WORK PLANS

FIRST ANNUAL WORK PLAN

This first Annual Work Plan is essentially an outline, designed to list the objectives and means of obtaining those objectives for the Soils and Water Laboratory. It lists job responsibilities and specific tasks and the time and people who will accomplish those tasks.

A Work Plan is a projection of the team's perception of work requirements and how they will be accomplished in the coming year. Progress towards goals will be reported quarterly.

To place this Annual Work Plan in perspective, an Implementation Plan has been attached which shows a broader and more comprehensive view of the projected timing of the effort toward successfully completing the project.

Objectives of the Soils and Water Testing Laboratory

The soils and Water Testing Laboratory has been established with many objectives in mind. All of the objectives are directed toward developing an agricultural capacity in Djibouti using existing soil and water resources to contribute to the social and economic development of the country and reduce the dependency on neighboring countries for food supplies.

Agriculture depending on irrigation will be the major beneficiary of the laboratory effort. The high-quality and broad capability of the equipment and personnel makes the laboratory an asset for the other government agencies which might choose to use its facilities.

The principal analysis will be directed toward soil fertility and water quality. Laboratory personnel will classify, map and describe the soils of Djibouti as an inventory of this valuable resource. They will collect, catalogue and disseminate information on surface and subsurface hydrology and soil analysis data. They will interpret the hydrologic and soils information for the purpose of agricultural development.

Equipment, amterials, space and personnel will be established, maintained and improved as necessary for high-quality results in sample testing and interpretation of the results.

Means for Achieving the Objectives of the Soil and Water Testing Laboratory

Personnel assigned to the laboratory will identify and define the potential soil, water and human resources available for agricultural production.

Laboratory personnel will further their expertise by graduate education to assure growth in the capability to accomplish high-quality analysis and interpretations. The laboratory will establish a research center for problems of soil and water inter-relationships in Djibouti. A library of technical information specific to Djibouti and soils and water will be established. Information gathered and derived about the country's soils and water will be assembled, assessed, summarized and disseminated in an appropriate manner to other agencies and individuals.

Systems for collecting samples and information on soils and water will be established. Local training will be given to personnel associated with the laboratory to increase the quality and quantity of analysis performed. A preliminary inventory of the soils of this country will be made using previous studies, current maps, aerial photographs and satellite imagery.

The data collected from the soils inventory and the soil and water sample analysis will be used to estimate further requirements of the soil and water resources.

Work Descriptions for Soils and Water Laboratory Personnel

Chief of the Laboratory - Aboubaker Duale

The Chief of the Laboratory is responsible for the overall internal performance of the Soils and Water Laboratory. He is to assure that the laboratory functions smoothly and meets its objective. In addition to general management of the laboratory, this person should be specifically responsible for the national soils inventory which includes describing, classifying and mapping and interpreting the soils of Djibouti. He will receive training on the procedures used in this laboratory for analyzing soil and water samples submitted. He will interpret the results of the laboratory analysis and report the results to the person or agency that submitted the sample for analysis. He will make general reports to other agencies as well as maintain a technical library of the information about soils and water of Djibouti. He will establish research relevant to the improvement of the usage of soils and water resources. He will, from time to time, receive further graduate and specific training necessary to fulfill the responsibilities of this position.

Senior Technical Advisor - Dr. Joseph E. Goebel

The Senior Advisor will be responsible for the laboratory achieving its technical goals in soils and water analyses, soil inventory, personnel training, laboratory organization, data collection, information dissemination and overall technical capability. He will facilitate equipping the soils laboratory. He will develop an initial annual work description. He will conduct a soil survey. He will assist in the preparation of reports of the soil survey. He will assist in developing land-use recommendations. He will provide on-the-job training for the laboratory director and laboratory assistant in soil survey, soil and water analysis, and reporting of results. He will coordinate the soil and water sample collection for analysis for donor agencies.

Soil and Water Analyst - Farah Omar

This analyst will be responsible for the accurate analysis of the soil and water samples submitted to the laboratory. He will be responsible for material and equipment ilnventories in the laboratory. He will maintain the laboratory facilities and procedures in high-quality condition to assure high-quality test results. He will receive training in soil and water analysis. Further, he will become acquainted with the soils of Djibouti with training in soil survey. He will receive further formal training as is necessary to meet his responsibilities.

Technical Assistants (Two People With Post-Secondary Training)

These personnel will assist in the laboratory to maintain the facilities at high standards and keep the materials and supplies in excellent condition. They will also assit in simple routine preparation of materials and samples, and in calculations.

Secretary (French Language Capability)

The secretary will receive and process written and telephone messages. She will type and mail reports and results. She will maintain the library for checking the materials out as required. She will maintain an accurate file system.

Annual Work Plan for 1980-1981		Contemplated Period (Mos.)
I.	SET UP TIME	
	Inventory of Materials	First half of August
	Drawing Plans for the Lab	Last half of August
	Supervise Construction of Laboratory	Last half of September thru March
	Order Lab Materials	Last half of Aug., thru first half October
	Order Satellite Imagery	First half September
II.	ESTABLISH LIBRARY	
	Order Books & Maps	First half September
III.	ANNUAL PLANNING	
	Write Annual Plan	Last half November
IV.	SOIL MORPHOLOGY & CLASSIF.	
	Field Review	First 3/4 October
	Trng. Profile Descr.	November and December
	Describe/Sample 30 Soils	First 1/2 Jan & all Feb.
V.	CARTOGRAPHY	
	Draw Slope Map	First 3/4 January
	Draw Drainage Network Map	First 3/4 January
	Draw Prelim. Soil Map	First half January
	Draw Random Inv. Sample	Middle 2-wks January
VI.	REMOTE SENSING TRAINING	
	Air Photo Interpretation	First 3/4 March
	Satellite Imagery Interp.	Last 3/4 March
VII.	LABORATORY IMPLEMENTATION	
	Equipment Set-Up	All of April
	Trng. Water Quality Analysis	May - June - July

IMPLEMENTATION PLAN

1979	Objective	Responsibility
January	Project proposal approved	AAO/D REDSO/EA
	Project Agreement signed	AAO/D REDSO/EA AID/W
	PIO/T issued and contracting for tech. services begin	AID/W REDSO/EA
February	Vehicles and equipment ordered	AAO/D REDSO/EA
April	Project agreement revised to include only the Soils & Water Laboratory	AAO/D REDSO/EA
June	Housing for technician obtained	AAO/D
1980		
February	Construction begins on lab. bldg.	GROD
March	Equipment arrives	AAO/D GROD
July	Temporary contract signed for tech. assistance	REA/AAO/D REDSO/EA AID/W GROD
August	Degree-trained Djiboutian pedologist assigned	GROD
	Laboratory material inventoried	RDA GENIE Rural
	Laboratory facilities layout & requirements defined	RDA GENIE Rural
September	Order chemicals, materials, field equipment and satellite imagery	RDA GENIE Pural AAO/D
	Construct laboratory facilities	GROD
October	Sign final contract agreement	RDA AAO/D REDSO/EA AID/W GROD
November	Write Annual Work Plan	RDA GENIE Rural
	Give training in soil description and classification	RDA GENIE Rural
December	Continue training in soils	RDA GENIE Rural

IMPLEMENTATION PLAN (continued)

1981	Objective	Responsibility
January	Give training in soil cartography	RDA GENIE Rural
	Make preliminary soils map	RDA
	Draw Random Soil Inventory Samples	RDA
	Write Quarterly Report	RDA
February	Collect, describe & classify 30 soils for soils inventory	RDA GENIE Rural
March	Give training in remote sensing	RDA GENIE Rural
	Install lab equipment	RDA GENIE Rural
April	Write Quarterly Report	RDA
	Receive equip. & materials ordered	RDA GENIE Rural
May-July	Enter detailed training in lab procedures & tech. for water quality tests	RDA GENIE Rural
	Write Annual Work Plan/Quart. Report	RDA GENIE Rural
Aug-Sept	Enter detailed training for lab procedures and tech. for soil tests	RDA GENIE Rural
Oct-Dec	Write Quarterly Report	RDA
	Do small & medium-scale soil survey investigation	RDA GENIE Rural
1982		
Jan-Feb	Write Quarterly Report	RDA
	Cont. small/med-scale survey invest.	RDA GENIE Rural
March	Interpret land-use for all soils stud.	RDA GENIE Rural
April	Compute the results of soil/water analysis	RDA GENIE Rural
	Give training on routine lab and soils reports	RDA GENIE Rural
May-June	Review/summarize/synthesize final rep.	RDA GENIE Rural
July	Bring the project to conclusion	RDA/GENIE Rural/AAO/D
1983		
January	Lab. Ass't. for 6-Mo. OJT	GENIE RURAL AAO/D
June-July	Follow-up tech. return visit	RDA/GENIE Rural/AAO/D
	Present Final Report	RDA
	Project Evaluation	AAO/D AID REDSO/EA

IMPLEMENTATION PLAN (Continued)

1983	Objective	Responsibility
August	Tech. advisor writes reports on visit	RDA
September	Pedologist begins 2-year post-grad. training	GENIE Rural AID
1984		
June-July	Technical advisor's final follow-up review of laboratory and assists lab technician while pedologist is gone	RDA GENIE Rural
August	Technical Advisor writes report on visit	RDA
1985		
June	Pedologist returns to resume lab responsibilities	GENIE Rural

SECOND ANNUAL WORK PLAN

This is the second Annual Work Plan designed to list the objectives and means of obtaining those objectives for the Soils and Water Laboratory. It lists job responsibilities and specific tasks, as well as, the time and people who will accomplish those tasks.

A work plan is a projection of the team's perception of what they will accomplish in the coming year and how they will do the work. Progress toward that goal will be reported quarterly.

To place the Annual Work Plan in perspective, an Implementation Plan has been attached which shows a broader and more comprehensive view of the projected timing of the effort toward successfully completing the project.

Objectives of the Soil and Water Testing Laboratory

The Soils and Water Testing Laboratory has been established with many objectives in mind. All of the objectives are directed toward developing an agricultural capacity in Djibouti using the soil and water resurces to contribute to the social and economic development of the country and reduce the dependency on neighboring countries for food supplies.

Agriculture depending on irrigation will be the major beneficiary of the laboratory effort. The high-quality and broad capability of the equipment and personnel makes the laboratory an asset for the other government agencies which might choose to use its facilities.

The principal analysis will be dircted toward soil fertility and water quality. The personnel will classify, map and describe the soils of Djibouti as an inventory of this valuable resource. It will collect, catalogue and disseminate information on surface and subsurface hydrology and soil analysis data. It will interpret the hydrologic and soils information for the purpose of agricultural development.

Equipment, materials, space and personnel will be established, maintained and improved as necessary for high-quality results in sample testing and interpretation of the results.

Means for Achieving the Objectives of the Soils and Water Testing Laboratory

Personnel assigned to the laboratory will establish the potential soil, water and human resources to be used here for agricultural production.

Laboratory personnel will further their expertise by a graduate education to assure growth in the capability to accompligh high-quality analysis and interpretations. The laboratory will establish a research center for problems of soil and water inter-relationships in Djibouti. A library of technical information specific to Djibouti and soils and water will be established. Information gathered and derived about the country's soil and water will be assembled, assessed, summarized and disseminated in an appropriate manner to other agencies and individuals.

Systems for collecting samples and information on the soils and water will be established. Local training will be given to personnel associated with the laboratory to increase the quality and quantity of analysis performed. A preliminary inventory of the soils of this country will be made using previous studies, current maps, aerial photographs and satellite imagery.

The data collected from the soils inventory and the soil and water sample analysis will be used to estimate further requirements of the soil and water resources.

Work Descriptions for Soil and Water Laboratory Personnel
Co-Responsible for the Laboratory - Aboubaker Duale

This person is responsible for the overall internal performance of thSoils and Water Laboratory. He is to assure that the laboratory functions smoothly and meets its objective. Besides the general management of the laboratory, this person will be specifically responsible for the national soils inventory which includes describing, classifying and mapping and interpreting the soils of Djibouti. He will receive training on the procedures used in this laboratory for analyzing soil and water samples submitted. This person will interpret the results of the laboratory analysis and report the results to the person or agency that submitted the sample for analysis. He will make general reports to other agencies as well as maintain a technical library of the information about soil and waters of Djibouti. He will establish research relevant to the improvement of the usage of soils and water resources. He will, from time to time, receive further graduate and specific training necessary to fulfill the responsibilities of this position.

Technical Consultant Co-Responsible - Dr. Joseph E. Goebel

This person will be responsible for the laboratory achieving its technical goals in soil and water analyses, soil inventory, personnel training, laboratory organization, data collection, information dissemination and overall technical capability. He will facilitate equipping the soils laboratory. He will develop an initial annual work description. He will conduct a soil survey. He will assist in developing land-use recommendations. He will provide on-the-job training for the laboratory director and laboratory assistant in soil survey, soil and water analysis, and reporting of results. He will coordinate the soil and water sample collection for analysis for donor agencies.

Soil and Water Analyst - Farah Omar

This person will be responsible for the accurate analysis of the soil and water samples submitted to the laboratory. He will be responsible for material and equipment inventories in the laboratory. He will maintain the laboratory facilities and procedures in high-quality condition to assure high-quality test results. He will receive training in soil and water analysis. Further, he will become acquainted with the soils of Djibouti with training in soil survey. He will receive further formal training as is necessary for him to meet his responsibilities.

Hydrogeologist - (One Person)

Guide and assist in water quality analysis.

Technical Assistants - (Two People With Post-Secondary Training)

These personnel will assist in the laboratory to maintain the facilities at high standards and keep the materials and supplies in excellent condition. They will also assist in simple routine preparation of materials and samples. They will assist in calculations.

Secretary

This person will have capability in French. She will receive and process written and telephone messages. She will type and mail reports and results. She will maintain the library by checking the materials out as requested. She will maintain an accurate file system.

Annual Work Plan for 1981-1982		Contemplated Completion Time (Mos)
I.	SET UP TIME	August
	Inventory of Material	August
	Drawing Plans for the Laboratory	Completed
	Supervise Laboratory Construction	Aug - Sept - Oct
	Order Laboratory Materials	Completed
	Order Satellite Imagery	Completed
II.	ESTABLISH LIBRARY	
	Order Books and Maps	October
III.	ANNUAL PLANNING AND BUDGET	August
	Field Reconnaissance	Completed
	Training in Profile Description	Completed
	Describe and Sample 45 Soils	Completed
	Describe and Sample Remaining 50 Sites	Dec - Jan - Feb
	Semi-detail Soil Mapping Trng.	Feb - Mar
	Soil Use Interpretation	Last Half March
	Vegetation Identification Trng.	Last Half December
V.	CARTOGRAPHY	
	Draw Slope Map	Completed
	Draw Watershed Map	Completed
	Draw Preliminary Soils Map	Completed
	Draw Random Sample	Completed
	Draw 1:250,000 Scale Soil Map	Last half September
	Draw 1:100,000 Scale Soil Map	Last Half September
	Draw 1:25,000 Scale Semi-detail Soil Map	Last Half March

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Annual Work Plan for 1981-1982 (cont'd)		Cont. Completion Time
VI.	REMOTE SENSING TRAINING	
	Aerial Phot Interpretation	Completed
	Satellite Imagery Interpretation	Completed
	Delivery of two Professional Papers (Cairo)	Last Half November
VII.	LABORATORY IMPLEMENTATION	
	Equipment Set-Up	Last Half November
	Training in Water Quality Analysis	Last Half November
	Training in Soil Testing	Last 1/2 May & April
	Soil and Water Sample Analyses	Last 1/2 June & July
VIII.	DATA ANALYSIS	
	Map Measurement (watershed/slope)	Last Half September
	(soil map)	Last Half May
	Computing Results of Analyses	May
	Establishing Laboratory Reports	Last Half May
IX.	ORGANIZE SOIL AND WATER SAMPLE COLLECTION AND DISTRIBUTION OF RESULTS	Last Half June
X.	SUMMARY, REVIEW, FINAL REPORT	All of July

IMPLEMENTATION PLAN

1979	Objective	Responsibility
January	Project proposal approved	AAO/D REDSO/EA
	Project Agreement signed	AAO/D REDSO/EA AID/W
	PIO/T issued and contracting for tech. services begin	AID/W REDSO/EA
February	Vehicles and equipment ordered	AAO/D REDSO/EA
April	Project agreement revised to include only the Soils and Water Laboratory	AAO/D REDSO/EA
June	Housing for technician obtained	AAO/D
1980		
February	Construction begins on Lab. bldg.	GROD
March	Equipment Arrives	AAO/D GROD
July	Temporary contract signed for tech. assistance	RDA/AAO/D REDSO/EA AID/W GROD
	Technical assistance arrives	RDA AAO/D
August	Degree-trained Djiboutian pedologist assigned	GROD
	Laboratory material inventoried	RDA Genie Rural
	Laboratory facilities layout & requirements defined	RDA/Genie Rural
September	Order chemnicals, materials, field equipment and satellite imagery	RDA/Genie Rural/AAO/D
	Construct laboratory facilities	GROD
October	Sign final contract agreement	RDA AAO/D REDSO/EA AID/W GROD
	Establish library	RDA Genie Rural
	Field Review of soils	RDA Genie Rural
November	Write Annual Work Plan	RDA Genie Rural
	Give training in soil description and classification	RDA Genie Rural
December	Continue training in soils	RDA Genie Rural

1981	Objective	Responsibility
January	Give training in soil cartography	RDA Genie Rural
	Make preliminary soils map	RDA
	Draw Random Soil Inventory Samples	RDA
	Write Quarterly Report	RDA
February	Collect, describe & classify 30 soils for soils inventory	RDA Genie Rural
March	Give training in remote sensing	RDA Genie Rural
	Install lab equipment	RDA Genie Rural
April	Write Quarterly Report	RDA
	Receive equipment & materials ordered	RDA Genie Rural
May-July	Enter detailed training in lab procedures & tech. for water quality tests	RDA Genie Rural
Aug-Sept	Enter detailed training for lab procedures & tec. for soil tests	RDA Genie Rural
Oct-Dec	Write Quarterly Report	RDA
	Do small & medium-scale soil survey investigation	RDA Genie Rural
1982		
Jan-Feb	Write Quarterly Report	RDA
	Continue small & med-scale survey investigation	RDA Genie Rural
March	Interpret land-use for all soils studied	RDA Genie Rural
April	Give training on routine lab/soils reports	RDA Genie Rural
May-June	Review, summarize, synthesize and make final reports	RDA Genie Rural
July	Bring the project to conclusion	RDA Genie Rural AAO/D
1983		
January	Laboratory ass't. goes for 6-mo OJT	Genie Rural AAO/D
June-July	Follow-up technical return visit	RDA Genie Rural AAO/D
	Present Final Report	RDA
	Project evaluation	AAO/D AID REDSO/EA
August	Tech. advisor writes reports on visit	RDA

1983	Objective	Responsibility
September	Pedologist begins 2-year post graduate training	Genie Rural AID
1984		
June-July	Technical Advisor's final follow-up review of laboratory and assists lab technician while pedologist is gone	RDA Genie Rural
August	Technical Advisor writes report on visit	RDA
1985		
June	Pedologist returns to resume lab responsibilities.	Genie Rural

Means for Achieving the Objectives of the Soils and Water Testing Laboratory

Personnel assigned to the laboratory will establish the potential soil, water and human resources to be used here for agricultural production.

Laboratory personnel will further their expertise by graduate education to assure growth in the capability to accomplish high-quality analysis and interpretations. The laboratory will establish a research center for problems of soil and water inter-relationships in Djibouti. A library of technical information specific to Djibouti and soils and water will be established. Information gathered and derived about the country's soils and water will be assembled, assessed, summarized and disseminated in an appropriate manner to other agencies and individuals.

Systems for collecting samples and information on the soils and water will be established. Local training will be given to personnel associated with the laboratory to increase the quality and quantity of analysis performed. A preliminary inventory of the soils of this country will be made using previous studies, current maps, aerial photographs and satellite imagery.

The data collected from the soils inventory and the soil and water sample analysis will be used to estimate further requirements of the soil and water resources.

Work Descriptions for Soils and Water Laboratory Personnel Co-Responsible for the Laboratory - Aboubaker Duale

This person is responsible for the overall internal performance of the Soils and Water Laboratory. He is to assure that the laboratory functions smoothly and meets its objectives. Besides the general management of the laboratory, this person will be specifically responsible for the national soils inventory which includes describing, classifying and mapping and interpreting the soils of Djibouti. He will receive training on the procedures used in this laboratory for analyzing soil and water samples submitted. This person will interpret the results of the laboratory analysis and report the results to the person or agency that submitted the sample for analysis. He will make general reports to other agencies as well as maintain a technical library of the information about soil and water of Djibouti. He will establish research relevant to the improvement of the usage of soils and water resources. He will, from time to time, receive further graduate and specific training necessary to fulfill the responsibilities of this position.

Soil and Water Analyst - Farah Omar

This person will be responsible for the accurate analysis of the sol and water samples submitted to the laboratory. He will be responsible for material and equipment inventories in the laboratory. He will maintain the laboratory facilities and procedures in high-quality condition to assure high-quality test results. He will receive training in soil and water analysis. Further, he will become acquainted with the soils of Djibouti with further training in soil survey. He will receive further formal training as is necessary for him to meet his responsibilities.

Hydrogeologist - One Person

Guide and assist in water quality analysis.

Technical Assistants - Two People with Post-Secondary Training

These personnel will assist in the laboratory to maintain the facilities at high standards and keep the materials and supplies in excellent condition. They will also assist in simple routine preparation of materials and samples. They will assist in calculations.

Secretary

This person will have capability in French. She will receive and process written and telephone messages. She will type and mail reports and results. She will maintain the library by checking the materials out as requested. She will maintain an accurate file system.

Annual Work Plan for Aug-Dec, 1982		Done
I.	SET UP TIME	
	Inventory of Material	XXX
	Drawing Plans for the Laboratory	XXX
	Order Laboratory Materials	XXX
	Order Satellite Imagery	XXX
II.	ESTABLISH LIBRARY	
	Order Books and Maps	XXX
III.	ANNUAL PLANNING AND BUDGET	XXX
IV.	SOIL MORPHOLOGY AND CLASSIFICATION	
	Field Reconnaissance	XXX
	Training in Profile Description	XXX
	Describe/Sample 45 Soils	XXX
	Describe/Sample remaining 50 sites	XXX
V.	CARTOGRAPHY	XXX
VI.	REMOTE SENSING TRAINING	XXX
VII.	LABORATORY IMPLEMENTATION	
	Equipment Set-Up	XXX
	Training in Water Quality Analysis	XXX
VIII.	DATA ANALYSIS	XXX
IX.	ORGANIZE SOIL AND WATER SAMPLE COLLECTION AND DISTRIBUTION OF RESULTS	XXX
X.	SUMMARY, REVIEW, AND INITIAL REPORT	XXX

Annual Work Plan for Aug-Dec, 1982 (cont'd)

		Done
XI.	VACATION	
	A. Douale	XXX
	F. Omar	XXX
	J. Goebel	XXX
XII.	FINAL REPORT	
	J. Goebel	XXX

APPENDIX C-3

Project Status Report -- January 1981

TO: Ellsworth Amundson
USAID
Djibouti

FROM: Dr. Joseph Goebel

SUBJECT: Project Status Report January 1981

A request was made for a detailed status update on the soil and water project in Djibouti. The purpose of this report is to put the present effort of the project into perspective relative to past objectives and developments.

Summary Description of the Project

The Government of the Republic of Djibouti has requested AID assistance in determining the long-term potential for agricultural development. By analyzing data on soils and water resources, Djiboutian officials will be able to make rational economic decisions regarding Djibouti's future development in food production and water and soil conservation.

A paucity of accurate and detailed information for providing a sound data base is a primary justification for AID assistance to Djibouti at this time. The nature and timing of AID assistance is predicted on the belief that agricultural potential exists in Djibouti and that American technical assistance, even if modest, can have a significant impact if concentrated on the most basic resource needs such as soil and water.

This project will institutionalize, through training within the Ministry of Agriculture, the capacity to undertake studies supportive of long-term agricultural sector development, that is, the capacity to do basic applied research which has immediate practical benefits to Djiboutian farmers. The key assumption is that initial results will indicate the agricultural inputs into which the farmers should invest and the extent to which that investment is economically and socially justifiable.

During the project, AID will provide the financial resources for the long-term services of a pedologist with experience in hydrology. This advisor will train Djiboutian counterparts in analysing water samples, taking soil samples, directing soil analysis, making soils inventory and interpreting the results to farmers who work those soils. He will also assist in the establishment of a water and soils analysis laboratory which is being built by the Djiboutian government.

Both long-term on-the-job training and short-term third country participant training will be offered to Djiboutian staff of the Soils and Water Laboratory. This staff will provide its research services to the existing agricultural extension service, and its agents who will, in turn, supply production information to the laboratory. This sharing of information will be of practical value and beneficial to the farmers. In addition, supplementary laboratory equipment and supplies will be purchased as well as two project vehicles and camping equipment. Aircraft rental, communictions, vehicle operation and maintenance, and miscellaneous operating expenses will be furnished.

In support of this project, the Djiboutian Government is constructing the facilities for the Soils and Water Laboratory and providing equipment, supplies, and utilities. Further it will supply the services of the following Djiboutian laboratory personnel: one pedologist, one laboratory technician, two laboratory assistants, one librarian, bilingual secretary, janitor and custodian. These technicians and facilities will backstop the ten-man Agricultural Extension Service which will bring soils and water samples along with field data to the laboratory and take practical advice derived from the laboratory findings and investigations back to the farmers.

Objective

The objective of this joint venture is to institutionalize within the Ministry of Agriculture the capacity to analyze surface and ground water quality, and soil fertility. (The hydrologic information will be compiled, catalogued and disseminated by the German hydologic assistance project in the same Ministry. The venture will also classify soils, prepare soils maps and provide evaluation concerning the proper utilization of soils.

In practical terms, farmers can be advised on soil treatments to obtain sustainable yields. Achievement of this project purpose should impact on the agricultural sector goal of developing an information base for use by the Djiboutian government in national agricultural planning and its dissemination through the Agricultural Extension Service.

By the end of the project the soil and water laboratory staff will be able to accomplish the following:

> They shall have the equipment and technical expertise to independently analyse all water and soil types in Djibouti.

They will have the necessary data upon which to base recommendations for the soil and water use in crop production and provide guidance for subsequent soil and water resource analysis in the field.

They shall have undertaken a soil inventory and developed a land classification system on a general scale and in selected priority areas.

Statement of Work

In order to accomplish the foregoing, the following will be necessary:

a. A soil and water data collection system will be established with an appropriate information form.

b. A system will be established to disseminate the soils and water data to other Djiboutian government, private and donor institutions.

c. The existing soil and water data will be collated, placed in the library, and applied during the project, and, to the extent possible, data collection activities of other agencies will be incorporated.

d. The Djiboutian personnel will be provided training in soil chemical analysis, description, classification, mapping, interpretation, inventory, and reporting.

e. The Djiboutian personnel will receive training in water quality analysis and reporting.

f. The project personnel and Djiboutian counterparts will undertake soil studies of the soils conditions for rangeland and irrigated cropland on both a general national inventory and in several selected priority agricultural sites.

g. Since no 1:10,000 or 1:50,000 scale base maps exist for Djibouti, and there are neither personnel, time or equipment to make base maps, the national soils inventory will be conducted on the best set of topographic maps available at 1:100,000 scale.

h. Since there is no basic land survey to accurately locate features on an aerial photograph to the base map (1:100,000), the large-scale high-priority areas will be mapped directly on aerial photographs.

i. Because the combined soil and water potential for possible agricultural sites has not been established, the high priority sites will be evaluated later in the

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project based on established agricultural capability. This way, valuable time will not be wasted on areas without either soil or water resources.

j. Soil samples from the present agricultural projects will be tested as soon as the laboratory facilities and procedures permit accurate analysis. Preliminary recommendations for soil amendments and practices will be made to the extent practicable.

k. Finally, with the information acquired in the soils inventory at a scale of 1:100,000 (best set of maps available and for which the film positive color separates have been ordered), from laboratory test results, and from assessment of water availability, an estimate will be provided for the further requirements needed to undertake a national overview of Djiboutian soil and water resources.

Indication that the statement of work has been satisfactorily attained will be evidenced by the following:

a. Field survey and testing methods will have been developed such that a small-scale 1:100,000 national soils map will be produced to be used in selecting potential agricultural sites and rangeland management capability.

b. A procedure will be established to methodically cover the areas of highest priority during the ensuing five or six years.

c. Soil survey and analysis will follow practices which will permit the use of existing or planned satellite or aerial imagery for future evaluation and monitoring of land use.

d. Satellite imagery and aerial photographs will be used to construct the national soils map so future imagery of this type will be easily correlated to the soils map.

e. A random-generated inventory based on a sample of 1,000, one-square-kilometer plots will be established to be used as an agricultural and rangeland needs inventory so specific sampling and detailed analysis can be directed to specific areas which will reflect its relative national impact. The data derived from these plots will serve in satellite imagery interpretation, resources inventory, production estimates and provide data for economic evaluation.

f. Map units will have appropriate soil classification, relying on field data, laboratory reports and other information sources.

g. The laboratory will be equipped and developed to the point that soil testing requirements can be independently handled therein.

Djiboutian personnel will conduct the following soil fertility tests: nitrogen, phosphorous, potassium, organic carbon, calcium, carbonate equivalence, pH, Boron, and sodium and other necessary micronutrients. The more specific analysis will include cation exchange capacity, total base saturation and electrical conductivity.

The soil physics tests the laboratory will include bulk density, soil structure, and particle size analyses. The equipment will not be furnished for testing water holding capacity, water infiltration, plasticity index, shear strength and others. At present, these can be estimated from other data acquired by the laboratory.

Some rare micronutrients and clay minerology will have to be analysed outside of Djibouti because their testing requires specialized equipment.

Coordination will be etablished for equipping the laboratory and implementing appropriate water quality analysis. Necessary chemicals and equipment will be ordered (see attached lists).

The equipment. chemicals, and transportation are funded by the UASID. Other commodities deemed critical for this project will be forthcoming from the Djiboutian government and other donor agencies. These include buildings, facilities, personnel and hydrologic field support. The layout for the laboratory will be drawn out and the laboratory so constructed.

A user service will be established which will include Genie Rural, Agricultural Service, ICERTS, Public Works, volunteer organizations and private individuals. These people will be able to present soil and water samples directly to the laboratory accompanied by a form giving relevant information about the sample. Alternatively, the laboratory will be able to collect the sample and the relevant information for the user. The user will then receive the results of the analysis and any appropriate and practical interpretation. The results will be stored and used in future assessments of the status and uses for Djiboutian soils. It is expected that the users will cooperate by furnishing information on the results of recommendations given by the laboratory so that further recommendations can be refined. Crop production is the final test of a soil analysis and subsequent recommendations for soil ammendments and practices. This information must be returned to the laboratory. A system will be designed to accommodate this flow of information to and from the field.

A technical library will be established and stocked with relevant texts, manuals and journal subscriptions in the fields of soil science, hydrology, geology and water resource, planning and land-use management. All past and present information, maps, studies, and reports specific to Djibouti will be catalogued. This will be a continuing effort during and after the project.

Several types of on-the-job training will be given by the technical advisor to the Djiboutian personnel. They include the following:

a. A Djiboutian-designated degree-trained laboratory assistant (Farah Omar) will be trained in water quality testing for the following tests: sodium, calcium, magnesium, manganese, iron, aluminum, silicon potassium, phosphorous, boron, chlorine, sulfates, carbonates and nitrates and others that may be deemed necessary.

b. The West German technical assistance team will train a Djiboutian hydrologist in well logging interpretation, aquifer reconnaisance, stream gauging, meteorological and general hydrological techniques and data management. This hydrologist will supervise the laboratory assistant on water quality testing.

c. A Djiboutian technican will be trained in cataloguing and data management to include equipment and materials inventory as well as technical correspondence and reports.

d. A Djiboutian-designated degree-trained soil scientist will receive on-the-job training in soils description, morphology, classification, cartography, reporting, interpretation and chemical analysis. He will assist the laboratory assistant in soil analysis.

e. There will be two candidates identified for training in America or a third country. While most short-term training will be presented as training on-the-job due to the qualifications of the contracted technical advisor, more structured training would be advisable for the candidates. At least, six months should be spent by the laboratory assistant in a functioning laboratory such as the S.C.S. laboratory in Lincoln, Nebraska and the U.S.G.S. Water Laboratory in Denver, Colorado or a third world country such as Tunisia, Portugal or France.

f. The pedologist will need two years of post graduate training in soil chemistry to assure that he has enough formal background to solve problems that will arise after the completion of the project.

g. Based upon project soils and water activities and other existing data, this project should develop comprehensive soils reports on the national soils inventory to be used in the location of agricultural sites and the evaluation of rangeland potential.

h. Geographical areas will be analyzed in terms of soil depth, structure, salinity, texture and drainage with subsequent recommendations regarding viability of various land-use options to include intensive irrigated row crops, irrigated pasture, and rangeland and brushland including cropping patterns, and pasturage, and range potential. This will be accomplished with maps, tables, dialogue and laboratory results.

i. The water resource component will address water quality based on its chemical composition and conductivity. This testing will be supportive of other donors' efforts to determine the quality of ground and surface water for human, animal and agricultural use. The water and soil priorities will be placed in that order.

j. Recommendations concerning further investment in the agricultural sector and will be made based on the data available. If further investment is warranted, the question of additional American cooperation to upgrade the capabilities in the laboratory will be assessed. At the end of this project, the laboratory will be able to perform all routine soil and water analysis and soil investigations.

Personnel

In order to implement this project, the following long-term resident services of an advisor pedologist will be provided:

a. There will be twenty-four months of an experienced PhD degree- qualified pedologist and geologist. This individual will be responsible for attaining the training objectives in soil and water analysis and in soil survey, reporting and interpretations.

In summary, the advisor pedologist will do the following:

a. He will facilitate equipping the soils and water laboratory by doing the design, layout and equipment inventory. He will install the equipment, test its serviceability, determine sample flow, decide on testing procedures and techniques, and organize the laboratory into a smooth flow of samples, test results and recommendations.

b. He will develop an annual work plan for the laboratory with the assistance of the Djiboutian assistants. Another will be developed for the second year and a third just prior to his departure at the end of the project.

He will conduct the following surveys:

a. Soil reports will be provided.

b. Family unit and detailed-scale surveys of potential or existing garden areas where management, irrigation techniques, reclamation procedures, crops and drainage have to be adapted to soil conditions and water quality and availability. This will include a soil characterization and description for each site. Since the 400 or so gardens average about 0.25 hectares maps at any reasonable scale would not be relevant. Thus, a verbal description of the soils and the geomorphology will be made and recorded for each farm. A large scale map on aerial photos of the garden region will be made when the soils of the country are understood and their relationship to the garden area is understood. The order of priority will include Mouloud, Doudubbala, Forrage, Gran Bara, Ambouli, and Atar amoung others. Service at this scale will be considered a personal service to the land user. (Service has been rendered at this scale to the Km 20 project and some gardens in Ambouli.)

c. Soil surveys will be made at a medium scale of 1:20,000 (the scale of the aerial photos) because there are not sufficient 1:50,000 scale base maps to provide proper control in reporting the survey. It is too time-consuming and costly to make impromptu base maps. The soils areas would be more accurately recorded directly on aerial photographs which can subsequently be referred to for land evaluation. This scale of mapping will be used on major plains and other areas identified as having both a soil and a water potential. These will include the Gobbad, Hanle, Tadjoura, Atar, Obock and many places scattered from Ali Sabei to Dorale. A soils map will not be developed until an area has been studied sufficiently to verify that is has both quality soils and water above the needs of the local inhabitants and their livestock to support irrigated agriculture. Then, only that portion which can be identified as productive will be surveyed to conserve efforts and to keep the attention directed towards areas which can be productive. Because of the low scattered rainfall and the various drainage conditions and configurations, agriculture will probably be concentrated in many small scattered areas throughout the country instead of one area of concentrated effort. This is mostly due to limited water supplies and erratic rains.

d. He has developed a plan for a small scale survey at a scale of 1:100,000 which will give Djibouti its first national soils inventory which will serve as a basis for rationally determining the high priorities for agriculture. It will also serve for rangeland management. The scale of 1:200,000 was rejected because the topographic control is considerably better at the larger scale. Further there are too few maps available at 1:50,000 (one sheet only) to do a survey at that scale. Therefore, a scale of 1:100,000 represents the best available. Enough detail can be presented at this scale to give all the information needed in planning and soils inventory evaluation until specific site maps are made at 1:20,000. This inventory has begun while the laboratory is being completed. It is also providing soil samples and soil descriptions which will be used for practice in laboratory training. The survey will provide basic information on uplands and stratify soil environments according to their potential for grazing, carrying capacity, etc.

e. He will prepare reports on the above surveys with accompanying land use recommendations. These will include soil, family, level description of soils at the individual garden level. It will include the recognition soil subgroups at the intermediary level of a scale of 1:20,000, and, it will include soil Great Group subdivisions at the general soil inventory on the national level.

f. He will develop land use recommendations for the foregoing areas surveyed relying principally upon field estimates to determine permeability and infiltration in areas where irrigation is planned, and also laboratory analyses to determine texture, pH, organic carbon, electric conductivity, total base saturation, cation exchange capacity, bulk density, boron and other relevant tests.

g. He will determine, as early as possible, the extent to which the soils and water laboratory can satisfy the above requirements, and, where he determines it is unable to do so, he will develop assistance outside of Djibouti which can perform the analysis. Assistance of this type can be expected for clay minerology analysis, some X-Ray diffraction analysis for selected soil minerals, and certain rare micronutrients. This assistance can probably be obtained from the Overseas Technical School in France.

h. He will provide work-related training for the Ministry of Agriculture's Djiboutian degree-trained pedologist assigned as Director of the Soil and Water Laboratory. This has included training in soil description, classification and cartography. It will include soil chemical analysis and procedures as well as soil reports. He will also be given training on managing the laboratory, maintaining quality control and recommendations based on the analysis and the soils inventory.

i. He will provide work related training to the laboratory assistant in soil chemical analysis to includetests for nitrogen, phosphorous, potassium, organic carbon, calcium carbonate equivalent, total base saturation, cation exchange capacity, micronutrients, sodium, boron, chlorine and electrical conductivity. There will also be training in bulk density, determination of textural analysis and mineral identification. The laboratory assistant will also learn to test water quality for sodium, potassium, calcium, magenesium, phosphorous, iron, aluminium, silicon, chloride, sulfide, nitrate and carbonate and any other appropriate analysis. He will further become acquainted with soil and water field procedures.

j. He will develop a base line of ground truth developed from 1,000 random samples and integration of present and planned satellite imagery and aerial photography into the soils map. He will develop a data base for comparison to future imagery for time-lapse analysis (the random sample has been drawn).

k. He will be responsible for establishing a technical library and user service.

l. He will coordinate soil sample collection and analysis activities with other donors as desired by the Djiboutian Government.

m. He will inform the government of Djibouti, the Ministry of Agriculture and USAID on the quarterly progress of project activities.

n. He will bring to the attention of the Djiboutian Government and USAID any problems or shortfalls expected as a result of possible insufficient manpower, training complications, commodity deficiencies, donor coordination, etc.

o. He will be responsible for synthesizing the results of this project in a final report.

p. He will provide training and guidance to the water quality chemist (laboratory assistant) since no short term hydrologist assistance is forthcoming. No other short-term technical assistance is needed due to the advisor's qualifications and therefore no coordination of T.D.Y visits will be necessary as was earlier anticipated. This is also true of the remote sensing qualifications. The advisor has ample experience in appropriate phases of remote sensing applications and interpretations. The West German donor assistance program will supply all the hydrological expertise except water quality analysis which will be provided by the pedologist advisor.

Timing

The project began late July 1980 with the arrival of the pedologist advisor, Dr. Joseph Goebel, and the subsequent assignment of Mr. Abubaker Duale as the Djiboutian degree-trained pedologist. In September, Farah Omar was assigned as the Djiboutian degree-trained laboratory assistant.

The first quarter from August through October was involved with equipment inventory, laboratory design and construction, and an airborne and vehicle reconnaisance of the soils of Djibouti. It also included listing and ordering the chemicals for the soil and water analysis, the equipment needed for field studies, other equipment and satellite imagery. The team became acquainted with each other and the dimensions of the project at hand. Materials were gathered for the technical library.

Because the laboratory facilities had not yet been constructed and the construction crews interfered with any office activities in the overcrowded cartography room, the second quarter was dedicated to planning and instructions on soil descriptions, classification, mapping and sample collection and labeling. Film positives of color separates for the 1:100,000 scale topographic map were made to serve as a stable base to accurately locate soil boundaries. A need for a second vehicle was also established to assist the laboratory in soil sample collection. The annual work plan was written and passed for review.

The third quarter will be involved with describing, classifying and sampling the dominant soils of Djibouti to serve as patrons for identifying comparable soils elsewhere. These soils will be sampled in the first 100 random survey plots. Specific data can be collected for planning and resource evaluation as well as the soil survey. Training will be given on remote sensing, soils mapping, and resources evaluations. It is then expected that construction will be completed on the laboratory and the equipment can be installed, adjusted, and prepared for operation.

The fourth quarter will be dedicated to training on water quality analysis. The procedures and techniques will be established for the tests mentioned earlier under water analysis. After this time, the laboratory should be fully qualified to do water quality testing. The next annual plan will be written and designed to accomplish the remaining goals of the project.

The first quarter of the second year will be dedicated to training on procedures and techniques for soil analysis. Samples collected previously and techniques for characterization will serve as practice samples.

The second quarter of the second planning year will be dedicated to the soils inventory and soils mapping. The remaining soils will be described, classified, mapped and interpreted. The last part of the quarter will be involved with training on soil use interpretation. In the meantime, those soils and water samples which arrive for analysis will be tested and reported.

The third quarter will also be dedicated to soil survey. The principal effort will be the completion of the national soils map so priority areas can be selected and all of that data will be available for the final report. Then land use interpretation will begin for all of the soils described and tested.

The fourth quarter will be involved with specific on-site investigations and reports, training in computing laboratory summary analysis, and writing laboratory reports. The final reports will be written and the project synthesized in another report.

It is projected that the pedologist advisor will need to return each year for two years for about eight weeks' time in Djibouti and four weeks' time in America. This will provide follow-through to backstop the laboratory personnel on items which occurred through the year which were out of the ordinary and not foreseen in the training.

Within the third year of the start of the project, the laboratory assistant should attend six months work-study at an established soils laboratory and an established water quality laboratory to observe and acquaint himself with a functional laboratory. In the fourth year, the Djiboutian pedologist should enter two years of formal post-graduate course work on soil chemistry and water quality chemistry. This will be essential for him to run the laboratory completely independently.

The above represents the expected scenairo, which however, is subject to amendment based upon USAID and Djiboutian government approval. It should be noted that on-the-job training will be provided throughout the period of the project and subsequent T.D.Y. For that reason, periodic reports are expected on the progress of the counterparts and the staff towards grasping instructions and guidance. These reports will define the success of the institutionalization of the project activities.

Reports

I. Annual Work Plan. This will include the goals and objectives of the laboratory. It will show the list of personnel and their job descriptions. There will be a list of the work to be accomplished and a chart which shows the schedule and the people responsible to accomplish the work.

II. Quarterly Report. This report will include the work that was anticipated for the Quarter. The work actually accomplished will be listed. There will be a section which describes the obstacles and deficiencies in the project. It will state the work to be accomplished during the coming quarter. It will also state how much progress has been made towards the completion of the project.

III. Specific Area Reports. Short individual descriptive reports will be written for individual land owners. Specific regional reports will be written on high priority areas for agricultural development. These will discuss the objectives of the study, the methods used, results and recommendations. In the case of soils work they will include proper maps.

IV. Final Report will synthesize comprehensive soils analysis and water quality testing reports which would cover all areas addresed during the life of the project. It will also provide preliminary recommendations regarding future American assistance in this area.

Administrative and Donor Coordination

The Soils and Water Laboratory presently functions within the Rural EWgineering Service of the Ministry of Agriculture and Rural Development as the institution responsible for surveying and analyzing Djibouti's soil and water potential and recommending preferable land use options, as well as providing for the utilization of water in rural areas. To accomplish the above objectives, the Rural Engineering Service is organized into the following sections:

a. A standard administrative and accounting section.

b. A maintainance section which can provide support and maintainance and service to all facets of the Service's operations.

c. A public works section dedicated to drilling wells for water exploration and production. This section develops recognized water sources in rural areas for human and agricultural use by the use of water points, dams, wells, etc. This section also provices test drilling using two Saudi Arabian well drilling rigs in order to identify potential water sources.

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d. A research section which is divided into one part for water resource evaluation and another for soils resources evaluation. Work under this project is in the domain of the research section.

The water research sub-section has undertaken well-logging and well net monitoring to determine the quantity of groundwater. It has undertaken wadi (stream) gauging to determine rain water run-off for purposes of identifying the surface water potential.

It will use the soils and water testing laboratory to test both the surface and ground water quality for human and agricultural use subsequently furnishing technical reports concerning the results. It will then develop a comprehensive plan synthesizing the data collected to make specific recommendations for Djiboutian water use potential.

The soils research sub-section undertakes field analysis, develops an appropriate soil classification system and maps the soils in order to determine the agricultural potential for irrigated, non-irrigated agriculture and rangeland. It is developing a soil laboratory into a unit capable of independently conducting the necessary soils analysis, testing water quality and furnishing technical reports on the analysis.

It will develop a comprehensive plan for effecting evaluation and analysis of potential agricultural areas with the intensive effort directed towards the plains, the mountains and the national soils maps in that order. This section is developing a technical library on soil and water studies pertinent to Djibouti.

The soils sub-section is headed by a Djiboutian pedologist. Mr. Abubaker Duale, who also supervises the soils and water laboratory with administrative support from Mr. Mohamad Waberi, the Chief of the Rural Engineering Service. The water section is still solely staffed by the West German hydrogeology team since an acceptable Djiboutian degree-trained hydrogeologist has not been agreed upon. The soils and water laboratory has a laboratory assistant with limited formal technical training in Ethiopia, Mr. Farah Omar. Besides assigning a degree-trained hydrogeologist to the water section the soils and water laboratory is expecting to have two laboratory technicians, a secretary and a library clerk-computer programmer assigned so it can meet its objectives in this project.

All of the sections are housed in an office complex of more than 150 square meters of floor space. The chemistry benches, distilled and tap water and stable electric power in both 110 Vac 60 Hz and 220 Vac 50 Hz is being installed and should be completed in March. Ample sinks, benches, cabinets, library shelves, sample receiving and storage shelves are all being constructed. There is an office, a soil cartography room, a wet laboratory and an analytical laboratory in the soil and water

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laboratory of the soils section. There are two offices for the water section, there is an office for the public works drilling section (French assistance, offices for accounting, administration, and drafting. The Minister of Agriculture is expected to occupy the building shortly and the Chief of Service will move his office to a nearby structure.

Other donor assistance is represented by the following endeavors. The French assistance is represented by two well loggers, Mr. Merer and Mr. Berger who have been working with the West German Hydrogeologist. They head the public works section in carrying out its objectives and, specifically, provide operational support for drill rig, on-the-job training to crews and special training to selected drill personnel. They are assisted by a contracted West German mechanic, Mr. Riedzig, and a United Nations drill expert, Mr. Martin.

The West German technical assistance in hydrology and hydrogeology is headed by Dr. Mueller with assistance from Mr. Treader. No Djiboutian counterpart has been assigned. This project has been extended for an extra year into 1982. The West Germans represent the water section. They log wells, determine water quantity by pump testing, gauging static and dynamic change in priority areas. Results have not yet been obtained. They determine sites for public works water test drilling. They establish well nets to determine aquifer volume and precise locations while training the public works section on well logging procedures. They provide field water samples which are presently tested in Germany but will be tested in the water laboratory. They will prepare reports and recommendations on the water resource of Djibouti based upon field and laboratory results.

There has been additional French expertise provided in administration. No land-use specialist has been mentioned to syntheisize the information from the water section (West German-assisted) and the soils section (American-assisted) in terms of development of a National Resource Inventory Plan.

The American pedologist advisor is responsible for the following:

He has designed the laboratory facilities and tended to their proper installation which is still in progress. He provides operational and advisory support to all of the soils section. He will train the laboratory assistant in water quality analysis as well as soil analysis. He is training the pedologist in soils investigations. He is developing a technical library and will train the librarian. He is working across organizational lines with the water section, the Agricultural Service, the Ministry of Agriculture, ISERTS and Public Works but he reports only to the Chief of Rural Engineering Service.

The Work Load for the Djiboutian

Soil and Water Project

To facilitate recognition of progress in the work for the Djiboutian soil and water laboratory project, included is the following list of work categories that were explicitly or implicitly stated to accomplish the goals and objectives of the project.

I. Equipment

A. Construction of the building
B. Construction of the laboratory facilities
C. Ordering and purchasing equipment, materials and supplies
D. Equipment and materials inventory
E. Equipment maintenance
F. Restocking materials and supplies

II. Laboratory Analyses

A. Test soils for nitrogen, phosphorous, potassium, micronutrients, salinity, conductivity, carbonates, lime, texture, structure, bulk density and others.
B. Test water for sodium, potassium, calcium, magnesium, phosphorous, manganese, iron, carbonate, sulfur, nitrate, chloride and others.
C. Independently analyze all soil and water types in Djibouti.
D. Establish proper laboratory techniques.
E. Establish proper laboratory procedures.
F. Establish sample flow.
G. Compute results of analyses.
H. Record results.
I. Make recommendations.
J. Arrange for outside analyses of clays and trace elements.

III. Water Quality Analyses

A. Test all samples received.
B. Receive all samples presented.
C. Test each specific analysis.
D. Record and report results of tests.
E. Coordinate the efforts with other agencies, i.e., ISERTS, Public Water and Public Works.

IV. <u>Soil Chemical Analyses</u>

A. Collect soil fertility samples.
B. Make appropriate tests for each user.
C. Acquire a predictive capability for recommendations based on Lab. results.
D. Distribute the information.
E. Report results.
F. Make recommendations on soil amendments and land use options.
G. Cooperate with extension service.

V. <u>Soil Survey</u>

A. Identify the natural soil bodies
B. Describe the soil characteristics
C. Classify the soils for comparison with similar soils elsewhere.
D. Write official soils description
E. Describe the soil mapping unit
F. Map the extent of similar soils at small and medium scales
G. Write a report on the soils and include the map descriptions and interpretations
H. Interpret the soils for agricultural uses for land use options, irrigation, and run-off agriculture, selected crops, cropping practices and production potential.
I. Make a national soils map at 1:100,000 scale
J. Make a national slope map at 1:100,000
K. Make a national watershed map at 1:100,000
L. Make appropriate interpretive maps
M. Make large scale maps of potential agricultural areas, i.e., Atar, Mouloud, Doudubbda, Gran Bara, Gobbad, Tadjura, Hanle, Etc.
N. Make individual soils reports for cooperative lab. cliental to be used in land use decisions.
O. Provide guidance for subsequent soil and water analyses in the field.

VI. <u>Land Use Planning</u>

A. Make random sample for National Resource Inventory
B. Describe all of the natural resources in detail for each sample ploy.
C. Summarize the results of the inventory.
D. Design the inventory for planning assistance.
E. Design the inventory for land use monitoring
F. Make rangeland interpretations
G. Make irrigated agricultural land interpretations

VII. Random Sample

A. Make random sample for National Resource Inventory
B. Describe all of the natural resources in detail for each sample plot
C. Summarize the results of the inventory
D. Design the inventory for planning assistance
E. Design the inventory for land use monitoring
F. Make rangeland interpretations
G. Make irrigated agricultural land interpretations

VIIa. Remote Sensing

A. Collect remote sensing imagery
B. Teach remote sensing techniques
C. Develop procedure for land use monitoring
D. Use remote sensing to make resources evaluation
E. Establish ground truth for remote sensing
F. Recommend future uses of remote sensing

VIII. Training Functions

A. Teach laboratory analysis of soil and water
B. Teach laboratory management
C. Teach laboratory reporting
D. Teach soil survey and reporting
E. Teach soil interpretation
F. Teach soil and water resource evaluation
G. Teach remote sensing interpretation and application
H. Teach cartography
I. Teach library management
J. Teach cataloguing and data management.
K. Identify short term training needs for two people
L. Evaluation of laboratory personnel

IX. Technical Library

A. Establish a library of technical information on soils, water, hydrology, geology and agronomy
B. Order texts, books, journals and reports
C. Establish cataloguing and checking procedures
D. Catalogue past and present reports

X. Project Recommendations

A. Give national overview of soils resource
B. Evaluate agricultural potential
C. Recommend for or against further investment in water
D. Recommend for or against further investment in the agricultural sector

E. Notify GROD and AID and MOA of the progress of the project
F. Notify GROD and AID and MOA of expected short falls in the project
G. Recommend future follow through guidance for adaptive studies and reports

XI. Establish User services

A. Determine who is intimately concerned with land use
B. Establish communication with land users
C. Establish servicing procedures for land users
D. Test a means and format for information dissemination

XII. Working Relationships

A. Report to the Chief of Service of Genie Rural
B. Advise the water section of Genie Rural
C. Cooperate with the Ministry of Agriculture
D. Cooperate with the Agricultural Service
E. Cooperate with ISERTS
F. Cooperate with private citizens
G. Keep AID informed on the project
H. Cooperate with Public Works
I. Represent Resources Development Associates

XIII. Reports

A. Annual work plan
B. Quarterly report
C. Specific area reports
D. Final report

IMPLEMENTATION PLAN

1979	OBJECTIVE	RESPONSIBILITY
January	Project Proposal approved	AAO/D REDSO/EA
	Project Agreement Signed	AAO/D REDSO/EA AID/W
	PIO/T issued and contracting for tech. services begin	AID/W REDSO/EA
February	Vehicles and equipment ordered	AAO/D REDSO/EA
April	Project agreement revised to include only the Soils & Water Laboratory	AAO/D REDSO/EA
June	Housing for technician obtained	AAO/D
1980		
February	Construction begins on laboratory building	GROD
March	Equipment arrives	AAO/D GROD
July	Temporary contract signed for Tech. assistance	RDA/AAO/D GROD REDSO/EA AID/W
	Technical assistance arrives	RDA AAO/D
August	Degree trained Djiboutian pedologist assigned	GROD
	Laboratory material inventoried	RDA Genie Rural
	Laboratory facilities layout & requirements defined	RDA Genie Rural
September	Order chemicals, materials, field equipment and satellite imagery	RDA Genie Rural AAO/D
	Construct laboratory facilitiesq	GROD
October	Sign final contract agreement	RDA AAO/D GROD REDSO/EA AID/W
	Establish library	RDA Genie Rural
	Field review of soils	RDA Genie Rural
November	Write Annual Work Plan	RDA Genie Rural
	Give training in soil description & classification	RDA Genie Rural
December	Continue training in soils	RDA Genie Rural

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January	Give training in soil cartography	RDA Genie Rural
	Make preliminary soils map	RDA
	Draw random soil inventory samples	RDA
	Write Quarterly Report	RDA
February	Collect, describe & classify 30 soils for soils inventory	RDA Genie Rural
March	Give training in remote sensing	RDA Genie Rural
	Install lab equipment	RDA Genie Rural
April	Write Quarterly Report	RDA
	Receive equipment & materials	RDA Genie Rural
May-July	Enter detailed training in lab procedures and tech. for water quality tests	RDA Genie Rural
	Write Annual Work Plan & Quarterly Report	RDA Genie Rural
Aug-Sept.	Enter detailed training for lab procedures and tech. for soil tests	RDA Genie Rural
Oct-Dec.	Write Quarterly Report	RDA
	Do small & medium scale soil survey investigations.	RDA Genie Rural

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Jan-Feb.	Write Quarterly Report	RDA
	Continue small & med. scale survey investigations	RDA Genie Rural
March	Interpret land use for all soils studied	RDA Genie Rural
April	Compute the results of soil & water analysis	RDA Genie Rural
	Give training on routine lab and soils reports	RDA Genie Rural
May-June	Review, summarize, synthesize and make final reports	RDA Genie Rural
July	Bring the project to conclusion	RDA Genie Rural AAO/D

1983		
January	Lab Assistant goes for 6 months OJT	Genie Rural AAO/D
June-July	Follow-up technical return visit	RDA Genie Rural AAO/D
	Present Final Report	RDA
	Project evaluation	AAO/D AID REDSO/EA
August	Tech. advisor writes reports on visit	RDA
September	Pedologist begins 2 yr post graduate training	Genie Rural AID
1984		
June-July	Tech. advisor's final follow-up review of lab & assists lab tech. while pedologist is gone	RDA Genie Rural
August	Tech advisor writes report on visit	RDA
1985		
June	Pedologist returns to resume lab responsibilities	Genie Rural

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TABLE I: SUPPLEMENTARY HOURS

PROFESSIONALS AND LABOURERS OF THE SOIL AND

WATER RESOURCES ANALYSES LABORATORY

Beneficiary	Salaries per month	No. of hours/	Account times			Annual Cost	Reserved for Finance Minister
			25%	50%	75%		
Agronomist	161,662	170	120			45,600	
Technician	109,917	120	120			31,200	
Laboratory Assistants (x 2)	90,542	120	120			25,800 x 2- 51,600	
Mechanic/ Driver	59,400	120	120			10,050	
Guards (x 2)	15,850						
Labourers (x 2)	15,850	120	120			2,681 x 2- 5,362	
Janitor	17,700						
Accoountant/ Secretary	67,900						
ANNUAL TOTAL	7,932,816					143,812	

APPENDIX C-4

Status of the Soils Analysis and Water Resources Laboratory

SUMMARY

FROM: Adoubaker Douale
Dr. Joseph Goebel

TO: Minister of Agriculture and Rural Development

SUBJECT: Report on the Status of the Soils Analysis and Water Resources Laboratory

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Introduction

Following your request of January 7, 1981, we are submitting this report to you concerning the status of the Soils Analysis and Water Resources Laboratory.

A laboratory for determining water quality, soil fertility, and soil characteristics is being installed in Djibouti with the technical assistance of Resources Development Associates, a California company, with assistance in financing and equipment from the Agency for International Development of the United States of America and the personnel and administrative support of the Minister of Agriculture and Rural Development of our country.

By the end of the two-year contract, a rational conclusion about the quantity and quality of soils and water for public, industrial and agricultural needs will be furnished.

Tasks of the Laboratory

The laboratory will make physical and chemical analyses of all of the soil and water samples and the resulting inventory and classification of the soils for the Genie Rural, the Agriculture Service, ISERTS, AFVP, CIDR and individual farmers. Thus, selected priority areas, Doudas, Grand Bara, Tadjourah, Atar, Mouloud and Bissidirou, among others, can be adequately exploited.

Library

In order to facilitate the tasks of the laboratory and aid all those interested in the aforementioned topics, a technical library of subjects relevant to soil and water will be installed very soon. It will also furnish scientific reports and recommendations concerning land use.

Personnel Training

Dr. Joseph Goebel, pedologist/advisor, will give all necessary on-the-job professional training to the national pedologist and technicians, including simple soil description, development and drafting of maps, and reasonable interpretation of the laboratory results. Formal post-graduate training is foreseen for the national pedolotgist in order to prepare him to surmount unusual and non-routine problems.

Estimated Number of Annual Samples

Considering the highly qualified personnel and the laboratory material and facilities that will be available, 2,000 soil fertility samples and 1,000 water quality samples could be analyzed annually.

Organizational Status of the Laboratory

As in every other country, the laboratory is expected to serve several governmental services and the private sector. Since the requirements of each client will vary from one time to another, it should hold a largely independent position under its assigned Ministry in order to have more freedom to evaluate and adjust the charges for the requested services and treat its clientele with more equality and objectivity while meeting specific requests.

Costs for Sample Analysis

Experience teaches us that if the services are free, the laboratory will receive too many useless samples, and the results will often be ignored. Therefore, taking into account the cost of equipment and construction, the following different charges will be effective:

For samples that come from other countries, the cost would be 6,990 DF for each water sample, 13,680 for fertility analysis of each soil sample, and 25,560 DF for a complete soil analysis.

For different national services, the costs would be: 1,530 DF for water samples, 2,880 DF for soil fertility samples and 5,740 DF for a complete soil analysis.

For private farmers using the services, we propose charging a nominal fee between 360 and 900 DF, depending on the type of analysis to be done.

We hope that after having read this report, you will wish to call a meeting concerning the status and the responsibilities of the laboratory and its personnel. We ask you, the Minister, to accept our respects.

Adoubaker Douale
Dr. Joseph Goebel
(Pedologists in charge)

enc: One (1) laboratory budget proposal

REPORT TO THE MINISTER OF AGRICULTURE ON THE STATUS OF THE SOIL AND WATER LABORATORY

by Dr. Joseph Goebel and Mr. Aboubaker Douale

January 20, 1981

Introduction

In response to your request of January 7, 1981, we are submitting this detailed status report on the soil and water laboratory in Djibouti.

A laboratory for the purpose of determining water quality, soil fertility and soil characteristics is being established in Djibouti with technical assistance from Resources Development Associates of California, a financial and equipment grant from the United States Agency for International Development and with personnel and administrative assistance from the Minister of Agriculture of Djibouti. It is anticipated that upon successful completion, this laboratory will be a major contribution to the development of the precious limited soil and water resources of this country. During the two years assigned to establish the laboratory, a rational conclusion will be made about the quantity and quality of both the soil and water resources to meet public, industrial and agricultural needs.

The building for the laboratory has been constructed; the necessary permanent installations are being made. The testing equipment has been received, the chemicals and field equipment are on order. A soil scientist and a laboratory technician have been assigned and are at work. Training has begun on field characterization of soils, soil mapping and cartography after a preliminary review of lands of Djibouti.

The laboratory is a joint venture between Djibouti and the United States of America under an agreement entered into in April of 1979. Implementation of the project was delayed for various reasons until July, 1980. Since that time, activity towards the objective of a fully functional soil and water laboratory has increased significantly. Dr. Joseph Goebel has arrived to direct the laboratory and soil investigations. A laboratory technician, Farah Omar, has been assigned to do the soil and water analysis. Final construction of the permanent laboratory facilities was initiated and is expected to continue until March, when the equipment can be installed and training for specific analysis can begin. In the meantime, assessment of the Djiboutian soils and soil morphology, classification and cartography has begun.

INTERAGENCY COOPERATION

Because of the primary importance of water and soils to the welfare of the Djiboutian people, many government agencies and people will need specific information on these resources which can be provided by the soil and water laboratory. As a consequence, the following agencies are expected to have soil and water tested regularly at the new facility:

Genie Rural
Agricultural Service
I.S.E.R.S.T.
R'egie des Eaux
A.F.V.P. agricultural projects
C.I.D.R. agricultural projects
Individual land owners

Under the general direction of the Ministry of Agriculture, the laboratory should be budgeted and authorized to meet the testing needs of these agencies.

ASSISTANCE TO BE PROVIDED BY THE LABORATORY

The laboratory will analyze water samples for calcium, magnesium, sodium, potassium, phosphorous, boron, manganese, iron, aluminum, sulphate, nitrate, carbonate and chlorine.

Soil analysis will include nitrogen, phosphorous, potassium, organic carbon, pH, calcium carbonate equivalent, cation exchange capacity, total bases, electrical conductivity, texture, and bulk density as well as reliable estimates for permeability, water infiltration rates, field water capacity, wilting point, soil structure and percentage of organic matter.

The soils in Djibouti will be classified according to comprehensive soil taxonomy and characterized according to morphology to expedite recognizing and grouping similar soils which will respond to similar treatment in a similar manner. A properly classified soil can also be compared with similar soils elsewhere in the world where more extensive information is available concerning their use and development.

The inventory of the soils will result in maps which will group the soil with similar characteristics so that the laboratory results can be correlated with soils having similar morphology. Since production is related to soil morphology and soil chemistry, and production is the final result of a soil analysis, chemistry and morphology relationships must be identified before recommendations can be made.

The personnel in the laboratory will describe and characterize the major soils of Djibouti with enough detail that decisions about land use can be made. A soils map of the entire country will be made at the 1:100,000 scale since this is the best map available which covers the entire country.

There will be a report on the characteristics of each major soil in Djibouti. There will be appropriate interpretations of the land use for each major soil.

There will be a selection of sites which have the most suitable combination of soils and water in order to establish a priority list of lands to be developed for agriculture to whatever extent the soils and water resources will permit.

Selected priority areas will receive specific soil studies and reports to facilitate development. These sites include Doudas, Grand Bara, Tadjoura, Atar, Hanle, Mouloud, Bissidirou and other sites identified by the soils and water investigations.

Each individual landowner will receive a report on the soils of his parcel of land to aid the agricultural technician in making specific recommendations as well as in identifying the piece of land and recongnizing its soil and water resources.

In summary, the laboratory will do chemical analyses of soil and water and also inventory and report on the soil resources.

LIBRARY

A technical library on subjects related to soils and water in general, as well as the soils and water specific to Djibouti, will be established to facilitate the laboratory and others interested in these subjects.

REPORTS

The laboratory will regularly produce the following reports. There will be an Annual Progress Report summarizing the achievements of the previous year, an Annual Work Plan projecting the needs of the coming year, an Annual Budget, Quarterly Progress Reports and various other specific technical reports.

PERSONNEL

The laboratory will require the following personnel to meet minimum needs:

A pedologist for the soils inventory and survey. He must also supervise the laboratory analyses and recommendations; a laboratory technician to conduct the soil and water analyses and maintain the laboratory facilities; two laboratory assistants to expedite routine and time-consuming procedures and for equipment maintenance; a secretary capable of some accounting for general communications and materials inventory as well as maintaining the technical library; Other services: a janitor, a chauffeur-mechanic and a guardian. Two laborers are also needed for profile drilling.

OFFICE CONSTRUCTION/EQUIPMENT

The laboratory requires 150 square meters of office space divided into four rooms as provided. This provides an office, a chemical laboratory, an analytical equipment room and a cartographic room for the soil survey. There is other space available for sample preparation, storage and disposal. The plan for these facilities is attached.

The equipment needed for the soil and water analysis is available, and the inventory list is attached. The chemicals needed for the analysis of soils and water have been ordered, and this inventory is attached. Equipment for field investigation of the soils has been ordered, and this inventory is attached. The laboratory has at its disposal two vehicles to expedite its field investigation and render service to other agencies.

The laboratory requires water, electricity and telephones which are being provided. Maintenance for the building and facilities are provided. At least six parking spaces are provided for laboratory use.

PERSONNEL TRAINING: Work-related Instruction

Pedologist

The pedologist will receive training in the following areas during his course of work. He will learn how to:

a. Describe the characteristics and morphology of the soil.

b. Classify the soils according to the comprehensive soil taxonomy of USDA.

c. Make soil maps so the location of similar soils will be ascertained.

d. Do chemical analyses of soil and water.

e. Interpret the soil characteristics for their limitations to specific land uses such as irrigation, crops, pasture and construction.

f. Make technical soils reports and reports on laboratory results.

Laboratory Technician

The laboratory technician will receive training in the following areas during his course of work. He will learn:

a. The procedures to analyze all of the constituents of water listed under water quality testing.

b. The procedures for the chemical tests of soil listed under soil analyses.

c. To test the physical characteristics of soils listed earlier.

d. Proper laboratory methods and techniques.

e. How the soil and water samples will proceed systematically and smoothly through the laboratory during their analysis.

f. To record and report the results of the soil and water analysis.

g. He will also receive training in soil description, classification and cartography.

Future Formal Instruction

The pedologist should receive two years of graduate instruction in soil chemistry for a more thorough background in the subject in order to supply non-routine services.

The laboratory technician should receive at least six months of instruction at a functioning laboratory so he can familiarize himself with his dutues, responsibilities, procedures and techniques in that functional setting.

After the laboratory becomes functional it would be appropriate for the pedologist, laboratory technician and the technical advisor to make a 3-week visit to a soil and water laboratory functioning in essentially the same environment. This would permit the two laboratories to communicate common problems and solutions.

POSITIVE DEVELOPMENTS

The arrival of the technical advisor, the assignment of a competent pedologist and a capable laboratory technician and the administrative assistance of Genie Rural have all been very beneficial in launching the laboratory. The building is constructed, and materials and equipment are on order or have already been received. The water investigation by the German team is well under way. The pedologist and laboratory technician have been responding well to their training in soil description and classification. Field reconnaissance has been made. Thus, the laboratory has been advancing toward its objectives in soil and water analyses and soils inventory.

INHIBITIVE DEVELOPMENTS

Some factors have retarded the laboratory in obtaining its objectives. The final construction of the laboratory facilities has not been completed. Therefore, the working facilities have been inadequate for a concentrated effort. This has also postponed training in the laboratory.

The chemicals needed for analysis have not been received, so neither training nor analyses could be accomplished even if the facilities had been completed. The equipment for field studies has not arrived, and therefore detailed descriptions cannot be made for the soils inventory.

The laboratory personnel are uncertain about their organizational affiliation. They are in the employ of the Agricultural Service, but assigned to Genie Rural. (The laboratory technician has not received his appointment or salary.) There are conflicting reports on the organizational position of the laboratory within the Ministry of Agriculture. This has to do with whether the laboratory is a subsection of Genie Rural or directly responsible to the Minister.

The laboratory has no specific budget to carry out its assigned duties and responsibilities. Financial assistance comes from Genie Rural in the form of building and administrative services. The pedologist's and laboratory technician's salries come from the Agriculture Service. Equipment is supplied by USAID. Technical services are supplied by Resources Development Associates. The laboratory has no specific and systematic budget with which to organize its expenditures and work.

Since the soil and water potential has not yet been determined, the amount of effort to be required by the laboratory has not been established. If there is an agricultural potential, it can be expected that soil fertility analyses will dominate the efforts of the staff; whereas with limited agricultural potential, water analysis will dominate their efforts. This has caused an emphasis on ascertaining the agricultural potential of the country so that the laboratory may thereby adjust its emphasis appropriately. Overall, the laboratory is proceeding well and should achieve its objectives, although perhaps not in the order originally planned.

ESTIMATED NUMBER OF ANALYSES PER YEAR

With the personnel, material and facilities previously mentioned, the laboratory should be able to process about 2,000 soil fertility samples and 1,000 water quality samples per year once it has become experienced and efficient. This probably will supply Djibouti's long-term analytical needs. At present, its needs are much smaller. We estimate the following: there will be two classes of soil analyses. There will be routine soil fertility tests, and there will be comprehensive tests for research in crop production. The first will require far less time and materials than the latter. We expect to do a standard set of analyses for the water samples, although special tests will be required from time to time.

Soil Samples

The laboratory expects to test the samples from 100 soils for the soil survey. Thus,

-	Genie Rural	Around	300 research samples
-	Agricultural Service	"	300 " '
		or	600 research samples/yr

-	I.S.E.R.S.T.	50 fertility samples
-	President's Development Office	20 " "
-	A.F.V.P.	50 " "
-	C.I.D.R.	10 " "
-	Agriculture Service Administrative Gardens	100 " "
-	Private individuals	600 " "
	or	830 Fertility samples/yr

Water Samples

-	Private farmers	300 water samples
-	Wells	40 " "
-	Wadi analyses	100 " "
-	I.S.E.R.S.T.	20 " "
-	Water Department	50 " "
	or	510 water samples/yr

ORGANIZATIONAL STATUS OF LABORATORIES

A soil and water laboratory may occur anywhere within the structure of the parent organization. Its actual position within the hierarchy depends upon those for whom it works more than anything else. Some laboratories are totally private and independent and solicit business. Others are attached to larger companies which offer soil and water testing as an additional service to their customers: or, they are used for internal research or to gain needed information to manage government property. They all do the same analyses, but they address different clientele from different positions.

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The laboratory should be in the best organizational position to dependably serve its major clientele. If it is expected to serve essentially one agency, then it should be associated with that agency as closely as possible to insure a good working relationship. On the other hand, if the laboratory is intended to serve several agencies as well as the private sector, and if the demands of each client shift from time to time, the laboratory should occupy a position of greater independence within the organization in order to have more freedom to evaluate and adjust charges for the services demanded of it. Within a less subordinate position, the laboratory can treat its clientele more equally and more objectively while meeting their specific requests.

CHARGES FOR TESTING SOIL AND WATER SAMPLES

Whether or not to charge for tests made by the laboratory is always a complex question. Many administrative decisions must be made to determine a reasonable price.

Private laboratories keep an account of all costs and projects. For all laboratories, the first step is to determine the total cost of analyzing a sample. These costs are: building/location, personnel, materials, chemicals and services. The laboratory must be funded for all of these before it can render any services.

In government laboratories, this cost is usually considered too high for the clientele, so other methods of estimation are used. The total cost of analyses can be charged to other services which can include such costs in their budget and still reimburse the laboratory. One can charge certain clients for the cost of supplies and services which are more directly related to the analyses. Others keep account only of service for clientele. Some charge a token fee, while others offer services totally supported by government funds. The administration of the last method is the easiest. The first method might be used if enough samples are received.

There are several methods used to charge users for soil and water tests. One may charge the entire cost per sample as in the case of a private laboratory. The total annual cost is the following: rent, $12,000; permanent equipment, $111,000; operational expenses $57,334; personnel, $49,000; for a total of $229,343. Testing 3,000 samples per year, each test would cost $76.45. However, some tests are more expensive than others. We expect that when the laboratory stabilizes, there will be about 500 water samples, 500 soil characterization tests and 2,000 soil fertility tests to analyze. This is a charge of $35.50 for water samples, $71.00 for soil fertility samples and $142.00 for soil characterization tests. This could be charged to different agencies to pay the actual cost of the laboratory. But this is excessive for the private land owner. He wouldn't use the services. So, the soils and water laboratory could seek public funding for rent, permanent equipment, and sometimes personnel since these costs are fixed, irrespective of the number of samples, and thus stable funding could be established. In this case, the operational costs would be $57,334 for 3,000 samples. This means water samples would cost $8.50 each, soil characterization tests would cost $32.00 and soil fertility tests would cost $16.00. These prices would encourage other government agencies to use the services, but, nevertheless, to do so with caution. However, this is still too expensive for the private landowner who needs to do several soil tests. So, often, instead of $16.00, he is charged a nominal fee of $2.00 for handling and up to $5.00 to cover the cost of chemicals. Free testing usually is not a good policy. Either too many useless samples are received, or the results are often ignored since there was no charge.

These considerations should serve as a guide for the government in establishing a pricing policy. These prices are reasonable and comparagle to those charged elsewhere. Free services are not normally respected and often encourage abuse of services. But, the real cost is much higher than most clients can pay. This means that laboratory facilities would bge underexploited due to the high cost of analyzing samples. In the near future, we will give several alternative estimative strategies based upon laboratory costs.

In hopes that, having read this report, you will wish to convene a meeting to discuss the status and the responsibilities of the laboratory and its personnel, please accept, Your Excellency, the renewed assurances of our respectful sentiments.

Dr. Joseph Goebel Mr. Aboubaker Douale Waiss

BUDGET PROPOSAL FOR THE YEAR 1981

FOR THE SOIL AND WATER

RESOURCES ANALYSES LABORATORY

INTRODUCTION

Within the American-Djiboutian agreement, the new laboratory for the analyses of Soil and Water Resources comes under the jurisdiction of the Ministry of Agriculture and Rural Development. To provide for the needs of a maximum number of Government agencies and individuals and do a good job of choosing the methods for irrigation and the best type of production for each soil, it has been decided that this laboratory should be independent of the other services of Ministry and have its own personnel.

The reason we must study minutely all of the soils of our country is to be able to inventory and map them. It is imperative we make the soils map of the country before starting any agricultural projects if adequate production is to be insured.

Also, the technical personnel of the laboratory will spend approximately one third of its time in the field where they will guide all the work of the survey, the description and mapping of the soils in their broad natural environment.

This laboratory will have the averge capacity to analyze 3,000 samples per year. We propose to describe about three hundred different soils this year. When this work is finished, as well as work on the national soils map at the scale of 1/100,000, we will be able to take a further step: detailed localized studies.

As a means for transportation for the laboratory, one Land-Rover, station wagon (10 passengers) and a Daihatsu Jeep (6 passengers) have been provided. Both these two vehicles use regular gasoline.

In order to proceed as rapidly as possible in describing the soils and making related maps, and with the slow and more difficult work of digging the soil profile pits, two permanent working teams will be necessary.

1. Personnel expenses

1.1 Existing posts

There exists an agronomist position (grade 1250) and an agricultural extension agent post, first class, third level (grade 700).

1.2 Other employees required

In order to achieve a good division of the work effort, the following position will be necessary:

Laboratory technician (grade 850). This man is responsible for making proper analyses and for equipment and material maintenance.

Laboratory assistant with high qualifications (grade 700). This man will do the routine analyses in the laboratory.

Accountant-secretary (category 3B): responsible also for the library.

Driver-mechanic (category 3A): responsible for vehicles' maintenance and driving in the field.

Janitor Position (category 1B): responsible for cleaning the offices.

Two watchmen (category 1A): charged with the security of all the materials.

Two laborers (category 1A), to dig the soil profile pits.

1.3 Per diem

As mentioned above, the laboratory personnel are occupied, in large part, by soil description and soil mapping in the field. This will require a credit to the amount of 500,000 Djibouti francs for per diem.

1.4 Overtime

(See table I, attached)

According to the table I attached, 143,812 Djibouti Francs are required for supplementary hours and 7,932,816 D.F. for wages.

2. Operating expenses

2.1 Ventilation

2.1.1 Paragraph 1: office supplies. the laboratory needs lots of paper. Thus the 500,000 DF budgeted are justified by the price of the large sheets of paper used in large quantities for making maps.

2.1.2 Paragraph 2: Telephone, 500,000 DF should be budgeted justified by the cost of communications and the numerous long-distance calls required for the laboratory.

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2.1.3 Paragraph 4 Uniforms

The technical personnel of the laboratory have a standing need for white lab coats to avoid all contact with acid. For this reason they will need a coat every three months, or twenty-eight coats per year. (5 technicians, one janitor, and one secretary). The two guards and the chauffeur will need six khaki uniforms and two hats.

Thus, 70,000 DF should be applied to the account, justified by the costs attached.

2.1.4 Paragraph 5: transportation

Having stated previously that the study of soils in the field will be a year-round activity, and having two all-terrain vehicles at our disposition, 500,000 DF are necessary.

2.1.5 Paragraph 6: Material and furniture (not to be replaced

The laboratory is new. In addition to what has been furnished by U.S.A.I.D., the following material is necessary:

- 5 chairs and 5 arm chairs
- 5 desks
- 2 stools
- 3 metal cupboards
- electric typewriter
- calculator
- photocopy machine
- 1 duplicator (AB Dick)

Thus the request for 2,253,500 DF to be credited to the account (see attached estimate).

2.1.6 Paragraph 7: Chemicals to be purchased

This paragraph and those following it concern the specific needs of the laboratory. Chemical reagents constitute the backbone of the laboratory. This year, USAID ordered $25,550 US worth of chemicals. Due to growing inflation, 1,000,000 DF credit are requested for the account.

2.1.7 Paragraph 8: Glassware and equipment

The laboratory is equipped with expensive modern scientific apparatus, a portion of which may be unusable or outdated at the end of a year's work. Soils Science is a young science which receives more and more attention and effort, so there is currently a boon of material: pipettes, glass beakers, plastic beakers, a still for kjildahl nitrogen test, graduated cylinders, dessicatores, etc. So that our work can procedd on a par with scientific developments in the field, a credit of 200,000 DF is requested for the account.

2.1.9 Fuel:

Two all-terrain vehicles are available (Land-Rover station wagon and 6-passenger Daihatsu jeep), both of which use gas. Based on a monthly consumption of 450 liters per vehicle, we request 900 liters/month or 10,800 liters per year.

2.2 Recapitulation

The Budget proposal for the Soil and Water Analyses Laboratory therefore totals:

Personnel	8,576,628 D.F.
Operating Expenses:	6,023,500 D.F.
Total	14,600,128 D.F.

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APPENDIX C-5

25 November 1981

Subject: USDA TDY Soil Scientist Evaluation of Djibouti Water and Soil Laboratory Project

To: Ellsworth M. Amundson,
AID Affairs Officer,
Djibouti

Enclosed is my evaluation report of the Djibouti Water and Soil Laboratory Project. I appreciate the help you have provided during the evaluation period and your valuable critique of my draft report. As I told you, this was my first time to conduct such an evaluation and your assistance is greatly appreciated.

Sincerely,

s/Al Hidlebaugh

Allen Hidlebaugh
Staff Leader, Soil Research
Coordination, Soils, USDA-Soil
Conservation Service,
Washignton, D. C.

Enclosure

SUMMARY

While many parts of the overall goal are being met and surpassed, the start-up of the laboratory is behind schedule. To assure a fully functional laboratory prior to Dr. Goebel's departure (Aug. '82) some change in scheduling and emphasis are needed.

Dr. Goebel and Resources Development Associates are to be commended for the excellent training provided to the Djiboutian staff to-date and for the excellent working relations developed with various GROD Ministeries, donor agencies and groups.

Portions of the overall project objectives achieved to date include the following:

1. Project start-up completed comprehensive inventory of material received, development of plans for laboratory operations, supervision of construction/equipping of Laboratory. Ordering any needed supplemental laboratory materials, including required satellite imagery.

2. Establish a library as evidenced by compilation of book lists, acquisition of key soils texts.

3. Submission of adequate and timely annual plans, quarterly reports, and budget.

4. Conducted preliminary study of the morphology and classification of the soils of Djibouti as evidenced by field reconnaissance, training in writing soil descriptions and describing and sampling 45 soils.

5. Undertaken basic cartography as evidenced by drawing the slope, watershed, and soil climate maps; drawing base map for random sample selection of Djibouti; drawing preliminary soils map of Djibouti; drawing 1:250,000 scale soil map of Djibouti; and 1:100,000 scale soil map of southern Djibouti.

6. Conducted remote sensing training -- as evidenced by aerial photo and satellite imagery interpretation; plus FAO remote sensing two-week course in Rome completed by Aboubaker Douale Waiss.

7. Laboratory operations as evidenced by preliminary training in water quality analyses.

8. Data analysis conducted via map measurements.

The tasks remaining and planned schedule to achieve the overall goals by 31 July 1982 (i.e., one month prior to project termination) consist of the following:

Dec.	Vegetation identification training.
Dec-Feb.	Optimally describe and sample 50 sites (northern Djibouti). Minimal requirement 25 sites to serve as adequate base for final report.
Feb-Mar.	Semi-detailed soil map training.
Mar.	Soil use interpretation training.
Mar.	Draw semi-detailed soil maps (1:25,000) of priority areas.
Mar-Apr.	Training in soil testing.
May	Map measurement.
May	Establish and test laboratory reporting modalities.
June	Conduct training in procedures for soil and water sample collection and means of distributing laboratory test results.
June-July	Soil and water sample analyses.
July	Summary, review, prepare final report.

Other tasks not presently scheduled in the contractor's work plan but which must be included are:

-- Laboratory equipment set-up
(a) verifying equipment functional;
(b) effecting labortatory operations not later than February 1982.

-- Training in detailed soil mapping (1:5,000 scale) in priority areas (two sites should suffice).

-- Deliver two professional papers (Cairo Symposium on Remote Sensing).

The last task was not planned for in the scope of work but was encouraged by RDA as a means for publicizing GROD soils activities at the international level.

The principal tasks remaining can be achieved, but some change in direction and emphasis is required. The evaluation recommends the following:

1. Concentrate virtually all field activities into the December thru mid-February time period to take advantage of the cooler temperature.

2. As soon as the generator arrives, install air conditioners and check out all analytical equipment in the laboratory to make sure it is functional. Target date is January, with any defective parts to be requested thru RDA representative to hand-carry to Djibouti when he comes in February.

3. Initiate test operation of all laboratory equipment the third week of February with one or both of the Djiboutian staff members to be in the laboratory receiving training and undertaking continuing soil and water analysis for the remainder of Dr. Goebel's stay. This will assure efficient operation of the laboratory by the time of Dr. Goebel's departure.

4. Any field soil survey tasks that are not accomplished by mid-February are to be delayed until next winter's cool season. The TDY USDA Soil Scientist tentatively scheduled to visit Djibouti during January 1983 could provide any needed technical support to the soil survey.

5. It is understood that there will be need for some field work after February to respond to other donor needs and for special GROD requests, but time devoted to these activities must be minimized in order to assure the achievement of a fully functioning laboratory.

Virtually all components of the PIO/T scope of work for the Water and Soils Laboratory project will have been achieved by the time the contractor delivers the expanded version of the final report (January 1983). The few remaining soil survey tasks can be accomplished by the Djiboutian staff with any needed technical back-up to come from TDY USDA Soil Scientist. Back-up is envisioned for periods of two weeks every four months thru January 1985.

EVALUATION METHODOLOGY

USDA TDY Soil Scientist Allen Hidelbaugh conducted the mid-term evaluation of the Water and Soils Laboratory project. The evaluation addresses the performance of the contractor (Resources Development Associates) against the "Statement of Work" provided in the PIO/T. The PIO/T is used rather than the project paper because of the intervention of the West Germans in the water part of the project. The PIO/T delineates the up-to-date objectives and contractor's tasks.

The scope of the evaluation included review of all requirements stated in the PIO/T and comparison of these with documents submitted by the contractor's representative, Dr. Joseph Goebel, to date. Manuscript (unpublished) soil maps, slope maps, watershed maps, soil climate maps and associated legends and descriptions were reviewed.

Three days were spent in the countryside looking at present garden sites and areas with potential for agricultural development that have been identified to date. Various facets of the different types of soil surveys being used by Dr. Goebel and the Djiboutian staff were examined during these field trips. These included examination of maps, soil descriptions, classification of taxonomic units, discussions of geology, composition of mapping units, etc.

A limited time was spent in examining the equipment and supplies in the water and soils lab. The pH and conductivity meters were the only instruments operational to date. The remaining equipment will become operational in the near future/

Time was spent in discussing all aspects of the project with Dr. Goebel and the Djiboutian staff members. A point was made of having discussions with Aboubaker Douale Waiss and Farah Omar without Dr. Goebel to give them the opportunity to fully express their personal views.

The evaluator observed Aboubaker Douale Waiss and Farah Omar describing, sampling and classifying soil profile and describing soil mapping units, with inclusions, identifying vegetation and estimating extent of vegetation and surface cover of stones.

The evaluation is based on all of the observations and documentation available during the evaluation period in Djibouti. (See attached exhibit.)

EXTERNAL FACTORS

The PIO/T for the Water and Soils project projected the equipping of the laboratory and the on-the-job training to laboratory assistants to be initiated during the first six months of contractor's designated soil scientist's time in Djibouti. The laboratory is not operational after an elapsed time of sixteen months. External factors contributing to this delay follow:

Major construction is complete. Air conditioners installed earlier would not operate correctly because of electric cycle problems. One machine burned out. New air conditioners have been purchased and will be installed as soon as the generator now on order arrives. This generator will solve many problems related to electric cycles and conversion of 230V to 110V. Other laboratory equipment will be dependent on the functioning of this generator. The original commodity order requested 220/50 or 110 with transformer. The latter of course does not affect cycle changes - hence the problem and delays in getting equipment operational.

There have been some routine administrative problems within Genie Rural. These problems have proved irritating but have not jeopardized achievement of the project's objectives.

Delays in shipment of U. S. manufactured laboratory supplies, particularly chemicals, is a serious problem. Shipments of field soil survey equipment have also been subject to similar delays.

Although the GROD has fielded qualified staff critical to this project per se in an extremely timely and adequate manner, delay in getting the Djiboutian staff called for in the PIO/T have also contributed to some delay in the project. Ideally the followinhg additional staff should have been acquired in the first year of the project and to date are not yet present: hydrogeologist, water chemist, hydrologist and a clerk for the library. Admittedly, since the original project scope (Project Paper) was reduced to allow for intervention of West German technical assistance in water resource inventory, these personnel are not directly critical to meeting the immediate objectives of this project, but, if not obtained could adversely affect the overall institution building goals of the U. S. Government Soils and West German hydrological efforts.

The PIO/T requires that soils investigation and mapping be accomplished on several scales. Some substitution of scales was required to match existing base maps. There had been delays in obtraining copies of existing base maps.

The participants during the evaluation besides Mr. Hidlebaugh were Dr. Goebel, Resources Development Associates, and Mr. Amundson, AID Affairs Officer.

PROJECT INPUTS

USAID has provided funds to the Water and Soils Laboratory project totaling $542,000. These funds have been sufficient to provide for one resident U. S. personnel for 24 person months and to provide for commodities and other costs incidental to the project.

The Government of the Republic of Djibouti's contribution to the project has been substantial. GROD has provided facilities for the laboratory consisting of 4 rooms totaling 150 square meters. This provides an office, a chemical laboratory, an analytical equipment room and a cartographic room for the soil survey. In addition, space has been provided for soil sample preparation, storage and disposal. GROD is also providing water, electricity, telephones, maintenance for the building and facilities, and six parking spaces for laboratory use. GROD has provided the following personnel to date:

> A qualified degree-trained pedologist for soils inventory and survey. He is also charged with general supervision of the laboratory to include analyses and planning.
>
> A laboratory technician to conduct the soil and water analyses and maintain laboratory facilities.

USAID inputs have consisted primarily of provision of essential commodities, (i.e., laboratory equipment and supplies, chemicals, vehicles and support to the contractor in form of housing and general support). Technical support in the form of one full-time resident soil scientist was furnished via a direct cost reimbursement contract to Resources Development Associates. One full-time resident soil scientist was provided without TDY back-up from a remote sensing expert and other to be identified experts, because AID contracting officer concurred in Resources Development Associates (contractor) contention that Dr. Goebel had the necessary background to cover these needs as well as his principal role as soil scientist. The evaluator concurs in this decision provided Dr. Goebel's expertise continues to be confined solely to soils, remote sensing and general laboratory operations as presently conceived.

In regard to inputs, in summary AID funding has been adequate and timely. Regarding delays encountered these are attributable to the nature of the U. S. source commodity procurement. Similarly the Water and Soiuls Laboratoruy use of funds based on a review of their records shows prompt and proper use of funds provided. A budget summary follows:

BUDGET SUMMARY

WATER RESOURCES & SOILS ANALYSIS PROJECT 603-0001

	Obligated	Disbursed	Pipeline	TOTAL
Tech Services				
P.O. (Issen)	1,603	1,603	-0-	1,603
PIO/T 90002 (RDA)	334,000	174,000	160,000	334,000
	(335,603)	(175,603)	(160,000)	(335,603)
Commodities				
PIO/C 900013 (Land-Rover)	16,000	16,000	-0-	16,000
PIO/C 90005 (Lab. Equipment)	72.000	62,000	-0-	62,000
PIO/C 9006 (Daihatsu)	8,000	8,000	-0-	8,000
PIO/C 90007 (A/C's)	3,000	3,000	-0-	3,000
PIO/C 90013 (Chemicals Franklin)	25,000	14,000	11,000*	25,000
	(114,000)	(103,000)	(11,000)	(114,000)
Other Costs				
PIL-0005 (House Renovations)	2,132	2,835	- 702	702
PIL-0014 (Housing Rental)	35,000	33,000	2,000	35,000
PIL-0006 (Housing Maintenance)	18,219	18,219	- 600	18,219
PIL-0020 (Recon. Flight)	527	527	-0-	527
PIL-0022 (Maps 1:100,000)	3,600	2,881	719	719
PIL-0024 (Housing, Rental Maintenance)	17,000	-0-	17,000	17,000
	(76,478)	(58,062)	(18,417)	(76,478)
TOTAL	526,081	336,665	189,416	526,081
Contingency			16,000	542,000

* Approximately 7,000 will be expended;
Balance 4,000 returned to contingency.

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PROJECT OUTPUTS

The project contractor was expected to provide an annual plan of operation and quarterly progress reports. Two annual plans of operation and quarterly progress reports were available for review. A status report prepared as of January 1981 for the Minister of Agriculture was also available. Manuscript (unpublished) maps, legends and descriptions were available for examination.

Based on the above, the USDA TDY Soil Scientist (evaluator) measured progress as the tendency towArds achieving the end-of-project targets as stated in the PIO/T. The findings were as follows:

1. Establishing and operating a water and soils laboratory.

(a) Facilities

The facilities are adequate. Construction delays and lack of dependable electric power at 230 and 110 volts have delayed project, but presently do not pose any severe limitation in view of RDA procured and soon to be delivered generator. The main problem has been one of cycles. Much of the equipment is functional at 60 Hz only. Transformers provided are not useable. Hence the need for a generator to supply correct, uniform voltage, cyclage.

The laboratory layout has proceeded smoothly for the most part except for a misunderstanding about the electrical outlets in the center of the main laboratory table. Although the work stand is not aesthetic it is functional.

Nearly all of the laboratory equipment ordered is in place. Most of it has not been set up or properly tested. A mini-computer is scheduled to arrive in January. This instrument should certainly assist an understaffed lab., admittedly now quite sophisticated, to properly manage its data input/output.

(b) Supplies

Ordering of chemicals and other supplies, after contractor's arrival, from U. S. sources, rather than from France, has probably delayed start-up operations of particularly critical testing in the lab. U. S. sources were opted for at contractor's request to insure uniformity, quality of chemicals and hence that of eventual analysis. Only time will tell if this was a sound decision.

(c) Operation of Laboratory

The PIO/T called for having the laboratory operational within six months of contractor's arrival. Sixteen months after the contractor's arrival the lab is not operational. Most everything is in place but additional time will be required to have e3verythinq properly functioning.

This is one area where the contractor must concentrate his immediate efforts in the time remaining even if it means delays and reduction in certain aspects of overall soil survey of Djibouti.

2. Soil Survey of Djibouti.

(a) Detailed Mapping (1:10,000)

Very limited progress in mapping present and prospective garden sites to date. Albeit number of sites per PIO/T should be reduced by half while simultaneously tasking contractor to enlarge scale to 1:5,000 to provide needed detail.

(b) Medium Scale (1:50,000)

Very limited work has been accomplished in this segment of the work plan. Some training has been provided to Djiboutian staff, and two areas with possible prospects for gardens were mapped at a scale of 1:25,000 for the United Nations High Commission. These areas are Chekkeyti and Sabbalou. With remaining time emphasis should be devoted to field soil survey at this scale, 1:25,000 only.

(c) Small Scale (1:200,000)

Availability of base maps at 1:200,000 was a problem. Contractor chose in place of the 1:200,000 to utilize available base of 1:250,000 and procure 1:100,000 scale maps. (The latter having been acquired with project funds, the former donated by GROD.) With these bases an exploratory soil survey of the nation has been developed at a scale of 1:250,000. The base is from Landsat imagery. The contractor has completed 1:100,000 scale soil maps (reconnaissance) for southern Djibouti and has also prepared supplemental maps .. slope, watershed, soil climate.

The above mapping activity (scale 1:200,000) was listed as third in priority of the soil surveys in the PIO/T. However, the greatest progress has been made in this activity. There is some justification for this in that exploratory and reconnaissance soil surveys are very valuable in determining where areas with agricultural potential exist and thus where the medium scale and detailed mapping should be concentrated.

The random sample approach used for constructing both of these maps is a sound one and is providing a great deal of information on the soils of Djibouti. The soils being described from the 100 random sites will represent the majority of the soils in Djibouti and the descriptions and soil samples will provide the basis for establishing soil series for use in the soil survey of Djibouti.

Soil descriptions and other data being collected is of sufficient detail to permit classification of taxonomic units into the USDA Soil Taxonomy. Djiboutian staff have already evidence of sufficient training to properly classify the soils of Djibouti.

(d) Soil Survey Reports

Training in soil survey report writing and in making interpretations of soils for various uses is scheduled for next spring.

Soil maps will be printed or otherwise reproduced in black and white. However, it is recommended that 2 or 3 copies be hand-colored (preferably by an artist) for use by the Minister of Agriculture. Given observed skills of Lab Technician Farah, it is suggested that he personally transfer the final map to several color enhancements at a later date -- time permitting.

3. Library

Progress in establishing library containing pertinent reference books and documents has been made. Reference books are in process of being ordered. The projected clerk will be responsible for the library.

Most of the materials in the library will be in French, but some books and papers in English will also be available.

4. System for water and soils data collection.

A system has been established for identification of samples and for the orderly progression (i.e., routing samples) thru the laboratory. The system has as one of its key components identification of the location from which the sample was taken.

Training is being provided in developing standard forms for reporting laboratory data and for standard laboratory reports.

5. System for data dissemination to farmers and other users.

Although a general presentation re possible modalities for user service has been made to the Minister of Agriculture as of this data no definitive plan has been established. Training will need to be provided to the Extension Service if they are going to be responsible for this task.

A part of this segment is of course the series of soil survey reports and laboratory reports to be prepared in the next few years.

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PROJECT PURPOSE

The overall purpose of the Water and Soils Laboratory project is to institutionalize within the MOA Rural Engineering Service the capacity to (1) analyze ground and surface water quality as well as to compile, catalogue and disseminate hydrological information, and (2) classify soils, prepare soils maps and provide evaluation concerning the proper utilization of soils.

In practical terms, farmers can be advised on soil treatments to obtain sustainable yields. Achievement of this project purpose should impact on the sector goal of developing an information base for use by the GROD in national agricultural planning, and its dissemination to farmers through the agricultural extension service.

By the end of the project, the laboratory staff of the Rural Engineering Service:

- possess equipment and technical expertise to independently analyze all water and soils types in Djibouti;
- have necessary data upon which to base recommendations for water/soil use for crop production and provide guidance for subsequent soils/water resource analyses in the field;
- have undertaken a soil inventory and developed a land classifications system in selected priority areas.

In the evaluator's estimation, given observed progress the purpose will be achieved provided certain adjustments, change of emphases, are made in the immediate future.

It is the reviewer's opinion that a more viable progress toward institutionalization can be achieved if the laboratory is established as an independent entity possessing its own budget within the Ministry of Agriculture. Its continued functioning as a branch of a de facto implementing service (Genie Rural) would in the long-run jeopardize its ability to provide objective analyses.

The contrctor and USAID, have brought this to the government's attention, and as of this submission, the government is formally entertaining the proposal to establish by decree the Water and Soils Laboratory under the MOA effective 1 January 1982.

This administrative action, if forthcoming, will probably have as much or more bearing on the achievement of the project purpose and goal than any other single factor.

PROJECT GOALS

Although not specifically addressed in any documentation, the project goal (as far as Djibouti is concerned) is to expand agricultural production (irrigated gardens) to the level that the country can make significant progress in realizing import substitution, primarily in vegetables and fruits.

This goal probably cannot be achieved in its entirety in the near future.

At issue here is the economics of developing an agricultural base in Djibouti. This project will serve to provide a data base for decision-makers. However, in the ultimate analysis it is not soils, nor necessarily even water that will prove the limiting factor but rather the investment costs versus the returns.

BENEFICIARIES

The immediate target group is a Djiboutian infrastructure capable of addressing the needs of present and future Djiboutian farmers. While this project will not have a direct impact in and of itself, it will, coupled with other donor-furnished data gathering (water), hopefully provide a solid base upon which the Government of the Republic of Djibouti can make rational and positive decisions regarding diversification into the agricultural sector and more importantly have maximum impact per dollar invested.

Djibouti Water Resources
and
Soils Analysis

FINAL REPORT

Volume III:
Appendices D, E, F, G

Prepared for the Agency
For International Development
Contract No: AID/afr-C-1673

Prepared By:

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Aboubaker Douale,
Farah Omar

February 1983

Resources Development Associates, P. O. Box 407, Diamond Springs, CA 95619
(916) 622-8841

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VOLUME III: NATIONAL SOILS AND WATER LABORATORY

Construction of the laboratory initiated the active phase of the Soils and Water Analysis Laboratory project. In August 1981, the building was constructed and four rooms assigned to the Soils and Water Analysis Laboratory. The workmen were assigned to construct the benches and install electricity, etc. according to a plan developed by the Technical Advisor. Later, all of the equipment was installed and checked out. Training was given in pantide-size analysis, pH, salinity, chloride, conductivity and moisture content evaluations. The electrode meter malfunctioned causing a delay in further training. A local technician was contacted who agreed to fix the equipment. In addition, the SCS - USDA agreed to continue expanding the soil and water analysis capability of the laboratory.

As part of this project, a special water study was started in Houmbouli and Grande Douda to ascertain the withdraw and recharge of the surficial aquifer. Several specific farm visits were also made to provide evaluations and advice. Presently the laboratory is well equipped. It should be capable of satisfying the needs of the country when its technicians are more practiced and experienced.

This volume of the report contains four appendices relating to the Soils and Water Laboratory. Appendix D is an inventory of the property in the laboratory. Appendix E contains copies of laboratory forms. Appendix F contains the reports from the individual farm visits and Appendix G is a copy of the special report on the Water Salinity of the Houmbouli and Grande Douda agricultural areas.

LABORATOIRE D'ANALYSE DES SOLS ET DES EAUX

RÉPUBLIQUE DE DJIBOUTI

APPENDIX D

PROPERTY INVENTORY

APPENDIX D

PROPERTY INVENTORY
Chemical Reagents

1 X 5 lb Acetic acid 80% rgt.
2 X 25mg 1-Amino-2-napthol-4-sulfonic
12 X 1 lb Ammonium acetate rgt cryst
2 X 1 lb Ammonium chloride rgt grannular
4 X 1 lb Ammonium flouride rgt cryst
2 X 1 bl Ammonium citrate rgt pdw.
4 lb Ammonium hydrixide reagent
2 X 4 ox Ammonium molybdate rgt cryst.
2 X 1 lb Ammonium oxalate rgt cryst.
2 X 1 lb Ammonium sulfate rgt cryst.
500 gom Ascarite II 8-20 mesh
1 X 1 lb Aarium chloride rgt Cryst
1 X 5 gm Barium diphenylamine sulfonate
1 lb Barium hydroxide rgt
1 X 25 gm Bromo cresol green ind.
1 lb Barium sulfate rgt
2 X 1 lb Bromine
2 X 1 Boric acid rgt pwd.
1 lb Calcium acetate rgt. pwd.
2 X 1 lb Calcium carbonate rgt pwd.
1 X 25 gm Calgon powder
1 X 23 kg Calcium chloride dihydrate
1 lb Calcium chloride rgt Anhs pdr.
20 cu ft Carbon dioxide 100%
1 X 5 pt. Carbon Tetra chloride rgt.
1 X 1 lb Charcoal activated pwd. norit A
1 lb Chlorite regular 8 mesh
1 Chloride selective ion electrode flacons of standardizing sol.
1 X 1 lb Citric acid, monohydrate
1 X 500 gm. Cupric sulfate shydrate fine crystal
4 X 25 gm. Curcumin, crystalline
1 X 1 lb. Devarda's alloy
2 X 500 ml. Diethonolamine
12 X 25 gm. Dithizone rgt.
1 X 500 gm. DL-alanine
1 X 25 gm. DL-serine
1 X 25 gm. DL-threonine
2 X 500 gm. DPTA (((Carboxymethyl)imino(bis(ethylene nitrilo))
-tetra-acetic acid
1 lb Drierite regular 8 mesh
2 X 25 mg. Dromothymol blue rgt. pwd.
1 X 250 mg. EDTA mag, disod, salt
1 X 100 mg. Erichrome blact T indicator
1 X 8 pt. Ethyl aclohol 95% denatured
1 X 1 lb. Ferric ammonium sulfate
1 X 1 lb. Ferric sulfate rgt. pwd.

1 X 1 pt. Formic acid rgt
450 mg. Gelatin granular IVD
1 X 25 gm. Glucoseamine hydrochloride
1 pt. Glycevol reagent
2 X 1 lb. Hydriodic acid rgt.

2 X 1 lb. Hydro bromic acid rgt.
6 X 6 Hydrochloric acid
2 X 1 lb. Hydroflouric acid rgt. 48
1 hydrogen ion triple purpose electrode solutions approx. orion
12 X 450 ml. Hydrogen peroxide 30% rgt.
2 X 1 kg. Hydroxylamine hydrochloride pr.
1 X 500 gm. Hypophosphorous acid 50-52%
32 oz. Iodine reagent
2 X 25 mg. Iodine
1 X 1 lb. Magnesiom shavings
1 X 1 lb. Magnesium oxide
1 X 1 lb. Magnesium perchlorate anhyel rgt.
2 X 1 oz Mercuric Chloride rgt. cry.
1 X 4 oz. Mercuric oxide yellow pwd.
4 X 24 gm. Methyl red ind.
1 X 4 oz. Molybdimum trioxide
10 X 5 mg. Murexide
1 X 500 ml. N,N, dimethylamine
20 cu. ft. Nitrogen gas
2 X 5 bl. Nitric acid reagent
1 X 25 gm. Nynhydrin monohydrate
1 X 500 gm. Octyl alcohol
5 X 10 gm. O-phenantholine rgt. needles
1 X 1 lb. Oxalic acid rgt. cryst.
12 X 1 pt. Parafin oil white
1 X 100 gm. P-Methyl amionphenol sulfate pr.
1 X 100 gm. P-nitrophenol ind.
100 gm. Para (p) nitrophenol
2 X 1.5 Perchloric acid 70% rgt.
1 X 4 oz. Periodic acid 99.5% cry.
2 X 1 bl. Phenol reagent Loose cryst
25 gm. Phenophtalene ind.
12 X 1 pt. Phosphoric acid rgt.
1 X 4 oz. Phosphorous pentoxide rgt.
2 X 4 oz. Potasium bromide rgt. cry.
5 X 1 lb. Potassium chloride rgt. anyst.
2 X 1 lb. Potasium chromate rgt.
1 X 4 oz. Potasium cyanide rgt.
1 X 1 lb. Potasium dichromate rgt. cry.
1 X 1 lb. Potasium ferro cyanide rgt.
2 X 1 lb. Potasium iodide rgt. pwd.
1 X 25 gm. Potassium meta perodate
2 X 1 lb. Potasium nitrate rgt. cry.
1 X 4 oz. Potassium permangonate rgt. cryst.
1 X 4 oz. Potasium phosphate MB
1 X 5 lb. Potasium sulfate rgt. cry.
1 X 25 gm. Pyrogallol
1 X 500 gm. Quinaldine
1 X 4 oz. Selenium pwd.

1 X 1 lb. Silicon lumps
5 X 1 oz. Silver nitrate #12/Oz.
1 X 25 gm. Silver perchlorate #12/25 gm.
2 X 4 oz. Silver sulfate rgt. pwd. #12 oz. on 96
1 X 5 lb. Soda & Lime rgt. 6-12 mesh.

1 lb. Sodium acetate rgt. cryst.
1 X 500 gm. Sodium acetate trihydrate
1 X 500 gm. Sodium arsenite
1 lb. Sodium bisulfite
1 X 1 lb. Sodium borate rgt. cry.
1 X 1 Sodium carbonate anhyd. rgt. pwd.
2 X 1 lb. Sodium chloride rgt. cryst.
1 X 1 lb. Sodium citrate rgt. cry.
1 X 4 oz. Sodium diethyldithiocaromate
4 X 5 lb. Sodium hydroxide rgt. spl.
2 X 1 lb. Sodium nitrate rgt. cryst.
1 X 500 gm. Sodium nitrite
1 X 500 gm. Sodium phosphate monobasic monohydrate
1 X 500 gm. Sodium phosphate tribasic 12 hydrate
2 X 100 gm. Sodium selenite
1 X 1 lb. Sodium sulfate anhyd rgt. gram.
1 X 1 lb. Sodium sulfite anhs rgt. cryst.
1 X 1 lb. Sodium thiosulfate rgt. cryst.
1 X 4 oz. Sodium tungstinate rgt. cryst.
1 X 500 gm. Stannous chloride dihydrate
1 X 4 oz. Stannous chloride rgt. cryst.
500 gm. Sorbents, column, micro crystaline, cellulose
1 X 100 gm. Sulfonic acid 99%
1 X 500 gm. Sulfur Colloidal
6 X 8 lb. Sulfuric acid rgt.
1 X 4 oz. Tartaric acid rgt. cryst.
1 X 500 ml. Trolamine
1 X 500 ml. Trolamine
1 X 1 lb. Zinc acetate rgt. cryst.
1 X 1 lb. Zine reagent 10 mesh

LABORATORY EQUIPMENT

1 Absorption Lamp - Aluminuim
1 Absorption Lamp - Boron
1 Absorption Lamp - Cr-Co-Cu-Mn-Ni
1 Absorption Lamp - Cu-Fe-Mn-Zn
1 Absorption Lamp - Magnesium
1 Absorption Lamp - Potasium
1 Absorption Lamp - Sodium
1 Absorption Lamp - Titanium
2 Acid Digestion Bomb
a B & L Illuminator 110/115v 50/60 Hz
1 pkg Beakers 50 ml.
1 pkg Beakers 100 ml.
1 case Beaker - Nalgene 100 ml.
1 case Beaker - Nalgene 250 ml.
2 pkg Beakers 250 ml.
3 pkg Beakers 400 ml.
2 pkg Beakers 1000 ml.
2 cases Bottles - Nalgene - Wide mouth 8 oz ml.
1 case Bottles - Nalgene - Wide mouth 16 oz ml.
1 case Bottles - Naglene - Wide mouth 32 oz. ml.
2 cases Bottles - Narrow mouth 500 ml.
2 cases Bottles - Narrow mouth 250 ml.
1 case Bottles - Polypropylene - Narrow mouth 16 oz. ml.
2 cases Bottles - Polypropylene - Narrow mouth 8 oz. ml.
1 case Bottles, solution, Polypropylene, Nalgene
2 Bouyoucos Moisture meter
50 Bouyoucos Soil Blocks
1 Brush - Balance
2 pkg Brush - Flask
1 case Buret 10 ml. glass
1 case Buret 50 ml. glass
2 pkg Brush - Nylon
1 pkg Brush - Nylon
1 pkg Brush - Nylon
2 Buret Support, Single Lincoln
6 Burner, high temperature
2 cart, Pan type
10 Cartridge demineraliser Barnstead
1 cast (11) Chart paper
1 1.5 lb. Cloth measuring tape
1 Coleman model 54 spectrophotometer 230v 50/60 Hz
1 Corning 125 ml. flask (1con)
1 Corning Chart Recorder 115 v/60Hz
1 ea. Culigan Reverse OSMOSIS DESALTER 5 gal/day capacity
1 Cylinderstand
1 Digital Thermometer
4 Dispensere Repipets 5.0 ml.
1 Distilling Apparatus Automatic, Electrical Barnstead, 115/230 V, 60 Hz.
2 Cases Distilling Apparatus

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1 Eppendorf Microliter pipet 10 1
1 Eppendorf Microliter pipet 25 1

1 Eppendorf Microliter pipet 50 1
1 Eppendorf Microliter pipet 100 1
1 Eppendorf Microliter pipet 250 1
1 Eppendorf Microliter pipet 1000 1
1 pkg Erlenmeyer Flask 25 ml.
1 pkg Erlemeyer Flask 50 ml.
1 pkg Erlemeyer Flask 125 ml.
4 pkg Erlemeyer Flask 500 ml.
1 pkg Erlemeyer Flask 1000 ml.
1 pkg Erlemeyer Flask 2000 ml.
1 pkg 25 sheets Filter sheets, glass microfiber reeve angle grade 934AH
10 X 1 pkg (100) Filter paper Whatman #43
3 pkg Flask - Filtering 1000 ml.
10 Flask holders 250 ml.
3 pkg Flask - Volumetric - 10 ml.
2 pkg Flask - Volumetric 25 ml.
4 pkg Flask - Volunetric 50 ml.
1 case Flask - Volumetric 250 ml.
1 case Flask - Volumetric 100 ml.
7 cases Flask - Volumetric 500 ml.
9 Cases Flask - Volumetric 1000 ml.
1 2 lb. Four Foot Extention
5 Graduated Cylinders 10 ml.
5 Graduated Cylinders 25 ml.
5 Graduated Cylinders 100 ml.
8 Graduated Cylinders 500 ml.
4 Graduated Cylinders 1000 ml.
1 Hot Plate 230v 50/60 Hz
3 Hydrometer analysis set, 220V, 50 Hz
12 Hydrometer
24 Hydrometer jar
1 IEC table top centrifuge 230 V AC
1 Ion Analizer (orion)
1 Illuminator, Reflector 110/220 V
1 8 lb. Instrument scale
1 case Kjeldahl Distillation Flasks 500 ml. pkg of 24
6 Kjeldahl Distillation heating elements 230V
1 LabConCo fiberglass 47 fume hood with services
1 No. 3551-10 Lab-Line Safety Refigerator or equal Gouples 120A
5 Magnetic Stir bars 1"
1 Mettler E2000 balance 200/240 V, capacity 1300 grams
1 Mettler HL-52 Electronic Balance, Capacity 161 grams 115/220V
1 Microscope Stereoscopic B & L 10 to 25 X
1 Motorized sieve shaker, 220v, 1 phase, 50Hz
1 Muffle Furnace 230 V
1 Oven Forced Circulation 240V
1 Perkin Elmer Model 303 Atomic Absorption Spectrophotometer, 220V with 2 extra burner heads
1 Perkin Elmer Atomic Absorption Lamp - Calcuim
1 PH meter, Research Corning model 12 105/220 V 50/60 Hz
1 4 lb. Ph meter

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6 pipe suction cap
1 case Pipet tips for 5-100 1

1 case Pipet Tips for 101-1000 1
1 Pump, pressure vacuum, little giant
1 Rack for Eppendorf pipets
1 pkg Recorder pens
1 Regulator, preset 2 stage
1 Reotemp 36" Thermometer
2 pkg Round Curvets 19 X 105 mm test tubes
1 Shaker 115 V
1 Shaker carries
1 Sieve cover
1 Sieve receiver
15 Spatula
5 Spatula
3 Square Flexa-mis Stirrers 230V 50/60 Hz
1 oz. Stopcock grease light temp vaccum
1 case Stopcock, Straight Bore Pyrex 12mm OD
15 Stopper No. 19
15 Stopper No. 24
1 ea. Superbrain 64K computer (5 1/4 inch floppy disk), with the following: 50Hz adapter, MPI printer (8 1/2 X 11), Dot Matrix 50 Hz, power surge protector, or equal Software accessories: Mpasic (computer programming Pkg), Graham-Dorian inventory pkg, work-star word processing Pkg (English), the software shall be compatable with the above computer.
1 4 lb. Temperature meter
4 pkg Test tubes - 150 X 20
1 ea. TI 59 Programmable calculator with PC-100 printer/plotter or equal
1 Turbidity, meter, Hellige 110-130V 60Hz, 2 tubes and 2 bulbs
1 Tygon tubing, 50 ft. 1/2" ID 5/8" OD
1 Tygon tubing, 50 ft. 3/8" ID 1/2" OD
1 U.S. standard sieve 1/4"
1 U.S. standard sieve 1/2"
1 U.S. standard sieve 3/8"
1 U.S. standard sieve 4 mesh
1 U.S. standard sieve 8 mesh
1 U.S. standard sieve 20 mesh
1 U.S. standard sieve 28 mesh
2 U.S. standard sieve 30 mesh
1 U.S. standard sieve 42 mesh
1 U.S. standard sieve 60 mesh
1 U.S. standard sieve 100 mesh
1 U.S. standard sieve 200 mesh
1 ctn. Wash Bottles 500 ml.
1 YSI Model 33-S-C-T Condctivity meter

OFFICE AND DRAFTING EQUIPMENT

1 Adapter
2 Air Conditioners Model WO-303 or equal
1 Apollo Large Bow Drawing Set
2 Bookcases (wood)
12 Bottles Lettering Ink (1002 blttle) (all black)
24 boxes Graphic drawing leads
1 Cleaning Brush
1 Cylinder stand
18 Documents cartographiques; carte des Somalis au 1/100,000
Films reproducibles
1 Drafting Machine Engineers-Metric 25 Grade 36" arm.
1 Drafting Table
1 Drawing Table 60" X 37 1/2"
1 Drawer storage Unit
12 each Eraser
6 each Lead Holders
3 Exacto Knives
1 Executive Wooden desk
1 French Curve No. 1
1 French Curve No. 3
1 French Curve No. 4
1 Index Card File
3 Kohinoor Ink
1 Lamp 24" extension, 220 V
1 Leroy Cleaning Kit
1 Leroy Lescrion pen set
1 Leroy Lettering Set
1 Leroy Pen Cleaning Fluid
1 Leroy Pen Holder
1 Leroy Pen Set 00,0,1,2,3,4,5
1 Measuring Scale-Metric 10 cm.
1 Measuring Scale-Metric 20 cm.
1 Measuring Scale-Metric-English 30 cm.
1 Measuring Scale-Metric 50 cm.
1 Metal Desk
2 Metal Desks
3 Metal file cabinets (from USAID office)
1 #8 Mirror Stererscope
6 Name Tags
1 Pencil Sharpener
1 Plainmeter (Metric)
18 Pkg Exacto Blades
3 Rolls Drawing File 20 yds X 36"
5 Rolls Tracing Paper 20 yds X 36"
400 Sheets Wet Media Acetate Ink
7 Standard Replacement Points sizes 00,0,1,2,3,4,5
1 Swivel chair (from USAID office)
1 Swivel chair
1 Template - Metric

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1 Template - Metric
1 Template - Metric
1 Triangle - 8" 25

1 Triangle - 12" 30
1 Triangle 6" 15
1 Triangular Scale - Metric
1 T. Square - Paragon 36" Doric
1 Versitility Light Table 37 1/2" X 50"
1 #14 Verticle sketchmaster
1 2 lb. Sketchmaster leg extention
6 6 lenses
8 8 lenses
3 2000W voltage Converters 230/250 to 115/130 60 Hz
2 1000W voltage Converters 230/250 to 115/130 60 Hz
250 yds Drawing Paper 20 yards X 36"

FIELD EQUIPMENT

1 #1 Abney level
1 #4 Alber Aldimeter
1 6 lb. Alumminum bag tags
1 #2 4' Auger extension
2 25 lb. camp cot
1 1.5 lb. Clipon Tags
1 #1 1/2 Cloth measuring tape
1 #4 Companion light
1 0.2 lb. Compas
1 #1/4 Emergency thermal blanket
1 50 ft. extension probe
1 14 lb. Fire Extinguisher
1 #1 1/4 Field Stereoscope
4 5 Gallon Jugs
6 Gypsum Blocks
1 #6 1/4 Hanging scale attachment
1 15 lb. 48 qt. ice chest 21 X 13 X 15
1 #8 Instrument Scale
3 #1 1/2 Knife
1 Map Measure (Metric)
3 #1/4 Munsel color chart
2 3 Oakfield soils sampling kit
1 #4 Ph meter
3 #5 Picks, Mattock
1 2oz. Pocket Magnifyer
1 #7 Soil Auger 3"
1 #1 Soil Moisture Meter
12 Soil Salinity Cups
1 2mm Standard Sieve for the field
1 #4 Temperature Meter
3 1.5 lb. Tent
4 18 lb. Two gallon Thermos
1 2 lb. Umbrella
1 9.5 Lb. Wood Chopping Mall

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LABORATOIRE D'ANALYSE DES SOLS ET DES EAUX

RÉPUBLIQUE DE DJIBOUTI

APPENDIX E

LABORATORY FORMS

APPENDIX E

LABORATORY FORMS

DATE RECEIVED:

SAMPLE RECIEPT FORM

Type of Sample: Water - Soil

Owner's Name:

Address:

Date of the analysis:

Geographic location of the samples:

Depth:

Laboratory Number:

Date the Samples were taken:

Geomorphic position:

Purpose of the results:

The date and kind of previous analysis:

List of analysis requested:

Type of vegetation or agriculture:

Next crop:

Other remarks:

F ØØ	IDENTIFICATION des ECHANTILLONS	D
deF's		Page ter /

RENSEIGNEMENTS COMPLEMENTAIRES
UTILES à l'ANALYSTE, à fournir par le DEMANDEUR

2) sur les HORIZONS et COUCHES PRELEVEES

Code	Profondeurs (cm) de ↓ à	Divers*, Texture, Taches, Indurations, Nappe, etc..	Profondeurs (cm) de ↓ à

de
sfer

1
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6
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8
9
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rer bons
tre Pages)

*Suite DIVERS au Verso

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. D

Page IV /

F ØØ

de F's

IDENTIFICATION des ECHANTILLONS

DIVERS

						1
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						35
						36

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D		F 00	IDENTIFICATION des ECHANTILLONS
Page bis /		de F's	

RENSEIGNEMENTS COMPLEMENTAIRES UTILES à l'ANALYSTE, à fournir par le DEMANDEUR

1) sur les PROFILS

N° Sac			Type de SOL (Class^n ____)	Roche Mère	Végétat... Culture(s)	Relief	Saison Prél.^t

N° Tran:

1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3

(Pour assu
Reports en

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PAGE RESERVEE A L'INFORMATIQUE

ORSTOM — BANQUE des DONNEES PEDOLOGIQUES RESULTATS LABORATOIRE

D | Origine : | Suite de
Page / | Destinataire(s): | D

Fraction F ØØ

IDENTIFICATION des ECHANTILLONS

F's

N° BANQUE		PROFIL PEDOLOGIQUE			Profondeurs(cm)		N° de Trans-fert
PROFIL	ECH.	Indicat	N° ++	Horizon	(Sup) de	(Inf) à	

CADRE INFORMATIQUE

Pour Reports entre Pages

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36

+:3 Lettres maximum. | ++: 001 à 999

Recto → Verso

IX.81.

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D : ____________

ORIGINE : ______________________________

DEMANDEUR : ______________________________

SERIE : ______________________________

Inventaire et Mise en Train des
ANALYSES

N° Échantillon	Mod 24	Granulo	pH	CO_3Ca		Mat : Org				Complex			Fertilité				Salinité			Divers			Fe_2O_3		Triacide			Physique			Spectro			Observations
													P_2O_5				Extr								Fract									
				Tot	Ac	C	N	Humus		BE	T Ca		As	Tot	BT		$\frac{1}{10}$	Sat		S	Mn	Al	Lib	Tot	tot	Fin		Struct.	pF	Permea	Miner	Oligo		

PROFIL (ou PARTIE du Profil)	COUCHE PRELEV.	INDICATIF EN LETTRES			N° EN CHIFFRES		
HORIZON PEDOLOGIQUE							
PROFONDEUR (cm)	Minimale						
	Maximale						
COUCHE PRELEVEE	Prof... de ... cm						
	à						
N° du LABO de							

TYPE de SOL PRESUME			CODE
	CLASSE		
	SOUS-CLASSE		
	GROUPE		
	SOUS-GROUPE		
	FAMILLE		
	SERIE		
	TYPE		
MATERIAU PARENTAL			
RELIEF			
VEGETATION			

PRELEVEMENT

par M / MME / MLLE

le . . à heures

pour le compte de

PAYS

REGION

LIEU

Aéroport le plus proche

LONGITUDE	LATITUDE	ALTITUDE
E ° ' "	N ° ' "	
W ° ' "	S ° ' "	mètres

Cond... Climat... du Jour __________ Saison __________

Observations diverses

du "Pédologue" :

du Laboratoire :

PARTIE RESERVEE au LABORATOIRE d'ANALYSES de : __________ Code

DOSSIER-SERIE

LIVRET / (Profil complet sur livrets à)

Livret comportant les Feuillets jusqu'à : A B C D E F G H

Echantillons arrivés au Labo le : - -

Résultats complets envoyés le : - -

Le Responsable des Analyses :

Signature :

Demandes d'Analyses : utiliser le Verso de la Pochette.

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D | Page /

Arrivé le | Liquidé le

ORIGINE

DESTINATAIRE(S)

Urgence(s) et Délai(s)

CHIMIE des SOLS

Laboratoires communs

ORSTOM-SSC

INVENTAIRES

ANALYSES (y compris Préparations)		Echantillons "Bruts" / Grossiers analysés / Fractions fines			Envoi(s) des Résultats
Nombre	Nature	en	Profils et	Livrets	

DISTRIBUTION du TRAVAIL		Techniciens (nes)	Analyses			En Commun avec D	Résultats remis le
				Nombres			
Fiche	Date		Type	Echant.	Tém.		

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D □□□□ F □□/□□

EXPLICITATION COMPLETE des METHODES d'ANALYSE en VUE du CODAGE des VARIABLES

MATERIAU	ANALYSE	METHODE	ELEMENT	EXPRESSION

ORSTOM — BANQUE des DONNEES PEDOLOGIQUES — RESULTATS LABORATOIRE.

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PAGE RESERVEE A L'INFORMATIQUE

D	F	de F's	VARIABLES ANALYTIQUES

N°d'Ordre	CODE	Variable "en clair"

CADRE INFORMATIQUE

1	2	3	4	5	6	7	8

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

?P_IX_81.

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ANALYSES : ______ éventuellement, biffer les mentions inutiles – Mettre une Croix (x) par Analyse demandée, dans chaque case correspondante

LIVRET : ___ / ___

PROFIL ...

Couche préle

N° LABO

TOTAL

OBSERVATIONS (Ex : Méthode désirée)

	p H
	Calcaire total
	" actif
	Granulométrie
	Extraction Fraction α ______
	C organique total [Meth : ______]
	N organique + NH_3 [Kjeldahl]
	N hydrolysable
	Humus-Détermination seule
	" " + Electrophorèse
	C N sur Résidu Humus = Humine
	Cations échangeables
	Capacité d'échange : TCa à pH7
	" " [______]
	Al^{+++} échangeable
	Extrait saturé avec + – λ
	" 1/2 " " " "
	" 1/ " " " "
	P_2O_5 total [NO_3H] [Fusion Na O H]
	" assimilable [Olsen] [______]
	" " [______]
	" Formes : sol.. Ca.. Fe.. Al.. org.. Inc..
	Fe_2O_3 total [HCl] [______]
	" libre [Deb] [______]
	" " [______] [______]
	Al_2O_3 libre [______] [______]
	SiO_2 " [______] [______]
	"Bases totales" [NO_3H] [______]
	Analyse totale [Fusion] [HF + ClO_4H]
	Triacide
	" avec Analyse du Résidu
	S total (organique + minéral)
	" assimilable [______]
	" soluble (total) (Gypse seul)
	Mn total [$NO_3H + H_2O_2$] [______]
	" hydrosoluble
	" échangeable Σ = Actif (direct
	" facilement réductible
	" assimilable [______]
	Amorphes : Fe_2O_3, Al_2O_3, SiO_2
	Résidus Amorphes en Spectro
PHYSIQUE	Instabilité Structurale
	pF : 2.0, 2.5, 3.0, 4.2.
	Perméabilité
SPECT	Oligo-éléments (Totaux) (Solubles)
	Minéraux (argileux-totaux) Ray... X
	Analyse thermique : diff.. pond...
GEOL	Lame mince : avec, sans det... min^{x}
	Etude des sables

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D

Page quat../

26	27	28	29	30	31	32	33	34	35	36	37

OBSERVATIONS (y compris les Précisions relatives aux Analyses désirées, pour cela utiliser les numéros de Colonnes)

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Page ter /

ANALYSES

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

TYPE ANALYSE

Ne pas hésiter à laisser une Colonne en blanc entre les grands groupes d'Analyses

[Indiq]uer correctement le Type d'analyse désirée. Utiliser éventuellement le verso (Observations) pour donner toutes Précisions à ce sujet

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D	Page bis /	LI-VRET parmi	ECHANTILLONS				
* Type de SOL et ROCHE-MERE ou TRAITEMENT AGRONOMIQUE	Type d'Horizon (Code)		Identification: Profil ou Série * — Indicatif (Lettres)	N° (Chiffres)	N° Couche prélevée	Profondeur * -Horizon -Couche prélevée Sup.. cm	Inf..

Laisser 1 ligne en blanc entre chaque Profil.
Ne pas répartir un Profil sur 2 Pages
* Biffer les mentions inutiles

Profils | Ech.. | ← TOTAUX de la Page

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D | dont Feuillet / | pour | F

PP: Indic.. | N° Hor. | Prof. de a

B D P
O R S
T O M

PE

R E S U L T A T S *

N° d'Ordre (Rappel)

CADRE INFORMATIQUE

Format F5.0 (Le Point décimal occupe une Case) (Cadrer à gauche)

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LIVRET	Feuillet	H	ANALYSES PHYSIQUES
___/___	PROFIL	INDICATIF (lettres)	H 1 · H 1 · H 1 · H 1 · H 1 · H 1
Profil complet sur livrets :		NUMERO (chiffres)	
___ à ___		Couche prélevée	
	N° Labo	Non codé	

PERMEABILITE en PLACE					Mesures de terrain affectant l'ensemble du profil
en cm/heure à l'équilibre	MÜNTZ	H	2	A	
	PORCHET	H	2	B	

				RAPPEL de quelques DONNEES des FEUILLETS A et B
Classement triangle	A	3		
Argile 0 à 2 μ %	A	3	G	
Limon fin 2 à 20 μ %	A	3	H	
LF / A	A	3	P	
Mat... org... tot... %	B	2	A	
pH H_2O (1/2.5)	A	4	A	
Calcaire ‰	A	6		
Sabl... gross... 200 à 2 000 μ	A	3	L	

STRUCTURE				en 10^{-2} du sol sec à ________
Densité apparente	H	3	A	
" réelle	H	3	B	
Porosité	H	3	E	
Instab... struct... maximum	H	3	F	
Instab... struct... eau	H	3	G	
Agrégats alcool	H	3	H	
" eau	H	3	J	
" benzène	H	3	K	
Dispersion benzène	H	3	L	
Dispersion eau	H	3	M	
Agreg... alcool – SG	H	3	P	
" benzène – SG	H	3	Q	
" eau – SG	H	3	R	

Rapports SOL - EAU				en 10^{-2} du sol sec à ________
Humidité en place	H	4	A	
pF 4.2	H	4	B	
pF 3.0	H	4	C	
pF 2.5	H	4	D	
pF 2.0	H	4	E	
pF Saturation	H	4	H	
Perméabilité (cm/heure)	H	4	J	
Indices				

LIMITES MECANIQUES				en 10^{-2} du sol sec à ________
Limite de LIQUIDITE	H	5	A	
" PLASTICITE	H	5	B	
Indice de Plasticité	H	5	C	
Point d'ADHESIVITE	H	5	E	

SURFACE SPECIFIQUE				en m^2 par g de produit sec à ________
Sol ________	H	6	A	
Fraction ________	H	6	B	

☐ Valeur "rappelée" Ne pas recoder | CODE ↑

LIVRET	Feuillet	G	OXYDES					
Profil complet sur livrets ... à ...	PROFIL	INDICATIF (lettres)	G 1	G 1	G 1	G 1	G 1	G 1
		NUMERO (chiffres)						
		Couche prélevée						
	N° Labo	Non codé						
Fraction étudiée	G 2							

OXYDES de FER				en $Fe_2O_3 . 10^{-2}$ du sol sec à ______ (sauf FeO mentionné)
Total : Meth H Cl conc : (1)	B	7	A	
" " (2)	C	3	J	
" (2) réel (moins FeO converti)	C	3	K	
Libre : Meth : DEB (1)	B	7	B	
" " ______ (2)	G	3	A	
" " ______ (3)	G	3	B	
Amorphe	G	3	C	
Echangeable	G	3	F	
Fe O	C	3	L	

ALUMINE				en $Al_2O_3 . 10^{-2}$ du sol sec à ______
Totale Meth ______ (1)	C	3	H	
" " ______ (2)	C	5	B	
Libre " ______ (1)	G	4	A	
" " ______ (2)	G	4	B	
" " ______ (3)	G	4	C	
Amorphe "	G	4	D	
Echangeable (en % Al_2O_3)	G	4	G	

SILICE (+ Divers)				en $SiO_2 . 10^{-2}$ du sol sec à ______
Totale : Meth : ______ (1)	C	7	B	
...dont "Quartz"				
...dont SiO_2 Silicates	C	3	G	
Totale : Meth ______ (2)	C	3	G	
Libre : " ______ (1)	G	5	A	
" " ______ (2)	G	5	B	
" " ______ (3)	G	5	C	
Amorphe	G	5	D	
TiO_2 Total	C	3	M	

MANGANESE				en PPM de Mn élément du sol sec à ______
Total en MnO_2 % ( )	C	3	N	
" id en PPM (1)	G	7	A	
" Meth ______ (2)	G	7	B	
Hydrosoluble	G	7	C	
Echangeable. Meth ______ (1)	G	7	D	
" " ______ (2)	G	7	E	
Facilement réductible	G	7	F	
Actif (avec éch ( ))	G	7	G	
Assimilable. Meth ______	G	7	H	

Variable "rappelée" Ne pas recoder | CODE ↑ | Extraction de la fraction étudiée : ______

N° Echantillon	Mod 24	Granulo	pH	CO_3Ca		Mat. Org				Complex			Fertilité				Salanité			Divers			Fe_2O_3		Triacide			Physique			Spectro			Observations
													P_2O_5		BT		Extr								Fract									
				Tot	Ac	C	N	Humus		BE	T Ca		As	Tot			$\frac{1}{10}$	Sat		S	Mn	Al	Lib	Tot	tot	fin		Struct.	PF	Permea	Miner	Oligo		

LIVRET	Feuillet	E Recto	Détermination HUMUS		
Profil complet sur livrets … à …	PROFIL — INDICATIF (lettres)		E 1	E 1	E 1
	PROFIL — NUMERO (chiffres)				
	PROFIL — Couche prélevée		Conditions Extraction 9 ml*	Conditions Extraction 9 ml*	Conditions Extraction 9 ml*
	N° Labo	Non codé			

Tous les résultats relatifs à la matière organique humifiée sont exprimés en C ‰ du SOL sec à ______

MOT — MATIERE ORGANIQUE TOTALE (Rappel du feuillet B)

MOT = C x 0.1724 (10^{-2})	B	2			A
C (Méth ______)	B	2			B
N (Méth ______)	B	2			C
C/N	B	2	Z	Z	D

Colonne non codée ↓

MOL — MATIERE ORGANIQUE LEGERE (Extraction par ◯)

M L Totale ‰ du sol (PESEE	E	2			A
C x 1.724 = M O L	E	2			B
C (Meth ______)	E	2			C
C de M O L / C Total	E	2	Z	Z	D
Extraction sur M L T par $P_2O_7Na_4$ — pH 7.0 — A F	E	2			E
Extraction sur M L T par $P_2O_7Na_4$ — pH 7.0 — A H	E	2			F
Extraction sur M L T par $P_2O_7Na_4$ — pH 9.8 — A F	E	2			G
Extraction sur M L T par $P_2O_7Na_4$ — pH 9.8 — A H	E	2			H
Σ AF+AH à pH7 et 9.8 = MOLH	E	2			J
M O L H / M O L	E	2	Z	Z	K

EXTRACTIFS
Successifs : Exemple :
Alcool + Bromoforme (dé)
PO_4H_3 2M-Eau-$P_2O_7Na_4$ 0.1M
NaOH 0.1N-Mélanges...etc...

① ______ pH ____ dé ____
② ______ " ____ " ____
③ ______ " ____ " ____
④ ______ " ____ " ____
⑤ ______ " ____ " ____

AF — ACIDES FULVIQUES

Extraction par ◯+◯+◯+◯+◯	E	3			A
◯+◯+◯+◯+◯	E	3			B
◯+◯+◯+◯+◯	E	3			C
◯+◯+◯+◯+◯	E	3			D
◯+◯+◯+◯+◯	E	3			E
ΣAF=◯+◯+◯+◯+◯	E	3			F
ΣAF / C Total	E	3	Z	Z	G
ΣAF / Σ AH	E	3			H
ΣAF / Σ AFH	E	3			J

AH — ACIDES HUMIQUES

Extraction par ◯+◯+◯+◯	E	4			A
◯+◯+◯+◯	E	4			B
◯+◯+◯+◯	E	4			C
◯+◯+◯+◯	E	4			D
ΣAH=◯+◯+◯+◯	E	4			E
ΣAH / C Total	E	4	Z	Z	F
ΣAF+ΣAH = ΣAFH	E	4			G
Σ AFH / C Total	E	4	Z	Z	H
Σ AH / ΣAFH	E	4			J

Hu — HUMINE (après extraction de M O L, AF et AH)

C (Hu) x 1.724	E	5			A
C (Méth ______)	E	5			B
N (Méth ______)	E	5			C
C/N	E	5	Z	Z	D
C de Hu / C Total	E	5	Z	Z	E
Σ AF / Hu	E	5	Z	Z	F
Σ AH / Hu	E	5	Z	Z	G
ΣAFH + Hu = M O H	E	5	Z	Z	H
Hu / M O H	E	5	Z	Z	J
Σ AF / M O H	E	5	Z	Z	K
Σ AH / M O H	E	5	Z	Z	L
M O H / C total	E	5	Z	Z	M
Σ MOL+AF+AH+Hu	E	5	Z	Z	N

☐ Variable "rappelée" Ne pas recoder — CODE ↑ — * à raison de 200 ml de réactif par phase de l'extraction.

LIVRET	Feuillet	F	FERTILITE
___/___	PROFIL	INDICATIF (lettres)	F 1 · F 1 · F 1 · F 1 · F 1 · F 1
Profil complet sur livrets		NUMERO (chiffres)	
___ à ___		Couche prélevée	☐ ☐ ☐ ☐ ☐ ☐
	N° Labo	Non codé	

AZOTE

en N élément – en 10^{-3} du Sol sec à ______

Rappel	Mat... org... tot... %	B	2			A
Rappel	N total (Méth______)	B	2			C
Rappel	C / N	B	2	Z	Z	D
Rappel	N hydrolysable	B	6			H
	NO_3^-	F	2			A
	NO_2^-	F	2			B
	NH_4^+	F	2			C

PHOSPHORE

en oxyde P_2O_5 – en 10^{-3} du Sol sec à ______

P_2O_5 tot (Meth______) ①	B	6			A
" " (" ______) ②	C	3			T
" assim (Meth____) ①	B	6			B
" " (______) ②	B	6			
" " (______) ③	B	6			
P_2O_5 assim ○/P_2O_5 tot ○	F	3			A
P_2O_5 tot ○ /N total	F	3			B

Formes physico-chimiq...	P_2O_5 soluble	F	3			E
Formes physico-chimiq...	" lié à Ca	F	3			F
Formes physico-chimiq...	" " " Al	F	3			G
Formes physico-chimiq...	" " " Fe	F	3			H
Formes physico-chimiq...	" organique	F	3			J
Formes physico-chimiq...	" d'inclusion	F	3			K
Formes physico-chimiq...	Somme des formes	F	3			L

POTASSIUM

en milli-équivalents (mé) pour 100 g de Sol sec à ______

K total (Meth______) ①	B	5			D
" " (" ______) ②	C	4			Q
K assim... (Meth______) ○	F	4			A
K échangeable (Rappel)	B	3			D
K ech / (Ca + Mg ech.s)	F	4			C
" " / Mg ech	F	4			D
" " / Somme cat... éch..[s]	F	4			E
" " / T (Meth ______)	F	4			F
K difficil[t]... échang (______)	B	6			F

SOUFRE

en S élément – en 10^{-3} de Sol sec à ______

S total (Meth______)	B	6			D
S organique total (______)	F	5			A
" soluble H_2O (______)	F	5			B
" assimilable (______)	F	5			C
S des sulfures (______)	F	5			E
Gypse (SO_4Ca, $2H_2O$)	A	7			A

Rappel	pH H_2O 1/2.5	A	4			A
Rappel	pH KCl N "	A	4			B
Rappel	CO_3Ca total ‰	A	6			A
Rappel	" actif "	A	6			E
Rappel	Argile 0 à 2µ %	A	3			G

☐ Variable "rappelée" Ne pas recoder — CODE ↑

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LIVRET	Feuillet	E Verso	FRACTIONNEMENT des Ac... Humiques		
___/___	PROFIL	INDICATIF (lettres)	E 1	E 1	E 1
Profil complet sur livrets :		NUMERO (chiffres)			
___ à ___		Couche prélevée			
	N° Labo	Non codé			

MODE DE FRACTIONNEMENT		Electrophorèse sur :
		Séphadex :

EXTRACTION des A.H	Rappeler ici le code recto de la fraction étudiée		Colonne non codée		Colonne non codée		Colonne non codée
avec g (SOL) (MOL)							
et ml de ○ +							
" ○ +	E 2						
" ○ +	E 4						
" ○							

	↓ Non codé	Redissolution des Acides Humiques en vue du FRACTIONNEMENT
Prise d'AH – en mg de C		
Redissolution – par		
Redissolution – de Normalité (N)		
Redissolution – Volume final (ml)		
Redissolution – Normalité finale (N)		
Fractionnement sur – Aliquote (ml) (µl)		
Fractionnement sur – mg C corresp...		

Nature des Fractions							
	C‰ du sol	E 6 A					
	% des AH	E 6 B					
	C‰ du sol	E 6 E					
	% des A H	E 6 F					
	C‰ du sol	E 6 J					
	% des A H	E 6 K					
	C‰ du sol	E 6 N					
	% des A H	E 6 P					
	C‰ du sol	E 7 A					
	% des A H	E 7 B					
	C‰ du sol	E 7 E					
	% des A H	E 7 F					
	C‰ du sol	E 7 J					
	% des AH	E 7 K					
	C‰ du sol	E 7 N					
	% des A H	E 7 P					

Compléments Rapports divers

CODE ↑

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LABORATOIRE D'ANALYSE DES SOLS ET DES EAUX

RÉPUBLIQUE DE DJIBOUTI

APPENDIX F

INDIVIDUAL FARM VISIT FORM

APPENDIX F

Individual Farm Visit Form

On Site Contact

Date: Apr. 10, 1981

Location: Yobohi - Dikhil Province

People Contacted: Maureen Yates

Technicians Present: Dr. Goebel & Dr. Yates

Purpose of the Visit: To see experimental garden

Comments or Recommendations: The garden was over for the year. The water seemed in good condition. We would test the water and soil as soon as possible.

Follow-up Schedule: Return as convenient.

Individual Farm Visit Form

On Site Contact

Date: May 14, 1981

Location: Douda Yer

People Contacted: Farmer's Cooperative

Technicians Present: Farah Omar, Dr. Joseph Goebal

Purpose of the Visit: To look into the needs of the farms of the Atar area to establish farms.

Comments or Recommendations: The people would need to wait until better data was available for locating farm sites.

Follow-up Schedule:

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Individual Farm Visit Form

On Site Contact

Date: September 2, 1981

Location: Aliade - Dikhil Province

People Contacted: Larry Barrazos C.R.S.

Technicians Present: Joseph Goebel

Purpose of the Visit: Determine well site for refugee camp

Comments or Recommendations: A spot was selected in the wadi and the work should be done by hand.

Follow-up Schedule: Follow-up showed the well to be a success, supplying plenty of clean sweet water. This was accomplished by the same refugees.

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Individual Farm Visit Form

On Site Contact

Date: October 5, 1981

Location: Asa Eala - Dikhil Province

People Contacted: The MOA Mohamed Harmed and other farmers of the town.

Technicians Present: Aboubaker Douale, Joseph Goebel, Wolfgang Mueller, Soventi.

Purpose of the Visit: See the Agricultural potential of the Dikhil Province, in particular, Asa Ela.

Comments or Recommendations: The wells were located too far from the Goffood Wadi channel and therefore the water was salty and the crops were suffering. Water must be gotten from the Wadi channel.

Follow-up Schedule: Return to set up a farm site for the French volunteers.

Individual Farm Visit Form

On Site Contact

Date: October 27, 1981

Location: Chekheti and Sabbalou - Dikhil Province

People Contacted: United Nations High Commission on Refugees

Technicians Present: Aboubaker Douale, Joseph Goebel, Wolfgang Mueller, Mohamed Awali

Purpose of the Visit: Determine sites and water suitable for a refugee relocation program in agriculture.

Comments or Recommendations: Two sites were selected and are suitable for development when the necessary wells are drilled.

Follow-up Schedule: prepare a report on the soils of the areas.

Individual Farm Visit Form

On Site Contact

Date: December 7, 1981

Location: Sublali, Oboch Province

People Contacted: Visit for the Minister of Agriculture

Technicians Present: Farah Omar, Joseph Geobel

Purpose of the Visit: Determine the suitability of the old garden for rehabilitation.

Comments or Recommendations: While the water of the well was somewhat saline the problem with this site was not having permission to use the water from the town well and also management and labor costs.

Follow-up Schedule: The area probably represents the best area for soils and water to develop vegetable gardening. Return visits will become more frequent.

Individual Farm Visit Form

On Site Contact

Date: April 3, 1982

Location: Mouhed, Eli Sabeah Province

People Contacted: Soventi FAO

Technicians Present: Joseph Goebel

Purpose of the visit: Observe the problems of this agricultural resettlement project.

Comments or Recommendations: The site is suffering saltiness and high loam. Recommend expanding to new land and working the old land during the next rainy season then let it dry for 2 years or so.

Follow-up Schedule: Will return in a few months.

Individual Farm Visit Form

On Site Contact

Date: March 16, 1982

Location: Atar Project

People Contacted: Michel Custer

Technicians Present: Farah Omar, Joseph Goebel

Purpose of the Visit: Test irrigation water

Comments or Recommendations: The water entering the catchment was 34 degrees centigrade 500 ppm salt. In the catchment the temp. was 28 degrees centigrade an 1000 pm salt. We recommended direct irrigation.

Follow-up Schedule: On demand

Individual Farm Visit Form

On Site Contact

Date: March 18, 1982

Location: East of Eas Eayla, Dikhil

People Contacted: Bernard Plat, Jaques Olivier, Ahmed Hamadrow

Technicians Present: Aboubaker Douale, Joseph Goebel, Mohomed Awali

Purpose of the Visit: Locate a garden site for a demonstration project as a cooperative effort between the Agricultural Service and the French volunteers.

Comments or Recommendations: A specific site was selected near the wadi channel with recommendations to construct some flood water diversion structures. Water samples were taken from two nearby wells.

Follow-up Schedule: on demand.

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Individual Farm Visit Form

On Site Contact

Date: May 12, 1982

Location: Atar, Djibouti Province

People Contacted: Michelle Custers and Goldstien

Technicians Present: Joseph Goebel

Purpose of the Visit: To review the condition of crops and soils at the agricultural project.

Comments or Recommendations: Drip irrigation will cut salt build-up. They need a new source of water or the gardens will be too saline in 5 years.

Follow-up Schedule: Continue to return regularly

Individual Farm Visit Form

On Site Contact

Date: May 16, 1982

Location: Houmbouli, Djibouti Province

People Contacted: Mohamed Awali for Minister of Agriculture, Mohamed Hamed

Technicians Present: Aboubaker Douale, Farah Omar, Joseph Goebel

Purpose of the Visit: Determine suitability of a site for a garden.

Comments or Recommendations: It was formerly a garden and seems to be suitable. Sweet water is important for this site.

Follow-up Schedule: on demand.

LABORATOIRE D'ANALYSE DES SOLS ET DES EAUX

RÉPUBLIQUE DE DJIBOUTI

APPENDIX G

WATER SALINITY INVESTIGATION OF HOUMBOULI AND GRANDE DOUDA AGRICULTURAL AREAS

APPENDIX G

Water Salinity Investigations of Houmbouli and Grande Douda Agricultural Areas

In the beginning of the 1982 - 1983 growing season, there was a possibility of stress being placed on the capacity of the aquifer to supply water for the extensive amount of agricultural expansion, especially in the Houmbouli area. The last major rain, with subsequent flooding was the previous January and there appears to be no weather pattern in the country.

It was our purpose to measure the depth of the well to the water, the depth of the water, the temperature in degrees celsius, the salinity in parts per 1,000 and conductivity in microhoms (mhos) at the surface and depth of the well on about the same time each month.

The Houmbouli and Grande Douda agricultural areas were selected because of their proximity to the laboratory and because the evidence of one area could support the other. Aboubaker Douale, and Farah Omar of the Soils and Water Laboratory, along with Beverly Rollins of the Agricultural Service selected a well distributed sample in each community. They also got permission from the land owner and made the readings each month.

November is the middle of the land preparation season for the winter crops. Therefore, the data would be collected right along with the increase in water consumption as crop needs would lower and/or the salinity would increase. In fact, the reverse happened. Storms caused flooding, especially on the Houmbouli in late November, so the record shows the water table raising and salinity declining.

The tables that follow are the data that was collected by the laboratory:

WATER SALINITY INVESTIGATION

HOUMBOULI

LAND OWNER	DATE	WELL DEPTH	TEMPERATURE OC SURFACE	TEMPERATURE OC DEEP	SALINITY 0/00 SURFACE	SALINITY 0/00 DEEP	CONDUCTIVITY IN MHOS SURFACE	CONDUCTIVITY IN MHOS DEEP
Agricultural Service	11-11-82	9.50		34.0		3.0		6000
Mohamed Salah	"	6.18 5.90		34.2		4.4		8800
Mohamed Amin	"	5.92 4.32	32.0	31.0	4.0	4.0	8000	8000
Abdella Shirwa	"	7.60 6.62	32.0	32.0	2.0	2.0	4000	4000
Osman Adeu	"	8.92 8.12	32.0	32.0	2.2	2.2	4500	4500
Mohamed Dabi	"	5.92 4.32	32.0	31.0	4.0	4.0	8000	8000
Said Hamada	"	8.10 5.40	32.0	32.0	3.0	3.0	6000	6000
Said Soremi	"	9.83 6.66	32.5	32.5	6.5	6.5	12500	12500
Administration Palm Plantation	"	4.76 4.00	31.0	31.0	6.1	6.1	12000	12000
Moumin Bader	"	2.33 1.78	32.3	32.3	2.5	2.5	5000	5000
Aguelleh Djama	"	3.22 2.29	30.0	30.0	3.0	3.0	6000	6000
Farah Tye	"	3.10 2.03	32.1	32.1	3.9	3.9	7600	7600
Aden Moussa	"	1.45 0.88	29.0	29.0	2.3	2.3	4700	4700
Idris Issa	"	4.9 4.00	37.0	37.0	2.9	2.9	5200	5200
Abdeltaziz	"	6.72 4.74	37.0	37.0	2.9	2.9	5200	5200

LAND OWNER	DATE	WELL DEPTH	TEMPERATURE OC SURFACE	TEMPERATURE OC DEEP	SALINITY 0/00 SURFACE	SALINITY 0/00 DEEP	CONDUCTIVITY IN MHOS SURFACE	CONDUCTIVITY IN MHOS DEEP
Dasud Assawch	11/11/82	5.62 4.22	30.2	30.0	1.0	1.0	2300	2300
Aden Roblech	"	9.20 6.17	30.0	30.0	3.0	3.0	6000	6000
Housin Djama	"	4.00 3.07	34.0	34.0	3.8	3.8	7500	7500
Agricultural Service	12/12/82	9.70 8.9		34.2	2.8	2.8		5900
Mohamed Salah	"	6.25		33		5.2		10000
Mohamed Amin	"	6.13		33		4.0		8000
Abdella Shirwa	"	7.16 .50		35.8		1.8		3850
Osman Adeu	"	9.94 .35		36.0		2.1		5000
Mohamed Dadai	"	7.49 .10		31.0		4.0		8000
Said Hamada	"	8.05 .80		35.8		2.9		6000
Said Soremi	"	8.00 4.05		32.0		6.5		12200
Administration Palm Plantation	"	5.25 .55		32.0		6.5		12500
Mowmin Bader	"	4.54 1.10		30.0		2.1		4500
Aguelleh Djama	"	3.20 .88		31.8		2.5		5100
Farah Tye	"	3.35 .74		32.0		3.4		6800
Aden Moussa	"	1.65 .60		30.0		2.2		5000
Idris Issa	"	4.64		38.0		2.4		5200

LAND OWNER	DATE	WELL DEPTH	TEMPERATURE OC SURFACE	TEMPERATURE OC DEEP	SALINITY 0/00 SURFACE	SALINITY 0/00 DEEP	CONDUCTIVITY IN MHOS SURFACE	CONDUCTIVITY IN MHOS DEEP
Abdellaziz	12/12/82	7.44 .70		34.0		2.4		6500
Dasud Assaweh	"	4.30 .45		32.0		1.0		2300
Aden Robleh	"	8.35		35.0		3.2		2550
Houssain Djama	"	3.81 .67		32.5		3.4		2000
Agricultural Service	1/1/83	9.59 .30		34.0		3.0		6000
Mohamed Salah	"	6.15 5.25 .90		34.0		4.5		9000
Mohamed Amin	"	6.00 5.65 .35		32.3		3.9		7800
Abdella Shirwa	"	7.56 .88		36.0		2.0		4000
Osman Aden	"	9.88 8.98 .90		32.4		1.9		4190
Mohamed Dadai	"	8.10 .80		36.0		2.5		6600
Said Hamada	"	7.50 8.90 .60		32.0		3.5		7000
Said Soremi	"			34.0		4.4		9000
Administration Palm Plantation	"	5.31 .23		32.0		6.0		11000
Moumin Bader	"	4.45 .74		32.0		2.1		4500
Agelleh Djama	"	3.00 .90		31.0		3.2		6000

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LAND OWNER	DATE	WELL DEPTH	TEMPERATURE OC		SALINITY 0/00		CONDUCTIVITY IN MHOS	
			SURFACE	DEEP	SURFACE	DEEP	SURFACE	DEEP
Farah Tye	1/1/83	3.24 1.24		30.5		3.2		6500
Aden Moussa	"	1.77 .67		32.0		2.9		5100
Adris Issa	"	4.75 .56		35.9		3.0		5500
Abdellaziz	"	7.44		34.0		3.5		6900
Dasud Assaweh	"	4.00 2.57 1.43		32.0		1.2		2850
Aden Robleh	"	8.60 6.30 2.30		34.0		2.9		5900
Houssien Djama	"	4.00 .99		30.1		3.5		6500
Agricultural Service	2/2/83	9.59 .30		38.0		2.8		5600
Mohamed Salah	"	Flooded						
Mohamed Amin	"	6.00 5.65 .35		28.0		3.7		6500
Abdella Shirwa	"	Missed						
Osman Adeu	"	9.88 8.98 .90		29.0		2.4		4500
Mohamed Dabai	"	8.10 .80		24.0		3.0		6100
Said Hamada	"	7.50 6.90 .60		28.0		2.9		5700
Said Soremi	"	8.05 4.05		25.0		5.5		11000

LAND OWNER	DATE	WELL DEPTH	TEMPERATURE OC SURFACE	TEMPERATURE OC DEEP	SALINITY 0/00 SURFACE	SALINITY 0/00 DEEP	CONDUCTIVITY IN MHOS SURFACE	CONDUCTIVITY IN MHOS DEEP
Administration Palm Plantation	2/2/83	5.25 .55		23.0		4.7		9000
Mowmia Bader	"	4.54 1.10		30.0		2.2		4650
Aguelleh Djama	"	3.20 .88		30.0		2.9		5500
Farah Tye	"	3.35 .74		30.0		3.5		7000
Aden Moussa	"	1.65 .60		27.0		0.5		5320
Idris Issa	"	4.75 .56		32.0		2.5		5000
Abdellaziz	"	7.44 .70		32.0		3.4		6500
Dasud Assaweh	"	4.30 .45		25.0		0.1		520
Aden Robleh	"	8.60 6.30 2.30		28.0		3.0		6100
Houssien Djama	"	3.81 .67		34.0		2.8		5900
Agricultural Service	3/16/83	9.59 .30		34.0		3.0		5500
Mohamed Salah	"	6.15 5.25 .90		28.0		4.3		8000
Mohamed Amin	"	6.00 5.65 .35		31.0		3.9		7000
Abdella Shirwa	"	7.66 .50		35.0		1.5		3400
Osman Aden	"	9.88 8.98 .90		31.0		2.5		4100

LAND OWNER	DATE	WELL DEPTH	TEMPERATURE oC SURFACE	TEMPERATURE oC DEEP	SALINITY 0/00 SURFACE	SALINITY 0/00 DEEP	CONDUCTIVITY IN MHOS SURFACE	CONDUCTIVITY IN MHOS DEEP
Mohamed Dabai	3/16/83	8.10 .80		32.0		4.5		5800
Said Hamada	"	7.50 6.90 .60		33.0		3.1		5700
Said Soremi	"	8.05 4.05		32.0		6.0		10800
Administration Palm Plantation	"	5.25 .55		26.0		5.0		8600
Mowmin Bader	"	4.54 1.10		27.0		2.3		4000
Aguelleh Djama	"	3.20 .88		30.0		3.0		6000
Farah Tyew	"	3.35 .74		30.0		3.5		6400
Aden Mousa	"	1.65 .60		27.0		2.9		5200
Idris Issa	"	4.75 .56		33.0		2.3		4800
Adbellaziz	"	7.44 .70		27.0		3.6		6200
Dasud Assawch	"	4.30 .45		28.0		0.5		950
Aden Robleh	"	8.60 6.30 2.30		34.0		3.0		6000
Houssien Djama	"	3.81 .67		31.0		3.4		6900

WATER SALINITY INVESTIGATIONS

GRANDE DOUDA

LAND OWNER	DATE	WELL DEPTH	TEMPERATURE OC SURFACE	DEEP	SALINITY 0/00 SURFACE	DEEP	CONDUCTIVITY IN MHOS SURFACE	DEEP
Ibrahim Igueh Hared	11/11/82	7.94 7.24	31.0	31.0	0.1	0.1	810	810
Ali Waberi	"	6.50 5.81	26.0	25.5	1.0	1.0	2150	2150
Bobakir Ohar	"	8.16 6.87	34.0	33.0	0.8	0.8	1800	1900
Ahmed Guireh	"	6.50 5.75	32.0	32.0	0.1	0.5	1100	1400
Aicha Goudi	"	5.74 5.40	30.0	30.0	0.3	0.3	900	900
Waberi Doubad	"	6.72 5.28	32.0	32.0	0.9	0.9	2000	2000
Issa Iobriss	"	6.44 5.01	28.0	27.0	3.5	3.5	7000	7000
Hassah Ibrahim	"	5.26 4.43	29.0	29.9	1.4	1.4	3100	3100
Nour Ainane	"	3.70 2.80	32.0	32.0	2.0	2.0	4400	4400
Ali Hassan	"	4.24 3.69	27.0	27.0	1.9	2.0	4000	4030
Ahmed Beileh	"	6.50 5.80	32.0	32.0	3.0	3.0	6000	6000
Ahmed Ibrahim	"	3.00 2.50	30.0	30.0	0.4	0.5	1550	1550
Moussa Weirah	"	2.74 2.12	28.0	27.0	2.0	2.0	4100	4100
Ibrahim Igueh Hared	12/9/82	7.40 .10		30.0		0.1		850

LAND OWNER	DATE	WELL DEPTH	TEMPERATURE OC SURFACE	TEMPERATURE OC DEEP	SALINITY 0/00 SURFACE	SALINITY 0/00 DEEP	CONDUCTIVITY IN MHOS SURFACE	CONDUCTIVITY IN MHOS DEEP
Ibrahim Igueh Hared	3/16/83	7.40 .31		29.0		0.6		820
Ali Waberi	"	6.75 .31		28.0		1.0		2180
Bobakir Ohar	"	7.90 .65		32.2		0.9		2050
Ahmed Guireh	"	6.65 1.10		30.0		0.3		1150
Aicha Goudi	"	5.90 .61		29.0		0.1		880
Waberi Doubad	"	6.80 .35		32.2		0.8		1700
Issa Iobriss	"	6.30 .45		32.0		4.8		7000
Hassan Ibrahim	"	5.20 .30		29.0		2.9		3390
Nour Ainane	"	3.40 .30		30.0		2.2		4390
Ali Hassan	"	5.60 .86		32.5		2.4		4900
Ahmed Beileh	"	2.64 .10		28.0		0.5		1680
Ahmed Ibrahim	"	2.65 .30		25.0		4.1		7000
Moussa Weirah	"	2.20 .50		27.0		2.5		4650
Ibrahim Igueh Hared	1/13/83	7.30 .20		30.		0.4		900
Ali Waberi	"	6.58 .12		30.1		1.0		2180
Bobakir Ohar	"	7.93 2.20		32.0		1.0		2200

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LAND OWNER	DATE	WELL DEPTH	TEMPERATURE OC SURFACE	TEMPERATURE OC DEEP	SALINITY 0/00 SURFACE	SALINITY 0/00 DEEP	CONDUCTIVITY IN MHOS SURFACE	CONDUCTIVITY IN MHOS DEEP
Ahmed Guireh	1/13/83	6.59 .17		30.2		0.5		1300
Aicha Goudi	"	6.08 .49		30.0		0.3		900
Waberi Doubad	"	6.62 .96		30.1		1.0		2150
Issa Iobriss	"	6.25 .70		32.0		2.9		5100
Hassan Ibrahim	"	5.03 .50		28.0		1.8		3200
Nour Ainane	"	3.70 .67		27.0		2.0		3900
Ali Hassan	"	5.40 .64		32.0		2.8		5000
Ahmed Beileh	"	6.30 .86		32.0		3.1		5100
Ahmed Ibrahim	"	2.77 .75		24.0		3.9		7100
Moussa Weirah	"	3.05 .90		28.0		1.9		3600
Ibrahim Igueh Hared	2/11/83	7.30 .20		24.0		0.2		800
Ali Waberi	"	6.58 .12		27.0		1.0		2100
Bobakir Ohar	"	7.93 2.20		25.0		1.0		2000
Ahmed Guireh	"	6.59 .17		26.0		0.5		1100
Aicha Goudi	"	6.08 .49		27.0		0.5		1000
Waberi Doubad	"	6.62 .96		24.0		1.0		2000

LAND OWNER	DATE	WELL DEPTH	TEMPERATURE OC SURFACE	TEMPERATURE OC DEEP	SALINITY 0/00 SURFACE	SALINITY 0/00 DEEP	CONDUCTIVITY IN MHOS SURFACE	CONDUCTIVITY IN MHOS DEEP
Issa Iobriss	"	6.25 .70		25.0		2.5		4350
Hassan Ibrahim	"	5.03 .50		23.0		1.5		3050
Nour Ainane	"	3.70 .67		23.0		1.2		2350
Ali Hassan	"	5.40 .64						
Ahmed Beileh	"	6.30 .86		29.0		2.9		5100
Ahmed Ibrahim	"	2.77 .75		23.0		0.1		600
Moussa Weirah	"	3.05 .90		22.0		2.0		3650
Ibrahim Igueh Hared	3/16/83	7.40 .31		29.0		0.6		820
Ali Waberi	"	6.75		28.0		1.0		2050
Bobakir Ohar	"	7.90 .65		31.0		0.9		1950
Ahmed Guireh	"	6.65 1.10		29.0		0.4		1150
Aicha Goudi	"	5.90 .61		29.0		0.1		870
Waberi Doubad	"	6.80 .35		31.0		1.1		2430
Issa Iobriss	"	6.30 .45		32.0		3.9		5100
Hassan Ibrahim	"	5.20 .30		29.0		1.5		3100
Nouv Ainane	"	3.40 .30		30.0		1.9		3700

LAND OWNER	DATE	WELL DEPTH	TEMPERATURE OC SURFACE	DEEP	SALINITY 0/00 SURFACE	DEEP	CONDUCTIVITY IN MHOS SURFACE	DEEP
Ali		5.60						
Hassam	"	.86		31.0		2.5		4700
Ahmed		2.64						
Beileh	"	.10		33.0		2.3		4900
Ahmed		2.65						
Ibrahim	"	.30		27.0		2.1		4200
Moussa		3.05						
Weirah	"	.90		31.0		2.0		3950

It is helpful to know other information to be able to understand the significance of the data. Now is a good time to review some of the water requirements for agricultural production.

Most crops need water with less than 2,000 parts per million (ppm) total dissolved salts to respond well to irrigation. The use of water with more saline than this eventually causes many complications. A single crop needs from 500 to 15,000 cubic meters (1,000 liters/cubic meter) of water. The demand depends on the type of crop, the length of the growing season and the kind of irrigation practice. Using large quantities of water is the biggest cause of accumulation of salt in the soil. At 2,000 ppm, water contains 500 grams of salt per cubic meter. This means salt accumulations per crop will range between 2,500 and 7,500 kilos per hectare. These rates go proportionately higher as the salt increases in the water. Some wells in the area have six times this amount of salt while others have less than one-fourth this amount. It is important to seek out the good water. These salts accumulate in the soils due to evaporation of the water. Then they re-dissolve in the fresh water added later. Therefore, depending on the texture of the soil, the soils must be washed deep beyond the zone of the roots, about two meters. This washing process takes even more good quality water to restore the land. Consequently, the salt content of the water must be kept low.

In the Houmbouli region, most of the well water has between 2,100 to 4,500 ppm salts. Grande Douda wells have between 300 and 2,400 ppm salts. This difference in salt content is clearly reflected in the quality and productivity of the crops. It is also directly related to the proximity of the wells to the wadi channel. The closer the well is to the channel, the lower the salt content. In the channel itself, the content may be as low as 100 ppm salts. This may well be why the nomads always dug their wells in the channel even though they would be lost during each rain. This is why the citizens of the City of Djibouti seek the water at Houmbouli. The sediments above and beside the channel have accpetable soils on the surface for agriculture but salts were deposited and accumulated in the subsoil below two meters. The salt in the subsoil is dissolved into the water infiltrating from the flood waters of the wadi channel. Thus salt content increases rapidly with distance away from the channel where the water begins with less than 100 ppm but appears later containing 12,000 ppm which won't even support date palms, the most salt-tolerant crop.

From our observations, it is clear that water quality increased progressively (with 1,500 ppm less salt in water containing 3,500 ppm salt). During December, the Houmbouli wadi flooded from rain in the mountains. Since the Grande Douda wadi was little affected by this major flood, the water quality change was not very clear during the same period. This again points out the importance of the flood waters to the availability of large quantities of good quality water which diluted the groundwater during the next several months.

From February to March, the conductivity of the well water dropped a significant 100 mhos. This drop is too low to sufficiently improve the quality of well water distant from the channel due to recharge.

The wells in the two areas are often between three and nine meters deep. There was some problems measuring the water depth because often the farmers had begun irrigating before the reading. Nevertheless, the procedure used produced significant information on the increase in the height of the water table. From November to January the Houmbouli area wells rose an average of 25 cm with a spread from 0-125 cm. This offers further evidence that the water was entering the water table from the flooding channel. If one would transfer the water directly overland to the gardens it could never have become salty. The water quality in the channel is between 100 and 500 ppm salt which is satisfactory for growing any plants. It should be pointed out that this water has arrived at Houmbouli after recharging the city's aquifer at the maximum rate. Therefore, if this good water is not used it will seep into the salty banks and the sea.

If the permeability of the aquifers under the gardens is considered to be 25 percent (25%), then this rise of 25 cm represents six centimeters of water available to irrigate all of the land along the channel, but less than 10 percent (10%) of this area is in production. Therefore, this means that more than 60 cm (or 6,000 cubic meters/hectare) would be available for farming if the water were removed from the channel before it seeped into its salty banks.

These are only preliminary results based on this five-month record of well depth, salinity and temperature. The actual recovery of water would depend on the design of the system to recover the channel water. A suggestion would be to trench the channel from the highway in Houmbouli to well past the airport. A trench five meters wide and ten meters deep refilled with rocks and boulders to within one meter of the surface and finished with sand and gravel would create a good drainage facility. The water could then be drawn by tubes to the gardens by the farmers or a larger pumping and distribution system could be designed. The same can be done in Grande Douda from about 100 meters below the Djibouti-Loyada road for one or two kilometers upstream. This same procedure can be applied to the Dey Dey wadi to supply water to Atar where the project is competing with the city for water. These areas will always be important for fresh agricultural products because of their proximity to the capitol. They also represent the greatest agricultural development in the country. This remedy would be quick, low-cost and permanent (not even destroyed by flood). It represents a project that can result in immediate implementation and import.

APPENDIX G-1

Particle Size Analysis

DATE: February 21, 1982

TECHNICIAN: Farah Omar

PARTICLE SIZE ANALYSIS

Hydrometer Reading		Temperature Correction					Correction Applied			
		0.5	0.2	0.1	0.05	0.02	0.005	0.002	0.001	
	Sieve Size:	#40	#60	.5	1	4	90	270	1400	
Lab No.	Dry Wt.									
1	49	63		37	35	31	16	16	6	Hydro Reading
		63		2	4	15	0	10	6	%passing
										%vesting
2	48.5	53		47	47	43	25	16	6	
		53		0	4	18	9	10	6	
3	48	50		50	48	46	29	23	8	
		50		2	2	17	6	15	8	
4	49	82		18	16	14	10	8	8	
		82		2	2	4	2	0	8	
5	49	63		37	33	26	16	12	12	
		63		4	17	10	4	0	12	
6	48	62		48	48	42	27	23	19	
		62		0	6	5	4	4	19	
7	47.5	41		59	57	57	40	32	9	
		41		2	0	17	12	21	9	
8	49	73		27	27	24	18	16	8	
		73		0	3	6	2	8	8	
9	46.5	40		60	60	60	52	45	37	
		40		0	0	8	7	8	37	
10	46.5	40		60	60	60	52	47	41	
		40		0	0	8	5	6	41	
11	46	39		61	61	59	50	17	9	
		39		0	2	9	33	8	9	
12	45.5	38		62	62	62	48	11	7	
		38		0	0	14	37	4	7	

Hydrometer % Sand = 100 - % in 1mm reading % Silt = 1mm reading - 270mm reading % Clay = 270mm reading

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DATE: February 17, 1982

TECHNICIAN: Farah Omar,
Aboubaker Douale

PARTICLE SIZE ANALYSIS

Hydrometer Reading		Temperature Correction					Correction Applied			
		0.5	0.2	0.1	0.05	0.02	0.005	0.002	0.001	.01
	Sieve Size:	#40	#60	.5	1	4	90	270	1400	30
Lab No.	Dry Wt.									
1	49	67				33	18	16	10	24
		67				9	2	6	10	6
2	48.5	65				35	21	16	12	23
		65				12	5	4	12	2
3	48	52				48	29	23	17	35
		52				13	6	6	17	6
4	49	87				13	10	8	8	10
		87				3	2	0	8	0
5	49	71				29	14	12	10	16
		71				14	2	2	10	2
6	48	58				42	27	23	21	29
		58				13	4	2	21	2
7	47.5	47				53	38	34	27	44
		47				9	4	7	27	6
8	49	73				27	20	18	14	22
		73				5	2	4	14	2
9	46.5	57				43	41	41	34	43
		57				0	0	7	34	2
10	46.5	37				63	56	49	41	58
		37				5	7	8	41	1
11	46	39				61	52	38	22	56
		39				5	6	26	22	4
12	45.5	41				59	51	37	11	55
		41				4	14	26	11	4

Hydrometer % Sand = 100 - % in 1mm reading % Silt = 1mm reading - 270mm reading % Clay = 270mm reading

DATE: February 18, 1982

TECHNICIAN: Farah Omar

PARTICLE SIZE ANALYSIS

Hydrometer Reading		Temperature Correction					Correction Applied			
		0.5	0.2	0.1	0.05	0.02	0.005	0.002	0.001	.01
	Sieve Size:	#40	#60	.5	1	4	90	270	1400	30
Lab No.	Dry Wt.	>.5mm								
1	49	64		36	34	30	20	14	8	23
		64		2	4	7	7	6	8	3
2	48.5	58		42	40	38	25	16	14	28
		58		2	2	10	9	2	14	3
3	48	48		42	49	45	31	23	15	39
		48		3	4	6	7	8	15	8
4	49	83		17	13	11	11	8	4	11
		83		4	2	0	3	4	4	0
5	49	66		34	32	28	18	10	6	18
		66		2	4	10	8	4	6	0
6	48	60		40	45	41	29	23	17	32
		60		5	4	9	6	6	17	4
7	47.5	34		66	54	52	40	32	19	43
		34		12	2	9	17	23	19	3
8	49	74		26	26	23	20	16	14	19
		74		0	3	4	4	2	14	1
9	46.5	52		48	48	48	43	41	34	46
		52		0	0	2	2	7	34	3
10	46.5	43		57	57	51	49	45	39	51
		43		0	6	0	4	6	39	2
11	46	40		60	58	58	52	46	9	55
		40		2	0	3	6	37	9	3
12	45.5	37		63	60	58	48	26	4	49
		37		3	2	9	22	22	4	1

Hydrometer % Sand = 100 - % in 1mm reading % Silt = 1mm reading - 270mm reading % Clay = 270mm reading

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DATE: February 20, 1982

TECHNICIAN: Farah Omar

PARTICLE SIZE ANALYSIS

Hydrometer Reading Temperature Correction Correction Applied

		0.5	0.2	0.1	0.05	0.02	0.005	0.002	0.001	.01
Sieve Size:		#40	#60	.5	1	4	90	270	1400	30
Lab No.	Dry Wt.									
1	49	69		31	29	28	12	10	4	
		69		2	1	16	2	6	4	
2	48.5	59		41	39	39	16	14	4	
		59		2	0	23	2	10	4	
3	48	54		46	44	42	25	21	13	
		54		2	2	17	4	8	13	
4	49	88		12	12	12	6	6	2	
		88		0	0	6	0	4	2	
5	49	69		31	29	26	12	8	6	
		69		2	3	14	4	2	6	
6	48	56		44	42	39	23	21	15	
		56		2	3	16	2	6	15	
7	47.5	49		51	48	48	34	29	2	
		49		3	0	14	5	27	2	
8	49	78		22	22	14	14	12	4	
		78		0	3	15	2	8	4	
9	46.5	51		49	49	49	43	39	32	
		51		0	0	6	4	6	32	
10	46.5	51		49	49	49	45	43	34	
		51		0	0	4	2	9	34	
11	46	43		57	57	57	47	28	2	
		43		0	0	10	19	26	2	
12	45.5	41		59	57	55	46	7	2	
		41		2	2	16	39	5	2	

Hydrometer % Sand = 100 - % in 1mm reading % Silt = 1mm reading - 270mm reading % Clay = 270mm reading

Djibouti Water Resources
and
Soils Analysis

FINAL REPORT

Volume IV: Appendices H, I

Prepared for the Agency
For International Development
Contract No: AID/afr-C-1673

Prepared By:

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Farah Omar

February 1983

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(916) 622-8841

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VOLUME IV: THE SOILS PROJECT

This volume of the report contains several appendices pertinent to the soil project. Appendix H is a report on the Random Resource Sample and Appendix I is a report on the National Soil Survey.

LABORATOIRE D'ANALYSE DES SOLS ET DES EAUX

RÉPUBLIQUE DE DJIBOUTI

APPENDIX H

THE RANDOM RESOURCE SAMPLE

APPENDIX H

THE RANDOM RESOURCE SAMPLE

1.0 INTRODUCTION

A set of 1,000 sites, each one square kilometer, were taken at random across the country. This sample represents approximately five percent (5%) of the land area of Djibouti. It is the purpose of this sample to expedite the collection and accurate description of the natural geographically-distributed resources. It is also intended to facilitate the collection of data by various scientific investigators with diverse interests.

The sample sites are organized in one list by the order of occurrence of the numbers when they were selected (Section 2.4). This is important for further subdividing the survey for analyses. A second arrangement is based on their arrangement by UTM coordinates to facilitate locating the sites on the map (Section 3.0). It is further divided into groups related to the 1:100,000 scale topographic map. The number 'universe' for the same lists all of the UTM coordinates, wherein the designated site north and east of the coordinate intersects, lies wholly within Djibouti and on land. The list is organized from west to east followed by ordination by south to north. The first 100 samples were set aside specifically as a 1/2% coverage of the country for especially rapid assessment of the resources. Photos H-1 through H-4 indicate the types of sites sampled.

Section 4.0 of this appendix contains the descriptions of the soils of the random sample sites. It is the intent of this project to encourage other investigations to use this sampling device to facilitate the compounding of detailed information based on the same sampled areas so that they may draw extensively on each other's expertise in a specific manner. A 1:100,000 scale map of the distribution of these 1,000 sites can be viewed at the soils and water laboratory.

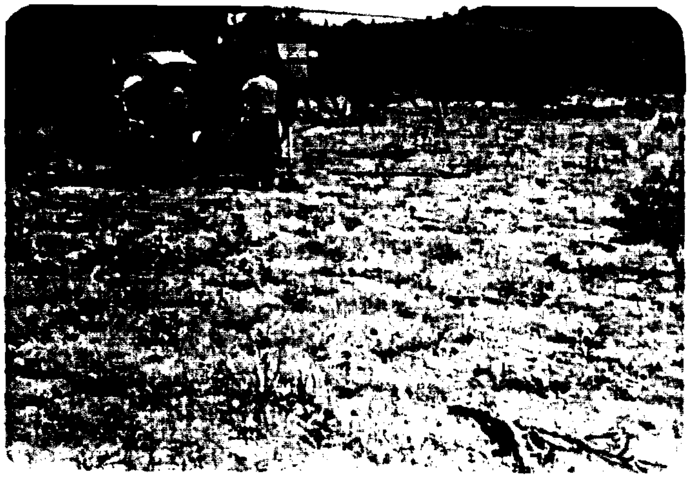

Photo H-1: Small Playa of Grand Bara soil northwest of Tadjoura

Photo H-2: Walking on Wanni Daear soil facing Oueah at a site in Gagade

Photo H-3: This is a wadi channel with a watering site with Didjan Der soil just behind the goats. Oueah soil is in the mountains.

Photo H-4: These two people are herding donkeys on the inundated Riffor Damoun soil in one of the great playas of the north.

2.0 LIST OF RANDOM NUMBERS BY ORDER OF SELECTION

1	286	1323
2	270	1387
3	264	1269
4	168	1278
5	196	1344
6	299	1370
7	304	1348
8	240	1246
9	273	1317
10	166	1221
11	247	1319
12	223	1361
13	267	1387
14	284	1369
15	228	1271
16	222	1279
17	150	1269
18	301	1273
19	251	1260
20	274	1220
21	208	1230
22	212	1348
23	165	1244
24	256	1235
25	275	1380
26	258	1265
27	222	1308
28	161	1292
29	230	1207
30	254	1346
31	206	1275
32	186	1225
33	256	1306
34	232	1373
35	190	1284
36	264	1221
37	234	1360
38	260	1304
39	226	1263
40	183	1323
41	262	1346
42	237	1324
43	209	1234
44	201	1287
45	296	1251
46	299	1393
47	273	1265
48	114	1260
49	219	1324
50	283	1340
51	316	1380
52	290	1277
53	155	1282
54	290	1400
55	211	1359
56	308	1372
57	266	1274
58	237	1251
59	159	1256
60	225	1291
61	230	1232
62	297	1387
63	293	1318
64	222	1369
65	158	1221
66	247	1234
67	274	1250
68	266	1272
69	201	1236
70	171	1246
71	272	1259
72	266	1348
73	215	1284
74	177	1236
75	241	1320
76	244	1341
77	199	1297
78	209	1260
79	270	1326
80	276	1303
81	183	1304
82	284	1391
83	226	1338
84	245	1354
85	249	1288
86	295	1218
87	220	1221
88	191	1284
89	272	1343
90	229	1307
91	182	1258
92	208	1317
93	301	1276
94	282	1393
95	267	1240
96	168	1293
97	227	1301
98	292	1380
99	307	1339
100	247	1245

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101	1849	136	464	171	1854
102	11440	137	5838	172	7022
103	14486	138	8639	173	18257
104	5723	139	17100	174	18789
105	12542	140	7990	175	9399
106	2767	141	427	176	973
107	12591	142	9701	177	13075
108	13512	143	16065	178	8041
109	4849	144	10021	179	19699
110	3699	145	7106	180	17708
111	13784	146	1327	181	8502
112	12557	147	10795	182	86
113	3239	148	15056	183	1032
114	3976	149	6227	184	9087
115	4646	150	2238	185	16657
116	15024	151	11925	186	2125
117	11618	152	14069	187	7613
118	3103	153	5351	188	809
119	5611	154	3162	189	10162
120	16315	155	13093	190	15633
121	20391	156	13103	191	16611
122	10694	152	4478	192	6731
123	2228	158	13703	193	1713
124	6596	159	4100	194	11271
125	17664	160	14306	195	14634
126	19259	161	12156	196	5854
127	9783	162	3605	197	2629
128	15650	163	5054	198	12417
129	1349	164	15567	199	13656
130	19082	165	11223	200	4979
131	7605	166	2731		
132	19077	167	6028		
133	18164	168	16882		
134	8882	169	19905		
135	4632	170	10305		

201	1045	236	10906	271	14022
202	14181	237	2430	272	12373
203	7957	238	6367	273	12680
204	19579	239	17347	274	3806
205	17795	240	19517	275	4830
206	8575	241	9992	276	15271
207	159	242	1552	277	21330
208	1921	243	7370	278	11437
209	9000	244	18745	279	2923
210	16741	245	18414	280	5801
211	1086	246	9089	281	16573
212	7686	247	669	282	20168
213	736	248	8634	283	10516
214	10073	249	8347	284	730
215	15715	250	20212	285	2057
216	15292	251	17343	286	6791
217	6803	252	8196	287	12934
218	1639	253	221	288	19044
219	11179	254	9453	289	9607
220	14714	255	16302	290	6612
221	5924	256	6720	291	1177
222	2554	257	7309	292	16259
223	12322	258	1119	293	7804
224	13735	259	10539	294	19360
225	5051	260	15287	295	17955
226	3452	261	6429	296	8708
227	13505	262	2027	297	291
228	12776	263	11661	298	3587
229	4178	264	14295	299	8843
230	4426	265	5553	300	20859
231	14734	266	2947		
232	11833	267	12820		
233	3305	268	13325		
234	5387	269	4679		
235	16012	270	3882		

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301	16897	336	7219	371	15081
302	7818	337	18532	372	11576
303	7343	338	18576	373	3063
304	602	339	9223	374	5655
305	9911	340	801	375	16375
306	15867	341	10520	376	20339
307	12948	342	8242	377	10653
308	6934	343	19988	378	2188
309	1504	344	17501	379	6642
310	11012	345	8320	380	17727
311	14862	346	87	381	19209
312	6056	347	9294	382	9742
313	2417	348	16455	383	1309
314	12149	349	4680	384	18413
315	13880	350	7441	385	7651
316	5181	351	984	386	19142
317	3343	352	10375	387	18115
318	13326	353	15437	388	8842
319	12918	354	19870	389	424
320	4308	355	6560	390	5306
321	4871	457	6560	391	8686
323	14547	358	14442	392	17053
324	11973	359	5684	393	7950
325	3435	360	8013	394	7612
326	5242	361	2809	395	468
327	15818	362	12644	396	9750
328	11044	363	13468	397	16019
329	20244	364	4810	398	10689
330	2561	365	3741	399	7066
331	6219	366	13839	400	1368
332	17144	367	12514		
333	19685	368	5362		
334	10128	369	3937		
335	1683	370	4689		

401	10845	436	17660	471	12521
402	15011	437	8462	472	19375
403	6187	438	46	473	9877
404	2280	439	546	474	1440
405	11977	440	9135	475	7499
406	14025	441	16610	476	18927
407	5312	442	2709	479	18276
408	3204	443	7573	480	8975
409	13147	444	850	481	3912
410	13060	445	10212	482	556
411	4438	446	15587	483	7021
412	11582	337	17354	484	8530
413	4142	448	6691	485	20403
414	14367	449	1755	486	17209
415	12113	450	11322	487	8083
416	3565	451	14589	488	334
417	5098	452	5814	489	9589
418	15625	453	2671	490	16172
419	21005	454	12469	491	8511
420	11182	455	13612	492	7198
421	4286	456	4940	493	1233
422	2691	457	3601	494	10680
423	6072	458	13658	495	15160
424	16943	454	12655	496	6318
425	19854	460	4067	497	1134
426	10264	461	4547	498	2143
427	1814	462	14893	499	11805
428	7068	463	11715	500	14171
429	18321	464	3194		
430	18740	465	5510		
431	9358	566	16179		
432	933	467	20510		
433	12470	468	10720		
434	8088	469	2319		
435	19766	470	6493		

501	5442	536	803	571	9109
502	3065	537	7705	572	13404
503	12970	538	715	573	689
504	13203	539	10049	574	8914
505	4569	540	15738	575	8374
506	18747	541	14934	576	20178
507	4001	542	6823	577	17367
508	14178	543	1619	578	8216
509	12253	544	11154	579	2314
510	19303	545	14737	580	201
511	3696	546	5945	581	9429
512	4954	547	2534	582	16325
513	15433	548	12296	583	6409
514	11320	549	13757	584	7329
515	2822	550	5070	585	1098
516	5925	551	3461	586	10515
517	16742	552	13478	587	15309
518	20023	553	12797	588	6449
519	10400	554	4197	589	2006
520	1946	555	4404	590	11635
521	6918	556	14705	591	14317
522	18111	557	11854	592	5573
523	18904	558	3324	593	2926
524	9492	559	5365	594	12793
525	1065	560	15983	595	13346
526	14489	561	10927	596	4699
527	7934	562	2450	597	3860
528	19546	563	6345	598	13994
529	17819	564	17317	599	12394
530	8595	565	19542	600	11547
531	3851	566	10013		
532	179	567	1572		
533	2168	568	7347		
534	8977	569	18713		
535	16765	570	18438		

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601	3826	636	12123	671	16479
602	4811	637	13902	672	4379
603	15242	638	5201	673	7461
604	11458	639	3322	674	964
605	2953	640	13299	675	10351
606	5779	641	12939	676	15459
607	16543	642	4328	677	19485
608	20193	643	5853	678	6580
609	10537	644	4263	679	1870
610	2077	645	14519	680	11465
611	6768	646	11994	681	14464
612	17902	647	3455	682	5703
613	19069	648	5220	683	10245
614	9627	649	15789	684	2788
615	1197	651	17739	685	12618
616	16579	652	2580	686	13490
617	7781	653	6197	687	4829
618	19327	654	17114	688	3720
619	17979	655	19710	689	13812
620	8728	656	10148	690	12535
621	311	657	1703	691	4303
622	3842	658	7196	692	3956
623	8819	659	18500	693	4668
624	16920	660	18601	694	15053
625	7838	661	9244	695	11597
626	581	662	16704	696	3083
627	9887	663	821	697	5633
628	15890	665	8219	698	16345
629	6954	666	19954	699	20364
631	1483	667	17525	700	10673
632	10987	668	8348		
633	14885	669	67		
634	6076	670	9270		
635	2396				

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701	2208	736	14334	771	1734
702	6619	737	12134	772	11297
703	17696	738	3585	773	14611
704	19234	739	5076	774	5834
705	9762	740	15596	775	2650
706	1328	741	11202	776	12443
707	18744	742	2019	777	13634
708	7628	743	2711	778	4960
709	19110	744	6050	779	3580
710	18139	745	16912	780	13631
711	8862	746	19879	781	12677
712	444	747	10284	782	4087
713	5569	748	1834	783	4525
714	8662	749	7045	784	14865
715	17076	750	18289	785	11736
716	7970	751	18764	786	3213
717	448	752	9378	787	5488
718	9725	753	953	788	16149
719	16042	754	12770	789	20536
720	10356	755	8065	790	10810
721	7086	756	19733	791	2338
722	1348	757	17683	792	6471
723	10820	758	8482	793	17490
724	15033	759	6097	794	19401
725	6207	760	66	795	9897
726	2259	761	787	796	1460
727	11951	762	9111	797	7476
728	14047	763	16633	798	18894
729	5331	764	2418	799	18301
730	3183	765	7593	800	8996
731	13120	766	829		
732	13082	767	10187		
733	4458	768	15619		
734	12630	769	16984		
735	4121	770	6711		

801	576	836	5903	871	5090
802	7353	837	16712	872	3440
803	8506	838	20049	873	13451
804	20369	839	10421	874	12818
805	17233	840	19801	875	4217
806	8103	841	1965	876	427
807	314	842	6895	877	4383
808	9565	843	18079	878	14677
809	16195	844	18928	879	11875
810	8190	845	9513	880	3344
811	7217	846	1085	881	5343
812	2206	847	14799	882	15954
813	1213	848	7911	883	10948
814	10655	849	19513	884	2469
815	15182	850	12843	885	6323
816	6338	851	8615	886	17286
817	4938	852	199	887	19568
818	2122	853	2417	888	10033
819	11780	854	8953	889	1591
820	14193	855	16788	890	7324
821	5462	856	522	891	18680
822	3044	857	7725	892	18463
823	12943	858	18851	893	9130
824	13225	859	695	894	709
825	4588	860	10024	895	9195
826	19868	861	15761	896	8351
827	3980	862	14577	897	20144
828	14150	863	6843	898	17391
829	12275	864	1598	899	8236
830	18101	865	11129	900	181
831	3715	866	14759		
832	4932	867	5965		
833	15404	868	2513		
834	11341	869	12270		
835	2842	870	13779		

901	9405	936	16900	971	20883
902	16348	937	7758	972	11085
903	6099	938	19294	973	15272
904	7349	939	18003	974	2600
905	1078	940	8748	975	6125
906	10490	941	331	976	17083
907	15332	942	4098	977	19736
908	6469	943	8796	978	10169
909	1986	944	16944	979	1723
910	11609	945	7858	980	7173
911	14339	946	7776	981	18468
912	5592	947	561	982	18625
913	2906	948	9863	983	9264
914	12767	949	15913	984	841
915	13368	950	12259	985	11100
916	4718	951	6974	986	8196
917	3839	952	1463	987	19921
918	13967	953	10962	988	17549
919	12415	954	14907	989	8368
920	10425	955	6095	990	9246
921	3846	956	2376	991	16502
922	4789	957	12097	992	4080
923	15214	958	13924	993	7481
924	11479	959	5220	994	279
925	2972	960	3301	995	944
926	5757	961	13272	996	10326
927	16513	962	12961	997	15482
928	20219	963	4347	998	47
929	10557	964	6845	999	19102
930	2096	965	4241	1000	6600
931	6746	966	14491		
932	17871	967	12015		
933	19093	968	3474		
934	9647	969	5198		
935	1217	970	15760		

3.0 RANDOM SAMPLE LIST OF NUMBERS BY UTM COORDINATES

EALI SABIEH

175	228 1227	445	245 1267	632	261 1234
901	228 1233	683	246 1256	985	261 1247
581	228 1257	426	247 1230	310	261 1259
15	228 1271	66	247 1234	328	262 1233
254	229 1230	100	147 1245	650	262 1254
524	229 1269	747	247 1250	865	263 1260
61	230 1232	170	248 1226	36	264 1221
845	230 1240	996	248 1247	544	264 1226
29	230 1270	675	248 1272	219	264 1251
808	231 1242	720	249 1227	420	264 1254
489	231 1256	352	249 1246	3	264 1269
289	232 1230	519	249 1271	741	265 1215
614	232 1258	839	250 1242	194	265 1225
934	233 1226	920	250 1246	165	265 1236
142	234 1231	19	251 1260	772	266 1241
718	234 1255	906	251 1261	514	267 1214
382	235 1225	586	252 1237	450	267 1216
396	235 1233	283	252 1238	834	267 1235
705	236 1237	341	252 1242	95	267 1240
127	236 1258	929	253 1230	278	268 1272
58	237 1251	377	255 1230	102	269 1215
948	237 1254	814	255 1232	604	269 1233
473	237 1268	700	255 1250	680	269 1240
795	238 1244	494	255 1257	924	269 1254
305	238 1258	398	255 1266	457	269 1267
627	239 1234	122	255 1271	600	270 1264
241	240 1254	24	256 1235	372	271 1234
566	241 1234	468	256 1247	695	271 1255
144	241 1241	259	256 1261	910	271 1265
860	241 1245	147	257 1270	117	272 1218
183	241 1248	664	258 1230	590	272 1235
888	241 1254	790	258 1231	71	272 1259
639	242 1230	723	258 1241	463	273 1257
214	242 1264	26	258 1265	47	273 1265
334	243 1268	401	258 1266	20	274 1220
656	244 1246	236	259 1269	785	274 1221
189	244 1260	561	260 1232	67	274 1250
978	264 1267	883	260 1243	819	274 1265
767	245 1242	953	260 1267	499	275 1233

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<u>**EALI SABIEH**</u>

232	275	1261
557	276	1225
879	276	1246
263	276	1261
151	277	1240
727	277	1266
324	278	1233
405	278	1237
646	278	1254
967	179	1222
737	279	1241
957	280	1253
415	280	1269
636	281	1230
314	281	1256
161	281	1263
8	240	1246

EASAL

312	173	1308	606	188	1321	355	201	1326
679	173	1309	998	189	1276	678	203	1291
262	174	1279	280	189	1287	124	203	1307
163	174	1283	452	189	1300	1000	203	1311
550	174	1299	774	189	1320	290	203	1323
739	174	1305	137	189	1324	702	204	1275
871	175	1276	643	190	1283	379	204	1298
417	175	1284	35	190	1284	212	204	1309
316	177	1281	836	191	1277	131	205	1273
234	177	1283	88	191	1284	448	205	1292
959	177	1298	516	191	1294	770	205	1312
969	178	1277	221	191	1299	256	205	1321
638	178	1280	546	191	1319	31	206	1275
648	178	1299	867	192	1283	192	206	1277
326	179	1273	167	193	1290	931	206	1292
390	180	1285	744	193	1312	611	206	1314
407	180	1290	423	194	1278	286	207	1282
729	180	1311	634	194	1282	217	207	1294
881	180	1323	955	194	1301	542	207	1314
153	181	1279	759	194	1303	863	208	1279
368	181	1290	903	194	1305	964	208	1281
559	181	1293	975	195	1276	92	208	1317
501	182	1277	403	196	1283	842	209	1276
77	181	1297	880	196	1288	308	109	1315
821	183	1283	653	196	1293	630	210	1280
81	183	1304	725	196	1303	951	210	1290
787	183	1309	331	196	1315	145	211	1277
40	183	1323	149	196	1324	483	211	1292
465	184	1276	496	198	1304	749	211	1316
265	184	1319	885	198	1312	399	212	1282
713	185	1279	816	198	1324	428	212	1284
592	185	1283	563	199	1276	721	212	1292
912	185	1302	238	199	1297	980	214	1279
119	185	1321	583	200	1285	658	214	1303
697	186	1287	261	200	1305	492	214	1305
374	186	1309	588	200	1325	811	214	1324
359	187	1282	44	201	1287	172	215	1274
682	187	1301	792	201	1292	73	215	1284
926	188	1299	470	201	1311	257	216	1320

EASAL

890	217	1280
584	217	1295
303	217	1310
568	217	1311
904	217	1316
802	217	1319
243	218	1281
49	219	1324
673	220	1284
797	220	1303
443	222	1275
16	222	1279
602	222	1283
687	222	1291
765	222	1306
27	222	1308
394	222	1315
187	222	1316
708	223	1276
385	223	1299
537	224	1298
104	224	1316
857	224	1318
60	225	1291
937	225	1296
946	225	1314
617	225	1319
293	226	1287
302	226	1301
625	226	1321
945	227	1286
97	227	1301

GAMMARI

493	151	1276
53	155	1282
146	156	1286
706	156	1287
722	157	1282
129	157	1283
400	158	1277
952	160	1291
796	161	1289
28	161	1292
631	162	1284
309	163	1273
247	163	1280
242	164	1289
889	165	1295
864	165	1302
543	166	1290
4	168	1278
335	168	1287
96	168	1293
657	168	1307
193	169	1282
979	169	1292
771	169	1303
585	170	1274
449	170	1288
427	171	1310
748	172	1292
101	172	1307
171	172	1312
356	173	1310
474	160	1296

490

DOUMERA

972	264	1384
475	267	1385
13	267	1387
121	268	1389
2	270	1387
743	271	1390
169	272	1388
318	273	1387
300	275	1383
666	275	1387
609	276	1384
534	276	1390
971	277	1395
155	279	1397
339	280	1397
210	282	1385
94	282	1393
222	282	1396
82	284	1391
112	285	1399
412	286	1387
419	286	1392
982	288	1396
198	289	1395
350	290	1393
315	290	1395
54	290	1400
378	290	1401
134	291	1389
733	291	1400
621	295	1387
62	297	1387
260	298	1395
46	299	1393
294	301	1388
225	302	1394
277	304	1389
624	304	1391

491

ABE BAD

17	150	1269
438	151	1265
760	152	1250
669	152	1251
82	152	1270
346	152	1272
207	154	1260
532	155	1220
900	155	1222
852	155	1255
580	155	1257
253	156	1217
297	157	1247
65	158	1221
941	158	1226
488	158	1229
59	159	1256
389	159	1271
141	160	1213
712	160	1230
717	160	1234
136	160	1255
395	160	1259
876	160	1263
856	161	1255
439	162	1218
482	162	1228
947	162	1233
801	162	1248
626	162	1253
304	163	1213
573	164	1241
859	164	1245
894	164	1259
538	164	1265
284	165	1219
213	165	1225
23	165	1244
761	166	1214

10	166	1221
536	166	1230
188	166	1236
766	166	1256
663	166	1258
984	166	1268
444	167	1213
340	167	1266
432	168	1235
995	168	1246
753	168	1255
674	168	1266
176	169	1212
351	169	1223
201	170	1221
525	170	1241
905	170	1254
846	170	1261
211	170	1262
258	171	1232
70	171	1246
497	171	1247
291	172	1227
615	172	1247
813	172	1263
935	172	1267

492

DADDAETO

591	228	1333
736	228	1350
829	229	1329
414	229	1339
358	230	1359
681	230	1381
103	231	1348
966	231	1353
526	231	1361
645	231	1381
323	232	1354
34	232	1373
862	233	1330
451	233	1342
773	233	1364
37	234	1334
195	234	1360
878	234	1377
556	235	1353
220	235	1362
231	236	1331
545	236	1333
866	236	1355
633	237	1330
847	237	1344
311	238	1357
784	238	1360
462	239	1341
954	239	1355
541	240	1334
402	241	1362
116	242	1330
724	242	1339
148	242	1362
567	243	1334
371	243	1343
76	244	1341
495	245	1335
84	245	1354
815	245	1357
603	246	1335
923	246	1347
276	247	1362
973	247	1363
694	248	1331
216	248	1342
587	248	1359
907	249	1342
833	251	1334
513	251	1363
676	252	1348
997	253	1329
30	254	1346
164	255	1330
740	255	1359
768	256	1340
418	256	1346
190	256	1354
128	257	1328
215	258	1339
540	258	1372
970	259	1349
861	259	1350
649	260	1334
327	260	1361
306	261	1364
628	262	1338
41	262	1346
949	262	1360
882	263	1351
560	263	1382
235	264	1366
397	264	1373
218	265	1338
719	265	1341
143	265	1364
366	266	1328
72	266	1348
490	267	1361
466	267	1368
788	268	1328
809	268	1329
292	269	1338
255	269	1381
120	270	1339
698	270	1369
902	270	1372
375	271	1342
89	272	1343
348	272	1369
908	273	1328
671	273	1338
991	273	1361
927	273	1372
281	274	1377
616	275	1328
441	275	1359
191	275	1360
25	275	1380
763	275	1382
185	276	1351
662	277	1343
837	277	1351
517	277	1381
535	278	1349
855	278	1372
168	280	1356
301	280	1371
936	280	1374
745	281	1331
521	281	1337
424	281	1362
944	281	1363
892	282	1335
981	282	1340
769	282	1348
659	282	1372

Dikhil

208	173	1236	197	184	1269	61	201	1236
520	173	1261	775	185	1232	298	201	1238
841	174	1217	453	185	1253	457	201	1250
909	174	1238	422	186	1215	162	201	1254
589	174	1258	166	186	1255	511	203	1232
48	174	1260	106	187	1234	110	203	1235
742	174	1271	684	187	1255	986	203	1248
838	175	1238	361	188	1219	831	203	1251
285	175	1246	515	188	1232	688	203	1256
610	175	1266	835	188	1252	365	204	1220
930	176	1222	913	189	1258	665	204	1242
186	176	1251	593	190	1221	274	205	1227
498	176	1269	279	190	1228	601	205	1249
533	177	1229	266	190	1242	917	205	1262
74	177	1236	605	190	1248	622	205	1265
812	177	1269	925	190	1267	921	205	1269
701	177	1271	822	192	1223	531	206	1218
818	178	1222	373	192	1242	597	206	1227
123	178	1228	502	192	1244	270	206	1249
150	178	1238	696	192	1262	481	207	1223
726	178	1259	118	193	1224	369	207	1248
872	178	1266	154	194	1224	692	207	1267
404	179	1217	730	194	1245	21	208	1230
579	179	1251	464	194	1256	114	208	1231
469	179	1256	408	194	1266	827	208	1235
791	180	1215	786	195	1216	507	208	1256
313	180	1233	113	195	1242	43	209	1234
635	181	1213	317	196	1241	78	209	1260
764	181	1225	960	196	1245	460	209	1267
956	181	1233	233	196	1249	992	210	1225
853	181	1234	639	196	1266	782	210	1232
237	181	1247	558	196	1268	942	210	1233
562	181	1267	325	198	1261	159	210	1245
884	182	1227	968	199	1214	735	210	1266
91	182	1258	226	199	1219	413	211	1229
868	182	1271	647	199	1222	230	211	1231
547	183	1233	551	199	1228	229	211	1267
330	183	1260	738	200	1235	554	212	1230
652	184	1220	416	201	1216	875	212	1250
974	184	1240	779	201	1231	965	213	1218

<u>DIKHIL</u>

644	213	1240
322	213	1261
421	213	1263
691	214	1224
320	214	1225
642	214	1249
963	214	1268
672	215	1243
877	215	1247
555	215	1268
411	216	1245
157	217	1228
783	218	1218
461	218	1240
505	218	1262
825	219	1225
135	219	1269
87	220	1221
115	220	1227
693	220	1249
269	220	1260
349	220	1261
370	220	1270
596	221	1225
916	221	1246
993	222	1253
922	222	1261
364	223	1228
275	223	1250
109	223	1267
321	224	1236
196	225	1232
832	225	1245
817	225	1251
456	225	1253
512	225	1267
778	226	1222
200	226	1241
39	226	1263
431	227	1237
752	227	1257
32	186	1225
442	186	1233

<u>KHOR ANGAR</u>

50	283	1340	528	301	1363
337	283	1349	565	301	1369
338	284	1338	887	302	1340
660	284	1363	204	302	1361
14	284	1369	425	303	1371
982	285	1332	435	304	1328
891	286	1332	333	304	1347
430	287	1337	7	304	1348
707	287	1341	179	304	1361
244	287	1342	655	304	1372
506	287	1344	756	305	1340
751	287	1361	977	305	1343
174	288	1331	99	307	1339
858	289	1338	826	307	1360
798	289	1381	354	307	1367
523	290	1336	746	307	1376
577	290	1343	56	308	1372
844	290	1350	343	309	1375
478	290	1359	518	310	1355
999	291	1379	897	312	1366
988	292	1366	709	312	1371
613	293	1336	282	313	1335
132	293	1344	576	313	1345
130	293	1350	608	313	1360
933	293	1360	250	313	1379
98	293	1380	928	314	1331
386	294	1354	329	314	1356
381	295	1368	332	315	1353
704	296	1336	699	316	1371
126	296	1361	804	316	1376
938	297	1341	51	316	1379
510	297	1350	485	317	1358
618	297	1374	467	319	1370
472	298	1367	789	320	1352
794	299	1338	446	326	1350
6	299	1370			
677	300	1367			
849	301	1340			
240	301	1344			

TADJOURA

509	229	1297
90	229	1307
950	229	1313
869	229	1314
548	230	1292
223	230	1318
272	231	1323
599	232	1298
919	232	1319
776	233	1301
454	233	1327
433	234	1282
367	234	1326
690	235	1299
105	235	1314
107	236	1307
629	236	1319
685	237	1286
734	237	1298
362	237	1312
454	237	1323
42	237	1324
781	238	1297
273	238	1300
594	239	1320
914	240	1291
754	240	1294
228	240	1300
553	240	1321
874	241	1295
267	241	1297
75	241	1320
319	243	1299
641	243	1320
823	243	1324
307	244	1280
962	244	1293
503	244	1312
383	245	1291
410	246	1292
177	246	1307
732	246	1314
156	247	1285
731	247	1302
11	247	1319
409	248	1274
85	249	1288
504	249	1295
824	249	1317
961	250	1321
640	251	1305
268	252	1276
595	252	1310
353	252	1326
915	253	1277
572	253	1327
873	255	1296
363	255	1314
552	255	1323
33	256	1306
686	256	1327
227	257	1307
108	257	1314
38	260	1304
455	260	1309
780	261	1273
777	261	1276
199	261	1317
458	261	1319
158	263	1273
224	263	1325
549	264	1313
870	265	1280
111	265	1306
68	266	1272
57	266	1274
689	266	1279
637	268	1326
958	269	1316
918	270	1324
79	270	1326
598	271	1317
271	272	1310
406	272	1313
728	273	1279
9	273	1317
152	273	1322
607	274	1309
828	276	1275
80	276	1303
500	276	1317
508	276	1324
202	276	1327
820	278	1306
264	281	1312
205	282	1313
160	282	1322

DJIBOUTI

529	283	1280
850	283	1327
932	284	1321
612	285	1318
287	286	1316
1	286	1323
295	287	1280
619	287	1327
564	288	1276
939	288	1318
447	289	1256
52	290	1277
843	291	1274
830	291	1322
522	292	1276
387	292	1280
710	293	1275
63	293	1318
133	294	1272
86	295	1278
173	297	1323
479	298	1285
799	299	1283
429	300	1280
757	301	1272
18	301	1273
93	301	1276
384	310	1324
245	310	1325
570	315	1327

498

LOYADA

392	282	1259
715	283	1235
976	283	1242
139	283	1259
654	284	1228
486	286	1237
805	286	1261
569	286	1265
886	288	1235
251	289	1255
447	289	1256
239	289	1259
898	290	1267
793	293	1269
344	294	1251
171	294	1271
667	295	1247
988	295	1271
45	296	1251
750	299	1271
436	300	1267
125	300	1271
703	302	1268
180	303	1265
380	304	1271
651	305	1271
987	306	1263

DORRA

848	188	1329	376	216	1346
527	191	1329	714	215	1372
393	192	1333	391	216	1349
203	192	1340	296	216	1371
716	191	1339	943	217	1344
140	195	1328	206	218	1339
360	196	1334	623	219	1331
5	196	1344	388	219	1354
178	197	1342	299	219	1355
668	198	1328	711	219	1374
755	198	1345	574	220	1374
487	199	1340	854	221	1360
434	199	1345	480	222	1328
252	203	1348	800	222	1349
578	204	1339	209	222	1353
899	205	1329	64	222	1360
342	205	1358	571	222	1362
810	206	1342	12	223	1361
840	206	1359	184	224	1329
345	207	1350	246	224	1331
249	208	1342	762	224	1353
896	208	1348	893	224	1372
989	209	1331	440	224	1377
575	209	1337	895	225	1380
758	211	1328	83	226	1338
55	211	1359	661	226	1352
181	212	1346	990	226	1374
22	212	1348	983	227	1336
803	212	1350	670	227	1342
491	212	1355	347	227	1364
437	212	1363	911	228	1355
484	213	1331			
530	213	1352			
336	214	1328			
851	214	1371			
248	215	1342			
138	215	1349			
620	217	1342			
940	217	1362			

500

AADA

Site No. 100

Location: 247.8 E
1245.2N

0-15 cm: A horizon; brown 10YR/5/3 (dry) texture sand; brown 7.5YR/4/4 (wet) structure: loose mildly effervescent; pH 7.5-8, abrupt boundary, sorted and stratified aeolian dune layers of 1-3 mm. Different percent material from underlying soil.

15-40+ cm: Bb horizon; dark brown 7.5/YR3/4 (dry) silt loam; dark brown 7.5YR/3/4 moderate large breaking medium subangular blocky structure; 15% fine gravels. Silty loam; 10YR/4/4 (wet) very friable, strong effervescent; few fine pores.

Comment: sandy dunes of 1-4 m profile between dunes shrubs and grass 5-10% vegetation cover of 30-50 cm high; 0.5% slope (smooth) location on the rim of the basin of Grand Bara (1 to 2 kms wide) at about 25 m of the East and 75 m SE corner of the Garden.

Classification: coarse loamy, mixed, hyperthermic typic Camborthid

14/12/81 A.D./F.O./J.G.

ADOYLA

Site No. 11

Location: 247.5 E
1319.8 N

0-10 cm: A horizon; 10YR/4/2 dark grayish brown (dry), 10YR/3/2 very dark grayish brown (moist); sandy loam; weak medium to fine subangular blocky structure; loose, friable, slightly sticky; strongly effervescent; few fine woody roots; clear and wavy boundary;

10-50+ cm: C horizon; 10YR/4/2 dark grayish brown (dry), 10YR/2/1 black (moist); gravelly sandy loam; Weakly stratified; loose, friable, slightly sticky; strongly effervescent; common woody roots;

Surface: 20% cobbles and 75% fine gravel

Inclusions: DIDJAN DER

Position: Terrace (in alluvium)

Parent Material: mixed alluvium

Vegetation: 25% cover (acacia tortilis 2-3 m, bush)

Erosion: occasional flooding

Temperature: 27.9 °C

Classification: coarse loamy mixed hyperthermic Typic Torrifluvent

502

26/5/81 A.D./J.G./F.O.

AFEASIN GAFAN

Site No. 44

Location: 193.1 E
1268.2N

Slope: Slope about 100%

Inclusions: 20% rock outcrop

Vegetation: 1% vegetation cover (wanait, draif, magal xid)

Comment: Talus slope about 75% full of sand and gravel in the interstices

Dominately boulders and stones

AFMEEAYTOU

Site No. 48

Location: 174.6 E
1260.7N

0-20 cm: A horizon; 10YR/4/3 (brown) dry, 10YR/3/3 (dark brown) moist; gravelly sand; 35% 3-20 cm stones; structure: none; loose, very friable, nonsticky; common fine fibrous roots; strongly effervescent; clear and wavy boundary;

20-35 cm: Bca horizon; 10YR/4/6 (strong brown) dry, 7.5YR/4/6 (strong brown) moist; gravelly sand; structure: none; loose, very friable, nonsticky; strong effervescent; $CaCO_3$ on all parts of the gravel; common fine fibrous roots; irregular and diffused boundary;

35-60 cm: C horizon; 7.5YR/4/4 (dark brown) dry, 5YR/3/3 (dark reddish brown) moist; Gravely sand; 30% fine gravel; structure: none; loose, very friable, nonsticky; strongly effervescent,

Slope: Slopes from 15-25%

Parent Material: 10-15% lava outcrop

Vegetation: 2% vegetation cover (different species of grass)

Comment: 80% soil covered with stones and boulders of 1-1.5m high

On alluvial slope

Classification: sandy mixed hyperthermic Typic Calciorthid

8/12/81 A.D/J.G./F.O.

AFNABA DABA

Site No. 82

Location: 289.7 E
1391.0 N

0-10 cm: C horizon; 7.5YR/5/4 brown (dry), 7.5YR/3/4 dark brown (moist); gravelly sandy loam; structure: none; loose, very friable, nonsticky; strongly effervescent.

Surface: 10% cobbles and 90% gravel

Inclusions: 50% rock outcrop

Slope: 18%

Similar Soil: Damerkaddae

Position: talus slope

Parent Material: metamorphised rhyolite

Vegetation: barren

Classification: loamy skeletel (shallow) mixed hyperthermic Typic Torriorthent.

14/12/81 J.G./A.D./F.O.

ALAYSIM

Site No. 12

Location: 223.7 E
1361.N

Land Type: Lava flow

Slope: Barren - Slope: 0 to 10%

Parent Material: Volcanic bounder bombs 50 to 150 cm on lava flow

Comment: On extensive land type;

The boulders are stacked deep and there is little loess between.

506

10/3/82 A.D./J.G.

AL KIBO

Site No. 49

Location: 219.7E
1320.7 N
Elevation: 450 m

0-25 cm: Cca horizon; 10YR/6/3 pale brown (dry), 10YR/4/3 brown (moist); very stony clay loam; 40% stones and cobbles, 15% gravel; structureless; loose, friable sticky; strongly effervescent; thick $CaCO_3$ coatings on rocks and fine disseminated $CaCO_3$; clear irregular boundary;

25=35 cm: I A horizon; 7.5YR/4/4 brown (dry), 7.5YR/3/4 dark brown (moist); sandy loam; structureless; loose, friable, slightly sticky; strongly effervescent; clear wavy boundary;

35-80+ cm: II Cca horizon; 10YR/6/4 light yellowish brown (dry); 10YR/4/4 dark yellowish brown (moist); loam; no structure; firm friable, slightly sticky; 5% incrusted 1-5 mm $CaCO_3$, and soft powdery disseminated $CaCO_3$; strongly effervescent.

Surface: 60% stones and boulders, 45% gravel and cobbles

Inclusions: 10% rock outcrops, 40% lithic variant

Slope: 1-3%

Position: plateau

Parent Material: igneous lava rocks and eolian buried soil

Erosion: moderate water erosion

Temperature: 35.6 ^{o}C

Classification: coarse loamy, mixed, hyperthermic Typic Calciorthid

10/3/82 A.D./J.G.

ALI KOMA

Site No. 27

Location: 222.9 E
1308.6 N

0-15 cm: A horizon; 10YR/5/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); clay; strong medium angular and subangular blocky structure; very firm, friable, sticky; common fine woody roots; strongly effervescent, clear wavy boundary,

15-100+ cm: B horizon; 10YR/3/3 dark brown (dry and moist); clay; strong coarse to medium angular and subangular blocky structure; very hard, friable sticky; strongly effervescent; few fine roots; 1% 1-5 mm hard pitted $CaCO_3$ concretions in upper 40 cms.

Surface: 1% stones, 1-3% cracks to 10 mm wide filled in (not vertic)

Inclusions: Sandy waterways

Slope: 1%

Position: Playa on lava

Parent Material: Alluvium

Vegetation: Kulan 1-3 meters. 5% few acacia on waterways

Erosion: none - floods 1-3 times 1 year

Temperature: 28.5 °C

Classification: fine loamy mixed hyperthermic Typic Camborthid

27/5/81 A.D./F.O./J.G.

ANDAD HADDA

Site No. 31

Location: 206.8 E
1275.1 N

0-30 cm: A horizon; 5YR/3/3 dark reddish brown (moist); silt loam; weak medium to fine angular blocky structure; loose, very friable, nonsticky; trace of NaCl; gradual and diffused boundary;

30-100 cm: B horizon; 7.5YR/3/4 dark brown (moist); clay loam; weak medium to fine subangular blocky structure; loose, friable, slightly sticky; 1-2% cristals of gypsum

Surface: Bare, flat, crusty on the surface

Classification: fine loamy, mixed, hyperthermic, Typic Camborthid,

Comment: Near Sueda fruticosa and "palmier doum"

26/5/81 A.D./F.O./J.G.

ARDIKOBA

Site No. 88

Location: 191.9 E
1284.8 N

Land type: Talus

Inclusions: Rock outcrop about 70%

Slope: Talus slope about 30%

Vegetation: Rare acacia

1/3/82 A.D./J.G.

ARRAHA OMMANE

Site No. 71

Location: 272.4 E
1256.3 N

0-5 cm: A horizon; 10YR/4/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); gravelly sand; weak medium to fine subangular blocky structure; firm, friable, nonsticky; strongly effervescent; 20 to 25% 2 to 20 mm gravel; few fine fibrous roots; $CaCO_3$ coatings on stones; clear and irregular boundary;

5-30 cm: B horizon; 7.5YR/3/4 dark brown (dry), 7.5YR/3/2 dark brown (moist); very gravelly loam; structureless; loose, friable, slightly sticky; strongly effervescent; thick $CaCO_3$ coatings on rock fragments; 60% stones, cobbles and gravel; common medium woody roots; abrupt irregular boundary,

30+ cm: Unfractured rock,

Surface: 90% gravel and stones

Inclusions: 5 to 10% outcroip -- 10-20% thicker soil at foot slopes -- 10% wadi channels

Slope: 13% (10-20%)

Position: side slope

Parent Material: rhyolite colluvium on rhyolite mountain

Vegetation: 5% grass 3 to 6 cm, 5% herbs 10 to 30 cm and 2 to 3% 1 m acacia

Erosion: Severe water

Temperature: 26.6 ^{o}C

Classification: loamy skelital Mixed Hyperthermic Lithic Camborthid

ARTA

Site No. 57

Location: 267.1 E
1274.9 N

0-15 cm: A11 horizon; dark yellowish brown 7.5YR/3/4 (Moist); clay loam (very gravelly), very fine and weak granular structure; soft and friable. pH=7.3 (pH meter); strongly effervescent many fine roots; thin film of $CaCO_3$ on the rock fragments, it is covered with 75% of cobbles, stones and boulders of 10 to 75 cm; clear and smooth boundary.

15-40 cm: A12 horizon; dark yellowish brown 7.5YR/3/4 (Moist); very gravelly silt loam; weak medium subangular blocky breaking to weak fine granular structure; pH=7.3 (pH meter); strongly effervescent; common fine roots; 60% coarse gravels; soft friable soft fine dissimulated powdery $CaCO_3$; gradual and wavy boundary.

40-70 cm: ACca horizon; yellowish brown 7.5YR/5/4 very gravelly clay loam texture; weak fine granular structure; 60% gravels; pH=7.1; strongly effervescent; gradual, diffused and irregular bounary;

70-200+ cm: C horizon; dark yellowish brown 7.5YR/3/4; volcanic lava fractures; coarse gravels; many films of $CaCO_3$ on the gravels; mildly effervescent.

Inclusions: These soils occur on slopes of 25-50% which represent about 35% of the area. 10% of the area are occupied by the tops of the mountains with thin soils, 10% with rock outcrop, 20% with slope shoulders, 20% with steep valley slopes. with thin soils, 10% with vegetation cover (sogsog dominant, guud rare, kulan 1% dhidin...)

Parent Material: steep mountains, 50 to 70% cover of large volcanic bombs.

Comment: Location: 5 to 7 m from the road to Arta on the west side and at 3 km from the junction of the roads to Arta and Queah.

Classification: loamy skeletal mixed hyperthermic Aridic Typic Torriorthent

512

17/11/80 A.D./J.G./F.O.

ATAR

Site No. 18

Location: 301.6 E
1274.3 N

0.10 cm: A horizon; brown 7.5YR/5/4 (dry), dark brown 7.5YR/3/4 (wet); sand loam; structure: loose; consistence: loose (dry); pH=7.5-8; wind deposited sand, no relationship with the sub-soil; abrupt contact.

10-110 cm: B horizon; strong brown 7.5YR/4/6 (dry), and dark brown 7.5YR/3/4 (wet); silt loam; moderate large angular blocky breaking to moderate medium and fine angular blocky structure; firm (dry) and friable (moist); 50% of 5-25 mm 10YR/8/1 carbonates; many pressure faces (sand on faces of large fine vertical cracks; few fine and medium roots; pH=8.5; gradual and smooth boundary.

110-130+ cm: strong brown 7.5YR/4/6 (dry), dark brown 7.5YR/3/4 (wet); silt loam texture; weak medium subangular block structure; 5% 5 to 10 mm of $CaCO_3$; pH 8.5.

Inclusions: few 20 cm sand dunes

Slope: flat area; near the sea;

Vegetation: 20% vegetation cover (90% acacia and 10% kulan)

Comment: 1 km NE of Damerjog at the junction of the roads to Loyada and irrigation water line to Atar.

Classification: fine loamy mixed hyperthemic Typic Calciorthid.

9/12/81 J.G./A.D./F.O.

AWDIEA

Site No. 56

Location: 308.7 E
1372.1 N

0-50 cm: Cca horizon; 10YR/6/2 light brownish gray (dry), 10YR/5/2 grayish brown (moist); gravelly sandy loam; weak medium to fine subangular blocky; firm, friable, slightly sticky; strongly effervescent; moderate CaCO3 coating on the gravel and 15% fine diseminated of CaCO3 and secondary pitted and indurated CaCO3.

Surface: 60% basaltic cobbles and boulders and 90% gravel

Inclusions: 20% rock outcrop, 20% talus slope (thinner soil) = lithic variant.

Slope: 16%

Vegetation: 2% herbs

Erosion: gully erosion

Temperature: 31.5 ^{o}C

Classification: coarse loamy mixed hyperthermic Typic Calciorthid

BALAMBAL

Site No. 19

Location: 251 E
1260 N

15-0 cm: volcanic bombs of 5 to 30 cm covering 75% of the area,

0-2 cm: A horizon; 5YR/4/6 yellowish red (dry); 5YR/3/4 dark reddish brown (wet); stony clay loam; moderate, medium and fine subangular blocky structure; friable (dry and moist); common pores (1-2 mm); thin discontinous CACO3 layer on rocks below the soil surface; strongly effervescent, fine disseminated CaCO3; pH 7.5; abrupt boundary;

2-35 cm: B horizon; 5YR/4/6 yellowish red (dry), 5YR/3/4 dark reddish brown (wet); stony clay loam; firm, friable, nonsticky; strong medium and large subangular blocky structure; strongly effervescent, finely disseminated CaCO3; pH 7.5; few coarse woody trees roots; clear and wavy boundary;

35-45+ cm: Cca horizon; many continuous white CaCO3 coatings on gravel uncemented; loose.

Slope: slope of 2 to 3%

Position: on a plateau, flat top

Vegetation: 2 to 3% cover; "bilcin", "ibateys"

Classification: fine loamy mixed hyperthermic Typic Calciorthid

14/12/81 J.G./A.D./F.O.

BOULLAEALI

Site No. 42

Location: 237.7 E
1324.4 N

0-7 cm: A horizon; 10YR/5/4 yellowish brown (dry), 10YR/3/4 dark yellowish brown (moist); gravelly loam; about 25% gravel; moderate medium subangular blocky structure; slightly firm, very friable, nonsticky; many 1 mm pores; few fine fibrous roots; indurated $CaCO_3$ coating on pebbles; strongly effervescent; clear irregular boundary;

7-40 cm: Bca horizon; 10YR/4/3 dark brown (dry), 10YR/3/3 dark brown (moist); gravelly loam; moderate medium and fine subangular blocky structure; slightly firm, very friable, nonsticky; 30% pitted and indurated 1 to 5 mm $CaCO_3$ concretions and fine disseminated soft powdery $CaCO_3$; few fine fibrous roots; strongly effervescent; clear wavy,

40-50 cm: Cca horizon; 10YR/6/2 light brownish gray (dry), 10YR/4/3 dark brown (moist); loam; weak medium subangular blocky; 20% 1 to 5 mm pitted indurated secondary $CaCO_3$ and soft powdery disseminated $CaCO_3$; 20% cobbles and gravel; strongly effervescent.

Surface: 95% cobbles and stones

Inclusions: 10% low sloping waterways with 15% vegetation (acacias)

Slope: 2% (long flat)

Position: Plateau

Parent Material: loess and water deposits.

Vegetation: less than 1% bushes

Erosion: sheet erosion and wind erosion

Temperature: 26.7 ^{o}C

Classification: coarse loamy mixed hyperthermic Aridic Calciustoll

A.D./J.G./F.O.

CHINILE

Site No. 47

Location: 273.6 E
1265.8 N

0-9 cm: A 11 horizon; 7.5YR/3/3 (very dark brown) day, 7.5YR/3/2 (very dark brown) moist; gravelly loam; moderate fine granular structure; firm, friable, nonsticky; many fine fibrous roots; mildly effervescent; clear irregular boundary;

9-50 cm: A12ca horizon; 10YR/4/3 (dark brown) dry; 10YR/3/3 moist; very gravelly loam (80% gravel); weak fine granular; strongly effervescent; common fine woody roots; fine disseminated and thick coating of 1-2 mm $CaCO_3$ (10%) in all parts of the stone, cobbles and gravels; gradual irregular boundary;

50-75+ cm: Bca horizon; 7.5YR/4/4 (brown) dry and moist gravelly sandy clay loam; about 85% gravel, stones and cobbles; weak fine granular; strongly effervescent; 25% $CaCO_3$ thick coating of 1-4 mm $CaCO_3$ on all rock fragment surfaces;

Inclusions: 20% rock outcrop

Slope: very steep slope

Vegetation: lithic variant

Classification: loamy skeletal mixed hyperthermic Aridic Calciustoll.

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8/3/81 A.D./J.G./F.O.

DABA EABDALLE

Site No. 87

Location: 220.3 E
1220.6 N

0-14 cm: A11 horizon; 5YR/4/3 (reddish brown) dry, 5YR/3/3 (dark reddish brown) moist; silt loam; moderate medium to fine angular blocky structure; firm, friable nonsticky; many fine fungus traces; many fine pores; strongly effervescent; clear and irregular boundary;

14-34 cm: A12 horizon; 5YR/3/3 (dark reddish brown) dry and moist; silt loam; moderate coarse to medium subangular blocky structure; firm friable, nonsticky; many fine fungus traces; many fine fibrous roots; strongly effervescent; clear and irregular boundary;

34-40 cm: B horizon; 5YR/3/4 (dark reddish brown) moist; silty clay loam; moderate coarse to medium subangular blocky structure; firm, friable slightly sticky; strongly effervescent; common fine fibrous roots; clear and irregular boundary;

40-62 cm: Cca horizon; 5YR/4/6 (yellowish red) dry, 5YR/3/4 (dark reddish brown) moist; gravelly silt clay loam; structure: none; loose, friable, slightly sticky; strongly effervescent; 35% gravel, thin $CaCO_3$ coating on all faces of the gravel; abrupt and smooth boundary;

62-70+ cm: R horizon; solid lava, basaltic rock.

Surface: On the surface 90% cobbles and boulders of volcanic bombs.

Parent Material: Lava flow plateau with 1-8% long slopes loess covered,

Vegetation: Vegetation cover of 15% (bilcin, Aousdameir, kulan 1 to 1.5 m high and dacar)

Temperature: Moderately cool

Comment: Extensive soil

Classification: fine loamy mixed hyperthermic Aridic Calciustoll

518

7/12/80 A.D./J.G./F.O.

DABAGALALEY

Site No. 93

Location: 301.2 E
1276.7 N

0-2 cm: En horizon; 7.5YR/4/4 brown; loamy sand; cemented on the top; structureless loose, loose and nonsticky; mildly effervescent (sea shells); when it is dry, crust on the surface; 5% fractured broken sea shells; abrupt and smooth boundary;

2-40 cm: B horizon; 7.5YR/4/4 brown (dry), 7.5YR/3/4 dark brown (wet); sandy clay loam; weak to moderate, medium subangular blocky structure; friable, sticky; mildly effervescent (5% shells); few common fine roots; soft powdery salt on pedfaces, some salt cementation in some fine soil crystals; abrupt and wavy boundary;

40-60+ cm: Mixed gravel, sand and silt; alternate layers of sand or silt or gravel (submarine gravels)

Vegetation: Land barren of vegetation.

Comment: Nearly level with slight undulations. Slightly above high tide about 5 meters; salt water table fluctuates with the tide from 5 to 2 meters below surface. This soil is located near the sea.

Location: 500 m S.E. of military post.

Classification: fine loamy, mixed hyperthermic Aeric Halaquept.

21/2/81 A.D./J.G./F.O.

DAGAH DERE

Site No. 95

Location: 267.1 E
1240.1 N

-2 to 0: Fine gravelly desert payment.

0-15 cm: A horizon; 10YR/5/4 (yellowish brown) dry; 10YR4/3 (brown) moist; common fine fibrous roots; fine weak granular structure; 0-1.5 cm leached of $CaCO_3$; very gravelly sandy loam; loose, friable; fine disseminated and 1-2 mm $CaCO_3$; strongly effervescent; 65% 2-10 mm gravel and cobbles from fractured rock; irregular and diffused boundary;

15-40+ cm: R horizon; 10-40 mm fractured rock; strongly effervescent; 2-5 mm $CaCO_3$;

Inclusions: 10-15% rock outcrop

Slope: Slope of 8-15% and strongly rolling slope;

Vegatation: 2-5% vegetation cover of Aurdawad and Aousdamer,

Classification: sandy skeletal mixed hyperthermic Lithic Torriorthent.

13/12/81 J.G./A.D.

DA LE DOLA

Site No. 51

Location: 316.5 E
1328.5 N

0-20 cm: IC horizon; 5YR/4/6 yellowish red (dry), 2.5YR/4/6 dark red (moist); loamy sand; structure: none; fine strata; strongly effervescent; few fine woody roots; fluvial deposit with an eolian cap of 8-10 cm; abrupt wavy boundary;

20-50+ cm: IIC horizon; 2.5YR/4/6 red (dry and moist);1 fine gravel; structure: none, laminated 1 to 2 cm gravel and sand; weakly cemented; strongly effervescent.

Surface: sand and fine gravel

Slope: 0-1%

Position: broad waterway

Parent Material: alluvium from nearby hills

Vegetation: 10% acacia and five (5%) grass

Erosion: surface erosion and inundation at each rain

Temperature: $31^{o}C$

Classification: sandy skeletal mixed hyperthermic Typic Torriorthent.

521

DAHIBOHTA

Site No. 74

Location: 227 E
1236 N

Surface: No sample taken

Classification: coarse loamy mixed hyperthermic Typic Torriorthent.

23/12/80 A.D./J.G./F.O.

DAMERKADDAE

Site No. 66

Location: 247.3 E
1234.0 N

0-15 cm: Al horizon; 10YR/5/4 yellowish brown (dry); 10YR/5/6 yellowish brown (moist); very gravelly sand; weak medium to fine subangular blocky structure; loose, 50% gravels; strongly effervescent; common fine 1-4 mm indurated CaCO3; irregular diffused boundary;

15-55 cm: Cllca horizon; 7.5YR/5/6 strong brown (dry), 7.5YR/4/4 brown (moist); very gravelly sand; 50% fractured pebbles and cobbles; weak fine angular; loose, common 1 to 5 mm indurated CaCO3; strongly effervescent; irregular diffused boundary;

55 - 140 cm: Cl2ca horizon; 7.5YR5/6 strong brown (dry) 7.5YR4/4 brown (moist); very gravelly sandy loam, 50% fractured pebbles and cobbles, structureless; loose common 1 to 5 cm indurated CaCO3; strongly effervescent.

Inclusions: This soil represents 40% of the area; 35% of the area consist of a coarse loamy skeletal mixed hyperthermic, Lithic Torriorthent, 25% rock outcrop;

Slope: 40 to 70% slope.

Parent Material: Rhyolthic rocks moderately fractured;

Vegetation: Sparse vegetation (cympobogon), "galan, gudac, bilcin, ibateys."

Comment: location at 247.3 E 500 m on the road to post control, 1234.0 N at Ali-Sableh; West of the road,

Classification: sandy skeletal mixed hyperthermic Typic Torriorthent.

10/3/82 J.G./A.D.

DARBI EALE

Site No. 75

Location: 241.8 E
1360.6 N

0-30 cm: C horizon; 10YR/5/3 brown (dry) 10YR/3/4 dark yellowish brown (moist); gravelly loam; 70% gravel; structureless; loose, friable, nonsticky; $CaCO_3$ coating on rock faces; strongly effervescent; clear wavy boundary,

Surface: 95% gravel

Inclusions: 10% rock outcrop, 10% wadi channel

Slope: 3%

Position: rolling foothill (valley)

Parent Material: basalt

Vegetation: 5% acacia along drainage ways

Erosion: severe water erosion with gullies

Temperature: 26.4 ^{o}C

Classification: loamy skeletal mixed hyperthermic Lithic Torriorthent.

20/12/81 A.D./F.O./J.G./M.J.

DARIYYOU

Site No. 38

Location: 260.7 E
1304.2 N

0-5 cm: A horizon; 10YR/5/3 brown (dry), 10YR/3/3 dark brown (moist); gravelly sand; structure: none; loose, friable, nonsticky; strongly effervescent; 50% gravel; clear wavy boundary;

5-45+ cm: Cca horizon; 10YR/5/3 brown (dry), 10YR/3/3 dark brown (moist); very gravelly sand; structure: none; loose, friable, nonsticky; 70% gravel and stones; strongly effervescent; fine disseminated and thick coating of $CaCO_3$ on gravel and stones.

Surface: 10% cobbles, 80% gravel and stones

Inclusions: 65-70% side slopes (Torriorthent) with about 10% similar vegetation.

Slope: 2 to 3%

Position: dissected alluvial fan

Parent Material: coarse alluvium

Vegetation: 3 to 5% 1 m "Jirme."

Erosion: rill erosion

Temperature: 32.8 ^{o}C

Classification: sandy skeletal, mixed hyperthermic, Lithic Torriorthent.

525

17/3/81 A.D./J.G./F.O.

DEGAMANKAL

Site No. 43

Location: 209.4 E
1234.2 N

0-6 cm: A horizon; 10YR/5/3 (brown) dry, 10YR/3/3 (dark brown) moist; gravelly sandy loam; structure: none; loose, very friable, nonsticky; strongly effervescent; 30% gravel; thin CaCO3 coating on all parts of the gravel; clear and wavy boundary;

6-15 cm: C horizon; 10YR/5/4 (Yellowish brown) dry, 10YR/3/4 (dark yellowish brown) moist; very gravelly sandy loam; structure: none; loose, very friable, nonsticky; mildly effervescent; 50% gravel; thin patchy CaCO3 coating on the gravel; Inclusion of rocks (lava flow); 50% covered with stones and boulders;

Inclusions: Inclusion in the Balambal soil mapping limit

Slope: Slopes from 3-8%

Parent Material: 10% lava outcrop

Vegetation: Vegetation rare (Aousdameir acacias)

Comment: Extensive soil

Classification: sandy mixed hyperthermic Lithic Torriorthent.

526

26/5/81 A.D./F.O./J.G.

DERJERA

Site No. 35

Location: 190
1284

Land type: Talus

See Sample 88

24/5/81 A.D./J.G./F.O.

DEROKKOMA

Site No. 70

Location: 171.7 E
1246.2 N

0-10 cm: A horizon; 7.5YR/4/4 brown (dry), 7.5YR/4/4 dark brown (moist); clay loam; strong coarse to medium subangular blocky structure; firm, friable, slightly sticky; strongly effervescent; few fine roots; gradual and smooth boundary;

10-54 cm: B11 horizon; 7.5YR/3/4 dark brown (dry); 5YR/3/3 dark reddish brown (moist); stony sandy clay loam; moderate medium subangular blocky structure; firm friable, slightly sticky; strongly effervescent; gradual and smooth boundary;

54-81 cm: B12 horizon; 7.5YR/4/4 brown (dry), 5YR/3/3 dark reddish brown (moist); stony sandy clay loam; moderate medium subangular blocky structure; firm, friable, slightly sticky; gradual and diffused boundary;

81-90 cm: C horizon; 7.5YR/4/4 brown (dry), 5 YR/3/3 dark reddish brown (moist); gravelly sandy clay loam; structure: none; firm, friable, nonsticky; strongly effervescent; 20% fine gravel

Surface: 60% cobbles and stones on the surface

Slope: 3-5%

Parent Material: loess on lava flow

Vegetation: 10% vegetation cover: "magal xid, daraf" (temporary grass)

Classification: fine loamy mixed hyperthermic Typic Torriorthent

24/12/80 A.D./J.G./F.O.

DIDJAN DER

Site No. 26

Location: 258.8E
1265.2 N

0-15 cm: A horizon; 7.5YR/5/4 brown (dry), 7.5YR/3/4 dark brown (moist); very gravelly sandy clay loam; weak medium subangular blocky structure; loose, friable nonsticky; few fine roots; 65% of 2 to 4 mm gravels; moderately effervescent; irregular diffused boundary;

15-85 cm: Cca horizon; 10YR/8/1 white (dry) 10YR/5/3 brown (moist); sandy clay loam; structureless; loose, friable, nonsticky; few medium roots; thick coating of CaCO3 on all rock surfaces, abundant fine CaCO3 deposits on the fine fraction; 40% gravels, 20% cobbles, 10% stones; extremely effervescent; irregular diffused boundary;

85-200 cm: IICca horizon; 10YR/6/4 light yellowish brown (dry), 10YR/6/3 pale brown (moist); stony sandy clay loam; firm, friable, nonsticky; 15% soft powdery 1 to 5 mm CaCO3; irregular diffused boundary;

200-350 cm: IIICca horizon; bouldery alluvium

Surface: between 40-80% gravel and about 30% cobbles and stones

Slope: 0-3% dissected (slightly)

Vegetation: About 20% vegetation cover (balanites aegyptioca, acacia...)

Comment: 100 m west of the road, on the west bank of the wadi,

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent

10/3/82 A.D./J.G.

DIMO Le BODA

Site No. 90

Location: 229.3 E
1307.4 N

0-50+ cm: A horizon; 10YR/4/2 dark grayish brown (dry), 7.5YR/3/2 dark brown (moist); very stony loam; 40% cobbles, 20% stones and 20% gravel; moderate medium crumb structure: firm, friable, slightly sticky; many fine and common medium and coarse woody roots; strongly effervescent; thin $CaCO_3$ coatings on stones.

Surface: 90% stones and cobbles

Inclusions: 15% rock outcrops and 40% lithic variant + 45% typic variant

Slope: 10%

Position: colluvial or talus slope

Parent Material: basaltic talus and eolian fill

Vegetation: 10% 2 m high acacia; 20% herbs and 2% grass

Erosion: severe water rills and gullies

Temperature: 28.9 °C

Classification: loamy skeletal mixed hyperthermic Aridic Haplustoll

DIR

Site No. 79

Location: 270 E
1226 N

Surface: no sample taken

Similar Soil: similar to Site No. 9

Classification: loamy mixed hyperthermic Lithic Torriorthent

531

15/3/82 J.G./A.D.

DITA

Site No. 14

Location: 284.4 E
1369.4 N

0-8 cm: A horizon; 10YR/6/3 pale brown (dry), 10YR/4/4 dark yellowish brown (moist); gravelly loam; structureless; loose, friable, nonsticky; strongly effervescent; abrupt irregular boundary;

8-40+ cm: Cca horizon; 7.5YR/6/2 pinkish gray (dry), 7.5YR/5/4 brown (moist); gravelly sandy loam; soft disseminated $CaCO_3$ and continuous thick $CaCO_3$ coatings on rocks; structureless; loose, friable, nonsticky; strongly effervescent.

Surface: 80% gravel, 20% cobbles

Inclusions: 15% waterways; 10% rock outcrop

Slope: 3%

Position: colluvial valley; pediment slope

Parent Material: rhyolite colluvium

Vegetation: barren except waterways

Erosion: moderate sheet erosion

Temperature: 31.7^{o} C

Classification: loamy skeletal mixed hyperthermic Lithic Calciorthid.

25/2/81 J.G./F.O./A.D.

DJABNANEARRE

Site No. 58

Location: 237.7 E
1221.3 N

0-7 cm: A horizon; 10YR/6/4 light yellowish brown (dry); 10YR/3/6 dark yellowish brown (moist); weak medium and coarse subangular blocky structure; soft, very friable, nonsticky; common fine fibrous roots; the surface (2 mm) puddles and destroys the structure; strongly effervescent; many fine pores of 0.5-2 mm; 80% boulders, stones and cobbles from 10-100 cm, clear wavy boundary;

7-39 cm: B21 horizon; 5YR/3/3 dark reddish brown (dry), 5YR/3/2 dark reddish brown (moist); clay loam; moderate medium and coarse subangular blocky structure; 10% 0.5-2 mm $CaCO_3$ concretions; strongly effervescent; firm, friable slightly sticky, few fine fibrous roots; few coarse pores; common white fungus traces; clear irregular boundary;

39-48 cm: B22ca horizon; 5YR/4/4 reddish brown (dry), 5YR/3/4 dark reddish brown (moist); sandy clay loam; moderate medium and fine angular and subangular blocky structure; firm, friable, slightly sticky; 15% $CaCO_3$ concretions of 1-3 mm and soft powdery disseminated $CaCO_3$; strongly effervescent; clear irregular boundary;

48-55+ cm: B3ca horizon; 5YR/4/4 reddish brown (dry) gravel, 5YR/3/4 dark reddish brown (moist); thin $CaCO_3$ on all faces; sandy loam between the interstices; from 65 to 100 cm to the bedrock;

Inclusions: Inclusions of 15% slope

Slope: about 5%

Parent Material: Volcanic bombs strewn loess covered lava flow

Vegetation: Acacias, bilcin, Dhirinithir, sarman, Aousdamer: 5% cover

Classification: loamy skeletal mixed hyperthermic Typic Calciorthid. (bouldery).

10/3/82 A.D./J.G.

EABALLOU

Site No. 22

Location: 210.6 E
1348.5 N

Land form: Lava flow

Surface: Barren

Slope: Rolling: 1-8%

Parent Material: Lava outcrops and Lava flow

Comment: Few small playas

534

J.G./A.D.

EADDORRA

Site No. 40

Location: 183.5 E
1320.1 N

0-25 cm: A horizon; 10YR/4/3 dark brown (dry), 10YR/2/2 very dark brown (moist); very gravelly loam; 55% cobbles, stones and boulders, 25% gravel; no structure; loose, friable, slightly sticky; common fine woody roots; common continuous $CaCO_3$ coatings on rock fragments; strongly effervescent; wavy irregular boundary,

25 cm: R horizon; rock (basalt)

Surface: 5% boulders; 45% stones and cobbles

Inclusions: 40% rock outcrop, 20% typic variant

Position: side slope

Parent Material: Talus (basaltic lava)

Vegetation: 2% "kulan" and bushes and 5% grass

Erosion: severe water (gulley erosion)

Classification: loamy skeletal mixed hyperthermic Lithic Torriorthent

Temperature: 29.5 ^{o}C

535

/6/81 A.D./F.O.

EADODANEAY

Site No. 39

Location: 222.4 E
1268.6 N

-3 cm: A horizon; gravelly sand; loose, very friable, nonsticky; very strongly effervescent; 40% gravel; clear and smooth boundary;

-20 cm: C horizon; very gravelly sandy loam; structure: none; loose, very friable, slightly sticky; 50% 2-50 mm gravel and 5-10 cm stones in the horizon; strongly effervescent.

urface: 90% cover of stones and boulders

lopes: 3-30% slopes

egetation: rare vegetation of temporary grass

omment: at the bottom of a hill

lassification: loamy, skeletal, mixed, hyperthermic, Lithic Calciorthed

536

11/3/81 A.D./J.G./F.O.

EADO GAFAN

Site No. 91

Location: 182.8 E
1285.3 N

0-10 cm: A horizon; 10YR/5/3 brown (dry), 10YR/3/3 strong brown (moist); sand; structure: none; slightly firm, very friable; some fresh water mollusks; clear, smooth; strongly effervescent,

10-75 cm: C horizon; 10YR/5/4 yellowish brown (dry), 10YR/3/3 strong brown (moist); sand; structure: none; slightly firm, very friable; laminated; moderately effervescent;

Position: Occurs on a pleistocene lacustrine plain

Vegetation: This particular soil has 5% bunch grass cover

Comment: The Hanle plain is about 65% of this soil. About 20% covered with dunes up to 2 m high. 15% wadi with dunes on the edge. The sand dunes have several species of trees: 30% cover up to 3-4 m (Qudac, Caday, dhagdhagan, moroh)

Classification: sandy mixed hyperthermic Typic Torriorthent.

537

7/12/81 J.G./F.O.

EANGALALO

Site No. 46

Location: 299.4 E
1393.6 N

0-9 cm: A horizon; 7.5YR/4/4 brown (dry), 7.5YR/4/4 brown (moist); sandy clay loam; weak coarse subangular blocky structure; slightly cemented with NaCl, brittle, friable, slightly sticky; salty to taste; sandy on pedfaces; many fine pores; clear irregular boundary,

9-40 cm: B2Na horizon; 5YR/4/6 yellowish red (dry and moist); sandy clay loam; weak medium subangular blocky structure; firm, friable, slightly sticky; salty to taste, 3% fine NaCl crystals; strongly effervescent; clear wavy boundary;

40-55 cm: B3Na horizon; 7.5YR/5/6 strong brown (dry and moist); sandy clay loam; weak coarse subangular blocky structure; hard, friable, slightly sticky; many coral pieces; slightly salty to taste; strongly effervescent.

Surface: 50% fine gravel and puffy crusty surface

Inclusions: few areas with dunes (40-75 cm high); few waterways with 50% dunes

Slope: 0-1%

Parent Material: loess on coral

Vegetation: 10% bushes on dunes, 90% barren; this soil occurs near the sea

Erosion: hazard-wind and sheet erosion

Temperature: 31.3 ^{o}C

Comment: Coral rocks at 1 m

Classification: fine loamy mixed hyperthermic Typic Natrargid.

EAMAYTOLE

Site No. 17

Location: 150
1269

Surface: No sample taken

Classification: loamy skeletal mixed hyperthermic Lithic Torriorthent.

539

10/3/82 J.G./A.D.

EASA DO

Site No 227 (No. 97)

Location: 227.1 E
1301.9 N

0-50 cm: C horizon; 7.5YR/3/4 dark brown (dry and wet); gravelly loam; 60% boulders, between the boulders 70% gravel and rocks; structureless; loose, friable, slightly sticky; common fine woody roots; strongly effervescent; common medium continuous $CaCO_3$ coatings on rocks,

Surface: 50% boulders, 35% stones cobble and gravel

Inclusions: 20% rock outcrops, 30% talus slope

Slope: 25-30%

Position: Steep mountains slope (rolling mountains)

Parent Material: basaltic lava

Vegetation: rare ("binin")

Temperature: 26.4 ^{o}C

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent.

540

12/12/81 A.D./F.O./J.G.

EASAGELAW

Site No. 7

Location: 304.4 E
1348.8 N

0-3 cm: A horizon; 10YR/5/3 brown (dry), 10YR/4/3 dark brown (moist); very cobbly sandy loam; weak fine subangular blocky; weakly cemented; friable and slightly sticky; strongly effervescent; few fine woody roots; clear, smooth boundary;

3-30 + cm: Cca horizon; 10YR/6/2 light brownish gray (dry), 10YR/6/4 light yellowish brown (moist); sandy clay loam; structure: none; loose, friable, slightly sticky; few fine woody roots; strongly effervescent; fine disseminated and 1 to 2 mm thick coating of $CaCO_3$ on the gravel and rocks; 70% stones and 10% gravel.

Surface: 75% cobbles

Inclusions: 25% rock outcrop

Slope: 11%

Position: talus colluvium

Parent Material: indurated rhyolitic ignimbrite

Vegetation: 5% acacia and "binin"

Temperature: 27.6 ^{o}C

Classification: loamy skeletal mixed hyperthermic Typic Calciorthid.

2/3/81 A.D./J.G./F.O.

EGEREALEYTA

Site No. 15

Location: 238.6 E
1271.7 N

0-30 cm: Aca horizon; 10YR/5/3 brown (dry) 10YR/3/4 dark yellowish brown (moist); very stony loam; weak coarse and medium subangular blocky structure; loose, very friable, nonsticky; strongly effervescent; many fine pores; few fine fibrous roots; CaCO3 on all faces of the rock fragments; few fine concretions of CaCO3 and fine disseminated and powdery CaCO3; 80% scorecous bombs boulder size 20-50 cm; gradual irregular boundary;

30-60+ cm: Cca horizon; 10YR4/3 dard brown (dry), 10YR/3/3 dark brown (moist); very stony sandy clay loam, moderate medium to fine subangular blocky structure; many fine pores; strongly effervescent; fine disseminated CaCO3 and CaCO3 on all faces of the rock fragments; many fine fungus traces; few fine coarse woody roots; boulders and stones represent 90% of the horizon;

Parent Material: 15-20% slopes on rolling lava flow 60% 10-50 cm boulder cover, 25% lava outcrop,

Vegetation: Vegetation cover: less than 5% but includes Wan'ad; dhidin, kulan, Qudac...

Comment: 40% of the soil are thinner than this one,

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent.

12/12/81 J.G./F.O./A.D.

EOULMA

Site No. 99

Location: 307.1 E
1339.1 N

0-20 cm: IC horizon; 10YR/6/3 pale brown (dry), 10YR/3/4 dark yellowish brown (moist); sandy clay loam; structure: none; loose, friable, slightly sticky; strongly effervescent; few fine woody roots; clear smooth boundary,

20-40+ cm: IIC horizon; 7.5YR/4/4 brown (dry), 7.5YT/3/4 dark brown (moist); sand; structure: none;weakly cemented, friable, nonsticky; strongly effervescent; fine disseminated CaCO3.

Surface: 50% gravel

Inclusions: 15% waterways with 20-30 cm of eolian sand

Slope: 0-1%

Position: Outer edge of a alluvial fan

Parent Material: mixed alluvium

Vegetation: 20% grass and woody tuft and 5% acacia in the waterways.

Temperature: 33.6 °C

Classification: sandy mixed hyperthermic Typic Torriorthent.

543

10/3/82 A.D./J.G.

FIEALOU

Site No. 60

Location: 225.2 E
1291.3 N

0-25 cm: A horizon; 10YR/5/3 brown (dry), 10YR/4/3 dark brown (moist); gravelly loamy sand; 20% rocks, 25% gravel; weak medium to fine subangular blocky structure; slightly firm, friable, nonsticky; many fine pores; strongly effervescent; irregular wavy boundary;

25-200+ cm: C horizon; 10YR/4/2 dark grayish brown (dry), 10YR/3/2 very dark grayish brown (moist); very stony sand; 50% stones, 20% gravel; strongly effervescent; loose, friable, nonsticky; structureless; common medium woody roots; very thin patchy $CaCO_3$ coating on rock fragment faces.

Surface: 70% gravel, 25% stones and cobbles

Inclusions: Wadi Channel

Slope: 1%

Position: terrace

Parent Material: deltaic alluvial cobbles

Vegetation: sparce acacia

Erosion: none to slight but dissected by meandering streams

Temperature: 34.5 ^{o}C

Classification: sandy skeletal mixed hyperthermic Typic Torriorthent.

544

14/12/81 J.G./A.D./F.O.

FAFFAHTO

Site No. 64

Location: 222.8 E
1369.6 N

Land form: Lava flow

Parent Material: Volcanic boulder bombs 50 to 1.5 meters on lava flow

Comment: This unit blocks the outlet to the nearby playa.

545

20/12/81 A.D./F.O./J.G./M.J.

GABHOTIM

Site No. 33

Location: 256.5 E
1306.1 N

0-15 cm: A horizon; 10YR/5/3 brown (dry), 10YR/3/2 very dark grayish brown (moist), very gravelly loamy sand; weak fine subangular blocky; firm, friable, nonsticky; weakly effervescent; 50% gravel; few fine woody roots; clear and wavy,

15-60+ cm: C horizon; 5YR/5/2 reddish gray (dry), 5YR/3/2 dark reddish brown (moist); very gravelly loam; weak medium to fine subangular blocky structure; firm, friable, nonsticky; 50% gravel; strongly effervescent; fine disseminated and thin coating of $CaCO_3$ on the gravel; common fine and medium roots.

Surface: 80% gravel

Inclusions: 70% rock outcrop

Slope: 15%

Position: talus slope

Parent Material: colluvium

Vegetation: 20% 1 m high "binin" dominantly

Erosion: rill and gully erosion

Temperature: 34.7 °C

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent

13/12/81 J.G./A.D.

GARAB

Site No. 63

Location: 293.9 E
1318.2 N

0-50+ cm: C horizon; 7.5YR/5/4 brown (dry), 7.5YR/4/6 strong brown (moist); gravelly sandy loam; structure: none; stratified sand; gravel and cobbles; common fine woody roots; strongly effervescent,

Surface: 50% cobbles and boulders

Inclusions: 15% rock outcrop and 15% plateau

Slope: 19%

Position: talus slope

Parent Material: mixed colluvium

Vegetation: 20 to 25% of "dhidin" (2 m high)

Erosion: gully erosion

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent

14/12/81 J.G./A.D./F.O.

GARBALI

Site No. 37

Location: 234.7 E
1360.6N

0-6 cm: A horizon; 10YR/5/4 yellowish brown (dry and moist); loam; very weak fine platy structure; 10% fine gravel; strongly effervescent; clear wavy boundary;

6-45 cm: B2 horizon; 7.5YR/4/4 brown (dry), 7.5YR/3/4 dark brown (moist); silty clay loam; moderate medium and fine angular blocky; firm, friable, nonsticky; common fine roots; 10% fine gravel; strongly effervescent; gradual wavy boundary;

45-70 cm: C horizon; 10YR/4/4 brown (dry), 10YR/3/4 dark brown (moist); silt loam; structure: none; loose, friable, nonsticky; 10% fine gravel; strongly effervescent.

Surface: 25% cobbles and stones (volcanic bombs), about 30% fine gravel

Inclusions: 10% cover of 30-4 cm sand on waterways, 10% barren playas

Slope: 1%

Position: playa

Parent Material: alluvium and eolian loess

Vegetation: 1% acacia and 25% "sarman" in the waterways

Temperature: 32.1 ^{o}C

Classification: fine loamy mixed hyperthermic Typic Camborthid

548

15/3/82 J.G./A.D.

GARRAYTO

Site No. 89

Location: 272.1 E
1343.1 N

0-10 cm: A horizon; 7.5YR/6/4 light brown (dry), 7.5YR/5/4 brown (moist); gravelly loam; structureless; loose, friable, slightly sticky; strongly effervescent; 40% fine gravel and stones; clear wavy boundary;

10-30 cm: C horizon; 7.5YR/5/4 brown (dry), 5YR/5/6 yellowish red (moist); gravelly loam; 75% gravel; structureless; loose, friable, slightly sticky; few fine roots; continuous $CaCO_3$ coatings on rocks; strongly effervescent; clear irregular boundary;

30 cm: R (Rock).

Surface: 50% gravel; 10% stones

Inclusions: 15% outcrop, 15% thicker soil in the waterways

Slope: 0-2%

Position: plateau

Parent Material: rhyolite

Vegetation: 3% 1 m shrubs, 3% herbs

Erosion: none to slight wind and sheet erosion

Temperature: 25.1 ^{o}C

Classification: loamy skeletal mixed hyperthermic Lithic Torriorthent.

549

27/5/81 A.D./F.O./J.G.

GIDOLI

Site No. 78

Location: 209.1E
1260.1 N

0-10 cm: A horizon; 10YR/6/4 light yellowish brown (dry), 10YR/3/3 dark brown (moist); silt loam; structureless; loose, very friable, nonsticky; strongly effervescent; clear and wavy boundary;

10-52 cm: B horizon; 7.5YR/3/4 dark brown (dry), 5YR/3/3 dark reddish brown (moist); gravelly sandy clay loam; weak to moderate medium subangular blocky structure; strongly effervescent; gradual and wavy boundary;

52-75 cm: B3 horizon; 7.5YR/4/6 strong brown (dry), 5YR/3/4 dark reddish brown (moist); gravelly sandy clay loam; 20% hard pitted secondary $CaCO_3$ from 1-5 cm; lava

Slope: Slopes about 3-35%

Parent Material: 90% cover of stones and boulders on a lava flow (loess)

Vegetation: rare vegetation, no trees, "darif and wan'ad."

Classification: fine loamy skeletal, mixed, hyperthermic, Typic Torriorthent.

29/12/80 A.D./J.G./F.O.

GOEONDALE MADOBE

Site No. 194

Location: 265.3 E
1225.8 N

0-5 cm: All horizon; 10YR/5/4 yellowish brown (dry), 10YR/3/4 dark yellowish brown (moist); sandy loam; weak medium to fine subangular blocky; soft, friable, nonsticky; 30% 1 to 3 cm gravels; mildly effervescent; few fine roots; clear boundary;

5-20 cm: A12ca horizon; 7.5YR/4/4 dark brown (dry), 7.5YR/3/4 dark brown (moist); very gravelly sandy clay loam; 60% 1 to 3 cm gravels; weak fine granular; soft, friable; nonsticky; strongly effervescent; thin continuous coating and fine disseminated and indurated CaCO3; few fine roots; clear irregular boundary,

20-4- cm: Bcs horizon; 10YR/5/4 yellowish brown (dry), 7.5YR/4/4 brown (moist); gravelly; sandy clay loam; moderate fine and medium angular blocky; firm, friable, nonsticky; strongly effervescent; 10% CaCO3; thin continuous coating and fine disseminated and indurated CaCO3; few fine roots,

40-50+ cm: Cca horizon; 10YR/6/4 light yellowish brown (dry), 7.5YR/5/6 strong brown (moist); gravelly sandy clay loam;

Surface: 70% of the surface is covered by 1 to 4 cm gravel and 20% by 4 to 15 cm cobbles.

Slope: 25-35% slope on the colluvium

Vegetation: Qudac, salal, caytin...

Comment: 80% fractured rocks in the colluvium. The colluvium represents 35% of the area, 30% are a lithic calciorthid and 30% tilted stratified rocks and 5% others.

Classification: loamy skeletal mixed hyperthermic Typic Calciorthid.

8/12/81 J.G./A.D./F.O.

GORAY EEEB

Site No. 94

Location: 282.4 E
1393.4 N

0-12 cm: A horizon; 10YR/5/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); gravelly sand; 30% gravel; structureless; loose, very friable, nonsticky; moderately effervescent; clear irregular boundary;

12-30 cm: B horizon; 10YR/4/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); gravelly sandy loam, 40% gravel; weak fine subangular blocky structure; loose, very friable, nonsticky; strongly effervescent; thin patchy coating of $CaCO_3$ and weak cemented $CaCO_3$ on the gravel; few fine woody roots; clear; irregular boundary;

30-40+ cm: C horizon; 7.5YR/4/4 brown (dry), 7.5YR/3/4 dark brown (moist); sandy loam; structureless; loose, friable, slightly sticky; effervescent.

Surface: flat and about 80% gravel cover

Inclusions: 20% waterways

Slope: 1%

Parent Material: colluvial fan of rhyolite

Vegetation: barren with 10% acacia albida in the waterways

Erosion: mostly wind and rill erosion

Temperature: 33.0 °C

Classification: loamy skeletal mixed hyperthermic Typic Calciorthid.

552

GRAND BARA

Site No. 8

Location: 240 E
1246 N

0-0.5 cm: A11 horizon; pink 7.5YR/7/4 (dry); brown 7.5YR/4/4 (moist); silty clay loam; laminar; hard (dry); friable (moist); slick (wet); moderately effervescent; pH 7.3; abrupt boundary,

0.5-10 cm: A12 horizon; pink 7.5YR/7/4 (dry), brown 7.5YR/4/4 (moist); clay loam; strong medium to fine angular blocky structure; firm (dry), friable (moist), slightly sticky (wet); moderately effervescent; gradual boundary,

10-30 cm: B1 boundary; brown 7.5YR/5/4 (dry), dark brown 7.5YR/3/4 (moist); clay loam; moderate medium to fine angular blocky structure; firm (dry), friable (moist); slightly sticky (wet); moderately effervescent; gradual and irregular boundary,

30-70 cm: B2 horizon; 10YR/6/2 brownish gray on ped faces; 7.5YR/3/4 dark brown (dry), 7.5YR/3/4 dark brown (moist); sandy clay loam; strong large to medium angular blocky structure; firm (dry), friable nonsticky (moist); common fine 1 to 2 mm faint dark brown feromanganese concretions; few fine gypsum crystals; thin alluviated silty coating on ped faces; moderately effervescent,

Surface: absolutely flat, surface covered with polyhedrons (4-10 cm, 1-3 mm wide and 2-10 mm deep)

Comment: location - 7 km from the east of the road to the west in the middle of Grand Bara

Classification: fine loamy mixed hyperthermic Typic Camborthid.

29/12/80 A.D./J.G./F.O.

GUISTIR

Site No. 20

Location: 274.3 E
1220.3 N

0-15 cm: A1 horizon; 7.5YR/4/4 dark brown (dry), 7.5YR/3/4 dark brown (moist); clay loam; weak medium to fine subangular blocky structure; soft, friable, nonsticky; 20% fine gravels; common fine roots; strongly effervescent; clear and irregular boundary;

15-30 cm: B1 horizon; 5YR4/4 reddish brown (dry), 5YR/3/4 dark reddish brown (moist); clay loam; moderate medium subangular blocky structure; firm; friable; nonsticky; fine disseminated and indurated $CaCO_3$; strongly effervescent; clear boundary;

30-70 cm: B2 horizon; 5YR/4/4 reddish brown (dry), 5YR/3/4 dark reddish brown (moist); clay loam; strong large to medium subangular blocky; hard, friable, slightly sticky; small cracks of 1 to 3 mm from 10 cm to 100 cm with 20 cm spacing and common medium pressure faces and common medium discontinuous slickensides; strongly effervescent; few rose gypsum of 2 to 4 mm; clear boundary;

70-120+ cm: B3 horizon; 5YR/4/4 reddish brown (dry); 5YR3/4 dark reddish brown (moist); clay loam; moderate large to medium angular blocky; hard, friable, nonsticky; many 1 to 4 mm rose gypsum; strongly effervescent;

Surface: 50% 5 to 15 cm cobbles and gravel on the surface

Inclusions: Eolian mantle over lava flow; 2 to 3 mm thick loess;

Slope: 2% slope

Position: little erosion and very long straight slope

Vegetation: 10% cover of sarman

Comment: 4 km from Guistir on the road to Ali-Adde streambank on the north side of the road,

Classification: fine loamy mixed hyperthermic Typic Camborthid.

3/3/81 A.D./J.G./F.O.

HADADDASO

Site No. 83

Location: 227.5 E
1238.4 N

0-8 cm: A11 horizon; 10YR/5/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); sandy loam; structureless, loose, nonsticky; many fine fibrous roots; a weak crust of 0.5 cm thick on surface; strongly effervescent; clear wavy boundary;

8-24 cm: A12 horizon; 10YR/5/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); sandy loam; weak medium to fine subangular blocky; loose, very friable, nonsticky, many medium woody roots; few coarse pores; strongly effervescent; few small shells, clear wavy boundary;

24-40 cm: A13 horizon; 10YR/5/3 brown (dry); 10YR/3/4 dark yellowish brown (moist); sandy loam; weak coarse to medium subangular blocky; firm, very friable, nonsticky; few coarse pores; strongly effervescent; few 1-5 cm stones, clear wavy boundary;

40-60 cm: B24 horizon; 5YR/4/3 reddish brown (dry), 5YR/3/2 dark reddish brown; sandy clay loam; moderate coarse to medium subangular blocky; firm, friable, nonsticky; few coarse pores; strongly effervescent; soft powdery disseminated $CaCO_3$ and 5% 1-4 mm masses of $CaCO_3$; common fine roots; clear wavy boundary;

60-70 cm: B22 horizon; 10YR/5/3 pale brown (dry), 10YR/4/3 brown (moist); loam; moderate coarse to medium subangular, blocky; firm, very friable, nonsticky; 5-10% gravels,

Slope: slope 1-2% and very long

Vegetation: Vegetation cover of 20% of Aousdameir, daraf, acacia (-2 m),

Comment: the A horizon is Colian sand over lacustrine sediments; the sand is eroded into rills, they represent 35% of the area with a depth of 30 cm

Classification: fine loamy mixed hyperthermic Typic Camborthid

22/12/80 A.D./J.G./F.O.

HADKODLEY

Site No. 24

Location: 256.6 E
1235.7 N

0-10 cm: A1 horizon; 10YR/5/3 brown (dry), 10YR/3/3 dark brown (moist); sandy loam; weak medium to fine subangular blocky structure; loose, friable, nonsticky; few fine roots; strongly effervescent; clear boundary;

10-20 cm: B1 horizon; 10YR/5/3 brown (dry), 10YR/3/3 dark brown (moist); sandy clay loam; strong large to medium subangular blocky structure; hard, friable; nonsticky; secondary powdery $CaCO_3$ strongly effervescent; clear boundary;

20-40 cm: B2 horizon; 10YR/4/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); sandy clay loam; moderate large to medium breaking to fine subangular blocky structure; loose; friable, nonsticky; fine powdery and indurated 1 to 4 mm common $CaCO_3$; strongly effervescent; gradual and irregular boundary;

40-60+ cm: C horizon; 10YR/3/3 dark brown (dry), 10YR/3/2 very dark greyish brown (moist); gravelly sandy clay loam; weak medium to fine subangular blocky; loose; friable, nonsticky; 1 to 10 mm indurated $CaCO_3$; strongly effervescent; 30% gravels, cobbles 1 to 10 cm in 0 and slope ranges 3-8%

Vegetation: (salvadora persicae, cympobogon, "Aurdawood")

comments: occurs in decomposed metamorphic rock

Location: at about 600 m north of DAEDAE and at 300 m of south Hadkodely

Classification: fine loamy mixed hyperthermic Typic Camborthid

14/12/81 A.D./F.O./J.G.

HAKARA

Site No. 76

Location: 244.2 E
1341.3 N

0-20 cm: A horizon; 10YR/4/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); loam weak medium to fine subangular and angular blocky structure; slightly firm, friable, slightly sticky; strongly effervescent; soft powdery and fine disseminated $CaCO_3$; clear and wavy boundary;

20-50+ cm: Bca horizon; 10YR/5/2 grayish brown (dry), 10YR/4/2 dark grayish brown (moist); loam; moderate medium to fine subangular and angular blocky structure; firm, friable, slightly sticky; strongly effervescent; fine disseminated $CaCO_3$ and 5% 1 mm soft $CaCO_3$,

Surface: 20% cobbles and stones and 80% gravel

Inclusions: 10% waterways with 20-3- cm sand on the surface, 5% 3 to 5% slopes along some wadis (lithic variant)

Slope: 1%

Position: Plateau

Parent Material: eolian loess and bombs (volcanic)

Vegetation: barren

Erosion: sheet and wind erosion

Temperature: 33.3 ^{o}C

Classification: coarse loamy mixed hyperthermic Typic Calciorthid.

HALBISSOYTA

Site No. 77

Location: 199 E
1297 N

No sample taken

Same as No. 28 MINKILLE

Classification: coarse loamy mixed hyperthermic Pachic Calciustoll

12/3/81 A.D./J.G./F.O.

HARAEIDE

Site No. 32

Location: 186.2 E
1225.7

0-10 cm: A horizon; 7.5YR/4/4 brown (dry), 7.5YR/4/4 brown (moist); sandy clay loam; weak medium to fine angular blocky structure; strongly effervescent; loose friable, nonsticky; clear and wavy boundary;

10-25 cm: B horizon; 5YR/3/3 dark reddish brown (dry), 5YR/3/2 dark reddish brown (moist); sandy clay loam; moderate coarse to medium angular blocky structure; firm, friable, nonsticky; strongly effervescent; gradual and wavy boundary;

20-60+ cm: C horizon; 5YR/3/2 dark reddish brown (dry), 5YR/5/2 dark reddish brown (moist); sandy clay loam; strong coarse to medium angular blocky structure; hard, friable, nonsticky; strongly effervescent,

Surface: The surface has 40% wave wash gravel as a desert pavement

Slope: Slopes from 1 to 5%

Position: Part of the lacustrine plain of GOBAAD

Vegetation: Soil is barren; grass and acacia on the sand dunes and the wadi

Comment: Has about 10% dunes from 50 cm to 4 m, the B horizon is too weak for a cambic

Classification: fine loamy mixed hyperthermic Typic Torriorthent

559

10/3/82 A.D./J.G.

HARRALOL

Site No. 92

Location: 220 E
1317 N

Comment: Salt Marsh. Couldn't land the helicopter, all of the playa had 5-20 cm of water. Salt cover on sides.

9/12/81 J.G./A.D./F.O.

HERRIYA

Site No. 6

Location: 297.7 E
1370.3 N

0-50+ cm: Cca horizon; 10YR/6/2 light brownish gray (dry), 10YR/5/2 grayish brown (moist); gravelly sandy loam; structureless; loose, very friable, nonsticky; strongly effervescent; thin coating of $CaCO_3$ on the gravel and stones 1-2 cm concretions of $CaCO_3$; about 10% gravel and 40% stones.

Surface: 25% boulders and 40% gravel

Inclusions: 20% rock outcrop, 15% talus slope

Slope: 6-15% (rolling)

Position: foot slope

Parent Material: basalt and rhyolite

Vegetation: 2% acacia in the waterways

Erosion: water erosion

Temperature: 31.3 ^{o}C

Classification: coarse loamy mixed hyperthermic Typic Calciorthid.

30/12/80 A.D./J.G./F.O.

HOLL-HOLL

Site No. 67

Location: 273.6 E
1250.7 N

o-20 cm: A horizon; 10YR/5/4 yellowish brown (dry), 7.5YR/3/4 dark brown (moist); very gravelly sandy clay loam; weak fine subangular blocky structure; loose, friable, slightly sticky; many fine roots; 60% 3 to 10 cm gravels; 1 to 4 mm fine powdery disseminated and indurated CaCO3; medium coating of CaCO3 on the gravels and the stones; strongly effervescent; irregular and diffused boundary;

20-50 cm: Cca horizon; 10YR/5/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); very gravelly sandy clay loam; weak fine granular structure; soft, friable, slightly sticky; 80% gravels; soil filling interstices; common fine and a few coarse roots; 1 to 4 mm fine powdery disseminated and indurated CaCO3; medium coating of CaCO3 on all parts of the rocks; strongly effervescent; irregular and diffused boundary;

50-200+ cm: IICca horizon; 10YR/5/4 yellowish brown (dry), 7.5YR/4/6 strong brown (moist); gravelly sandy clay loam; 30% volcanic colluvium gravel plus 20% 1 to 15 mm of indurated CaCO3; from 120 cm to the bottom 10% 1 to 10 mm of soft powdery CaCO3 reprecipitated from above; few CaCO3 coating on the rock fragment faces; strongly effervescent;

Surface: 70% boulders and cobbles on the surface;

Inclusions: this soil occupies 35% of the area and a thinner soil occupies 30% of the area.

Slope: 45 to 70% slopes

Parent Material: lava outcrops 30%

Vegetation: 20% vegetation cover on this soil and the other soil about less than 5% vegetation;

Comment: on the south side of the road and the south bank of the HOLL-HOLL river and at 150 m west of the military school.

Classification: fine loamy mixed hyperthermic Typic Calciorthid.

12/11/80 A.D./J.G./F.O.

HOUMBOULI

Site No. 86

Location: 295.9 E
1278.1 N

On surface: Ag

0-8 cm: desert pavement. Fluvial gravels and cobbles.

4-12 cm: A horizon; brown 10YR/5/3 (dry), and dark grayish brown 10YR/4/2 no structure (loose), sand, rare roots, Ph 7.5

12-40+ cm: brown 7.5YR/5/4 (dry) and dark brown 715YR/4/4 (wet); loose; few fine roots; few cobbles (5-10%) pH 8-8.4

Slope: 1%

Vegetation: acacia tortilis - "kulan"

Erosion: wind

Classification: mixed hyperthermic Typic Torripsamment

563

16/12/81 A.D./J.G./F.O.

INAEITO

Site No. 69

Location: 202.3 E
1336.8 N

0-16 cm: A horizon; 10YR/6/4 light yellowish brown (dry); 10YR/4/4 dark yellowish brown (moist); silty loam; moderate medium to fine angular blocky structure; firm, friable, sticky; strongly effervescent; many fine pores; clear wavy boundary;

16-50+ cm: B horizon; 7.5YR/4/4 brown (dry), 7.5YR3/4 dark brown (moist); loam; weak medium subangular and angular blocky; firm friable, nonsticky; strongly effervescent,

Surface: 90% cobbles and boulders

Inclusions: 10% lava outcrop, thick boulders (20-40%)

Slope: 3-8%

Position: lava plateau

Vegetation: rare 5% aeaciu in the waterways

Erosion: gully erosion

Temperature: 31.9 °C

Classification: coarse loamy mixed hyperthermic Typic Camborthid

564

13/11/80 A.D./J.G./F.O.

JABAN EAS

Site No. 52

Location: 290.3 E
1277.8 N

0-5 cm: A horizon; yellowish red 5YR/5/6 (dry) red 2.5YR/4/6 (wet); loose, 90% cobbles and boulders; clear boundary;

5-19 cm: B1 horizon; yellowish red 5YR/5/6 (dry) and red 2.5YR/4/6 (wet); clay loam very fine, weak granular structure; friable (wet) and loose (dry); very fine roots; pH 8.4 clear boundary,

19-49+ cm: B2ca horizon; red 2.5YR/4/8 (dry) red 2.5YR/3/6 (wet); gravelly clay loam; moderate fine subangular structure; consistence: loose; 10% 7.5YR/3/1 powdered 1 to 5 mm secondary $CaCO_3$; very fine roots.

Inclusions: big rock outcrops of basalt (2%)

Slope: 2 to 3%

Vegetation: Acacias 5% cover

Classification: fine loamy, mixed hyperthermic, Typic Calciorthid.

10/3/82 A.D./J.G.

KADDA MOUS

Site No. 34

Location: 230.2 E
1373.1 N

0-40 cm: A horizon; 10YR/4/3 dark brown (dry), 10YR/3/3 dark brown (moist); very bouldery loam; 50% rock and boulders; 20% stones and cobbles, 15% gravel; no structure; loose, friable, slightly sticky; strongly effervescent; thick continuous $CaCO_3$ coatings on rock fragments; common medium roots; irregular boundary;

40 cm: rock

Surface: 70% rocks and boulders, 30% cobbles and gravel

Inclusions: 10% playas and level accumulation zones of 1 to 5 hectares, 20-30% rock outcrops 15% thicker soil at foot of slope,

Slope: 12%

Position: side slope on lava flow

Parent Material: lava talus and eolian filler

Vegetation: 1% 1 m acacia

Erosion: moderate gully

Temperature: 32.3 °C

Classification: loamy skeletal mixed hyperthermic Lithic Torriorthent.

566

7/12/81 J.G./F.O.

KADDA OUDLI

Site No. 98

Location: 293.9 E
1380.3 N

0-8 cm: A11 horizon; 7.5YR/7/4 pink (dry), 7.5YR/4/4 brown (moist); very gravelly loamy sand; 70% gravel; structureless; loose, friable, nonsticky; effervescent; clear boundary;

8-30 cm: A12 horizon; 7.5YR/7/5 pink (dry), 7.5YR/5/6 strong brown (moist); very gravelly loamy sand, 75% gravel; structureless; loose, friable, nonsticky; slightly effervescent; thin patchy $CaCO_3$ coating on the gravel; clear wavy boundary;

30-50+ cm: C horizon; 5YR/6/4 light reddish brown (dry), 5YR/5/6 yellowish red (moist); gravely loamy sand; structureless; loose, friable, nonsticky; slightly effervescent,

Inclusions: (soil units) this unit includes 20-30% wadi channels with sand dunes 50 cm high on 30% of the area on the colluvial slope on rhyolite.

Position: This description is 50 yards from the mountain; thus more gravelly than some km farther.

Vegetation: rare (acacia, 5% herbs in the waterways)

Erosion: rill erosion due to long straight slope a hazard.

Temperature: 32.2 ^{o}C

Classification: sandy skeletal mixed hyperthermic Typic Torriorthent.

20/12/81 A.D./F.O./J.G./M.J.

KALLOLOU

Site No. 85

Location: 249.7 E
1218.2 N

0-50 cm: C horizon; 10YR/3/3 dark brown (dry), 10YR/3/2 very dark grayish brown (moist); stony sand; structure: none; loose, friable, nonsticky; 50% gravel and stones; moderately effervescent; few fine woody roots.

Surface: 30% stones and boulders. 70% gravel

Inclusions: 20% stream channels

Slope: 3%

Position: delta

Parent Material: alluvium

Vegetation: 20% 1.5 to 2 m high acacia tortilis

Erosion: frequent flooding

Temperature: 32.8 ^{o}C

Classification: sandy skeletal mixed hyperthermic Typic Torrifluvent.

7/12/81 J.G./F.O.

KENANNABA

Site No. 62

Location: 297.8 E
1387.8 N

0-8 cm: All horizon; 7.5YR/5/4 brown (dry), 7.5YR/3/4 dark brown (moist); gravelly sand; structureless; loose, very friable, nonsticky; effervescent; clear smooth boundary few fine roots,

8-30 cm: A12 horizon; 7.5YT/6/4 light brown (dry), 7.5 YR/4/4 brown (moist); gravelly sand; structureless; loose, very friable, nonsticky; effervescent; thin patchy coating on the gravel; few woody roots; clear smooth boundary.

30-50 cm: C horizon; gravel; laminated, stratified.

Inclusions: 30-40% on waterways with sand dunes (20-50 cm high) covering 30-40% on waterways.

Slope: 0-1%

Vegetation: woody bush in the waterways

Erosion: rill and sheet erosion hazard

Temperature: 33 °C

Classification: sandy skeletal mixed hyperthermic Typic Torriorthent.

19/11/81 J.G./A.D./F.O./M.A./A.H.

KOLALOHO

Site No. 3

Location: 264.4 E
1269.6 N

0-45 cm: Cca horizon; 10YR/4/3 brown (moist), 10YR/5/3 brown (dry); very gravelly loam; 60% gravel and stones; weak fine to medium subangular blocky structure; firm, friable, slightly sticky; strongly effervescent, fine disseminated $CaCO_3$ and thin coating of $CaCO_3$ on gravel and stones; few fine woody roots; highly fractured rocks,

45+ cm: C horizon; 10YR/5/3 brown (dry), 10YR/4/3 brown (moist); loam

Surface: 50% boulders and stones, soil thickness varying from 10 to 50 cm.

Slope: 3 to 5% slope

Vegetation: Vegetation cover: 1 to 2% ("jirme," acacia radiana...)

Classification: loamy skeletal mixed hyperthermic Lithic Torriorthent.

15/12/81 A.D./F.O./J.G.

KOUHOULLI

Site No. 84

Location: 245.4 E
1345.2 N

0-5 cm: A horizon; 10YR/4/2 dark grayish brown (dry), 10YR/3/2 very dark grayish brown (moist); 30% gravel; gravelly sandy loam; weak medium to fine subangular blocky structure; firm, friable, slightly sticky; strongly effervescent; fine disseminated $CaCO_3$ and soft powdery and thin coating of $CaCO_3$ on the gravel; clear and wavy boundary;

5-30 cm: C21ca horizon; 10YR/6/3 pale brown (dry), 10YR/4/3 brown (moist); very cobbly sandy loam; structure: none; 50% cobbles and 30% gravel; loose, friable, slightly sticky; strongly effervescent; fine disseminated and thin coating of $CaCO_3$ on the gravel and cobbles; clear and wavy boundary;

30-50+ cm: C22ca horizon; 10YR/6/4 light yellowish brown (dry), 10YR/5/4 yellowish brown (moist); very gravelly sand; structure: none; 60% gravel; loose, friable, nonsticky; strongly effervescent; thin $CaCO_3$ coating on the gravel.

Surface: 30% cobbles and 90% gravel and pebbles

Inclusions: 10% rock outcrop, 10% lithic variant

Slope: 3 to 5%

Position: foot slope along the plateau

Parent Material: Colluvium

Vegetation: 1% bushes

Erosion: gully and wind erosion

Temperature: 29.6 ^{o}C

Classification: sandy skelital mixed hyperthermic Typic Calciorthid

571

12/3/81 A.D./J.G./F.O.

KOUTABBOUYYA

Site No. 65

Location: 167.1 E
1274.2 N

0-20 cm: A horizon; 10YR/4/2 dark grayish brown (dry), 10YR/3/2 very dark grayish brown (moist); sand; structure: none; loose; very friable; strongly effervescent; a few lacustrine shells; gradual and smooth boundary

20-42+ cm: Ccahorizon; 10YR/4/2 dark grayish brown (dry), 10YR/3/2 very dark grayish brown (moist); sand; structure: none; loose, very friable; laminated layers; snail shells; strongly effervescent,

Surface: Barren

Slopes: Long slopes of 1 to 3% and 10-20% of 8-10% slopes

Position: Lacustrine plain

Vegetation: dwarf

Comments: Soil covering an extensive area, 30% cover of sand dunes having grass. Sand dunes from 50 cm to 125 cm high. Some regions have sand dunes to 3 m high over 35% of the area,

Classification: sandy mixed hyperthenic Typic Torriorthent

23/2/81 A.D./J.G./F.O.

KOUTABBOUYYA

Site No. 10

Location: 116.9 E
1221.7 N

Land Type:	Marl
0-15 cm:	Sand eolian
15-40 cm:	sandy colluvium over marl
Surface:	Barren
Slope:	10%
Erosion:	many small gullies on the old pleistocene lake bottom

573

1/3/81 A.D./J.G./F.O.

LAC ASSAL

SITE NO. 73

LOCATION: 215.7 E
1284.7 N

Land Type: Marl

Comments: Steep slope thin rubble covered rock barren of vegetation. Very steep. Assal climate zone. The lower slopes are high marly, gypsiferous lacustrine sands. They are barren of vegetation, very steep and hot. Highly dissected. Very windy. Both are miscellaneous land type.

15/3/82 J.G./A.D.

LAHI DADDAEO

Site No. 9

Location: 273.6 E
1317.8 N

0-15 cm: Al horizon; 7.5YR/4/4 brown (dry), 7.5YR/3/4 dark brown (moist); gravelly loam; weak medium and fine subangular blocky structure; loose, friable, nonsticky; many fine roots, 30% gravel; strongly effervescent; clear irregular boundary;

15-30 cm: A3 horizon; 7.5TYR/6/4 light brown (dry), 7.5YR/4/6 strong brown (moist); clay loam; weak and moderate medium subangular blocky structure; firm, friable, slightly sticky; strongly effervescent; many fine fibrous roots; 25% weathered rocks; gradual diffused boundary,

30-45 cm: C horizon; 5YR/5/4 reddish brown (moist); sandy clay loam; weak medium subangular blocky structure; common fine woody roots; 25-30% weathered rocks; white masses of decayed rocks; gradual diffused boundary,

45 cm: Rock

Surface: 60% gravel and cobbles, 10% boulders

Inclusions: 20% rock outcrop, 30% of thicker soil (lower slope)

Slope: 25%

Position: side slope

Parent Material: colluvium and rhyolite

Vegetation: 20% grass, 5% herbs, few brushes (3 m high)

Erosion: Severe gully erosion

Temperature: 25.5 °C

Classification: fine loamy mixed hyperthermic Lithic Torriorthent

23/9/81 A.D./J.G./F.O.

LAMMOUDLEY

SITE NO. 36

Location: 264.2 E
1221.8 N

0-3 cm: All horizon; 10YR/5/4 yellowish brown (dry), 10YR/4/4 dark yellowish brown (moist); gravelly loamy sand; no structure; loose, very friable, nonsticky; common fine woody roots; strongly effervescent; clear irregular boundary,

3-25 cm: A12 horizon; 7.5YR/4/4 brown (dry), 7.5YR/4/6 very dark brown (moist); very strong sandy loam; firm, friable, slightly sticky; strongly effervescent; 70% stones and gravel; the soil fills the interstices; medium woody roots.

Slope: 18%

Comment: Fractured rocks

Parent Material: 20% rock outcrop, 50% colluvium

Vegetation: 10% vegetation: mainly "sallel"

Classification: loamy skeletal mixed hyperthyermic Lithic Torriorthent

576

15/3/82 J.G./A.D.

MAARIGI

Site No. 1

Location: 286.3 E
1323.8 N

0-23 cm: A horizon; 7.5YR/4/4 brown (moist); gravelly clay loam; moderate medium and coarse subangular blocky structure; firm, slightly friable, sticky; common woody roots; not effervescent; mottled grayish brown and reddish brown; clear irregular boundary;

23-65 cm: C horizon; 7.5YR/5/2 brown (moist); gravelly clay loam; 60% gravel; structureless; hard, firm, sticky; not effervescent; few medium woody roots; gradual irregular boundary;

60-110+ cm: C2 horizon; 10YR/6/2 light brownish gray (moist); gravelly loam; 60% gravel; not effervescent.

Surface: 60% gravel, 15% stones and boulders

Inclusions: 10% rock outcrop

Slope: 5-7%

Position: plateau

Parent Material: decayed rock

Vegetation: 20-25% grass, 10% herbs, 5% bushes to 3 m (sarman)

Erosion: severe gully

Temperature: 26.6 ^{o}C

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent.

577

10/3/82 J.G./A.D.

MAGABBALA

Site No. 55

Location: 211.8E
1359.6 N

0-30 cm: A horizon; 10YR/6/3 pale brown (dry), 10YR/5/4 yellowish brown (moist); very cobbly loam; 60% cobbles and stones, 15% gravel; weak medium and fine subangular blocky structure; very fragile, friable, slightly sticky; strongly effervescent; common fine and medium woody roots; continuous $CaCO_3$ coatings on the rock fragments;

Surface: 60% stones, boulders, 40% cobbles and gravel

Inclusions: 40% rock outcrop, 15% typic variant

Slope: 8-10%

Position: Side slope

Parent Material: lava talus and eolian

Vegetation: 5% 50 cm to 2 m shrubs (acacia, herbs)

Erosion: gully erosion

Temperature: 35.4 ^{o}C

Classification: loamy skeletal mixed hyperthermic Lithic Torriorthent.

8/3/81 A.D./J.G./F.O.

MALHADLOU

Site No. 21

Location: 208.7 E
1230.3 N

0-24 cm: A1 horizon; 5YR/5/3 brown (dry), 7.5YR/4/2 dark brown (moist); gravelly sand; structure: none; loose, very friable, nonsticky; 70% gravel and stone of 4-10 cm; strongly effervescent; $CaCO_3$ on all parts of the gravel; smooth and clear boundary;

24-40 cm: B2a horizon; 7.5YR/5/4 brown (dry), 7.5YR/4/6 strongly brown (moist); silty clay loam; weak coarse to medium angular blocky structure; firm, friable, slightly sticky; 2-10 cm $CaCO_3$ concreations and soft powdery $CaCO_3$; strongly effervescent; irregular, diffused boundary;

40-90 cm: B3ca horizon; 7.5YR/4/6 strong brown (dry) 5YR/5/6 yellowish red (moist); silt loam; moderate medium to fine angular blocky; firm, friable, slightly sticky; strongly effervescent; clear and diffused boundary;

90-120+ cm: Cca horizon; 10YR/8/1 white (dry), 10YR/8/4 pale yellow (moist); sandy clay loam; unconsolidated lacustrine marl,

Surface: covered with 60% stones and cobbles volcanic bombs and rounded lacustrine gravel of quartz, calcite and jasper.

Inclusions: Pleistocene lake sediments

Slope: Slopes range from 5 to 25%

Vegetation: 3% vegetation cover: acacia (1-1.5 m) and Aousdameir

Comment: Soil formed on dissected lacustrine marl.

Classification: fine loamy mixed hyperthermic Typic Calciorthid

15/3/82 J.G./A.D.

MANDI

Site No. 41

Location: 262.8 E
1346.4 N

Surface: no soil

Inclusions: 40-50% pediment soils on the lower slopes

Slope: 15%

Position: upper part of the slope on edge of lava plateau

Parent Material: rock outcrop

Vegetation: less than 1% shrubs

Erosion: Severe water and wind

9/3/81 A.D./J.G./F.O.

MINKILLE

Site No. 28

Location: 167.4 E
1292.4 N

0-10 cm: A11 horizon; 10YR/5/3 brown (dry), 10YR/3/3 dark brown (moist); gravelly loam; structure: none; loose, very friable, nonsticky; strongly effervescent; clear and wavy boundary;

10-30 cm: A12 horizon; 10YR/3/2 very dark grayish brown (dry); 10YR/2/1 black (moist); stoney loam; weak medium to fine angular blocky structure; firm friable, slightly sticky; strongly effervescent, irregular and diffused boundary;

30-50+ cm: B horizon; 10YR/3/2 very dark grayish brown (dry), 10YR/2/1 black (moist); stony clay loam; moderate coarse to medium subangular blocky structure; strongly effervescent; hard, friable, slightly sticky;

60 cm (estimated): $CaCO3$ horizon

Surface: Thin fine gravel eolian lay (desert pavement)

Inclusions: Inclusions in the high plateau soils

Slope: Slopes from 1-3%

Parent Material: 40% cobbles volcanic bombs cover

Vegetation: Vegetation cover of 15% (most in the wadi; bilcin, kulan, quduc),

Comments: Colluvial slope in a minor basin on a lava plateau near the wadi.

Classification: fine loamy mixed hyperthermic Pachic Calcustoll

15/3/82 J.G./A.D.

MOULLOULI

Site No. 72

Location: 266.3 E
1348.3 N

0-15 cm: A11 horizon; 10YR/6/4 light yellowish brown (dry), 10YR/5/4 yellowish brown (moist); very gravelly loam; moderate medium subangular blocky structure; firm, friable, slightly sticky; strongly effervescent; clear irregular boundary;

15-35 cm: A12 horizon; 10YR/6/3 pale brown (dry) 10YR/5/4 yellowish brown (moist); very gravelly loam; structureless; firm, friable, slightly sticky; strongly effervescent; continuous $CaCO_3$ coatings on rock fragments; common very fine roots; clear irregular boundary;

35 cm: fractured rock

Surface: 50% gravel, 5% stones

Inclusions: 10% rock outcrop, 10% thicker soil

Slope: 1%

Similar Soils: No. 89

Position: Basaltic lava plateau

Parent Material: eolian and alluvium

Vegetation: Less than 1% (acacia)

Erosion: slight sheet erosion and wind erosion

Temperature: 26.7 ^{o}C

Classification: loamy skeletal mixed hyperthermic Lithic Torriorthent.

26/2/81 A.D./J.G./F.O.

MOULOUD YAR

Site No. 61

Location: 230.3E
1232.8 N

0-18 cm: A horizon; 7.5YR/4/2 brown (dry), 7.5YR/3/2 dark brown (moist); gravelly sandy clay loam; weak medium to fine subangular blocky structure; loose, friable, slightly sticky; strongly effervescent; gradual irregular boundary;

18-47 cm: Aca horizon; 7.5YR/5/2 brown (dry), 7.5YR/3/2 dark brown (moist); gravelly sandy clay loam; moderate medium subangular blocky structure; firm, friable slightly sticky; strongly effervescent, 25% $CaCO_3$ and fine powdery disseminated and masses of 1-3 mm; clear irregular boundary;

47-117 cm: Cca horizon; 10YR/5/3 brown (dry); 10YR/3/3 dark brown (moist); gravelly loam; loose very friable nonsticky; strongly effervescent; fine disseminated $CaCO_3$ and $CaCO_3$ coatings on all parts of the rock fragments.

Surface: Covered with desert pavement of boulders and cobbles (60-70%),

Parent Material: Soil formed on stratified lava flow

Position: 1-3% long flat slopes on alluvial fan,

Vegetation: Aousdamer, acacia (1-4m), kulan,

Comment: Fluvial deposits, strata with 10-50% cbbles and stones at 600 m high.

Classification: loamy skeletal mixed hyperthermic Typic Calciorthid.

15/12/81 A.D./F.O./J.G.

OUDLI

Site No. 30

Location: 254.9 E
1346.7 N

0-40+ cm: CC horizon; 10YR/3/2 very dark grayish brown (dry and moist); very gravelly loam; structureless; loose, friable slightly sticky; 70% gravel and cobbles; common medium woody roots; strongly effervescent; fine disseminated and thin coating of $CaCO_3$ on the cobbles and gravel.

Surface: 80% cobbles and gravel and 20% rock outcrop

Inclusions: 40% rock outcrop and bluffs

Slope: 15%

Position: talus and foot slope

Parent Material: mixed lava flow

Vegetation: 50% cover of acacia 1 to 3 m high

Erosion: gully and wind erosion

Temperature: 28.1 ^{o}C

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent

584

2/12/80 A.D./J.G./F.O.

OUEAH

Site No. 68

Location: 266.4 E
1274.8 N

-25 cm to 0: Rock fragments on the surface (10% boulders, cobbles and stones 40%, gravels 40%),

0-12 cm: A1 horizon; 10YR/5/2 grayish brown (dry), 10YR/3/3 dark brown (moist); very gravelly sandy loam; weak medium to fine subangular blocky structure; loose (dry; friable (wet); nonsticky (moist); many fine and few coarse fibrous roots; fine disseminated and 1 to 4 mm indurated $CaCO_3$; strongly effervescent; 60% gravels and about 10% cobbles and stones; clear and diffuse boundary,

12-50+ cm: C horizon; 10YR/5/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); very gravelly sandy loam; weak fine angular structure; loose, friable nonsticky; 70% gravels, fine disseminated 1 to 4 mm indurated $CaCO_3$, continuous $CaCO_3$ coating on the rocks surface; strongly effervescent; common fine roots,

Inclusions: 20% rock outcrop

Slope: 45% of the slopes are occupied by this soil

Similar Soil: 35% similar lithic entisol

Vegetation: 20% of bilcin and qudac cover

Comment: Colluvial slope mixed ignious rocks, 25 to 40% of slopes on the mountains,

Location: Military firing range at 500 m west of the road at Queah,

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent (about 45% oif the area); loamy skeletal mixed hyperthermic Lithic Torriorthent (about 35% of the area).

22/2/81 A.D./F.O.L/J.G.

OUMADA

Site No. 45

Location: 296.1 E
1251.5 N

0-15 cm: A horizon; 5YR/5/6 yellowish red (dry), 2.5YR/3/6 dark red (moist); silt loam; moderate coarse and medium subangular blocky; firm, friable, nonsticky; common fine fibrous roots; strongly effervescent; gradual wavy boundary;

15-31 cm: B1 horizon; 2.5YR/3/6 dark red (moist and dry); silt loam; strong coarse and medium angular blocky structure; few fine fibrous roots; strongly effervescent; 2-5 mm soft powdery $CaCO_3$; gradual wavy boundary;

31-60 cm: B2 horizon; 2.5YR/3/4 dark reddish brown (dry and moist); silty clay loam; strong coarse subangular blocky structure; hard, friable, slightly sticky; strongly effervescent; 2% 2-5 mm powdery masses of $CaCO_3$,

60-80+ cm: B3 horizon; 2.5YR/3/4 dark reddish brown (dry and moist); clay loam; 20% 2-4 mm white unweathered minerals; weak medium angular blocky structure; strongly effervescent; 10% fine gravel,

Surface: 80% cobbles and boulders,

Slope: 0-2%

Parent Materials: Eolian mantle

Vegetation: Spotty, in the spots the cover is 10% and represents 60% of the area (sarman, cadad),

Classification: fine loamy mixed hyperthermic Typic Camborthid.

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20/12/81 A.D./F.O./J.G./M.J.

RAYSALI

Site No. 80

Location: 276.6E
1303.5 N

0-15 cm: A horizon; 10YR/5/3 brown (dry), 10YR/3/3 dark brown (moist); very gravelly sand; structure: none; weakly cemented; loose, friable, nonsticky; 60% gravel; few fine woody roots; moderately effervescent; clear wavy boundary,

15-5-+ cm: Cca horizon: 10YR/5/3 brown (dry), 10YR/4/3 dark brown (moist); very gravelly sandy loam; structure: none; loose, friable, nonsticky; strongly effervescent; fine disseminated and thin coating of $CaCO_3$ on the gravel and stones; common fine and medium woody roots,

Surface: 80% gravel and 10% cobbles and stones

Inclusions: 5% rock outcrop (lava bluff) and 10% plateaus

Slope: 20-25%

Position: Side slope

Parent Material: ancient alluvial delta

Vegetation: 15% "binin and Jirme."

Erosion: Severe gully erosion

Temperature: 30.1 ^{o}C

Classification: loamy skeletal mixed hyperthermic Typic Calciorthid

RIFFUR-DAMOUN

Site No. 4

Location: 168.3 E
1273.2 N

0-42 cm: A horizon; 7.5YR/4/4 brown (dry), 7.5YR/4/4 brown (moist); clay loam; strong coarse to medium angular blocky structure; hard, very firm, sticky; strongly effervescent; few medium woody roots; clear and diffused boundary;

42-80+ cm: Cna horizon; 7.5YR/3/4 dark bgrown (dry), 7.5YR/4/4 brown (moist); silty clay loam; moderate coarse to medium angular blocky; strongly effervescent; hard, friable, slightly sticky; 10-15% 1-3 mm sodium sale concretions; few coarse woody roots.

Surface: Barren

Position: Lake plain

Temperature: Windy, hot and dry.

Comments: Mud cracks on the surface (3 to 5 cm; at 20 cm deep to the surface, cracks of 1 cm wide,

Classification: fine loamy mixed hyperthermic Typic Salorthid (except for a).

13/12/81 A.D./F.O./J.G.

SADAI

Site No. 50

Location: 283.9 E
1340.3 N

Land Type:	Wadi channel
Surface:	Boulders and cobbles represent 30 to 60% of the mass
Slope:	Less than 1%
Vegetation:	Rare acacia
Comment:	Wadi channel; stratified sand, gravels and boulders subject to frequent inundation; channels change with storms; this will be the coarse textural wadi channel;
Temperature:	28.3 ^{o}C

10/3/82 A.D./J.G.

SAEIDA DALA

Site No. 5

Location: 196.17 E
1344.3 N

Land Type: Lava flow

Inclusions: 5% inclusions of small playa areas

Slope: 1-3%

Parent Material: Lava flow and rock outcrops only,

Vegetation: Less than 1% vegetation.

SAKHISSO

Site No. 59

Location: 159 E
1255 N

Surface: No sample taken,

Similar Soil: Similar to Site No. 70 DEROKKOMA,

Classification: fine loamy mixed hyperthermic Typic Camborthid.

591

8/12/81 J.G./A.S./F.O.

SARIG

Site No. 54

Location: 290.1 E
1390.8 N

0-25 cm: C1 horizon; 10YR/4/2 dark grayish brown (dry), 10YR/3/2 very dark grayish brown (moist); sand; structure: none; loose, very friable, nonsticky; weakly stratified strongly effervescent; 20% gravel; clear irregular boundary;

25-60 cm: C2 horizon; 10YR/5/4 yellowish brown (dry), 10YR/3/4 dark yellowish brown (moist); sand; weak medium subangular blocky structure; weakly stratified; slightly hard cemented; very strongly effervescent; clear irregular boundary;

60-70+ cma; C3 horizon: 10YR/5/2 grayish brown (dry), 7.5YR/3/2 dark brown (moist); gravelly sand; structure: none; loose, friable, nonsticky; about 50% gravel,

Surface: 15% cobbles and 90% fine gravel

Inclusions: 10% rills, 2% small 20 cm sand dunes

Slope: 0-1%

Parent Material: Alluvium (alluvial fan) silt, sand and gravel

Vegetation: rare, 2% bush (woody...)

Erosion: High wind erosion and moderate rill erosion

Classificatin: sandy mixed hyperthermic Typic Torriorthent

15/3/82 J.G./A.D.

SAROU

Site No. 2

Location: 270.9 E
1387.2

0-15 cm: All horizon; 10YR/5/4 yellowish brown (dry); 10YR/4/6 dark yellowish brown (moist); very gravelly loam; weak medium and fine subgranular blocky; fragile, friable, slightly sticky; strongly effervescent; thin $CaCO_3$ coatings on rock fragments; 80% gravel and cobbles; gradual irregular boundary;

15-40 cm: A12 horizon; 7.5YR/4/4 brown (dry), 7.5YR/3/4 dark brown (moist); very gravelly loam, 80% gravel and cobbles; strongly effervescent; thin $CaCO_3$ coatings on rock fragments; few fine roots,

40 cm: Rock

Surface: 100% gravel, cobbles and stones

Inclusions: 20% rock outcrop, 10% waterways

Slope: 12%

Position: Side slope (of a mountain)

Parent Material: rhyolite (talus)

Vegetation: None, 2% on the waterways

Erosion: Severe water erosion

Temperature: 32.6 ^{o}C

Classification: loamy skeletal mixed hyperthermic Lithic Torriorthent

593

9/3/81 A.D./J.G./F.O.

SEKAYTO

Site No. 96

Location: 168.5 E
1293.5 N

0-15 cm: A horizon; 7.5YR/4/4 dark brown (dry), 7.5YR/3/3 dark brown (moist); clay loam; weak coarse to medium subangular blocky to platy structure; firm, friable; slightly sticky; common fine woody roots; strongly effervescent; clear and wavy boundary;

15-34 cm: B21 horizon; 7.5YR/4/3 dark brown (dry), 7.5YR/3/2 dark brown (moist); clay loam; moderate medium subangular blocky structure; strongly effervescent; common fine woody roots; gradual and wavy boundary;

34-50+ cm: B22 horizon; 7.5YR/3/2 dark brown (dry), 7.5YR/3/2 dark brown (moist); clay loam; moderate coarse to medium subangular blocky structure; hard friable, slightly sticky; 2% 0.5 to 1 mm indurated CaCO3; few coarse woody roots,

60 cm (estimated): CaCO3 horizon

Surface: 80% stones and boulders to 1 m porous volcanic bombs on the surface,

Slopes: From 1-8%

Vegetation: Cover of 109% of 1-kl.5 m (carancar, dacar, bilcin, gimar),

Comments: Soil comprised of loess

Classification: find loamy mixed hyperthermic Pachic Calciustoll

15/3/82 J.G./A.D.

SIDIHA MENGALA

Site No. 13

Location: 267.3 E
1362.5 N

0-20 cm: A horizon; 10YR/5/4 yellowish brown (dry), 7.5YR/4/4 brown (moist); very stony loam; structureless; loose, friable, slightly sticky; 70% stones and cobbles; thin $CaCO_3$ coatings on rock faces; strongly effervescent; clear irregular boundary;

20-35 cm: Bca horizon; 5YR/5/4 reddish brown (dry), 5YR/4/4 reddish brown (moist); very gravelly loam; 70% gravel; loose, friable, slightly sticky; continuous medium $CaCO_3$ coatings on rock fragments; strongly effervescent; clear irregular boundary;

35 cm: Rock, fractured

Surface: 80% gravel, 20% stones,

Inclusions: 15% of a soil, 20 cm thicker,

Slope: 2%

Position: lava plateau along WEEIMA wadi,

Parent Material: Fractured basaltic lava

Vegetation: Very sparce acacia

Erosion: none to slight water erosion

Temperature: 33.8 ^{o}C

Classification: loamy skeletal mixed hyperthermic Lithic Calciorthid.

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16/3/81 A.D./J.G./F.O.

SOULAYTOU

Site No. 81

Location: 183.6 E
1304.7 N

0-50 cm: A horizon; 10YR/2/2 very dark brown (moist); gravelly sandy clay loam; weak medium to fine angular blocky structure; firm, friable, slightly sticky; many fine fibrous roots; 50% 2-15 cm gravel and cobble thin $CaCO_3$ coating on all parts of the stones; irregular diffused boundary;

50-90 cm: C horizon; 10YR/5/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); very gravelly sand; structure: none; loose, very friable, 40% 5-20 mm gravel and 40% 20-40 cm stones and boulders; strongly effervescent; thin $CaCO_3$ coating on all parts of the gravel, stones and cobbles; a few fine fibrous and woody roots; irregular diffused boundary;

90-150 cm: C horizon; 10YR/4/3 dark brown (moist); very bouldery sand; structure: none; loose, very friable; strongly effervescent; 80% gravel, stones, cobbles and boulders; thin $CaCO_3$ coating on all parts of the major fraction,

Surface: 80% cover of stones and boulders (desert pavement)

Position: Wadi terrace

Vegetation: 5% vegetation cover in the wadis and ravines (Cadad, Aousdameir, Wan'ad),

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent.

24/5/81 A.D./J.G./F.O.

SOUNNATI

Site No. 23

Location: 166.4 E
1244.3 N

0-17 cm: A horizon; 10YR/4/3 brown (dry), 10YR/3/3 dark brown (moist); loam; moderate medium to fine subangular blocky structure; firm, friable, slightly sticky; strongly effervescent common fine roots; gradual and smooth boundary;

17-63 cm: B horizon; 10YR/3/4 brown (dry), 10YR/3/3 dark brown (moist); loam; strong coarse to medium angular blocky structure; firm; friable; slightly sticky; few fine roots; strongly effervescent; rare 1 to 2 mm hard pitted $CaCO_3$; gradual and wavy boundary;

63-120+ cm: C horizon; 15YR/3/2 dark brown (moist); clay loam; structureless; strongly effervescent; rare 1 to 5 mm hard pitted $CaCO_3$,

Surface: 90% cobbles, stones, and boulders on the surface,

Slope: 5%

Parent Material: Loess on lava flows

Vegetation: Weeds (magal xid, xarfe), temporary grass,

Comments: 15% cobbles, stones, and boulders in the soil profile; very light coating of $CaCO_3$ on the bottom of the rocks,

Classification: fine loamy, mixed, hyperthermic, Aridic Calciustoll

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10/3/82 J.G./A.D.

TAGADDO

Site No. 29

Location: 230.5 E
1307.7 N

0-40 cm: A horizon; 5YR/3/3 dark reddish brown (dry); 5YR/3/2 dark reddish brown (moist); very stoney loam; 40% stones and boulders; 20% gravel and cobbles; weak medium subangular blocky structure; breaking to moderate medium crumb; slightly firm, friable, slightly sticky; many fine, medium and coarse woody roots; strongly effervescent; gradual irregular boundary;

40-60+ cm: C horizon; 7.5YR/4/6 strong brown (dry), 7.5YR/3/4 dark brown (moist); very stony loam; 40% stones and boulders, 20% gravel and cobbles; weak medium subangular blocky structure; firm, friable, nonsticky; common medium woody roots; $CaCO_3$ coatings on rock fragments and 1 to 2 mm soft powdery $CaCO_3$; strongly effervescent,

Elevation: 1150 m

Surface: 60% stones and boulders, 35% cobbles

Slope: 5%

Position: crest of the cuesta

Parent Material: basaltic lava, talus

Vegetation: 10% 2 m high acacia, 20% herbs, 10% grass

Erosion: severe water erosion

Temperature: 29.0 ^{o}C

Classification: loamy skeletal mixed hyperthermic Aridic Haplustoll

10/3/81 A.D./J.G./F.O.

WANNI DAEAR

Site No. 53

Location: 155.2 E
1282.2 N

0-5 cm: A1 horizon; 10YR/5/3 brown (dry); 10YR/3/4 dark yellowish brown; gravelly silt loam; moderate medium to fine angular blocky; firm, friable; slightly sticky; strongly effervescent; clean and irregular boundary;

5-25+ cm: C horizon; 2.5YR/7/2 light gray (dry); 2.5YR/4/2 dark grayish brown (moist); marly sand; structure: none; loose, very friable, nonsticky, strongly effervescent,

Surface: About 30-35% cobbles and stones in the profile; about 80% surface covered by boulders, stones and cobbles up to 1 m.

Inclusions: Other areas of this soil range down to 5 cm of gravel; at the surface over marly lacustrine sand,

Slope: ranges from 5% (smooth) to 25% (rolling)

Position: This is a recently dissected lacustrine, offshore sediments,

Vegetation: Wan'cart (rare)

Classification: coarse loamy mixed hyperthermic Typic Torriorthent

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LABORATOIRE D'ANALYSE DES SOLS ET DES EAUX

RÉPUBLIQUE DE DJIBOUTI

APPENDIX I

EXHIBIT
REPORT ON NATIONAL SOIL SURVEY FOR DJIBOUTI

APPENDIX I

REPORT ON NATIONAL SOIL SURVEY FOR DJIBOUTI

1.0 INTRODUCTION

The national soil inventory was undertaken in this project to supply Djibouti with suitable basic information to make decisions on land use development. This includes water recharge, agricultural development, rangeland development, resettlement and engineering projects. This inventory also made it possible to prioritize the best soils areas with the best water supplies for agricultural development. Photos I-1 through I-20 are pictures of the various soils found throughout Djibouti.

This inventory will permit more rational and informed planning in development. It provides enough information to make preliminary decisions on development use and location. When more detailed information is needed a more detailed study can be made. Development need no longer be delayed for lack of soils information

Section 2.0 of this appendix is a description of mapping procedures used in the inventory. Section 3.0 contains a description of soils mapping units and the extent to which each unit occurs in the country. Section 4.0 shows the locations of the random sample sites and contains both a key to the soils interpretation and the soils interpretations of the random sample sites.

Photo I-1: Road crossing Dada soil to Mouloud. The houses are on Queah soil.

Photo I-2: Sadai Wadi channel. A good site for fruit due to vicinity of good water and frequent floods.

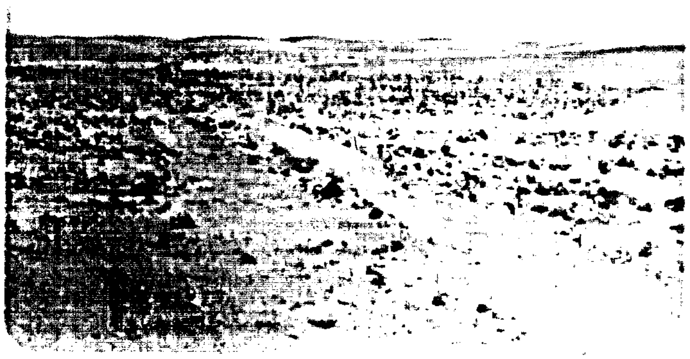

Photo I-3: Dunes are drifting on Aada soil in the Gagade playa.

Photo I-4: Wadi channel and Didjan Der terrace with the brush. Soil in foreground is Eada Gafan.

Photo I-5: Aboubaker Douale describes a Queah soil

Photo I-6: Mountainous Lahi Daddaeto soil. Water runs off well near Kohr Angor

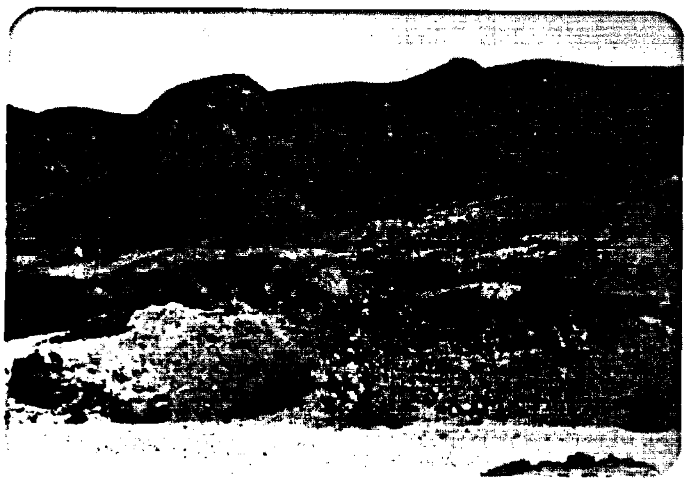

Photo I-7: Another example of Lahi Daddaeto soil near Yoboki

Photo I-8: A talus footslope

Photo I-9: Boulder cover north of country. In this case, they cover the Balambal soil.

Photo I-10: This is Riffor Damoun soil being flooded. The water evaporates and leaves the white salt in foreground.

Photo I-11: An Aada soil when flood-water can infiltrate and pass out of the bara. Trees grow well here.

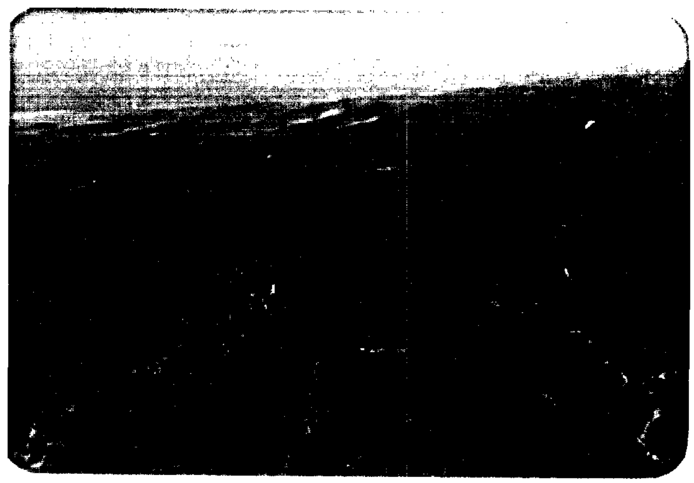

Photo I-12: The Al Kiba and Dimo le Boda complex of soils on cuestas. Note nomad trail on crest of cuesta.

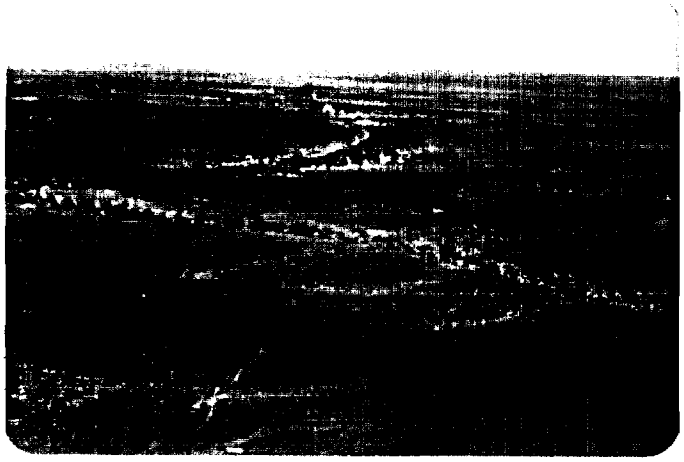

Photo I-13: The Daba Eabdalle soil on the Eas Galan plateau

Photo I-14: This wadi is flooding between Didjan Der and Queah soils

Photo I-15: The town of Easa Galan above the wadi channel and Didjan Der soil

Photo I-16: The canyon is lined with Holl-Holl soil. Jaban Eas soils occur on the plateaus

Photo I-17: The Maarigi soil, a prairie soil, high in the mountains between Obock and Tadjoura

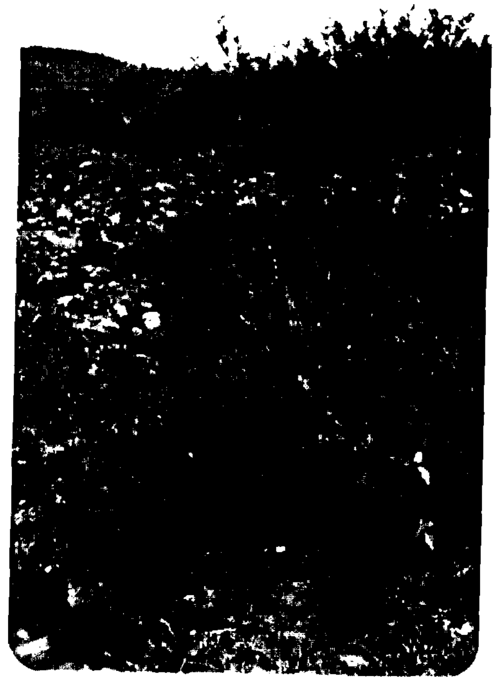

Photo I-18: Vegetation that occurs on Lahi Daddaeto soil

Photo I-19: Lava cliff with a cave between lava floor. Soil above is the Daba Eabdalle

Photo I-20: Soil is the very thin, high, wind-swept Galaytou

2.0 MAPPING PROCEDURE

This soil survey was conducted by first selecting 100 randomly distributed sites throughout the country as specific objectives to search out and describe. All of the sites were visited. The first attempt was made by all terrain vehicle and the remainders by helicopters.

A significant soil was picked within the one square kilometer site and thoroughly described in profile and geomorphic distribution. On site the relationships between soils was estimated and clarrified. The UTM coordinate numbers were used to identify the sites along with a local site name. All of this information was acquired and recorded on the 1:100,00 topographic map.

These sites were then located on 1:500,000 colored Landsat image and the photographic characteristics identified and mapped-out in similar areas. This was aided by familiarity with the ground. This information was then enlarged and compared to the features of the 1:100,000 topographic maps and the slope maps. The final map resulted from the judicious comparison of the previous information and the final soil lines were established. The map is registered to positive film factor of the 1:100,000 topographic map and drafted on mylar to faclitate reproduction. Copies can be obtained from the laboratory.

3.0 NATIONAL SOIL MAPPING UNIT DESCRIPTION

3.1 Soils Mapping Symbols and Random Sample Site Inclusions

(1:100,000 Soils Map)

Map Symbol	Series Name
Aa 15	Aada
AD 9	Afnada Daba
AK 33	Al Kibo - Easa Galaw
Ar 9	Arta - Dagah Dere
At 1	Atar - Eoulma
Aw 6	Awdiea
Ba 16	Balambal - Derokoma
DA 16	Daba Eabdalle
DG 1	Dabagalaley
DD 10	Dagah Dere -.Goendale Madobe
Da 9	Damerkaddae - Afnaba Daba
Di 5	Didjan Der
DB 33	Dimo Le Boda
Dt 10	Dita
EG 12	Eado Gafan
Ea 31	Eangalalo
Eo 4	Eoulma
Ga 16	Garrayto
GB 12	Grand Bara
Ha 10	Hadkodley
HH 27	Holl-Holl - Afmeeaytou
JA 16	Jaban Eas - Guistir
Kl 4	Kallolou
Kn 4	Kenannaba
LD 9	Lahi Daddaeo - Afnaba Daba
Ou 9	Oueah - Degamankal
RD 12	Riffor Damoun
WD 13	Wanni Daear - Malhadlou
17	Lava flow
19	Wadi Channel
20	Beach
22	Salt
25	Mud flat
28	Marl
29	Coral slopes

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3.2 Mapping Unit Predominance

The following chart shows the amount of each soil mapping unit in the country in square kilometers.

Aa 15	Aada	483
AD 9	Afnaba Daba	807
AK 33	Alkibo - Easa Galaw	371
Ar 9	Arta - Daga Dere	1100
At 1	Atar - Eoulma	90
Aw 6	Awdiea	442
Ba 16	Balambal - Derokoma	2772
DA 16	Daba Eabdalle	1381
DG 1	Dabagalaley	277
DD 10	Dagah Dere - Goendole Madobe	66
Da 9	Damerkaddae - Afnaba Daba	1219
Di 5	Didjan Der	298
DB 33	Dimo le Boda	543
Dt 10	Dita	741
EG 12	Eado Gafan	504
Ea 31	Eangalalo	169
Eo 4	Eoulma	363
Ga 16	Garrayto	309
GB 12	Grand Bara	1562
Ha 10	Hadkodley	156
HH 27	Holl-holl - Afmeeayton	1108
JA 16	Jabaneas - Guistiv	1099
KI 4	Kallolou	582
LD 9	Lahi Daddaeo-Afnabadaba	1108
Ma 16	Maarigi	144
Ou 9	Oueah - Degamankal	1840
RD 12	Riffor Damoun	517
WD 13	Wanni Daear - Malhadlou	566
17	Lava flow	1030
19	Wadi Channel	510
20	Beach	8
22	Salt	61
25	Mud flat	136
28	Marl	169
29	Coral Slopes	7

3.3 Soils Mapping Units

The following section contains the following descriptions of the soils mapping units.

Symbol: AA 15

Name of the Principal soils: Aada

Location and distribution: In playas distributed around the country.

Climate: Hot and dry, local dust devils in the daytime, winds coming down from the local mountains at night.

Predominance in the country: Minor soil in the country.

Composition of Mapping Units:

1) Name of the Soil Series: Aada

Classification: coarse loamy, mixed hyperthermic, Typic Camborthid.

Brief Description: Deep dark brown silt loam with up to 50 cm. of sand cover.

Percentage of the mapping unit:

Geomorphic position: Occurs alongside of the playas in the sandy alluvium that covers the old lacustrine silts and clays.

Parent Material: alluvium

Slope: 2%

Dominant uses: pasture and irrigated agriculture.

Symbol: AD 9

Name of principal soils: Afnaba Daba

Composition of Mapping Units:

1) Name of the soil series: Afnaba Daba

Classification: loamy skeletal (shallow), mixed hyperthermic Typic Torriorthent.

Brief description: Very shallow brown very gravelly sandy loam soil.

Percentage of the mapping unit: 50%

Geomorphic position: Talus slope.

Parent Material: ryolitic Talus, rhrolite Talus.

Slope: 10-20%

Dominant uses: Watershed and range.

Minor inclusions: 40% rock outcrop represents major use for watershed, 10% Goray Eeeb and, 10% Easa Gelaw.

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Symbol: AK 33

Name of principal soils: Al Kibo - Easa Galaw

Location and distribution: Occurs north and west of Lac Assal.

Climate: Hot and dry

Predominance in the country: Limited soil in the country.

Composition of Mapping Units:

1) Name of the soil series: Al Kibo

Classification: coarse loamy, mixed hyperthermic, Typic Calciorthid.

Brief description: Moderately deep pale brown very stony clay loam underalin by brown loam and sandy loam with accumulation of calcium cabonate in entire profile.

Percentage of the mapping unit: 50%

Geomorphic position: Plateaus in a cuesta position.

Parent Material: thin eolian material over lava flow, igneous lava rock.

Slope: 1-3%

Dominant uses: range and watershed.

2) Name of soil series: Easa Galaw

Classification: Loamy skeletal, mixed hyperthermic, Typic Calciorthid.

Brief description: Shallow, brown very cobbly sandy loam over light brownish gray very stoney clay loam with calcium carbonate accumulations.

Percentage of the mapping unit: 40%

Geomorphic position: Talused alluvium.

Parent Material: Indurated igneous rock.

Slope: 15-25%

Dominant uses: range and watershed.

Minor inclusions: 10% of area is rock outcrop. Steep slopes over 20%, mostly igneous material.

Symbol: Ar 9

Name of principal soils: Arta-Dagah Dere

Location and Distribution: well distributed around the country.

Climate: warm and dry or moist.

Predominance in the country: moderate extent.

Composition of Mapping Units:

1) Name of the soil series: Arta

Classification: Loamy skeletal, mixed hyperthermic, Aridic Calciustoll (Torriorthent?).

Brief discription: moderately deep soil, very gravelly silt loam or very gravelly clay loam, some calcium carbonate at about 40-70 cm., color is dark yellowish brown to yellowish brown.

Percentage of mapping unit: 40%

Geomorphic position: mountain side slope, Talus.

Parent Material: Talus

Slope: 15-50%

Dominant uses: Range and watershed.

2) Name of soil series: Dagah Dere

Classification: loamy skeletal, mixed hyperthermic, Lithic Torriorthent.

Brief description: less than 50 cm. thick, yellowish brown to brown, very gravelly sandy loam.

Percentage of the mapping unit: 30%

Geomorphic position: upper part of the steep mountain slopes.

Parent Material: thin colluvium.

Slope: 15-50%

Dominant uses: watershed and range Talus without a soil formation represents about 10% of the mapping unit and occurs in the interior of the country where soil formation has occured. About 20% of the mapping unit is rock outcrop which is suitable for watershed, as is the Talus.

Symbol: At 1

Name of principal soil: Atar - Eoulma

Location and distribution: along the southern coast.

Climate: hot and humid

Predominance in the country: minor soil in the country.

Composition of Mapping Units:

1) Name of the soil series: Atar

Classification: fine loamy, mixed hyperthermic, Typic Calciorthid.

Brief discription: Thick soil, over 150 cm. thick, dark brown to dark reddish brown or stony brown sandy loam over a slit loam, calcium carbonate and calcium sulfate in the lower part of the profile.

Percentage of the mapping unit: 60%

Geomorphic position: coastal plain

Parent Material: recent marine sediments.

Slope: 1-3%

Dominant uses: range and limited irrigated agriculture.

2) Name of soil series: Eoulma

Classification: sandy, mixed hyperthermic, Typic Torriorthent.

Brief description: sandy soil with a pale brown sandy clay loam, sandy loam or sand over a dark brown sand, thick soil.

Percentage of the mapping unit: 30%

Geomorphir position: recent alluvium or eolian sands from nearby alluvial deposits.

Parent Material: sand

Slope: 1-2%

Dominant uses: Irrigated agriculture and range.

Symbol: Aw 6

Name of principal soil: Awdiea

Location and distribution: dominantly located in the north part of the country.

Climate: hot and dry

Predominance in the country: minor soil in the country.

Composition of Mapping Units:

1) Name of the series: Awdiea

Classification: coarse loamy, mixed hyperthermic, Typic Calciorthid.

Brief description: moderately deep soil, more than 50 cm. thick, light brownish gray or grayish-brown, gravelly sandy loam with some calcium carbonate on the gravel.

Percentage of the mapping unit: 50%

Geomorphic Position:

Parent Material: ingeous rock.

Slope: 15-20%

Dominant Uses: Range and watershed.

2) Name of the soil series: Dita

Classification: loamy skeletal, mixed hyperthermic, Lithic Calciorthid.

Brief description: thin soil, less than 50cm., pale brown or pinkish gray gravelly loam or gravelly sandy loam with a calcium carbonate layer below 10%.

Percentage of the mapping unit: 20%

Geomorphic Position: Colluvial valley and pediment slope.

Parent Material: ryolitic colluvium

Slope: 1-8%

Dominant Uses: range and watershed also includes 20% rock outcrop, steep slopes that are 25%, principal use is watershed.

Symbol: Ba 16

Name of principal soil: Balambal - Derokoma

Location and distribution: all over the country west of the mountain ranges, and the plateaus.

Climate: warm and dry

Predominance in the country: one of the major soils in the country.

Composition of Mapping Units:

1) Name of the soil series: Balambal

Classification: fine loamy mixed hyperthermic, Typic Calciorthid.

Brief description: between 50-75 cm. thick, yellowish-red to dark reddish-brown, stony clay loam.

Percentage of the mapping unit: 40%

Geomorphic position: eolian material on the lava plateau.

Parent Material: Eolian silt and sand

Slope: 1-3% sometimes up to 5%

Dominant uses: range

2) Name of the soil series: Derokoma

Classification: fine loamy, mixed hyperthermic Typic Torriorthent.

Brief description: 75-125 cm. thick, dark brown or brown, stony sandy clay loam B horizon.

Percentage of the mapping unit: 30%

Geomorphic Position: on the lava plateau

Parent Material: eolian mantle

Slope: 1-5% mostly 1-2%

Dominant uses: range.

Minor inclusion of 10% Easa Do and 10% of Garrayto are included in this mapping unit.

Symbol DG 1

Name of principal soil: Dabagalaley

Location and distribution: next to the coast in both the north and the south part of the country just above the high tide zone.

Climate: hot and humid.

Predominance in the country: limited, minor soil in the country.

Composition of Mapping Units:

1) Name of the soil series: Dabagalaley

   Classification: fine loamy, mixed hyperthermic, Aeric Halaquept.

   Brief description: brown sandy clay loam saturated below 10-40 cm., underlain by stratified gravel, sand and silt at about 40 cm. May have very thin loamy sand overburden.

   Percentage of the mapping unit: 70%

   Geomorphic position: coastal plain.

   Parent Material: recent marine sediments.

   Slope: 0-1%

   Dominant uses: no suitable uses.

Symbol: DA 16

Name of principal soil: Daba Eabdalle

Location and distribution: located in the plateaus and the mountainous regions around the country.

Climate: moderate and dry.

Predominance in the country: Dominant soil.

Composition of Mapping Units:

1) Name of the soil series: Daba Eabdalle

Classification: fine loamy mixed hyperthermic, Aridic Calciustoll.

Brief discription: moderately deep 50-100 cm., reddish brown or dark reddish brown, silt loam, many stones, weak mollic epipedon in the surface, yellowish red gravelly silty clay loam below and about 40 cm.

Percentage of the mapping unit:

Geomorphic position: on lava plateaus

Parent Material: eolian mantle

Slope: 1-3%

Dominant uses: range

2) Name of the soil series: Minkille

Classification: fine loamy, mixed hyperthermic, Pachic Calciustoll

Brief description: millic epipedon more than 50 cm. thick, it is dark grayish brown, stony loam or stoney clay loam.

Percentage of the mapping unit: 20%

Geomorphic position: plateau

Parent Material: eolian, sometimes local alluvium

Slope: 1-2%

Dominant uses: range.

Minor inclusion of 10% inclusion of Talus which is useful for watershed, with a slop of less than 10%.

Symbol: DD 10

Name of principle soil: Dagah Dere-Goendale Madobe

Location and distribution: Eli Sabieh region and mountainous region of Obock.

Climate:

Predominance in the country: minor soil.

Composition of Mapping Units:

1) Name of the soil series: Dagah Dere

Classification: loamy skeletal, mixed hyperthermic, Lithic Torriorthent.

Brief description: less than 50 cm. thick, yellowish brown, very gravelly sandy loam over rock.

Percentage of the mapping unit: 50%

Geomorphic position: on rolling hills.

Parent Material: rhyolite

Slope: 8-15%

Dominant uses: watershed and range.

2) Name of the soil series: Goendale Madobe

Classification: Loamy skeletal, mixed hyperthermic, Typic Calciorthid.

Brief description: less than 50 cm. thick, over fractured rock, dark brown to light yellowish brown gravelly sandy clay loam with a calcic horizon.

Percentage of mapping unit: 30%

Geomorphic position: Talus or mountain slopes

Parent Material: rhyolitic sandstone

Slope: 15-20%

Dominant Uses: watershed and range.

Symbol Da 9

Name of principal soil: Damerkaddae - Afnaba Daba

Location and distribution: in the ryolitic mountain zones throughout the country near Eli Sabieh and north of Tadjoura

Climate: Usually warm and dry

Predominance in the country: moderately dominant soil in the country.

Composition of Mapping Units:

1) Name of the soil series: Damerkadda

Classification: sandy skeletal, mixed hyperthermic, Typic Torriorthent.

Brief description: thick, yellowish brown to strong brown very gravelly sand and very gravelly sandy loam.

Percentage of the mapping unit: 40%

Geomorphic position: mountain side slope and Talus

Parent Material: Colluvium

Slope: 15-20%

Dominant uses: range and watershed.

2) Name of soil series: Afnaba Daba

Classification: loamy skeletal mixed hyperthermic, Typic Torriorthent.

Brief description: very thin soil, less than 25 cm. brown very gravelly sandy loam.

Percentage of the mapping unit: 40%

Geomorphic position: on high slopes of the mountain above the Talus.

Parent Material: thin talus or colluvium

Slope: 20-50%

Dominant uses: watershed and range

Minor inclusions: other soils included: Arraha Ommane 10%, Da Le Dola 10%.

Symbol: Di 5

Name of principal soil: Didjan Der

Location and distribution: along streams and terraces throughout the country.

Climate: hot and dry or warm and dry

Predominance in the country: minor

Composition of Mapping Unit:

1) Name of the soil series: Didjan Der

Classification: loamy skeletal, mixed hyperthermic, Typic Torriorthent.

Brief description: thick stony and very gravelly soil with a dark brown sandy clay loam, has a calcium carbonate layer over 200 cm. thick.

Percentage of the mapping unit: 70%

Geomorphic position: terraces

Slope: 1-3%

Dominant uses: irrigated agriculture and range land.

Minor inclusions: about 15% stream channels 10% side slopes and the Eoulma soil.

Symbol: DB 9

Name of principal soil: Dimo le Boda

Location and distribution: north of Lac Assal region in the questor mountains.

Climate: hot and dry

Predominance in the country: minor

Composition of Mapping Unit:

1) Name of the soil series: Dimo le Boda

Classification: loamy skeletal, mixed hyperthermic, Aridic Haplustoll

Brief description: thin soil less than 50 cm. thick over fractured rock, dark brown stony loam.

Percentage of the mapping unit: 50%

Parent Material: colluvium and Talus

Slope: 10-30%

Dominant uses: watershed and range

Minor inclusions: 40% of a Lithic variant that has been undescribed but recognized and suitable for watershed also 15% Minkille.

Symbol: Dt 10

Name of principal soil: Dita

Location and distribution: in and along coastal mountains.

Climate: hot and humid.

Predominance in the country: minor soil.

Composition of Mapping Units:

1) Name of the soil series: Dita

Classification: loamy skeletal, mixed hyperthermic, Lithic Calciorthid.

Brief description: less than 50 cm. thick, pale brown and pinkish gray gravelly sandy loam and gravelly loam with a Ca CO3 layer.

Percentage of the mapping unit: 70%

Geomorphic position: rolling hills.

Parent Material: coluvial side slopes or pediment sediments.

Slope: 3-10%

Dominant uses: watershed and range.

Minor Inclusions: 15% waterways; 10% rock outcrop.

Symbol: EG 12

Name of principal soil: Eado Gafan

Location and distribution: on the lower end of the larger playas

Climate: hot and dry

Predominance in the country: minor soil

Composition of Mapping Units:

1) Name of the soil series: Eado Gafan

Classification: sandy, mixed hyperthermic, Typic Torriorthent.

Brief description: yellowish brown to brown sand has lavinations of sandy loam up to 2 cm. thick below 10-20 cm.

Percentage of the mapping unit: 70%

Geomorphic position: lacustrine playa

Parent Material: old lacustrine sediments

Slope: 0-1%

Dominant uses: none

Minor inclusions: up to 20% Eoulma and sand dunes.

Symbol: Ea 31

Name of principal soil: Eangalalo

Location and distribution: northern part of the country near the northern border.

Climate:

Predominance in the country: minor soil

Composition of Mapping Units:

1) Name of the soil series: Eangalalo

Classification: fine loamy, mixed hyperthermic, Typic Natrargid.

Brief description: 50-100 cm. thick, brown to yellowish red sandy clay loam has a weak B horizon.

Percentage of the mapping unit: 70%

Geomorphic position: colluvial plain

Parant Material: alluvium

Slope: 0-1%

Dominant uses: irrigated agriculture and range.

Minor inclusions: 10% waterways and few areas with dunes up to 75 cm. high.

Symbol: Eo 4

Name of principal soil: Eoulma

Location and distribution: on the coastal side of the country in association with the colluvial fans.

Climate: hot and humid

Predominance in the country: minor soil

Composition of Mapping Units:

1) Name of the soil series: Eoulma

Classification: sandy mixed hyperthermic, Typic Torriorthent.

Brief Description: thick soil, over 200 cm. of pale brown or brown sand, essentially no structure of character.

Percentage of the mapping unit: 60%

Geomorphic position: alluvial plains, alluvial terraces.

Parent Material: alluvium

Slope: 0-35%

Dominant uses: irrigated agriculture and rangeland.

Minor inclusions: 15% waterways, 20% of the area is covered with dunes up to 30 cm. high.

Symbol: Ga 16

Name of principal soil: Garrayto

Location and distribution: high plateaus in northern part of the country, limited distribution.

Climate: mild to cool.

Predominance in the country: minor soil.

Composition of Mapping Units:

1) Name of the soil series: Garrayto

Classification: loamy skeletal, mixed hyperthermic, Lithic Torriorthent.

Brief description: thin soil, less than 40 cm. thick, light brown to brown, gravelly and very gravelly loam.

Percentage of the mapping unit: 60%

Geomorphic position: top of plateaus

Parent Material: thin eolian material on lava

Slope: 0-3%

Dominant Uses: limited range

Minor inclusions: 15% Sidah Mangala, 15% waterways

Symbol: GB 12

Name of principal soil: Grand Bara

Location and distribution: mountainous areas throughout the country on large playas, well distributed.

Climate: hot and dry with local dust twirls during the day and rapid cooling at night.

Predominance in the country: moderate extent.

Composition of Mapping Units:

1) Name of the soil series: Grand Bara

   Classification: fine loamy, mixed hyperthermic, Typic Camborthid.

   Brief description: thick soil, over 150 cm. thick, brown or dark brown, clay or sandy clay loam with a B horizon with some ferromanganese and gypsum crystals below 30cm.

   Percentage of the mapping unit: 80-90%

   Geomorphic position: playa basin

   Parent Material: lacustrine sediments

   Slope: 0-1%

   Dominant uses: water catchment

   Minor inclusions: some gullies, small inclusions of Aada soil.

Symbol Ha 10

Name of principal soil: Hadkodley

Location and distribution: in small areas around Eli Sabieh.

Climate: warm and dry.

Predominance in the country: minor extent.

Composition of Mapping Units:

1) Name of the soil series: Hadkodley

Classification: fine loamy, mixed hyperthermic, Typic Camborthid.

Brief description: moderately deep soil, 50-100 cm. thick, dark brown to very dark yellowish-brown, sandy clay loam with a B horizon. May have sandy loam surface layer and may have gravel in the C horizon.

Percentage in the mapping unit: 80%

Geomorphic position: weathered rolling hills.

Parent Material: weathered rock

Slope: usually 8-10%

Dominant uses: range and watershed.

Symbol HH 27

Name of principal soil: Holl-Holl - Afmeeaytou

Location and distribution: distributed throughout the country on steep side slopes.

Climate: warm or hot and dry

Predominance in the country: limited.

Composition of Mapping Units:

1) Name of the soil series: Holl-Holl

Classification: loamy skeletal , mixed hyperthermic, Typic Calciorthid.

Brief description: moderately deep to deep soil, 50-150 cm., dark yellowish brown to brown very gravelly sandy clay loam B horizon and a calcic horizon, underlain at about 50 cm. with yellowish brown gravelly sandy clay loam.

Percentage of the mapping unit: 35%

Geomorphic position: steep canyon side slopes or slopes off the lava plateaus.

Parent Material: Eolian and colluvium on lava flow.

Slope: 25-70%

Dominant uses: watershed and range.

2) Name of the soil series: Afmeeaytou

Classification: sandy, mixed hyperthermic, Typic Calciorthid.

Brief description: less than 75 cm. thick, dark brown or strong brown gravelly sand.

Percentage of the mapping unit:

Geomorphic position: on pediment slopes along canyons or the steep slopes off the lava plateaus.

Parent Material: Eolian Material and colluvium.

Slope: 15-25%

Dominant uses: range and watershed.

Minor Inclusions: 20% rock outcrop with a dominant use of watershed.

Symbol JA 16

Name of principal soil: Jaban Eas-Guistir

Location and distribution: principally on the coastal plains in the southern part of the country.

Climate: humid, hot climate.

Predominance in the country: moderate extent.

Composition of Mapping Units:

1) Name of the soil series: Jaban Eas

Classification: fine loamy, mixed hyperthermic, Typic Calciorthid.

Brief description: thick, over 150 cm., red or yellowish gravelly clay loam or clay loam with a B horizon, at 75 cm. accumulations of calcium sulfate with accumulations of sodium carbonate.

Percentage of the mapping unit: 35%

Geomorphic position: lava flows on the coastal plain.

Parent Material: eolian mantle.

Slope: 2-4% some areas up to 8%.

Dominant uses: range.

2) Name of the soil series: Guistir

Classification: fine loamy, mixed hyperthermic, Typic camborthid.

Brief description: thick over 150 cm. thick of reddish-brown or dark reddish brown clay loam with a B horizon, rose gypsym below about 30 cm and disseminated calcium carbonate below 75 cm.

Percentage in the mapping unit: 25%

Geomorphic position: lava flow on the coastal plain.

Parent Material: eolian mantle.

Slope: 2-4%

Dominant uses: range

Minor inclusions: 20% of areas of 5-8% slopes and also 15% water channels.

Symbol: Kl 4

Name of principal soil: Kallolou

Location and distribution: northern coastal plains, and along stream channels.

Climate: hot and humid.

Predominance in the country: minor extent.

Composition of Mapping Units:

1) Name of the soil series: Kallolou

Classification: sandy skeletal, mixed hyperthermic, Typic Torrifluvent.

Brief description: thin soil with no development, dark brown stony sand.

percentage of the mapping unit: 50%

Geomorphic position: alluvial terrace and stream deposits.

Parent Material: Alluvium

Slope: 0-2%

Dominant uses: irrigated agriculture and range.

Minor inclusions: 20% of Houmbouli soil, 20% of water courses.

Symbol: Kn 4

Name of principal soil: Kenannaba

Location and distribution: along stream channels and in larger areas in the northern part of the country.

Climate: hot or warm and dry

Predominance in the country: limited soil.

Composition of Mapping Units:

1) Name of the soil series: Kenannaba

   Classification: sandy skeletal, mixed hyperthermic, Typic Torriorthent.

   Brief description: deep soil, no significant development, light brown or brown gravelly sand.

   Percentage of the mapping unit: 50%

   Geomorphic position: terraces and pediment colluvial slopes.

   Parent Material: alluvium on colluvial sands and gravels.

   Slope: 1-2%

   Dominant uses: irrigated agriculture and range.

   Minor inclusions: 20% Houmbouli, 20% water courses.

Symbol: LD 9

Name of principal soil: Lahi Daddaeo - Afnaba Daba

Location and distribution: in northwestern part of the country.

Climate: usually hot and dry or mild and dry.

Predominance in the country: limited extent.

Composition of Mapping Units:

1) Name of the soil series: Lahi Daddaeo

   Classification: fine loamy, mixed hyperthermic, Lithic Torriorthent.

   Brief Description: medium thick, less than 60 cm. thick, light brown to brown gravelly loam or gravelly clay loam or sandy clay loam.

   Percentage of the mapping unit: 40%

   Geomorphic position: mountain side slope

   Parent Material: rhyolitic colluvium

   Slope: 20-35%

   Dominant uses: watershed and range.

2) Name of the soil series: Afnaba Daba

   Classification: loamy skeletal mixed hyperthermic, Typic Torriorthent.

   Brief description: very thin, less than 20 cm. thick, brown very gravelly sandy loam.

   Percentage of the mapping unit:

   Geomorphic position: upper slopes in the mountains.

   Parent Material: thin colluvium.

   Slope: 15-50%

   Dominant uses: watershed.

   Minor inclusions: 20% rock outcrop.

Symbol: MA 16

Name of principal soil: Maarigi

Location and distribution: principally in the high plateaus in the northern part of the country.

Climate: usually mild and dry.

Predominance in the country: limited extent.

Composition of Mapping Units:

1) Name of the soil series: Maariagi

Classification: loamy skeletal, mixed hyperthermic, Typic Torriorthent.

Brief description: moderately deep to deep 100-150 cm. thick, brown and light brownish gray gravelly and very gravelly clay loam and gravelly loam.

Percentage of the mapping unit: 60%

Geomorphic position: weathered rock material on high plateaus.

Parent Material: weathered rock.

Slope: 3-8%

Dominant uses: range and watershed.

Minor inclusions: 15% of Dagah Dere, 10% rock outcrop.

Symbol: Ou 9

Name of principal soil: Oueah-Degamankal

Location and Distribution: distributed throughout the country in the mountainous region.

Climate: warm to hot dry areas.

Predominance in the country: moderate extent.

Composition of Mapping Units:

1) Name of the soil series: Oueah

   Classification: loamy skeletal, mixed hyperthermic, Typic Torriorthent.

   Brief description: moderately deep, more than 50 cm. thick of grayish brown and brown very gravelly sandy loam.

   Percentage of the mapping unit: 45%

   Geomorphic position: steep mountain slopes.

   Parent Material: colluvium and Talus.

   Slope: 25-40%

   Dominant uses: watershed.

2) Name of soil series: Degamankal

   Classification: sandy, mixed hyperthermic, Lithic Torriorthent.

   Brief description: thin soil less than 25 cm. thick, brown and yellowish brown, gravelly and very gravelly sandy loam with some calcium carbonate coatings on the gravel.

   Percentage of the mapping unit: 35%

   Geomorphic position: upper mountain slopes.

   Parent Material: Colluvium.

   Slope: 8-25%

   Dominant uses: watershed.

   Minor inclusions: 10% Talus, 20% rock outcrop.

Symbol: RD 12

Name of principal soil: Riffor Damoun

Location and distribution: in the lower parts of the larger undrained playas.

Climate: hot and dry.

Predominance in the country: minor extent.

Composition of Mapping Units:

1) Name of the soil series: Riffor Damoun

Classification: loamy, mixed hyperthermic, Typic Salorthid.

Brief description: thick soil, over 150 cm. thick, brown or dark brown, silty clay loam or clay loam with sodium salt concentrations below 20-40 cm.

Percentage of the mapping unit: 100%

Geomorphic position: lower playa basin or playa basin catchment.

Parent material: Lacustrine sediments

Slope: less than 1%

Dominant uses: none.

Symbol: WD 13

Name of principal soil: Wanni Daear-Malhadlou

Location and distribution: along the side slopes of playa basins throughout the country principally in the western part.

Climate: usually hot and dry.

Predominance in the country: limited extent.

Composition of Mapping Units::

1) Name of the soil series: Wanni Daear

Classification: loamy, mixed hyperthermic, Typic Torriorthent.

Brief description: thin soil less than 30 cm. thick, dark yellowish brown gravelly silt loam often over marl or marly sand.

Percentage of the mapping unit: 60%

Geomorphic position: side slopes of lucustrine plains often eroded.

Parent Material: marl and sands and gravels.

Slope: 5-25%

Dominant uses: range and watershed.

2) Name of soil series: Malhadlou

Classification: loamy, mixed hyperthermic, Typic Calciorthid.

Brief description: moderately thick between 100-150 cm. strong brown or yellowish-red silt loam or silty clay loam with a calcic horizon, may have overburden of very gravelly sand, overlies lucustrine marl at 1.5 to 2 m.

Percentage of the mapping unit: 25%

Geomorphic position: side slopes on disected lacustrine marl.

Parent Material: lacustrine marl.

Slope: 5-25%

Dominant uses: watershed.

Symbol: 17

Name of the unit: Lava flow

Location and distribution: throughout the country, principally west of the higher mountain ranges.

Climate: hot or warm and dry.

Predominance in the country: moderate extent.

Geomorphic position: lava flow

Parent Material: lava

Slope: 1-25%

Dominant uses: watershed

Minor inclusions: 20% of Dagah Dere soil, 10% of Kallolou. soil.

Symbol: 19

Name of the Unit: Wadi channel

Location and distribution: throughout the entire country.

Climate: often hot and dry

Miscellaneous land type - Wadi channel

Predominance in the country: limited extent.

Precentage of the mapping unit: 70-75%

Geomorphic position: Wadi Channel

Parent Material: Stream sediment

Slope: 1-3%

Dominant uses: water storage

Minor inclusions: 10% of Didjan Der soil, 10% of Eoulma soil.

Symbol: 20

Name of the Unit: Beach

Location and distribution: along the coastal region.

Climate: hot and humid.

Predominance in the country: limited extent.

Miscellaneous land type: Beach

Brief description: sand

Geomorphic position: beach

Parent Material: sand

Dominant uses: recreation

Symbol: 22

Name of Unit: Salt

Location and distribution: occurs on Lac Assal

Climate: very hot and dry

Predominance in the country: limited

Dominant uses: salt and tourism

Symbol: 25

Name of the Unit: mud flat.

Location and distribution: near Lac Abbe

Climate: hot and dry.

Predominance in the country: limited extent.

Miscellaneous land type: mud flat

Brief description: Exposed lake mud is barren.

Geomorphic position: recently exposed lacustrine mud flats.

Parent material: recent lacustrine sediments.

Slope: 0-1%

Dominant uses: none.

Symbol: 28

Name of the Unit: Marl

Location and distribution: in association at the periphery of the major lacustrine lake bed.

Climate: usually hot and dry.

Predominance in the country: limited extent.

Miscellaneous land type: Marl.

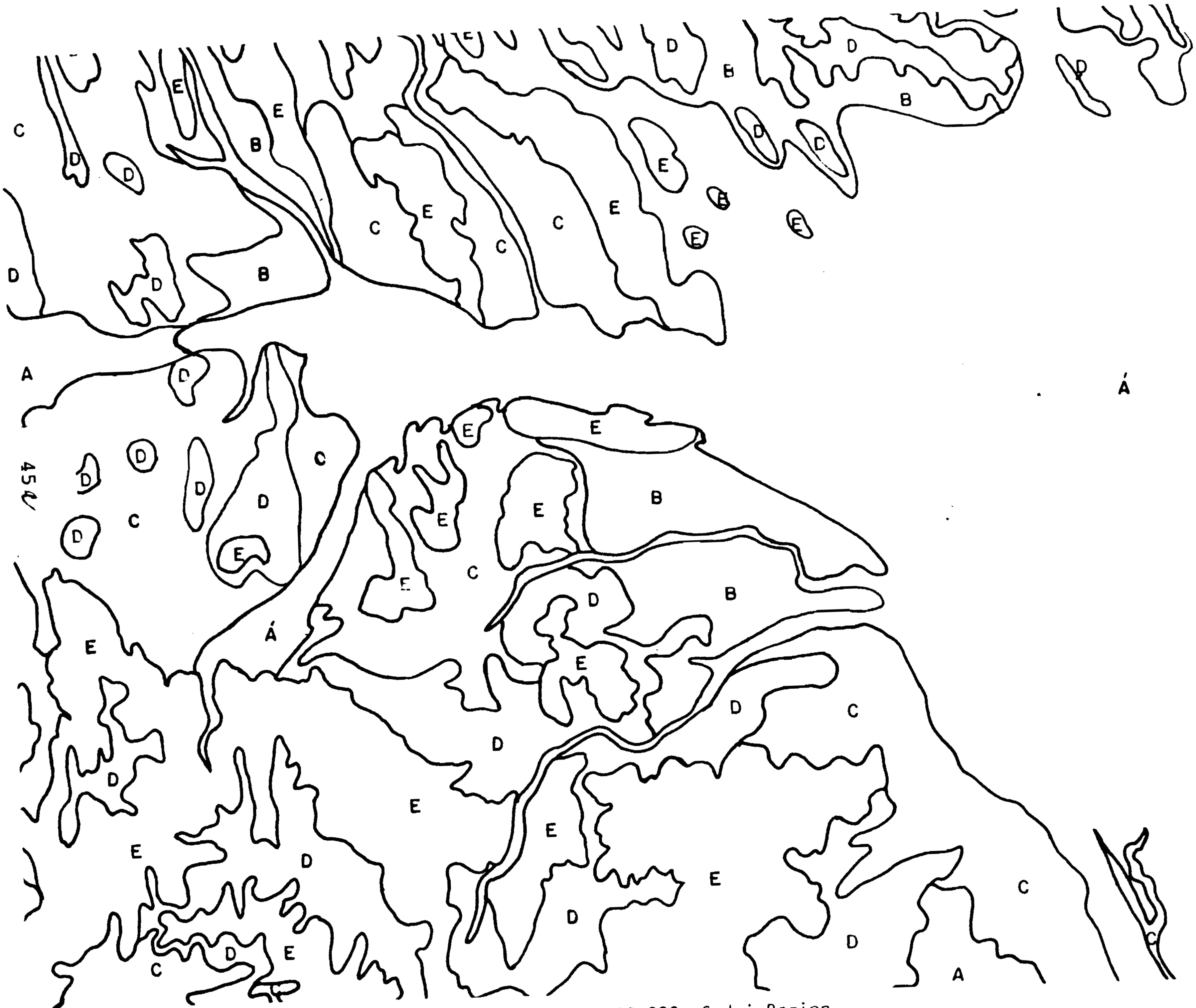

Figure 35: Example of Slope Map, Scale 1:100,000, Sadai Region

Symbol: 29

Name of the Unit: Coral slopes

Location and distribution: occurs on the islands and the coast between Tadjuon and Obock

Climate: Hot and humid

Predominance in the country: very limited

Composition of Mapping Units: no significant soils included.

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4.0 NATIONAL SOILS MAP SOIL SERIES -- INTERPRETATIONS

4.1 Location of Random Sample Sites (1:100,000 SOILS MAP)

The following chart shows the location of random sample sites and their attendent map symbol.

Map Symbol	Series Name	Location of Description Sites
Aa 15	Aada	100;83
Ay 5	Adoyla	11
Af 9	Afmeeaytou	48
AD 9	Afnaba Daba	82;30;2
AG 9	Easa Gelaw	7
AK 33	Al Kibo	49
AO 9	Arraha Ommane	71
Ar 9	Arta	57;47
At 1	Atar	18
AW 6	Awdiea	56;6;84
Ba 16	Balambal	19;78;74
DA 16	Daba Eabdalle	87;42;76
DG 1	Dabagalaley	93
DD 10	Daga Dere	95;75;40;17;36; 55
DL 4	Da le Dola	51;39
Da 9	Damerkaddae	66
Di 5	Didjan Der	26;61;81
DB 33	Dimo Le Boda	90;29
De 16	Degamankal	43;3
Dr 16	Derokkoma	70;37;69;59;23
Dt 10	Dita	14;13
ED 9	Easa Do	92;15
Eg 12	Eado Gafan	91;74;32;65
Ea 31	Eangalalo	46
Eo 4	Eoulma	89
Ga 16	Garrayto	89;34;72
GE 6	Goray Eeeb	94
GB 12	Grand Bara	8;27;31
Gu 16	Guistir	20;45
Ha 10	Hadkodley	24
HH 27	Holl-Holl	67;80;38
Ho 3	Houmbouli	86;54
JA 16	Jaban Eas	52
Kl 4	Kallolou	85;60
Kn 4	Kenannaba	98;62
LK 9	Lahi Daddaeo	9;79
Ma 16	Maarigi	1
Ma 6	Malhadlou	21
Mi 16	Minkille	28;96;77
Ou 9	Oueah	68;33;63

Map Symbol	Series Name	Location of Description Sites
RD 12	Riffor-Damoun	4
WD 13	Wanni Daear	53
9	Talus slope	44;88;35
17	Lava flow	16;12;22;64;5
19	Wadi channel	50
20	Beach	
25	Mud flat	
28	Marl	10;73
32	Salt marsh	92
33	Rock outcrop	41;25

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4.2 Key to Soil Interpertations Symbols

4.2.1 Land Capability Classification

The Soils are divided into 8 (I-VIII) categories depending on the intensity of land use (see Buchman and Brandy) from well tilled row crops to watershed and wildlife habitat. For all categories, except I, there is a limitation to the use of that soil for agriculture. All of Djibouti is too arid for class I land because these soils require irrigation for agricultural production. Therefore, the arid limitation is assumed for all soils of the country. The following list of letters which follow the Roman Numerals of this classification system indicate the important specific restraint:

w = available water capacity
r = rooting zone depth in less than one meter
s = slope is greater than 5 percent
d = drainage for leaching salts
c - susceptibility to water overflow
a - alkalinity
g - stoniness
v = wind erosion and blowing
e = erosion susceptibility

4.2.2 Irrigation Suitability Classification

The code for irrigation suitability is the same for all 8 (I through VIII) catagories of the land capability classification without the aridity limitation as a constraint. The same symbols of limitation are indicated as they affect irrigation agriculture. Therefore, irrigation is assumed for all these soils and no additional symbol is used.

4.2.3 Internal Drainage Classification

Here the land capability categories are:

I no limits to internal drainage practices
II moderate limits
III severe limits

The limits considered to affect internal drainage are:

t = permeability, texture and structure
r = depth to bedrock
w = depth to the water table
i = steepness of slope
b = ditch bank stability
c = flooding or ponding
a = salinity or alkalinity
s = available outlets

4.2.4 Terraces and Diversions Suitability Classifications

The categories here are:

I no limits to building terraces
II moderate limits
III severe limits

The factors determining the suitability for terraces are:

p = slope, steepness and length
r = depth to bed rock
f = stones and outcrops
w = wind hazard
t = texture and permeability
c = channel siltation
s = outlet availability
e = flooding hazard

4.2.5 Embankments Suitability Classification

The major categories are:

I no limits to construct embankments
II moderate limits
III severe limits

The factors determing suitability are:

r = depth of the soil
t = soil texture
e = Soil erosiveness
p = percent and length of slope
g = presence of gypsum or salt
c = stones

4.2.6 Pond Reservior Suitability Classification

The major categories are:

I no limits to pond construction
II moderate limits
III severe limits

The factors determing suitability are:

t = permeability
w = depth to the water table
r = depth to bedrock, less than 2 meters
p = slope
e = flooding hazard

4.2.7 Rangeland Classification, estimated production

I good production of 200-500 K per Hc
II limited production of 50-200 K per Hc
III non-usable production 0-50 K per Hc

4.3 Interpretation

What follows are the actual soils interpretation of the random sample sites.

27/11/80 A.D./F.O./J.G.

AADA

Location: 247.8 E
1245.2 N

0-15 cm: A horizon: color brown 10YR/5/3 (dry) sand; brown 7.5YR/4/4 (wet) structureless; loose mild effervescent; pH 7.5-8, sorted and stratified aeolian dune layers of 1-3 mm. Different parent material from underlying soil abrupt boundary;

15-40+cm: Bb horizon; dark brown 7.5YR/3/4 (dry) silt loam dark brown 7.5YR/3/4 (moist) moderate large breaking medium subangular blocky structure; 15% fine gravels. 10YR/4/4 (wet) very friable, strongly effervescent; few fine pores.

Comment: sandy dunes of 1-4 m profile between dunes shrubs and grass 5-10% vegetation cover of 30-50 cm high; 0-5% slope (smooth) location: on the rim of the basin of Grand Bara (1 to 2 mks wide) at about 25 m of the East and 75 m SE corner of the Garden.

Classification: coarse loamy, mixed, hyperthermic Typic Camborthid

Soil Interpretation:

Land Capability Classification: IIIs

Irrigation suitability classification: IIIs

Range: 20% herbs and grass

Internal drainage: I

Terraces and diversions: IIp

Embankments, dikes and levees: II t;e;p

Pond reservior: IIIp;t

14/12/81 A.D./F.O./J.G.

ADOYLA

Location: 247.5 E
1319.8 N

0-10 cm: A horizon: 10YR/4/2 dark grayish brown (dry), 10YR/3/2 very dark grayish brown (moist); sandy loam; weak medium to fine subangular blocky structure; loose, friable, slightly sticky; strongly effervescent; few fine woody roots; clear and wavy boundary;

10-50 cm: C horizon; 10YR/4/2 dark grayish brown (dry), 10YR/2/1 black (moist); gravelly sandy loam; weakly stratified; loose, friable, slightly sticky; strongly effervescent; common woody roots.

Surface: 20% cobbles and 75% fine gravel

Inclusions: DIDJAN DER

Position: Terrace (in alluvium)

Parent Material: Mixed alluvium

Vegetation: 25% cover (acacia tortilis 2-3 m, bush)

Erosion: Occasional flooding

Temperature: 27.9 ^{o}C

Classification: coarse loamy mixed hyperthermic Typic Torrifluvent

Soil Interpertation:

Land Capability Classification: IIIg

Irrigation suitability classification: IIg

Range: II 25% bush

Internal drainage: IIb

Terraces and diversions: IIf

Embankments, dikes and levees: IIc

Pond reservior: IIIp

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26/5/81 A.D./J.G./F.O

AFEASIN GAFAN

Location: 193.1 E
1268.2 N

Land Type: Talus

Slope: Slope about 100%

Inclusions: 20% rock outcrop

Vegetation: 1% vegetation cover (wanait, draif, magal xid)

Comment: Talus slope about 75% Full of sand and gravel in the interstices. Dominantly boulders and stones.

Land Use Interpretation:

Land Capability Classification: VIIIs

Irrigation suitability classification: None

Range: Barren

Internal drainage: IIIi

Terraces and diversions: IIIp

Embankments, dikes and levees: IIIp

Pond reserviour: IIIp

11/3/81 A.D./J.G./F.O.

AFMEEAYTOU

Location: 174.6 E
1260.7 N

0-20 cm. A horizon; 10YR/4/3 (brown) dry, 10YR/3/3 (dark brown) moist; gravelly sand; 35% 3-20 cm stones; structure: none; loose, very friable, non-sticky; common fine fibrous roots; strongly effervescent; clear and wavy boundary;

20-35 cm: Bca horizon; 10YR/4/6 (strong brown) dry, 7.5YR/4/6 (strong brown) moist; gravelly sand; structure: none; loose, very friable, non-sticky; strongly effervescent; CaCO3 on all parts of the gravel; common fine fibrous roots; irregular and diffused boundary;

35-60 cm: C horizon; 7.5YR/4/4 (dark brown) dry, 5 YR/3/3 (dark reddish brown) moist; gravelly sand; 30% fine gravel; structure: none; loose, very friable, nonsticky; strongly effervescent,

Slope: Slopes from 15-25%

Parent Material: 10-15% lava outcrop

Vegetation: 2% vegetation cover (different species of grass)

Comment: 80% soil covered with stones and boulders of 1-1.5 m high. On alluvial slope.

Classification: sandy mixed hyperthermic Typic Calciorthid

Soil Interpretation:

Land Capability Classification: VIIs

Irrigation suitability classification: IVs

Range: III 2% bush

Internal drainage: I

Terraces and diversions: IIt

Embankment, dikes and levees: IIt

Pond reservior: IIIt;p

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8/12/81 A.D./J.G./F.O.

AFNABA DABA

Location: 289.7 E
1391.0 N

0-10+ cm: C horizon; 7.5YR/5/4 brown (dry), 7.5YR/3/4 dark brown (moist); very gravelly sandy loam; structure: none; loose, very friable, nonsticky; strongly effervescent.

Surface: 10% cobbles and 90% gravel

Inclusions: 50% rock outcrop

Slope: 18%

Position: talus slope

Parent Material: metamorphised rhyolite

Vegetation: Barren

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent.

Soil Interpretation:

Land Capability Classification: VIIs

Irrigation suitability classification: none

Range: III 2% bush

Internal drainage: IIIi

Terraces and diversions: III p;r

Embankments, dikes and levees: IIIr;p

Pond reservior: IIIr;p

10/3/82 A.D./J.G.

AL KIBO

Location 219.7 E
1320.7 N
Elevation: 450 m

0-25 cm: Cca horizon; 10YR/6/3 pale brown (dry), 10YR/4/3 brown (moist); very stony clay loam; 40% stones and cobbles, 15% gravel; structureless; loose, friable sticky; strongly effervescent; thick $CaCO_3$ coatings on rocks and fine disseminated $CaCO_3$; clear irregular boundary;

25-35 cm: I A horizon; 7.5YR/4/4 brown (dry), 7.5YR/3/4 dark brown (moist); sandy loam; structureless; loose, friable, slightly sticky; strongly effervescent; clear wavy boundary;

35-60+ cm: II Cca horizon; 10YR/6/4 light yellowish brown (dry); 10YR/4/4 dark yellowish-brown (moist); loam; no structure; firm friable, slightly sticky; 5% incrusted, 1-5 mm $CaCO_3$, and soft powdery disseminated $CaCO_3$; strongly effervescent.

Surface: 60% stones and boulders, 45% gravel and cobbles

Inclusions: 10% rock outcrops, 40% lithic variant

Slope: 1-3%

Position: plateau

Parent Material: igneous lava rocks and eolian buried soil

Erosion: moderate water erosion

Temperature: 35.6 ^{o}C

Classification: coarse loamy mixed hyperthermic Typic Calciorthid

Soil Interpretation:

Land Capability Classification: VIIs

Irrigation suitability classification: none

Range: III 5% herbs; 150-400k/Hc.

Internal drainage: III r;t;i

Terraces and diversions: III p;r;t

Embankments, dikes and levees: III r;t;p

Pond reservior: III r;t;p

1/3/82 A.D./J.G.

ARRAHA OMMANE

Location: 272.4 E
1256.3 N

0-5 cm: A horizon; 10YR/4/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); gravelly sand; weak medium to fine subangular blocky structure; firm, friable, nonsticky; strongly effervescent; 20 to 25% 2 to 20 mm gravel; few fine fibrous roots; CaCO3 coatings on stones; clear and irregular boundary;

5-30 cm: B horizon; 7.5YR/3/4 dark brown (dry), 7.5YR/3/2 dark brown (moist); very gravelly loam; structureless; loose, friable, slightly sticky; strongly effervescent; thick CaCO3 coatings on rocks and gravel; 60% stones, cobbles and gravel; common medium woody roots; abrupt irregular boundary;

30+ cm: R unfractured rock.

Surface: 90% gravel and stones

Inclusions: 5 to 10% outcrop - 10-20% thicker soil at foot slopes - 10% wadi channels

Slope: 13% (10-20%)

Position: side slope

Parent Material: rhyolite colluvium on rhyolite mountain

Vegetation: 5% grass 3 to 6 cm, 5% herbs 10 to 30 cm, and 2 to 3% 1 m acacia

Erosion: severe water

Temperature: 26.6 ^{o}C

Classification: loamy skeletal mixed hyperthermic Lithic Camborthid

Soil Interpretation:

Land Capability Classification: V s;g

Irrigation suitability classification: None

Range: II 5% grass; 5% herbs; 2% bush

Internal drainage: III r

Terraces and drainage: III p;r;f

ARRAHA OMMANE

continued

Embankments, dikes and levees; III r;p

Pond reservior: III p;r

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1/12/80 A.D./J.G./F.O.

ARTA

Location: 267.1 E
1274.9 N

0-15 cm: A11 horizon; dark yellowish brown 7.5YR/3/4 (moist); gravelly clay loam very fine and weak granular structure; soft and friable. pH=7.3 (pH meter); strongly effervescent many fine roots; thin film of $CaCO_3$ on the rock fragments, it is covered with 75% of cobbles, stones and boulders of 10 to 75 cm; clear and smooth boundary;

15-40 cm: A12 horizon; dark yellowish brown 7.5YR/3/4 (moist); very gravelly silt loam weak medium subangular blocky breaking to weak fine granular structure; pH=7.3 (pH meter); strongly effervescent; comon fine roots; 60% coarse gravels; soft friable soft fine dissimulated powdery $CaCO_3$; gradual and wavy boundary;

40-37 cm: Acca horizon; yellowish-brown 7.5YR/5/4 very gravelly clay loam texture; weak fine granular structure; 60% gravels; pH=7.1; strongly effervescent; gradual, diffused and irregular boundary;

70-200+ cm: C horizon; dark yellowish-brown 7.5YR/3/4; volcanic lava fractured; coarse gravels; many films of $CaCO_3$ on the gravels; mildly effervescent.

Inclusions: These soils occur on slopes of 25-50% which represent about 35% of the area. 10% of the area is occupied by the tops of the mountains with thin soils, 10% with rock outcrop, 20% with slope shoulders, 20% with steep valley slopes with thin soils, 10% with vegetation cover (sogsog dominant, guud rare, kulan 1% dhidin...)

Parent Material: steep mountains, 50 to 70% cover of large volcanic bombs.

Comment: Location: 5 to 7 m from the road to Arta on the west side and at 3 km from the junction of the roads to Arta and Queah.

Classification: loamy skeletal mixed hyperthermic Aridic Calciustoll (Typic Torriorthent?)

Soil Interpretation:

Land Capability Classification: VII s

Irrigation suitability classification: none

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ARTA

continued

Range: II 10%

Internal drainage: III i;r

Terraces and diversions: III p;r

Embankments, dikes and levees: III t;p

Pond reservior: III t;r;p

17/11/80 A.D./J.G./F.O.

ATAR

Location: 301.6 E
1274.3 N

0-10 cm: A horizon; brown 7.5YR/5/4 (dry), dark brown 7.5YR/3/4 (wet); sand loam; structureless; loose; (dry); pH=7.5-8; wind deposited sand, no relationship with the sub soil; abrupt contact.

10-110 cm: B horizon; strong brown 7.5YR/4/6 (dry), and dark brown 7.5YR/3/4 (wet); silt loam; moderate large angular blocky breaking to moderte medium and fine angular blocky structure; firm (dry) and friable (moist); 50% of 5-25 mm 10YR/8/1 carbonates; many presure faces (sand on faces of large fine vertical cracks; few fine and medium roots; pH=8.5; gradual and smooth boundary;

110-130+ cm: strong brown 7.5YR/4/6 (dry), dark brown 7.5YR/3/4 (wet); silt loam texture; weak medium subangular blocky structure; 5% of 5 to 10 mm $CaCO_3$, Ph=8.5.

Inclusions: Few 20 cm sand dunes

Slope: flat area; near the sea;

Vegetation: 20% vegetation cover (90% acacia and 10% kulan)

Comment: 1 km NE of Damerjog at the junction of the roads to Loyada and irrigation water line to ATAR.

Classification: fine loamy mixed hyperthermic Typic Calciorthid.

Soil Interpretation:

Land Capability Classification: III b

Irrigation suitability classification: II d;c;v

Range: I 20% bush

Internal drainage: II t

Terraces and diversions: II p

Embankments, dikes and levees; II p;g

Pond reservior: II t;w

9/12/81 J.G./A.D./F.O.

AWDIEA

Location: 308.7 E
1372.1 N

0-50 cm: Cca horizon; 10YR/6/2 light brownish gray (dry), 10YR/5/2 grayish brown (moist); gravelly sandy loam; weak medium to fine subangular blocky; firm, friable, slightly sticky; strongly effervescent; moderate $CaCO_3$ coating on the gravel and 15% fine disseminated of $CaCO_3$ and secondary pitted and indurated $CaCO_3$.

Surface: 60% basaltic cobbles and boulders and 90% gravel

Inclusions: 20% rock outcrop, 20% talus slope (thinner soil) lithic variant.

Slope: 16%

Vegetation: 2% herbs

Erosion: gully erosion

Temperature: 31.5 ^{o}C

Classification: coarse loamy mixed hyperthermic Typic Calciorthid

Soil Interpretation:

Land Capability Classification: VII s

Irrigation suitability classification: None

Range: III 2% herbs

Internal drainage: III r;t;i

Terraces and diversions: III p;r;t

Embankments, dikes and levees: III r;t;p

Pond reservior: III r;t;p

14/12/80 IA.D./J.G./F.O.

BALAMBAL

Location: 251 E
1260 N

-15-0 cm: volcanic bombs of 5 to 30 cm covering 75% of the area.

0-2 cm: A horizon; 5YR/4/6 yellowish red (dry) 5YR/3/4 dark reddish brown (wet); stony clay loam; moderate medium and fine subangular blocky structure; friable (dry and moist); common pores (1-2 mm); thin discontinous $CaCO_3$ layer on rocks below the soil surface; strongly effervescent, fine disseminated $CaCO_3$; pH 7.5; abrupt boundary;

2-35 cm: B horizon; 5YR/4/6 yellowish red (dry), 5YR/3/4 dark reddish brown (wet); stony clay loam; firm, friable, nonsticky; strong medium and large subangular blocky structure; strongly effervescent, finely disseminated $CaCO_3$; pH 7.5; few coarse woody trees roots; clear and wavy boundary;

35-45+ cm: Cca horizon; many continuous white $CaCO_3$ coatings on gravel uncemented; loose.

Slope: Slope of 2 to 3%

Position: on a plateau, flat top

Vegetation: 2 to 3% cover; "bilcin", "ibateys"

Classification: fine loamy mixed hyperthermic Typic Calciorthid

Soil Interpretation:

Land Capability Classification: VII r;g

Irrigation suitability classification: none

Range: III 5% bush

Internal drainage: III r

Terraces and diversions: III r;f

Embankments, dikes and levees; III r;c

Pond reservior: III r

8/3/81 A.D./J.G./F.O.

DABA EABDALLE

Location: 220.3 E
1220.6 N

0-14 cm: All horizon; 5YR/4/3 reddish-brown (dry), 5YR/3/3 dark reddish brown (moist); silt loam; moderate medium to fine angular blocky structure; firm, friable nonsticky; many fine fungus traces; many fine pores; strongly effervescent; clear and irregular boundary;

14-34 cm: A12 horizon; 5YR/3/3 dark reddish brown (dry and moist); silt loam; moderate coarse to medium subangular blocky structure; firm friable, nonsticky; many fine fungus traces; many fine fibrous roots; strongly effervescent; clear and irregular boundary;

34-40 cm: B horizon; 5YR/3/4 dark reddish brown (moist), silty clay loam; moderate coarse to medium subangular blocky structure; firm, friable slightly sticky; strongly effervescent; common fine fibrous roots; clear and irregular boundary;

40-62 cm: Cca horizon; 5YR/4/6 yellowish red (dry), 5YR/3/4 dark reddish brown (moist); gravelly silt clay loam; structure: none; loose, friable, slightly sticky; strongly effervescent; 35% gravel, thin $CaCO_3$ coating on all faces of the gravel; abrupt and smooth boundary;

62-70+cm: R horizon; solid lava, basaltic rock.

Surface: On the surface 90% cobbles and boulders of volcanic bombs.

Parent Material: Lava flow plateau with 1-8% long slopes loes covered.

Vegetation: Vegetation cover of 15% (bilcin, Aousdameir, kulan 1 to 1.5 m high and dacar)

Temperature: Moderately cool

Comment: Extensive soil

Classification: fine loamy mixed hyperthermic Aridic Calciustoll

Soil Interpretation:

Land Capability Classification: VI g

Irrigation suitability classification: None g;d

DABA EABDALLE

continued

Range: 5% bush; 10% grasses and herbs; 400k/Hc

Internal drainage: III r

Terraces and diversions: III r;p;f

Embankments, dikes and levees: III r;t

Pond reservior: III t;r

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7/12/80 A.D./J.G./F.O.

DABAGALALEY

Location: 301.2 E
1276.7 N

0-2 cm: En horizon: 7.5YR/4/4 brown; loamy sand; cemented on the top; structureless; loose, loose and nonsticky; mildly effervescent (sea shells); when it is dry, crust on the surface; 5% fractured broken sea shells; abrupt and smooth boundary;

2-40 cm: B horizon; 7.5YR/4/4 brown (dry), 7.5YR/3/4 dark brown (wet); sandy clay loam; weak to moderate medium subangular blocky structure; friable, sticky; mildly effervescent (5% shells); few common fine roots; soft powdery salt on pedfaces, some salt cementation in some fine soi crystals; abrupt and wavy boundary;

40-60+ cm: Mixed gravel, sand and silt; alternate layers of sand or silt or gravel (submarine gravels)

Vegetation: land barren or vegetation.

Comment: Nearly level with slight undulations. Slightly above high tide about 5 meters; salt water table fluctuates with the tide from 5 to 2 meters below surface. This soil is located near the sea.
Location: 500 m S.E. of Military post.

Classification: fine loamy, mixed hyperthermic Aeric Halaquept.

Soil Interpretation:

Land Capability Classification: VIII r;a;d

Irrigation suitability classification: none

Range: III 2% tidal zone brush

Internal drainage: III w;c;a;s

Terraces and diversions: II s

Embankments, dikes and levees: II r;g

Pond reservior: II w

21/2/81 A.D./J.G./F.O.

DAGAH DERE

Location: 267.1 E
1240.1 N

-2 to 0: Fine gravelly desert pavement.

0-25 cm: A horizon; 10YR/5/4 yellowish brown (dry); very gravelly sandy loam; 10YR/4/3 brown (moist); fine granular structure; 0-1.5 mm leached of $CaCO_3$; loose, friable; fine disseminated and 1-2 mm $CaCO_3$; strongly effervescent; 65% 2-10 mm gravel from fractured rock; common fine fibrous roots; irregular and diffused boundary;

15-40+ cm: R horizon; 10-40 mm fractured rock; strongly effervescent; 2-5 mm $CaCO_3$;

Inclusions: 10-15% rock outcrop

Slope: Slope of 8-15% and strongly rolling slope

Vegetation: 2-5% vegetation cover of Aurdawad and Aousdamer

Classification: loamy skeletal mixed hyperthermic Lithic Torriorthent.

Soil Interpretation:

Land Capability Classification: VI r;s;g

Irrigation suitability classification: none

Range: II 5% bush; 5% grass

Internal drainage: III r;i

Terraces and diversions: III p;r;f

Embankments, dikes and levees: III r;t;p

Pond reservior: III t;r;p

13/12/81 J.G./A.D.

DA LE DOLA

Location: 315.5 E
1328.5 N

0-20 cm: IC horizon; 5YR/4/6 yellowish red (dry), 2.5YR/4/6 dark red (moist); loamy sand; structure: none; fine strata; strongly effervescent; few fine woody roots; fluvial deposit with an eolian cap of 8-10 cm; abrupt wavy boundary;

20-50+ cm: IIC horizon; 2.5YR/4/6 red (dry and moist); fine gravel; structure: none; laminated 1 to 2 cm gravel and sand; weakly cemented; strongly effervescent.

Surface: sand and fine gravel

Slope: 0-1%

Position: broad waterway

Parent Material: alluvium from nearby hills

Vegetation: 10% acacia and five (5%) grass

Erosion: surface erosion and inundation at each rain

Temperature: 31 ^{o}C

Classification: sandy skeletal mixed hyperthermic Typic Torriorthent.

Soil Interpretation:

Land Capability Classification: VI w;r;s

Irrigation suitability classification: none

Range: II 10% bush; 5% grass; 150k/Hc

Internal drainage: III r;i

Terraces and diversions: III p;r;f

Embankments, dikes and levees: III r;t;p;c

Pond resevior: III t;r;p

23/12/80 A.D./J.G./F.O.

DAMERKADDAE

Location 247.3 E
1234.0 N

0-15 cm: Al horizon; 10YR/5/4 yellowish brown (dry); 10YR/5/6 yellowish brown (moist); very gravelly sand; weak medium to fine subangular blocky structure; loose; 50% gravels; strongly effervescent; common fine 1-4 mm indurated CaCO3; irregular diffused boundary;

15-55 cm: C11ca horizon; 7.5YR/5/6 strong brown (dry), 7.5YR/4/4 brown (moist); very gravelly sand; 50% fractured pebbles and cobbles; weak fine angular blocky structure; loose, many 1-10 mm indurated CaCO3; strongly effervescent; irregular, diffused boundary;

55-140 cm: C12ca horizon; 7.5YR/5/6 strong brown (dry), 7.5YR/4/4 brown (moist); very gravelly sandy loam; 50% fractured pebbles and cobbles: structureless;loose, loose: common 1 to 5 mm indurated CaCO3; strongly effervescent; irregular diffused boundary;

Inclusions: this soil represents 40% of the area; 35% of the area consists of a loamy skeletal mixed hyperthermic Lithic Torriorthent, 25% rock outcrop

Slope: 40 to 70% slope

Parent Material: Rhyolthic rocks moderately fractured

Vegetation: sparse vegetation (compobogon), "galan, gubac, bilcin, ibateys".

Comment: Location at 247.3 E 500 mm on the road to post control 1234.0 N at Ali-Sableh; west of the road

Classification: sandy skeletal mixed hyperthermic Typic Torriorthent

Soil Interpretation:

Land Capability Classification: VII w;r;g;e

Irrigation suitability classification: none

Range: II 5% brush; 150k/Hc

DAMERKADDAE

continued

Internal drainage: III r;i;b

Terraces and diversions: iii p;r;f;t

Embankments, dikes and levees: III r;t;p;c

Pond reservior: III t;r;p

17/3/81 A.D./J.G./F.O.

DEGAMANKAL

Location: 209.4 E
1234.2 N

0-6 cm: A horizon; 10YR/5/3 brown (dry), 10YR/3/3 dark brown (moist); gravelly sandy loam; structure: none; loose, very friable, nonsticky; strongly effervescent; 30% gravel; thin $CaCO_3$ coating on all parts of the gravel; clear and wavy boundary;

6-15 cm: C horizon; 10YR/5/4 yellowish brown (dry), 10YR/3/4 dark yellowish brown (moist); very gravelly sandy loam; structure: none; loose, very friable, nonsticky; mildly effervescent; 50% gravel; thin patchy $CaCO_3$ coating on the gravel; Inclusion of rocks (lava flow); 50% covered with stones and boulders;

Inclusions: Inclusion in the Balambal soil mapping units.

Slope: Slopes from 3-8%

Parent Material: 10% lava outcrop

Vegetation: Vegetation rare (Aousdameir acacias)

Comment: Extensive soil

Classification: sandy mixed hyperthermic Lithic Torriorthent

Soil Interpretation:

Land Capability Classification: VIII r;s;g;e

Irrigation suitability classification: none

Range: III 2% bush

Internal drainage: III r;i

Terraces and diversions: III p;r;f;t

Embankments, dikes and levees: III r;t;e;p;c

Pond reservior: III t;r;p

24/5/81 A.D./J.G./F.O.

DEROKOMA

Location: 171.7 E
1246.2 N

1-10 cm: A horizon; 7.5YR/4/4 brown (dry), 7.5YR/4/4 dark brown (moist); clay loam; strong coarse to medium subangular blocky structure; firm, friable, slightly sticky; strongly effervescent; few fine roots; gradual and smooth boundary;

10-54 cm: B11 horizon; 7.5YR/3/4 dark brown (dry), 5YR/3/3 dark reddish brown (moist); stony sandy clay loam; moderate medium subangular blocky structure; firm, friable, slightly sticky; strongly effervescent; gradual and smooth boundary;

54-81 cm: B12 horizon; 7.5YR/4/4 brown (dry), 5YR/3/3 dark reddish brown (moist); stony sandy clay loam; moderate medium subangular blocky structure; firm, friable, slightly sticky; gradual and diffused boundary;

81-90+ cm: C horizon; 7.5YR/4/4 brown (dry), 5YR/3/3 dark reddish brown (moist); gravelly sandy clay loam; structure: none; firm, friable, nonsticky; strongly effervescent; 20% fine gravel

Surface: 60% cobbles and stones on the surface

Slope: 3-5% slope

Parent Material: loess on lava flow

Vegetation: 10% vegetation cover: "magal xid, daraf" (temporary grass)

Classification: fine loamy, mixed, hyperthermic Typic Torriorthent

Soil Interpretation:

Land Capability Classification: VI g

Irrigation suitability classification: V g;d

Range: II 10% bush; 5% grass and herbs

Internal drainage: III r

Terraces and diversions: II f

Embankments, dikes and levees: II c

Pond reservior: III w;r

21/12/80 A.D./J.G./F.O

DIDJAN DER

Location: 258.8 E
1265.2 N

0-15 cm: A horizon; 7.5YR/5/4 brown (dry), 7.5YR/3/4 dark brown (moist); very gravelly sandy clay loam; weak medium subangluar blocky structure; loose, friable nonsticky; few fine roots; 65% of 2 to 4 mm gravels; moderately effervescent; irregular diffused boundary;

15-85 cm: Cca horizon; 10YR/8/1 white (dry) 10YR/5/3 brown (moist); very gravelly sandy clay loam; structureless; thick coating of CaCO3 on all rock surfaces, abundant fine fraction; 40% gravels, 20% cobbles, 10% stones; extremely effervescent; irregular diffused boundary;

85-200 cm: IICca horizon: 10YR/6/4 light yellowish (dry), 10YR/6/3 pale brown (moist); stony sandy clay loam; firm friable, nonsticky; 15% soft powdery 1 to 5 mm CaCO3; irregular diffused boundary;

200-350 cm: IIICca horizon; bouldery alluvium

Surface: between 40-80% gravel and about 30% cobbles and stones

Slope: 0-3% dissected (slightly)

Vegetation: About 20% vegetation cover (balanits aegyptioca, acacia...)

Comment: 100 m west of the road, on the west bank of the wadi

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent

Soil Interpretation:

Land Capability Classification: IV g

Irrigation suitability classification: II g

Range: 5% bush

Internal drainage: I

Terraces and diversions: II f

Embankments, dikes and levees: II c

Pond reservior: II t

DIMO Le BODA

Location: 229.3 E
1307.4 N

0-50+ cm: A horizon; 10YR/4/2 dark grayish brown (dry) 7.5YR/ 3/2 dark brown (moist); very stony loam; 40% cobbles, 20% stones and 20% gravel; moderate medium crumb structure; firm, friable, slightly sticky; many fine and common medium and coarse woody roots; strongly effervescent; thin $CaCO_3$ coatings on stones.

Surface: 90% stones and cobbles

Inclusions: 15% rock outcrops and 40% lithic variant = 45% typic variant

Slope: 10%

Position: colluvial or talus slope

Parent Material: basaltic talus and eolian fill

Vegetation: 10% 2 m high acacia; 20% herbs and 2% grass

Temperature: 28.9 ^{o}C 50 cm

Classification: loamy skeletal mixed hyperthermic Aridic Haplustoll

Soil Interpretation:

Land Capability Classification: VI s

Irrigation suitability classification: none

Range: II 10% bush; 20% herbs and grass

Internal drainage: III i

Terraces and diversions: III p;f

Embankment, dikes and levees: III t;p;c

Pond reservior: III t;p

15/3/82 J.G./A.D.

DITA

Location: 284.4 E
1369.4 N

0-8 cm: A horizon; 10YR/6/3 pale brown (dry), 10YR/4/4 dark yellowish brown (moist); gravelly loam; structure less; loose, friable, nonsticky; strongly effervescent; abrupt irregular boundary.

8-40+ cm: Cca horizon; 7.5YR/6/2 pinkish gray (dry), 7.5YR/ 5/4 brown (moist); gravelly sandy loam; soft disseminated CaCO3 and continous thick CaCO3 coatings on rocks; structureless; loose, friable, nonsticky; strongly effervescent.

Surface: 80% gravel, 20% cobbles

Inclusions: 15% waterways; 10% rock outcrop

Slope: 3%

Position: colluvial valley; pedment slope

Parent material: rhyolite colluvium

Vegetation: barren except waterways

Erosion: moderate sheet erosion

Temperature: 31.7 ^{o}C at 30cm

Classification: loamy skeletal mixed hyperthermic Lithic Calciorthid

Soil Interpretation:

Land Capability Classification: VI w;r;g

Irrigation suitability classification: none

Range: III 2% bush

Internal drainage: III r;i

Terraces and diversions: iii p;r;f;t

Embankments, dikes and levees; III r;t;c

Pond reservior: III t;r;p

11/3/81 A.D./J.G./F.O.

EADO GAFAN

Location: 182.8
1285.3

0-10 cm: A horizon; 10YR/5/3 brown (dry) 10YR/3/3 strong brown (moist); sand; structure: none; slightly firm, very friable; some fresh water mollusks; strongly effervescent, clear, smooth boundary;

10-75 cm: C horizon; 10YR/5/4 yellowish brown (dry), 10YR/3/3 strong brown (moist); sand; structure: none; slightly firm, very friable; laminated; moderately effervescent;

Position: Occurs on a pleistocene lacustrine plain

Vegetation: This particular soil has 5% bunch grass cover

Comment: The Hanle plain is about 65% of this soil. About 20% covered with dunes up to 2 m high. 15% wadi with dunes on the edge. The sand dunes have several species of trees; 30% cover up to 3-4 m (Qudac, Caday, dhagdhagan, moroh)

Classification: sandy mixed hyperthermic Typic Torriorthent

Soil Interpretation:

Land Capability Classification: VI v

Irrigation suitability classification: II v;e

Range: II 5% grass

Internal drainage: I

Terraces and diversions: II p;w

Embankments, dikes and levees: II p

Pond Reservior: II t;w

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7/12/81 J.G./F.O.

EANGALALO

Location: 299.4 E
1393.6 N

0-9 cm: A horizon; 7.5YR/4/4 brown (dry), 7.5YR/4.4 brown (moist); sandy clay loam; slightly cemented with Nacl, brittle, friable, slightly sticky; weak coarse subangular blocky structure; salty to taste; sandy on pedfaces; many fine pores; clear irregular boundary,

9-40 cm: B2Na horizon; 5YR/4/6 yellowish red (dry and moist), sandy clay loam; weak medium subangular blocky structure; firm, friable, slightly sticky; salty to taste, 3% fine Nacl crystals; strongly effercescent; clear wavy boundary;

40-55 cm: B3Na horizon; 7.5YR/5/6 strong brown (dry and moist); sandy clay loam; weak coarse subangular blocky structure; hard, friable, slightly sticky; many coral pieces; slightly salty to taste; strongly effervescent.

Surface: 50% fine gravel and puffy crusty surface

Inclusions: few areas with dunes (40-75 cm high); few waterways with 50% dunes

Slope: 0-1%

Parent Material: loess on coral

Vegetation: 10% bushes on dunes, 90% barren; this soil occurs near the sea

Erosion: Hazard - wind and sheet erosion

Temperature: 31.3 ^{o}C

Comment: Coral rocks at 1 m

Classification: fine loamy mixed hyperthermic Typic Natrargid

Soil Interpretation:

Land Capability Classification: VII w;r;a;v

Irrigation suitability classification: none

Range: III 2% bushes; 100k/Hc

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EANGALALO

continued

Internal drainage: III r;a

Terraces and diversions: III p;r;w

Embankments, dikes and levees: III r;g

Pond reservior: III r

10/3/82 J.G./A.D.

EASA DO

Location: 227.1 E
1301.9 N

0-50 cm: C horizon; 7.5YR/3/4 dark brown (dry and wet); very gravelly loam; 60% boulders, between the boulders 70% gravel, cobbles and stones; structureless; loose, friable, slightly sticky; common fine woody roots; strongly effervescent; common medium continous $CaCO_3$ coatings on rock fragments.

Surface: 50% bed rock and boulders, 35% stones, cobbles and gravel

Inclusions: 20% rock outcrops, 30% kalus slope

Slope: 25-30%

Position: Steep mountains slope (rolling mounts)

Parent Material: basaltic lava

Vegetation: rare ("binin")

Temperature: 26.4 C at 50 cm

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent

Soil Interpretation:

Land Capability Classification: VIII r;w;s;g

Irrigation suitability classification: none

Range: III 2% bush

Internal drainage: III t;r;i

Terraces and diversions: III p;r;f

Embankments, dikes and levees: III r;t;e;p;c

Pond reservior: III t;r;p

12/12/81 A.D./F.O./J.G.

EASA GELAW

Location: 304.4
1348.8

0-3 cm: A horizon; 10YR/5/3 brown (dry), 10YR/4/3 dark brown (moist); very cobbly sandy loam; weak fine subangular blocky; weakly cemented; friable and slightly sticky; few fine woody roots; clear smooth boundary;

3-20+ cm Cca horizon; 10YR/6/2 light brownish gray (dry) 10YR/6/4 light yellowish brown (moist); very stony sandy clay loam; structureless; loose, friable, lightly sticky; few fine woody roots; strongly effervescent; fine disseminated and 1-2 mm thick coatings of $CaCO_3$ on the gravel and stones; 70% stones and gravel.

Surface: 75% cobbles

Inclusions: 25% rock outcrop

Slope: 11%

Position: talus colluvium

Parent Material: indurated rhyolitic ignimbrite

Vegetation: 5% acacia and "binin"

Temperature: 27.6 C at 30 cm

Classification: loamy skeletal mixed hyperthermic Typic Calciorthid.

Soil Interpretation:

Land Capability Classification: VII r;s;g;w

Irrigation suitability classification: none

Range: III 5% bush

Internal drainage: III i;r

Terraces and diversions: III p;r

Embankments, dikes and levees: III t;r;p

Pond reservior: III t;r;p

12/12/81 J.G./F.O./A.D.

EOULMA

Location: 307.1 E
1339.1 N

0-20 cm: IC horizon; 10YR/6/3 pale brown (dry), 10YR/3/4 dark yellowish brown (moist); sandy clay loam; structure: none; loose, friable, slightly sticky; strongly effervescent; few fine woody roots; clear smooth boundary,

20-40+ cm: IIC horizon; 7.5YR/4/4 brown (dry), 7.5YR/3/4 dark brown (moist); sand; structure: none; weakly cemented, friable, nonsticky; strongly effervescent; fine disseminated $CaCO_3$.

Surface: 50% gravel

Inclusions: 15% waterways with 20-30 cm of eolian sand

Slope: 0-1%

Position: Outer edge of a alluvial fan

Parent Material: mixed alluvium

Vegetation: 20% grass and woody tuft and 5% acacia in the waterways.

Temperature: 6^{o} C

Classification: sandy mixed hyperthermic Typic Torriorthent

Soil Interpretation:

Land Capability Classification: VI w;v

Irrigation suitability Classification: II c;v

Range: I 20% grass; 5% bush

Internal drainage: I

Terraces and diversions: II t

Embankments, dikes and levees: II t

Pond reservior: III t

15/3/82 J.C./.A.D.

GARRAYTO

Location: 272.1 E
1343.1 N

Altitude: 850 m

0-10 cm: A horizon; 7.5YR/6/4 light brown (dry), 7.5YR/5/4 brown (moist); gravelly loam; structureless; loose, friable, slightly sticky; strongly effervescent; 40% fine gravel and stone; clear wavy boundary;

10-30 cm: C horizon; 7.5YR/5/4 brown (dry), 5YR/5/6 yellowish red (moist); very gravelly loam; 75% gravel; structureless; loose, friable, slightly sticky; few fine roots; continous $CaCO_3$ coatings on rocks; strongly effervescent; clear irregular boundary;

30 cm: R (rock).

Surface: 50% gravel; 10% stones

Inclusions: 25% outcrop, 15% thicker soil in the waterways

Slope: 0-2%

Position: plateau

Parent Material: rhyolite

Vegetation: 3% 1 m shrubs, 3% herbs

Erosion: none to slight wind and sheet erosion

Temperature: 25.1 ^{o}C at 30 cm(9H 15)

Classification: loamy skeletal mixed hyperthermic Lithic Torriorthent

Soil Interpretation:

Land Capability Classification: VIII w;r;g;v

Irrigation suitability classification: none

Range: III 1% bush

Internal drainage: III r

Terraces and diversions: III r;f

Embankments, dikes and levees: III r;c

Pond reservior: III r

8/12/81 J.G./A.D./F.O.

GORAY EEFB

Location: 282.4 E
1393.4 N

0-12 cm: A horizon; 10YR/5/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); gravelly sand; 30% gravel; structureless; loose, very friable, nonsticky; moderately effervescent; clear irregular boundary;

12-30 cm: B horizon; 10YR/4/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); gravelly sandy loam, 40% gravel; weak fine subangular blocky structure; loose, very friable, nonsticky; strongly effervescent; thin patchy coating of $CaCO_3$ and weak cemented $CaCO_3$ on the rock fragments; few fine woody roots; clear; irregular boundary;

30-40+ cm: C horizon; 7.5YR/4/4 brown (dry), 7.5YR/3/4 dark brown (moist); sandy loam; structureless; loose, friable, slightly sticky; strongly effervescent.

Surface: flat and about 80% gravel cover

Inclusions: 20% waterways

Slope: 1%

Parent Material: colluvial fan of rhyolite

Vegetation: barren with 10% acacia albida in the waterways

Erosion: Mostly wind and rill erosion

Temperature: 33.8 ^{o}C

Classification: loamy skeletal mixed hyperthermic Typic Calciorthid

Soil Interpretation:

Land Capability Classification: VI g;e

Irrigation suitability classification: II g

Range: III 2% bush

Internal drainage: II c

Terraces and diversions: II p

Embankments, dikes and levees: II t

Pond reservior: III t

18/12/80 A.G./J.G./F.O.

GRAND BARA

Location: 240 E
1246 N

A11 0-0.5 cm: Pink 7.5YR/7/4 (dry); brown 7.5YR/4/4 (moist); silty clay loam; laminar; hard (dry); friable (moist); slick (wet); moderately effervescent; pH 7.3; abrupt boundary.

A12 0.5-10 cm: Pink 7.5YR/7/4 (dry), brown 7.5YR/4/4 (moist); clay loam; strong medium to fine angular blocky structure; firm (dry), friable (moist), slightly sticky (wet); moderately effervescent: gradual boundary,

B1 10-30 cm: Brown 7.5YR/5/4 (dry, dark brown 7.5YR/3/4 (moist); clay loam; moderate medium to fine angular blocky structure; firm (dry), friable (moist); slightly sticky (wet); moderately effervescent; gradual and irregular boundary

B2 30-70 cm: 10YR/6/2 light brownish gray on ped faces; 7.5YR/3/4 dark brown (dry); 7.5YR/3/4 dark brown (moist); sandy clay loam; strong large to medium angular blocky structure; firm (dry), friable none sticky (moist); common fine 1 to 2 mm faint dark brown feromanganese concretions; few fine gypsum crystals; thin alluviated silty coating on ped faces; moderately effervescent.

Surface: Absoutely flat, surface covered with polyhedrons (4-10 cm, 1-3 mm wide and 2-10 mm deep)

Comment: Location - 7 km from the east of the road to the west in the middle of Grand Bar

Classification: fine loamy mixed hyperthermic Typic Camborthid

Soil Interpretation:

Land Capability Classification: VIII c

Irrigation suitability classification: II c;v

Range: barren

Internal drainage: II s

Terraces and diversions: II p

Embankments, dikes and levees: II p

Pond reservior: II w

29/12/80 A.D./J.G./F.O.

GUISTIR

Location: 274.3 E
1220.3 N

0-15 cm: A1 horizon; 7.5YR/4/4 dark brown (dry), 7.5YR/3/4 dark brown (moist); clay loam; weak medium to fine subangular blocky structure; soft, friable, nonsticky; 20% fine gravels; common fine roots; strongly effervescent; clear and irregular boundary;

15-30 cm: B1 horizon; 5YR/4/4 reddish brown (dry), 5YR/3/4 dark reddish brown (moist); clay loam; strong large to medium subangular blocky structure; firm, friable, nonsticky; fine disseminated and indurated CaCO3; strongly effervescent; clear boundary;

30-70 cm: B2 horizon; 5YR/4/4 reddish brown (dry), 5YR/3/4 dark reddish brown (moist); clay loam; strong large to medium subangular blocky structure; hard, friable, slightly sticky; small cracks of 1 to 3 mm from 10 cm to 100 cm with 20 cm spacing and common medium pressure faces and common medium discontinous slickensides; strongly effervescent; few rose gypsum of 2 to 4 mm; clear boundary;

70-120+ cm: B3 horizon: 5YR/4/4 reddish brown (dry) 5YR/3/4 dark reddish brown (moist); clay loam; moderate large to medium angular blocky structure; hard, friable, nonsticky; many 1 to 4 mm rose gypsum; strongly effervescent;

Surface: 50% 5 to 15 cm cobbles on the surface

Inclusions: Eolian mantle over lava flow; 2 to 3 mm thick loess;

Slope: 2% slope

Position: little erosion and very long straight slope

Vegetation: 10% cover of sarman

Comment: 4 km from Guistir on the road to Ali-Adde stream bank on the north side of the road.

Classification: fine loamy mixed hyperthermic Typic Camborthid.

Soil Interpretation:

Land Capability Classification: VI a;g

Irrigation suitability classification: VI a;g

GUISTIR

continued

Range: II 10% bush; 10% grass and herbs

Internal drainage: II t;a

Terraces and diversions: II p;r;f

Embankments, dikes and levees: II p;c;g

Pond reservior: II w;r

22/12/80 A.D./J.G./F.O.

HADKODLEY

Location: 256.6 E
1235.7 N

0-10 cm: A1 horizon; 10YR/5/3 brown (dry), 10YR/3/3 dark brown (moist); sandy loam; weak medium to fine subangular blocky structure; loose, friable, nonsticky; few fine roots; strongly effervescent; clear boundary;

10-20 cm: B1 horizon; 10YR/5/3 brown (dry), 10YR/3/3 dark brown (moist); sandy clay loam; strong large to medium subangular blocky structure; hard, friable; nonsticky; secondary powdery CaCO3, strongly effervescent; clear boundary;

20-40 cm: B2 horizon; 10YR/4/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); sandy clay loam; moderate large to medium breaking to fine subangular blocky structure; loose; friable, nonsticky; fine powdery and indurated 1 to 4 common CaCO3; strongly effervescent; gradual and irregular boundary;

40-60+ cm: C horizon; 10YR/3/3 dark brown (dry), 10YR/3/2 very dark grayish brown (moist); gravelly sandy clay loam; weak medium to fine subangular blocky structure; loose; friable, nonsticky; 1 to 10 mm indurated CaCO3; strongly effervescent; 30% gravels, cobbles 1 to 10 cm in 0 and slope ranges 3-8%

Vegetation: (salvadora persicae, cympobogon, "Aurdawood")

Comments: Occurs on decomposed metamorphic rock

Location: At about 600 m north of Daedae and at 300 m of South Hadkodely

Classification: fine loamy mixed hyperthermic Typic Camborthid

Soil Interpretation:

Land Capability Classification: VI s

Irrigation suitability classification: none

Range: III 5% bush

Internal drainage: II w;i

Terraces and diversions: II p

Embankments, dikes and levees: II e

Pond Reservior: III p;w

10/3/82 A.D./J.G.

HARRALOL

Location: 220 E
1317 N

Land Type: Salt Marsh
Couldn't land the helicopter. All of the playa had 5-20 cm of water.

Salt cover on sides

Land Use Interpretation:

Land Capability Classification: VIII r;c

Irrigation suitability classification: None, a;c

Range: barren

Internal Drainage: III w

Terraces and diversions: III c

Embankments, dikes and levees: III g

Pond reservior: II c

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30/12/80 A.D./J.G./F.O.

HOLL-HOLL

Location: 273.6 E
1250.7 N

0-20 cm: A horizon; 10YR/5.4 yellowish brown (dry), 7.5YR/ 3/4 dark brown (moist); very gravelly sandy clay loam; weak fine subangular blocky structure; loose, friable, slightly sticky; many fine roots; 60% 3 to 10 cm gravels; 1 to 4 mm fine powdery disseminated and indurated $CaCO_3$; medium coating of $CaCO_3$ on the gravels and the stones; strongly effervescent; irregular and diffused boundary;

20-50 cm: Cca horizon; 10YR/5/3 brown (dry), 10YR/3/4 dark yellowish brown (moist); very gravelly sandy clay loam; weak fine granular structure; soft, friable, slightly sticky; 80% gravels; soil filling interstices; common fine and a few coarse roots; 1 to 4 mm fine powdery disseminated and indurated $CaCO_3$; medium coating of $CaCO_3$ on all parts of the rocks; strongly effervescent; irregular and diffused boundary;

50-200+ cm: IICca horizon; 10YR/5/4 yellowish brown (dry), 7.5YR/4/6 strong brown (moist); gravelly sandy clay loam; 30% volcanic colluvium gravel plus 20% 1 to 15 mm of indurated $CaCO_3$; from 120 cm to the bottom 10% 1 to 10 mm of soft powdery $CaCO_3$ reprecipitated from above; few $CaCO_3$ coating on the rock faces; strongly effervescent;

Surface: 70% boulders and cobbles on the surface;

Inclusions: thin soil occupies 35% of the area and a thinner soil occupies 30% of the area

Slope: 45 to 70% slopes

Parent Material: lava outcrops 30%

Vegetation: 20% vegetation cover on this soil and the other soil about less than 5% vegetation;

Comment: On the South side of the road and the south bank of the HOLL-HOLL river and at 150 m west of the Military school.

Classification: loamy skeletal mixed hyperthermic Typic Calciorthid.

Soil Interpretation:

Land Capability Classification: VIII s

Irrigation suitability classification: none

Range: II 10% bush

HOLL-HOLL

Continued

Internal drainage: III i;r

Terraces and diversions: III p;f;

Embankments, dikes and levees: III r;t;e;p

Pond reservior: III r;p

12/11/80 A.D./J.G./F.O.

HOUMBOULI

Location: 295.9 E
1278.1 N

On surface: Ag

0-8 cm: desert pavement. Fluvial gravels and cobbles

4-12 cm: A horizon; brown 10YR/5/3 (dry) and dark grayish brown 10YR/4/2 no structure (loose), sand, rare roots, pH 7.5

12-40+cm: C horizon; brown 7.5YR/5/4 (dry) and dark brown 7.5YR/ 4/4 (wet); loose; few fine roots; few cobbles (5-10%) pH 8-8.4

Slope: 1%

Vegetation: acacia tortilis - "kulan"

Erosion: wind

Classification: mixed hyperthermic Typic Torripsamment

Soil Interpretation:

Land Capability Classification: VI w;e

Irrigation suitability classification: III w

Range: III 2% bush

Internal drainage: II t

Terraces and diversions: II t

Embankments, dikes and levees: II t;e

Pond reservior: III t;w

13/11/80 A.D./J.G./F.O.

JABAN EAS

Location: 290.3 E
1277.8 N

0-5 cm: A horizon; yellowish red 5YR/5/6 (dry) red 2.5YR/4/6 (wet); loose, 90% cobbles and boulders; clear boundary;

5-19 cm: B1 horizon; yellowish red 5YR/5/6 (dry) and red 2.5YR/ 4/6 (wet); clay loam; weak very fine, granular structure; friable (wet) and loose (dry); very fine roots; pH 8.4 clear boundary

19-49+ cm: B2ca horizon; red 2.5YR/4/8 (dry) red 2.5YR/ 3/6 (wet); gravelly clay loam; moderate fine subangular structure; consistence loose; 10% 7.5YR/8/1 powdered 1 to 5 mm secondary $CaCO_3$; very fine roots.

Inclusions: big rocks of basalt (2%)

Slope: 2 to 3%

Vegetation: Acacias 5% cover

Classification: fine loamy, mixed hyperthermic, Typic Calciorthid

Soil Interpretation:

Land Capability Classification: VII a;g

Irrigation suitability classification: none a;g

Range: II 5% bush; 200k/Hc

Internal drainage: III t;a;b

Terraces and diversions: II p;t;c

Embankments, dikes and levees: II p;g

Pond reservior: III w;r

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20/12/81 A.D./F.O./J.G./M.J.

KALLOLOU

Location: 249.7 E
1218.2 N

0-50 cm: C horizon; 10YR/3/3 dark brown (dry), 10YR/3/2 very dark grayish brown (moist); stony sand; structure: none; loose, friable, nonsticky; 50% gravel and stones; moderately effervescent; few fine woody roots.

Surface: 30% stones and boulders, 70% gravel

Inclusions: 20% stream channels

Slope: 3%

Position: delta

Parent Material: alluvium

Vegetation: 20% 1.5 to 2 m high acacia tortilis

Erosion: frequent flooding

Temperature: 32.8 ^{o}C

Classification: sandy skeletal mixed hyperthermic Typic Torrifluvent.

Soil Interpretation:

Land Capability Classification: VI w;g

Irrigation suitability classification: III w;s;g

Range: I 20% bush; 350k/Hc

Internal drainage: II b

Terraces and diversions: II p;t

Embankments, dikes and levees: II t;e

Pond reservior: III t;w

7/12/81 J.G./F.O

KENANNABA

Location: 297.8 E
1387.8 N

0-8 cm: A11 horizon; 7.5YR/5/4 brown (dry), 7.5YR/3/4 dark brown (moist); gravelly sand; structureless; loose, very friable, nonsticky; effervescent; few fine roots, clear smooth boundary;

8-30 cm: A12 horizon; 7.5YR/6/4 light brown (dry), 7.5 YR/4/4 brown (moist); gravelly sand; structureless; loose, very friable, nonsticky; effervescent; thin patchy coating on the gravel; few woody roots; clear smooth bondary.

30-50 cm: C horizon; gravel; laminated, stratified

Inclusions: 30-40% on waterways with sand dunes (20-50 cm high) covering 30-40% on waterways.

Slope: 0-1%

Vegetation: woody bush in the waterways

Erosion: rill and sheet erosion hazard

Temperature: $33^{o}C$

Classification: sandy skeletal mixed hyperthermic Typic Torriorthent

Soil Interpretation:

Land Capability Classification: VII w;v

Irrigation suitability classification: II v;w

Range: III 5% herbs

Internal drainage: I

Terraces and diversions: II p;t

Embankments, dikes and levees: II t;p

Pond reservior: III t;p

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23/2/81 A.D./J.G./F.O.

KOUTABBOUYYA

Location: 116.9
1221.7

Land type: Marl

0-15 cm: eolian sand

15-40+ cm: sandy colluvium over marl

Surface: Barren

Slope: 10% slope

Erosion: Many small gullies on the old pleistocene lake bottom

Land Use Interpretation:

Land Capability Classification: VIII a

Irrigation suitability classification: none

Range: barren

Internal drainage: III i

Terraces and diversions: III p

Embankments, dikes and levees: III p

Pond reservior: III p

15/3/82 J.G./A.D.

LAHI DADDAEO

Location: 273.6 E
1317.8 N

0-15 cm: A1 horizon; 7.5YR/4/4 brown (dry), 7.5YR/3/4 dark brown (moist); gravelly loam; weak medium and fine subangular blocky structure; loose, friable, nonsticky; many fine roots; 30% gravel; strongly effervescent; clear irregular boundary;

15-30 cm: A3 horizon; 7.5YR/6/4 light brown (dry), 7.5YR/4/6 strong brown (moist); clay loam; weak and moderate medium subangular blocky structure; firm, friable, slightly sticky; strongly effervescent; many fine fibrous roots; 25% weathered rocks; gradual diffused boundary,

30-55 cm: C horizon; 5YR/5/4 reddish brown (moist); sandy clay loam; weak medium subangular blocky structure; common fine woody roots; 25-30% weathered rocks; white masses of decayed rocks; gradual diffused boundary,

55 cm: R (rock)

Surface: 60% gravel and cobbles, 10% boulders

Inclusions: 20% rock outcrop, 30% of thicker soil (lower slope)

Slope: 25%

Position: side slope

Parent Material: colluvium and rhyolite

Vegetation: 20% grass, 5% herbs, few bushes (3 m high)

Erosion: severe gully erosion

Temperature: 25.5 ^{o}C at 20cm

Classification: fine loamy mixed hyperthermic Lithic Torriorthent

Soil Interpretation:

Land Capability Classification: VII s;w;g;e

Irrigation suitability classification: none

Range: I 20% grass; 5% herbs; 2% bush

Internal drainage: III t;r;i

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LAHI DADDAEO

continued

Terraces and diversions: III p;f;t

Embankments, dikes and levees: III r;p;c

Pond reservior: III p;r

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15/3/82 J.G./A.D.

MAARIGI

Location: 286.3 E
1323.8 N

0-23 cm: A horizon; 7.5YR/4/4 brown (moist); gravelly clay loam; moderate medium and coarse subangular blocky structure; firm, slightly friable, sticky; common woody roots; not effervescent; mottled grayish brown and reddish brown; clear irregular boundary;

23-65 cm: C horizon; 7.5YR/5/2 brown (moist); very gravelly clay loam; 60% gravel; structureless; hard, firm, sticky; not effervescent; few medium woody roots; gradual irregular boundary;

66-110+ cm: C2 horizon; 10YR/6/2 light bronish gray (moist); very gravelly loam; 60% gravel; not effervescent.

Surface: 60% gravel, 15% stones and boulders

Inclusions: 10% rock outcrop

Slope: 5-7%

Position: plateau

Parent Material: decayed rock

Vegetation: 20-25% grass, 10% herbs, 5% bushes to 3 m (sarman)

Erosion: severe gully

Temperature: 26.6 ^{o}C

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent.

Soil Interpretation:

Land Capability Classification: VI g;s

Irrigation suitability classification: none e

Range: I 20% grass; 10% herbs; 5% bush

Internal drainage: III r;i

Terraces and diversions: III p;r

Embankments, dikes and levees: III r;t;e;p

Pond reservior: III w

8/3/81 A.D./J.G./F.O.

MALHADLOU

Location: 208.7 E
1230.3 N

0-24 cm: Al horizon; 5YR/5/3 brown (dry), 7.5YR/4/2 dark brown (moist); very gravelly sand; structure: none; loose, very friable, nonsticky; 70% gravel and cobble of 4-10 cm; strongly effervescent; $CaCO_3$ on all parts of the gravel; smooth and clear boundary;

24-40 cm: B2 horizon; 7.5YR/5/4 brown (dry), 7.5YR4/6 strongly brown (moist); silty clay loam; weak coarse to medium angular blocky structure; firm, friable, slightly sticky; 2-10 cm $CaCO_3$ concreations and soft powdery $CaCO_3$; strongly effervescent; irregular, diffused boundary;

40-90 cm: B3ca horizon; 7.5YR/4/6 strong brown (dry), 5YR/ 5/6 yellowish red (moist); silt loam; moderate medium to fine angular blocky structure; firm, friable, slightly sticky; strongly effervescent; clear and diffused boundary;

90-120+ cm: Cca horizon; 10YR/8/1 white (dry), 10YR/8/4 pale yellow (moist); sandy clay loam; unconsolidated lacustine marl.

Surface: Surface covered with 60% stones and cobbles volcanic bombs and rounded lacustrine gravel of quartz, calcite and jasper.

Inclusions: Pleistocene lake sediments

Slope: Slopes range from 5 to 25%

Vegetation: 3% vegetation cover: acacia (1-1.5 m) and Aousdameir

Comment: Soil formed on dissected lacustrine marl.

Classification: fine loamy mixed hyperthermic Typic Calciorthid

Soil Interpretation:

Land Capability Classification: VII s;a;g

Irrigation suitability classification: none

Range: III 3% bush

Internal drainage: III i;a

MALHADLOU

continued

Terraces and diversions: p;f

Embankments, dikes and levees: III e;p;c

Pond Reservior: III w;p

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15/3/82 J.G./A.D.

MANDI

Location: 262.8 E
1346.4 N

Surface: no soil

Inclusions: 40-50% pediment soils on the lower slopes

Slope: 15%

Position: upper part of the slope on edge of lava plateau

Parent Material: rock outcrop

Vegetation: less than 1% shrubs

Erosion: severe water and wind

Soil Interpretations: Barren - no interpretations

9/3/81 A.D./J.G./F.O.

MINKILLE

Location: 167.4 E
1292.4 N

0-10 cm: A11 horizon; 10YR/5/3 brown (dry), 10YR/3/3 dark brown (moist); gravely loam; structure: none; loose, very friable, nonsticky; strongly effervescent; clear and wavy boundary

10-30 cm: A12 horizon; 10YR/3/2 very dark grayish brown (dry); 10YR/2/1 black (moist); stony loam weak medium to fine angular blocky structure; firm friable, slightly sticky; strongly effervescent, irregular and diffused boundary;

30-50+ cm: B horizon; 10YR/3/4 very dark grayish brown (dry), 10YR/2/1 black (moist); stony clay loam; moderate coarse to medium subangular blocky structure; strongly effervescent; hard, friable, slightly sticky;

CaCO3 horizon estimated at 60 cm.

Surface: Thin fine gravel eolian lay (desert pavement)

Inclusions: Inclusions in the high plateau soils

Slope: Slopes from 1-3%

Parent Material: 40% cobbles volcanic bombs cover

Vegetation: vegetation cover of 15% (most in the wadi; bilcin, kulan, quduc)

Comments: Colluvial slope in a minor basin on a lava plateau near the wadi.

Classification: fine loamy mixed hyperthermic Pachic Calciustoll

Soil Interpretation:

Land Capability Classification: VI r;g

Irrigation suitability classification: none, r;g

Range: II 10% bush

Internal drainage: III r

Terraces and diversions: III p;r;f

Embankments, dikes and levees: III r;p;c;e

Pond reservior: III r

2/12/80 A.D./J.G./F.O.

OUEAH

Site No. 68

Location: 266.4 E
1274.8 N

-25 cm to 0: Rock fragments on the surface (10% boulders, cobbles and stones 40%, gravels 40%),

0-12 cm: A1 horizon; 10YR/5/2 grayish brown (dry), 10 YR/3/3 dark brown (moist); very gravelly sandy loam; weak medium to fine subangular blocky structure; loose (dry; friable (wet); nonsticky (moist); many fine and few coarse fibrous roots; fine disseminated and 1 to 4 mm indurated CaCO3; strongly effervescent; 60% gravels and about 10% cobbles and stones; clear and dispersed boundary,

12-50+ cm: C horizon; 10 YR/5/3 brown (dry), 10 YR/3/4 dark yellowish brown (moist); very gravelly sandy loam; weak fine angular structure; loose, friable nonsticky; 70% gravels, fine disseminated 1 to 4 mm indurated CaCO3, continuous CaCO3 coating on the rocks surface; strongly effervescent; common fine roots,

Inclusions: 20% rock outcrop

Slope: 45% of the slopes are occupied by this soil

Similar Soil: 35% similar lithic entisol

Vegetation: 20% of bilcin and qudac cover

Comment: Colluvial slope mixed ignious rocks, 25 to 40% of slopes on the mountains,

Location: Military firing range at 500 m west of the road at Queah,

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent (about 45% of the area); loamy skeletal mixed hyperthermic Lithic Torriorthent (about 35% of the area).

Soil Interpretation:

Land Capability Classification: VII s;g;e;r;w

Irrigation suitability classification: none

OUEAH

continued

Range: I 20% bush

Internal drainage: III r;i

Terraces and diversions: III p;r;f

Embankments, dikes and levees: III r;t;p;c

RIFFUR-DAMOUN

Site No. 4

Location: 168.3 E
1273.2 N

0-42 cm: A horizon; 7.5YR/4/4 brown (dry), 7.5YR/4/4 brown (moist); clay loam; strong coarse to medium angular blocky structure; hard, very firm, sticky; strongly effervescent; few medium woody roots; clear and diffused boundary;

42-80+ cm: Cna horizon; 7.5YR/3/4 dark brown (dry), 7.5YR/4/4 brown (moist); silty clay loam; moderate coarse to medium angular blocky structure; strongly effervescent; hard, friable, slightly sticky; 10-15% 1-3 mm sodium salt concretions; few coarse woody roots.

Surface: Barren

Position: Lake plain

Temperature: Windy, hot and dry.

Comments: Mud cracks on the surface (3 to 5 cm; at 20 cm deep to the surface, cracks of 1 cm wide,

Classification: fine loamy mixed hyperthermic Typic Salorthid.

Soil Interpretation:

Land Capability Classification: VIII r;d;c;a

Irrigation suitability classification: none r;d;a

Range: barren

Internal drainage: III w

Terraces and diversions: III s

Embankment, dikes and levees: III r;g

Pond reservior: III w

13/12/81 A.D./F.O./J.G.

SADAI

Site No. 50

Location: 283.9 E
1340.3 N

Land Type: Wadi Channel

Surface: Boulders and cobbles represent 30 to 60% of the mass,

Slope: Less than 1%

Vegetation: Rare acacia

Comment: Wadi channel; stratified sand, gravels and boulders subject to frequent inundation; channels change with storms; this will be the coarse textural wadi channel,

Temperature: 28.3oC

Land Use Interpretation:

Land Capability Classification: VIII c

Irrigation suitability classification: none

Range: barren

Internal drainage: III c

Terraces and diversions: III c

Embankments, dikes and levees: III e

Pond reservior: III c

10/3/82 A.D./J.G.

SAEIDA DALA

Site No. 5

Location: 196.17 E
1344.3 N

Land Type: Lava flow

Inclusions: 5% inclusions of small playa areas

Slope: 1-3%

Parent Material: Lava flow and rock outcrops only,

Vegetation: Less than 1% vegetation.

Land Use Interpretation:

Land Capability Classification: VIII g

Irrigation suitability classification: none

Range: barren

Internal drainage: III r

Terraces and diversions: III r

Embankments, dikes and levees: III r

Pond reservior: III r

10/3/81 A.D./J.G./F.O.

WANNI DAEAR

Site No. 53

Location: 155.2 E
1282.2 N

0-5 cm: A1 horizon; 10YR/5/3 brown (dry); 10YR/3/4 dark yellowish brown; gravelly silt loam; moderate medium to fine angular blocky structure; firm, friable; slightly sticky; strongly effervescent; clean and irregular boundary;

5-25+ cm: C horizon; 2.5YR/7/2 light gray (dry); 2.5YR/4/2 dark grayish brown (moist); marly sand; structure: none; loose, very friable, nonsticky, strongly effervescent.

Surface: About 30-35% cobbles and stones in the profile; about 80% surface covered by stones and cobbles up to 1 m.

Inclusions: Other areas of this soil range down to 5 cm of gravel; lake at the surface over marly lacustrine sand,

Slope: ranges from 5% (smooth) to 25% (rolling)

Position: This is a recently dissected lacustrine, offshore sediments,

Vegetation: Wan'cart (rare)

Classification: coarse loamy mixed hyperthermic Typic Torriorthent

Soil Interpretation:

Land Capability Classification: VIII s;e

Irrigation suitability classification: none

Range: III 1% bush

Internal drainage: III i

Terraces and diversions: III p

Embankments, dikes and levees: III p

Pond reservior: II p

SOIL SERIES BY CLASSIFICATION

Similar American Soils	Djiboutain Soils
Aridisols	
Calcorthids	
sandy, mixed hyperthermic, Typic Calciorthid	
Eastland	Afmeeaytou
fine loamy, mixed hyperthermic, Typic Calciorthid	
Lareen	Atar
Wintersburg; Sotim	Jaban Eas
loamy skeletal, mixed hyperthermic, Typic Calciorthid	
Tonopah	Easa Gelaw
Gunsight	
Whitlock	Goray Eeeb
loamy, mixed hyperthermic, Typic Calciorthid	
Masonfort	Al Kibo
Masonfort	Awdiea
loamy skeletal, mixed hyperthermic, Lithic Calciorthid	
Hobog; Lozier	Dita
Cambborthids	
fine loamy, mixed hyperthermic, Typic Camborthid	
Lalande	Grand Bara
Lalinda	Guistir
Adelino	Hadkodley
loamy, skeletal mixed hyperthermic, Lithic Camborthid	
Laposa	Arraha Ommane
Aridisols	
Salorthids	
fine loamy, mixed hyperthermic, Typic Salorthid	
Bunker Hill	Riffor Damoun
Natrargids	
fine loamy, mixed hyperthermic, Typic Natrargid	
Casa Grande	Eangalalo

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Similar American Soils	Djiboutian Soils

Inceptisols

Halaquepts

fine loamy, mixed hyperthermic, Aeric Halaquept

Hilmar	Dabagalaley

Entisols

Torriorthents

loamy skeletal, mixed hyperthermic, Typic Torriorthent

Laposa	Easa Do
Arizo	Maarigi
	Oueah
	Afnaba Daba

sandy skeletal, mixed hyperthermic, Typic Torriorthent

Kokan; Arden	Da le Dola

coarse loamy, mixed hyperthermic, Typic Torriorthent

Kimberlina; Seaman	Wanni Daear

sandy, mixed hyperthermic, Typic Torriorthent

Aco; Yellowrock	Eado Gafan

loamy skeletal, mixed hyperthermic, Lithic Torriorthent

Tecopa; Upspring	Dagah Dere
Minlith	Garrayto

sandy, mixed hyperthermic, Lithic Torriorthent

Cantua	Degamankal

fine loamy, mixed hyperthermic, Lithic Torriorthent

Trigger; Delgado	Lahi Daddaeo

Entisols

Torrifluvents

coarse loamy, mixed hyperthermic, Typic Torrifluvent

Ireteba; Anthony	Adoyla

sandy skeletal, mixed hyperthermic, Typic Torrifluvent

Momoli; Ripley	Kallolou

Psamments

mixed hyperthermic, Typic Torripsamment

Rositas; Yturbide	Houmbouli

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Similar American Soils	Djiboutian Soils

Mollisolls

Calciustolls

fine loamy skeletal, mixed hyperthermic, Aridic Calciustoll

Pozo Blanco	Arta

fine loamy, mixed hyperthermic, Aridic Calciustoll

Engle; Sarnosa	Daba Eabdalle

loamy, mixed hyperthermic, Pachic Calciustoll

Elfrida	Minkille

Haplustolls

loamy, skeletal, mixed hyperthermic, Aridic Haplustoll

Wainee	Dimo Le Boda

Miscellaneous Land Types

Talus slope

Lava flow

Wadi channel

Beach

Mud flat

Marl

Salt marsh

Rock outcrop

LIST OF AMERICAN SOILS SIMILAR TO DJIBOUTIAN SOILS

Acado	
Aco	Coarse loamy mixed (cal) Hypth. Typic Torriorthent
Adelino	Fine loamy, mixed, th. Typic Camborthid
Akela	Loamy skeletal, mixed (cal), th, Lithic Torriorthent
Agua	Coarse loamy over sandy or skeletal, mixed (cal), thermic, Typic Torrifluvent
Agualt	Course loamy over sandy or skeletal, mixed (cal), Hythermic, Typic Torrifluvent
Aguilita	Loamy skeletal, Carbonatic, Isohyth Shallow Typic Calciustall
Alemeda	Loamy skeletal, mixed, th, Typic Calciorthid
Algerita	Coarse loamy, mised, th, Typic Calciorthid
Amole	Sandy, mixed, th, Typic Torriorthent
Anthony	Coarse Loamy, Mixed (cal), Th, Typic Torrifluvent
Arden	Sandy skeletal, Mixed, Th, Typic Torriorthent
Arizo	Sandy skeletal, Mixed, Th, Torriorthent
Bazito	Mixed, thermic, Typic Torripsamment
Begay	Course loamy, Mixed, Mesic Ustollic Camborthid
Blue Point	Mixed thermic Typic Torripsamment
Bridge	Fine loamy, Mixed th, Typic Calciorthid
Burson	Loamy, mixed, (cal), th, shallow, Utic Torriorthent
Cajon	Mixed, thermic, Typic Torripsamment
Caliza	Sandy skeletal, Mixed, thermic Typic Calciorthid
Cantua	Coarse loamy, Mixed, nonacid, th, Typic Torriorthent
Canutio	Loamy skeletal, Mixed (cal), th, Typic Torriorthent
Carsitas	Mixed, Hyth, Typic Torripsamment
Carrizo	Sandy skeletal, Mixed, Hyth, Typic Torriorthent
Casa Grande	Fine loamy, Mixed, Hyth, Typic Natrargid
Charberino	Loamy skeletal, Mixed, thermic, Typic Calciorthid
Cherum	Coarse loamy, mixed, (Na), th, Typic Torriorthent
Clark	Fine loamy, Mixed, th, Typic Calciustall
Comoro	Coarse loamy, Mixed, (cal), th, Typic Torrifluvent
Coolidge	Coarse loamy, Mixed, Hyth, Typic Calciorthid
Cotton Wood	Loamy, Mixed, (cal), th, shallow Ustic Torriorthent
Dant	Fine loamy, Mixed, Hyth, Aridic Haplustoll
Dateland	Coarse loamy, Mixed, Hyth, Typic Camborthid
Delgado	Loamy, Mixed, (cal), th, Lithic Torriorthent
Doss	Loamy, Carbonatic, th, shallow, Typic Calciustoll
Eastland	Sandy skeletal, Mixed, Hyth, Typic Calciorthid
Elfrida	Fine Loamy, Mixed, th, Pachic Calciustoll
Emauda	Coarse loamy, Mixed, (Na), thermic, Typic Torriorthent
Emot	Loamy skeletal, Mixed (cal), th. Typic Torriorthent
Engle	Fine loamy, Mixed, th, Typic Calciustoll
Excelsior	Coarse loamy, Mixed, (cal), th. Typic Calciustoll
Fredensborg	Loamy, Carbonatic, Isohyth, shallow, Typic Calciustoll
Gallegos	Loamy skeletal, Mixed, th, Ustollic Camborthid
Garces	Fine loamy, Mixed, thermic, Typic Natragid
Gila	Coarse loamy, Mixed, (cal), th, Typic Torrifluvent
Gilliam	Fine silty, Mixed, Mesic, Fluvaquentic Hapludoll
Gilland	Loamy skeletal, Mixed, thermic Ustollic Camborthid
Gothard	Fine loamy, Mixed th, Typic Natrargid
Grapevine	Coarse loamy, Mixed, th, Typic Calciorthid

American Soils (continued)

Gunsight	Loamy skeletal, Mixed Hyth, Typic Calciorthid
Holloran	Coarse loamy, Mixed, th, Typic Natrargid
Hidalgo	Fine loamy, Mixed, Hyth, Typic Calciustall
Hilmar	Sandy over loamy, Mixed, (cal), th, Typic Aeric Halaquept
Hobog	Loamy skeletal, Mixed, th, Lithic Calciorthid
Ignacio	Coarse loamy, Mixed, Mesic, Ustollic Camborthid
Ireteba	Coarse loamy, Mixed (cal), thermic, Typic Toirrifluvent
Jean	Sandy skeletal, Mixed, th, Typic Torriorthent
Junction	Coarse loamy, Mixed (cal), th, thermic Typic Torrifluvent
Kettleman	Fine loamy, Mixed, (cal), th, Typic Torriorthent
Kimberline	Coarse loamy, Mixed, th, Typic Torriorthent
KoKan	Sandy skeletal, Mixed, th, Typic Torriorthent
Lagunita	Mixed, Hyth, Typic Torripsamment
Lalande	Fine loamy, Mixed, thermic, Ustochreptic Camborthid
Lalinda	Fine loamy, Mixed, Hyth, Ustollic Camborthid
Latent	Coarse loamy, Mixed, th, Typic Calciorthid
Laposa	Loamy skeletal, Mixed, (cal), Hyth, Typic Torriorthent
Laverkin	Fine loamy, Mixed, th, Typic Calciorthid
Laveen	Coarse loamy, Mixed, th, Typic Calciorthid
Lozier	Loamy skeletal, carb, th, Lithic Calciorthid
Lupe	Loamy, skeletal, Mixed, Hyth, Typic Calciustoll
Mabray	Loamy, skeletal, Mixed, Hyth, Typic Calciustoll
Mabray	Loamy skeletal, carb, thermic, Lithic Torriorthent
Maricopa	Coarse loamy over sorsk, Mixed, (cal), th, Typic Torrifluvent
Maripo	Coarse Loamy over sorsk, Mixed, (cal), Hyth, Typic Torrifluvent
Maynard Lake	Mixed thermic Typic Torripsamment
Mcclough	Coarse loamy, Mixed, (cal), th, Typic Torriorthent
Mescal	Fine loamy, Mixed, (cal), th, Typic Torriorthent
Minlith	Sandy skeletal, Mixed, thermic, Lethic Torriorthent
Moapa	Mixed, thermic, Typic Torripsamment
Momoli	Sandy, skeletal, mixed, Hyth, Typic Torrifluvent
Myoma	Mixed, Hyth, Typic Torripsamments
Nickel	Loamy skeletal, Mixed, th, Typic Calciorthid
Nickey	Coarse loamy, Mixed, th, Typic Calciorthid
Norob	Fine Loamy, Mixed, th, Typic Natrargid
Ogral	Loamy skeletal, Mixed, (cal), Thermic, Typic Torriorthent
Masonfort	Loamy, Mixed, th, shallow, Typic Calciorthid
Paloduro	Fine loamy, Mixed, th, Aridic Hapustoll
Panoche	Fine loamy, mixed (cal), th, Typic Torriorthent
Pantano	Loamy skeletal, mixed, th, Typic Calciorthid
Pettus	Loamy skeletal, carbonatic, Hyth, Typic Calciustoll
Pintura	Mixed, thermic, Typic Torripsamment
Pozo Blanco	Loamy, carb, Isohyth, shallow, Typic Calciustoll
Randsberg	Loamy, Mixed, (cal), th, shallow, Typic Caluistoll
Real	Loamy skeletal, carb, th, shallow, Typic Caluistoll
Remmit	Coarse loamy, Mixed, Mesic, Ustollic Camborthid
Retriever	Loamy, carb, th, Lithic Torriorthent

American Soils (continued)

Rillino	Coarse loamy, Mixed, th, Typic Calciorthid
Rillito	Coarse loamy, Mixed Hyth, Typic Calciorthid
Ripley	Sandy, skeletal, Hyth, Typic Torrifluvent
Rositas	Mixed, Hyth, Typic Torripsamment
Sanderson	Loamy skeletal, carb, th, Ustollic Camborthid
Sornosa	Coarse loamy, Mixed, Hyth, Typic Calciustoll
Satatton	Sandy, Mixed, Hyth, Typic Salorthid
Schenco	Loamy skeletal, Mixed, Hyth, shallow, Typic Camorthid
Schrap	Loamy skeletal, Mixed, (Na), th, Ustic Torriorthent
Seaman	Coarse loamy, Mixed, (cal), th, Typic Torriorthent
Searchlight	Sandy over loamy, Mixed, th, Typic Torrifluvent
Sion	Loamy, Carbon, Isohyth, shallow, Typic Calciustoll
Sotim	Fine loamy, Mixed, th, Typic Calciorthid
St. Thomas	Loamy skeletal, carb, th, Lithic Torriorthent
Stagecoach	Loamy skeletal, Mixed, th, Typic Calciorthid
Sunrise	Fine loamy, Mixed, th, Typic Calciorthid
Superstition	Mixed, Hyth, Typic Calciorthid
Tecopa	Loamy skeletal, Mices, (cal), th, Lithic Torriorthent
Tidwell	Loamy, Mixed, (cal), th, Lithic Torriorthent
Tobaer	Coarse loamy, Mixed, (cal), th, Typic Torrifluvent
Tonopah	Sandy skeletal, Mixed, th, Typic Calciorthid
Toquop	Mixed, thermic, Typic Torripsamment
Trigger	Loamy Mixed, (cal), th, Lithic Torriorthent
Turney	Fine loamy, Mixed, th, Typic Calciorthid
Upspring	Loamy skeletal, Mixed, (cal),th, Lithic Torriorthent
Valencia	Coarse loamy, Mixed, (cal), Hyth, Typic Torrifluvent
Venus	Fine loamy, Mixed, th, Typic Calciustoll
Victorville	Coarse loamy, Mixed, (cal), th, Typic Torrifluvent
Wainee	Clayey, skeletal, Kool, Ishyth, Aridic Haplustoll
Wasco	Coarse Loamy, Mixed, (Na), Th, Typic Torriorthent
Whitlock	Coarse loamy, Mixed, th, Typic Calciorthid
Wikenborg	Loamy skeletal, Mixed, th, Typic Torriorthent
Wink	Coarse loamy, Mixed, th, Typic Calciothid
Yana	Coarse loamy, Mixed, (Na), th, Typic Torriorthent
Yellow Rock	Sandy, Mixed, Typic Torriorthent
Yermo	Loamy skeletal, Mixed, (cal), th, Typic Torriorthent
Yturbide	Mixed, Typic Torripsamment
Zita	Fine loamy, Mixed, Aridic Heplustoll

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LIST OF GEOMORPHIC ZONES NUMERICAL CODE

1. Recent Litoral sediments
2. Cemented Litoral sediments
3. Wadi delta
4. Alluvium
5. Terrace deposits
6. Colluvial deposits
7. Dissected Colluvial fans
8. Steep valley slopes (foot slopes)
9. Steep mountain slopes (talus slopes)
10. Rolling hills
11. Undulating hills
12. Lacustrine playa
13. Dissected lacustrine plain
14. Intermountain basin plain
15. Eolian sand
16. Loess capped lava flow
17. Lava flow
18. Pleasteaw
19. Wadi channel
20. Beach
21. Rock outcrop
22. Crystal salt
23. Active sand dunes
24. Intertidal zone
25. Exposed lake mud
26. Recently exposed lake bottom
27. Short cliffs
28. Marl
29. Coral islands
30. Volcanos
31. Loess capped coral

RDA P-116

Djibouti Water Resources and Soils Analysis

FINAL REPORT

Volume V - Appendices
J, K, L, M, N, O

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Volume 5: Miscellaneous Reports

Volume 5 contains several reports which were generated during the course of this project.

Appendix J: Report on the soils of the Sabbalou and Chekheti region.

Appendix K: Report on the soils and watersheds of the Dey Dey region.

Appendix L: Study on land ownership of Houmbouli and Douda agricultural areas.

Appendix M: List of the books held by the Soils and Water Laboratory Library.

Appendix N: Contains two papers presented at the conference on "Remote Sensing of Arid and Semi-Arid Lands" in Cairo, Egypt.

Appendix O: Contains Field Trip Guides.

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LABORATOIRE D'ANALYSE DES SOLS ET DES EAUX

RÉPUBLIQUE DE DJIBOUTI

APPENDIX J

REPORT ON THE SOILS OF THE SABBALOU AND CHEKHEYTI REGIONS

APPENDIX J

Report on the Soils in the Region of Sabbalou and Chekheyti

by

Dr. Joseph Goebel and Mr. Aboubaker Douale

The outline of the report presented here contains a resume of the soils in the two sectors in the region of Dikil, Djibouti, known as Sabbalou and Chekheyti.

The maps have been made specifically to serve as a guide for decision making on the placement of dispossessed people residing in Djibouti and under the responsibility of the United Nations. The objective is to establish the feasibility of a resettlement project. If this project is approved, we will enter the region to make a more detailed and specific soil study of specific lots for development.

This soil study is only a guide to the soil conditions of the region. Eventually, more specific data will be collected on the region. Due to the very short time alloted to do the project, we have estimated the soil conditions based on soils in nearby areas.

Since it is still uncertain where and how much water will be available, the descriptions and their interpretations on site have not been accomplished until productive wells have been located and the project approved. At that time, the soils for each lot will be determined and specific interpretations made.

The soils described here are those encountered in Djibouti during the National Soil Survey and are those which most represent those of the area involved. But, they are not necessarily the same.

We have also included the name of an American soil which is identical to that soil found in Djibouti based on their interpretation. More specific interpretations will be furnished when the sites are definately selected.

Key to Soil Interpertations Symbols

Land Capability Classification

The Soils are divided into 8 (I-VIII) categories depending on the intensity of land use (see Buchman and Brandy) from well tilled row crops to watershed and wildlife habitat. For all categories, except I, there is a limitation to the use of that soil for agriculture. All of Djibouti is too arid for class I land because these soils require irrigation for agricultural production. Therefore, the arid limitation is assumed for all soils of the country. The following list of letters which follow the Roman Numerals of this classification system indicate the important specific restraint:

w = available water capacity
r = rooting zone depth in less than one meter
s = slope is greater than 5 percent
d = drainage for leaching salts
c - susceptibility to water overflow
a - alkalinity
g - stoniness
v = wind erosion and blowing
e = erosion susceptibility

Irrigation Suitability Classification

The code for irrigation suitability is the same for all 8 (I through VIII) categories of the land capability classification without the aridity limitation as a constraint. The same symbols of limitation are indicated as they affect irrigation agriculture. Therefore, irrigation is assumed for all these soils and no additional symbol is used.

Internal Drainage Classification

Here the land capability categories are:

I no limits to internal drainage practices
II moderate limits
III severe limits

The limits considered to affect internal drainage are:

t = permeability, texture and structure
r = depth to bedrock
w = depth to the water table
i = steepness of slope
b = ditch bank stability
c = flooding or ponding
a = salinity or alkalinity
s = available outlets

Terraces and Diversions Suitability Classifications

The categories here are:

- I no limits for building terraces
- II moderate limits
- III severe limits

The factors determining the suitability for terraces are:

p = slope, steepness and length
r = depth to bed rock
f = stones and outcrops
w = wind hazard
t = texture and permeability
c = channel siltation
s = outlet availability
e = flooding hazard

Embankments Suitability Classification

The major categories are:

- I no limits to construct embankments
- II moderate limits
- III severe limits

The factors determining suitability are:

r = depth of the soil
t = soil texture
e = soil erosiveness
p = percent and length of slope
g = presence of gypsum or salt
c = stones

Pond Reservior Suitability Classification

The major categories are:

- I no limits to pond construction
- II moderate limits
- III severe limits

The factors determining suitability are:

t = permeability
w = depth to the water table
r = depth to bedrock, less than 2 meters
p = slope
e = flooding hazard

Rangeland Classification, Estimated Production

I good production of 200-500 K per Ha
II limited production of 50-200 K per Ha
III non-use of production 0-50 K per Ha

725

AADA

Location: 247.8 E
1245.2 N

0-15 cm: A horizon: color brown 10YR/5/3 (dry) sand; brown 7.5 YR 4/4 (wet) structure: loose mild effervescent; pH 7.5-8, abrupt boundary, sorted and stratified aeolian dune layers of 1-3 mm. Different parent material from underlying soil.

Bb horizon: dark brown 7.5 YR 3/4 (dry) silt loam; dark brown 7.5 YR 3/4 (moist), moderate structure, large breaking to medium, subangular blocky, 15% fine gravels. 10YR 4/4 (wet) very friable, strongly effervescent; few fine pores.

Comment: sandy dunes of 1-4 m profile between dunes shrubs and grass 5-10% vegetation cover of 30-50 cm high; 0-5% slope (smooth) location: on the rim of the basin of Grand Bara (1 to 2 mks wide) at about 25 m of the East and 75 m SE corner of the Garden.

Classification: loamy, mixed, hyperthermic Typic Camborthid

Soil Interpretation:

Land Capability Classification: IIIs

Irrigation suitability classification: IIIs

Range: 20% herbs and grass

Internal drainage: I

Terraces and diversions: IIp

Embankments, dikes and levees: II t;e;p

Pond reservior: IIIp;t

Similar American Soil: DATELAND (Arizona)

WANNI DAEAR

Location: 155.2 E
1282.2 N

0-5 cm: A1 horizon; 10 YR/5/3 brown (dry); 10 YR/3/4 dark yellowish brown; gravelly silt loam; moderate medium to fine angular blocky structure; firm, friable; slightly sticky; strongly effervescent; clean and irregular boundary.

5-25+ cm: C horizon; 2.5 YR/7/2 light gray (dry); 2.5 YR/4/2 dark grayish brown (moist); marly sand; structure: none; loose, very friable, nonsticky, strongly effervescent,

Surface: About 30-35% cobbles and stones in the profile; about 80% surface covered by stones and cobbles up to 1 m.

Inclusions: Other areas of this soil range down to 5 cm of gravel; lake at the surface over marly lacustrine sand,

Slope: ranges from 5% (smooth) to 25% (rolling)

Position: This is a recently dissected lacustrine, offshore sediments,

Vegetation: Wan'cart (rare)

Classification: Coarse loamy mixed hyperthermic Typic Torriorthent

Soil Interpretation:

Land Capability Classification: VIII s;e

Irrigation suitability classification: none

Range: III 1% bush

Internal drainage: III i

Terraces and diversions: III p

Embankments, dikes and levees: III p

Pond reservior: II p

A Similar American Soil is: ACO (California)

G 12-d
G 12-c

EADO GAFAN

Location: 182.8
1285.3

0-10 cm: A horizon; 10YR/5/3 brown (dry) 10YR/3/3 strong brown (moist); sand; structure: none; slightly firm, very friable; some fresh water mollusks; strongly effervescent; clear, smooth boundary;

10-75 cm: C horizon; 10YR/5/4 yellowish brown (dry), 10YR/3/3 strong brown (moist); sand; structure: none; slightly firm, very friable; laminated; moderately effervescent;

Position: Occurs on a pleistocene lacustrine plain

Vegetation: This particular soil has 5% bunch grass cover

Comment: The Hanle plain is about 65% of this soil. About 20% covered with dunes up to 2 m high. 15% wadi with dunes on the edge. The sand dunes have several species of trees; 30% cover up to 3-4 m (Qudac, Caday, dhagdhagan, moroh)

Classification: sandy mixed hyperthermic Typic Torriorthent

Soil Interpretation:

Land Capability Classification: VI v

Irrigation suitability classification: II v;e

Range: II 5% grass

Internal drainage: I

Terraces and diversions: II p;w

Embankments, dikes and levees: II p

Pond Reservior: II t;w

A Similar American Soil is: YELLOW ROCK (California)

DIDJAN DER

Location: 258.8 E
1265.2 N

0-15 cm: A horizon; 7.5YR/5/4 brown (dry), 7.5YR/3/4 dark brown (moist); very gravelly sandy clay loam; weak medium subangular blocky structure, loose, friable nonsticky; few fine roots; 65% of 2 to 4 mm gravels; moderately effervescent; irregular diffused boundary;

15-85 cm: Cca horizon; 10YR/8/1 white (dry) 10YR/5/3 brown (moist); very gravelly sandy clay loam; structureless; thick coating of CaCO3 on all rock surfaces, abundant fine fraction; 40% gravels, 20% cobbles, 10% stones; extremely effervescent; irregular diffused boundary;

85-200 cm: IICca horizon: 10YR/6/4 light yellowish (dry), 10YR/6/3 pale brown (moist); stony sandy clay loam; firm friable, nonsticky; 15% soft powdery 1 to 5 mm CaCO3; irregular diffused boundary;

200-350 cm: IIICca horizon; bouldery alluvium

Surface: between 40-80% gravel and about 30% cobbles and stones

Slope: 0-3% dissected (slightly)

Vegetation: About 20% vegetation cover (balanits aegyptioca, acacia...)

Comment: 100 m west of the road, on the west bank of the wadi

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent.

Soil Interpretation:

Land Capability Classification: IV g

Irrigation suitability classification: II g

Range: 5% bush

Internal drainage: I

Terraces and diversions: II f

Embankments, dikes and levees: II c

Pond reservior: II t

Ba 16

BALAMBAL

Location: 251 E
1260 N

-15-0 cm: volcanic bombs of 5 to 30 cm covering 75% of the area.

0-2 cm: A horizon; 5YR/4/6 yellowish red (dry) 5YR/3/4 dark reddish brown (wet); stony clay loam; moderate medium and fine subangular blocky; structure; friable (dry and moist); common pores (1-2mm); thin discontinuous CaCO3 layer on rock fragments below the soil surface; strongly effervescent, fine disseminated CaCO3; pH 7.5; abrupt boundary;

2-35 cm: B horizon; 5YR/4/6 yellowish red (dry), 5 YR/3/4 dark reddish brown (wet); stonly clay loam; firm friable, nonsticky; strong medium and large subangular blocky structure; strongly effervescent, finely disseminated CaCO3; pH 7.5; few coarse woody trees roots; clear and wavy boundary;

35-45+ cm: Cca horizon; many continous white CaCO3 coatings on gravel uncemented; loose.

Slope: Slope of 2 to 3%

Position: on a plateau, flat top

Vegetation: 2 to 3% cover; "bilcin", "ibateys"

Classification: fine loamy mixed hyperthermic Typic Calciorthid

Soil Interpretation:

Land Capability Classification: VII r;g

Irrigation suitability classification: none

Range: III 5% bush

Internal drainage: III r

Terraces and diversions: III r;f

Embankments, dikes and levees; III r;c

Pond reservior: III r

A Similar American Soil is: Wintersberg (Arizona)

OUEAH

Location: 266.4 E
1274.8 N

-25 cm to 0: Rock fragments on the surface (10% boulders, cobbles and stones 40%, gravels 40%),

0-12 cm: Al horizon; 10YR/5/2 grayish brown (dry), 10 YR/3/3 dark brown (moist); very gravelly sandy loam; weak medium to fine subangular blocky structure; loose (dry; friable (wet); nonsticky (moist); many fine and few coarse fibrous roots; fine disseminated and 1 to 4 mm indurated $CaCO_3$; strongly effervescent; 60% gravels and about 10% cobbles and stones; clear and dispersed boundary;

12-50+ cm: C horizon; 10 YR/5/3 brown (dry), 10 YR/3/4 dark yellowish brown (moist); very gravelly sandy loam; weak fine angular structure; loose, friable nonsticky; 70% gravels, fine disseminated 1 to 4 mm indurated $CaCO_3$, continuous $CaCO_3$ coating on the rocks surface; strongly effervescent; common fine roots;

Inclusions: 20% rock outcrop

Slope: 45% of the slopes are occupied by this soil

Similar Soil: 35% similar lithic entisol

Vegetation: 20% of bilcin and qudac cover

Comment: Colluvial slope mixed igneous rocks, 25 to 40% of slopes on the mountains,

Location: Military firing range at 500 m west of the road at Oueah,

Classification: loamy skeletal mixed hyperthermic Typic Torriorthent (about 45% oif the area); loamy skeletal mixed hyperthermic Lithic Torriorthent (about 35% of the area).

OUEAH

continued

Soil Interpretation:

Land Capability Classification: VII s;g;e;r;w

Irrigation suitability classification: none

Range: I 20% bush

Internal drainage: III r;i

Terraces and diversions: III p;r;f

Embankments, dikes and levees: III r;t;p;c

A Similar American Soil is: TECOPA (California)

HOUMBOULI

Location: 295.9 E
1278.1 N

On surface: Ag

0-8 cm: desert pavement. Fluvial gravels and cobbles

4-12 cm: A horizon; brown 10YR/5/3 (dry) and dark grayish brown 10YR/4/2 no structure (loose), sand, rare roots pH 7.5;

12-40+cm: Chorizon; brown 7.5 YR 5/5 (dry) and dark brown 7.5 YR 4/4 (wet); loose; few fine roots; few cobbles (5-10%) pH 8-8.4;

Slope: 1%

Vegetation: acacia tortilis - "kulan"

Erosion: wind

Classification: mixed hyperthermic Typic Torripsamment

Soil Interpretation:

Land Capability Classification: VI w;e

Irrigation suitability classification: III w

Range: III 2% bush

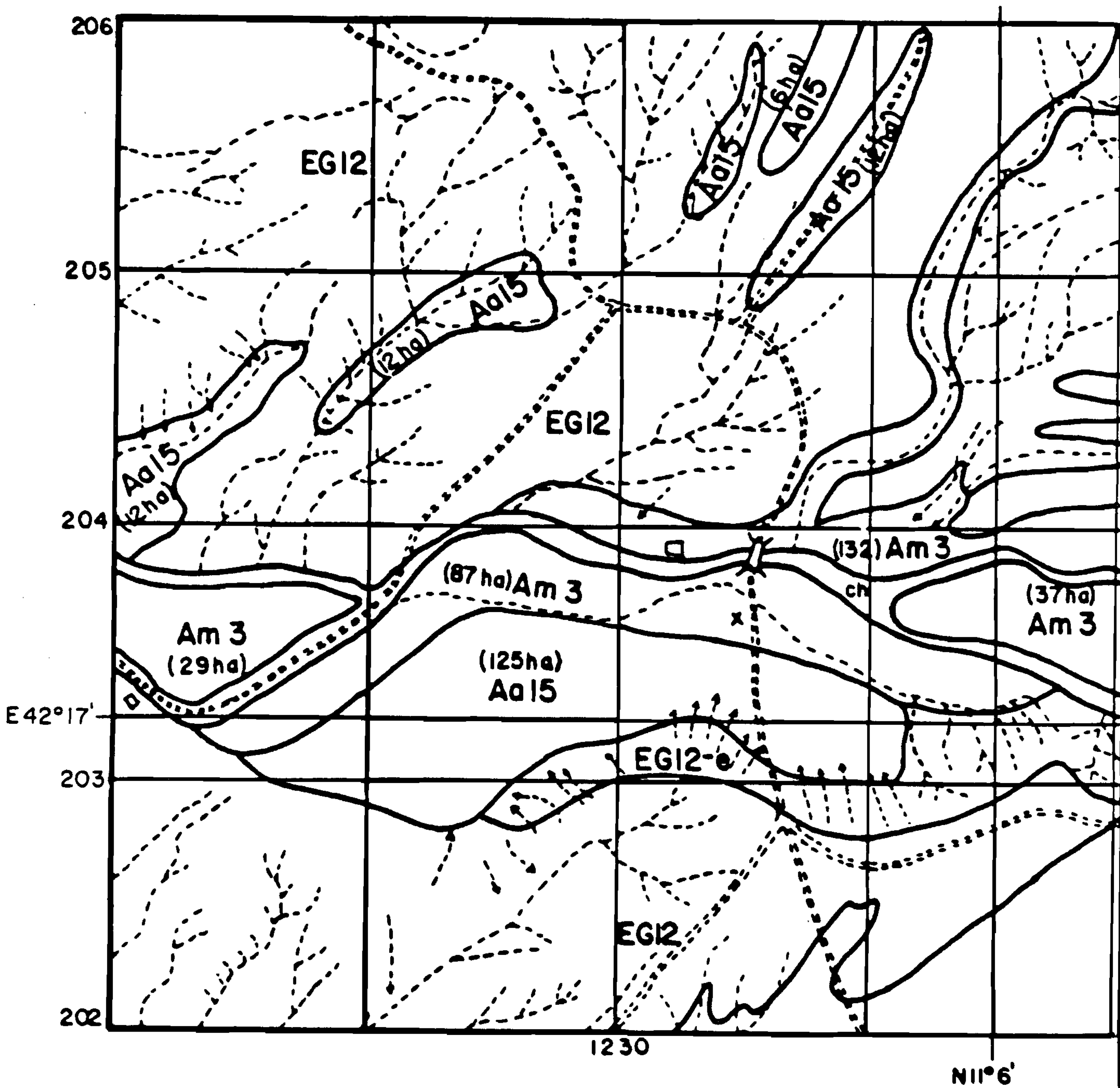
Internal drainage: II t

Terraces and diversions: II t

Embankments, dikes and levees: II t;e

Pond reservior: III t;w

Similar American Soils are: DIANOLA, TATTOM (Texas)

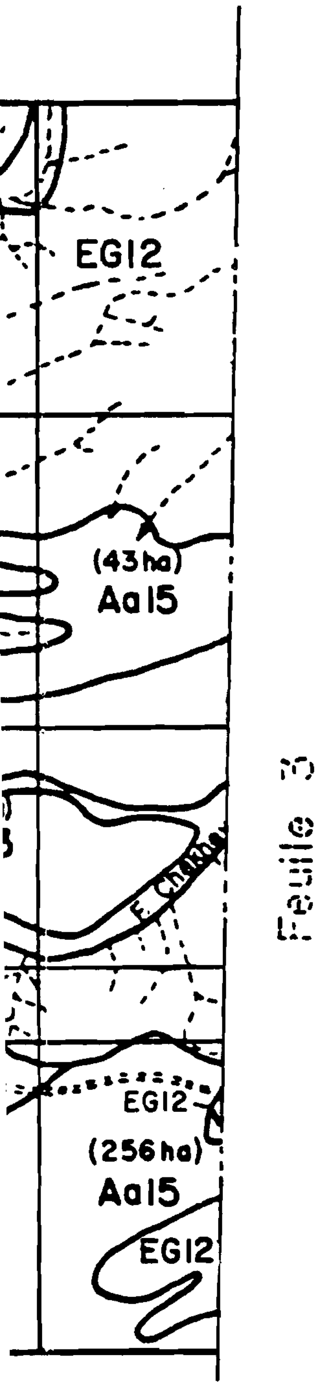

206
205
204
203
202
E42°17'
1230
N11°6'
EG12
Aa15
(6ha)
Aa15
(12ha)
(12ha)
Aa15
EG12
Aa15
(12ha)
(132) Am 3
(87 ha) Am 3
ch
(37 ha)
Am 3
Am 3
(29ha)
(125ha)
Aa 15
EG12-e
EG12

734

Esquisse de Carte Pédologique
Region de Chekheyti

Octobre 1981

Feuile 2 de 3



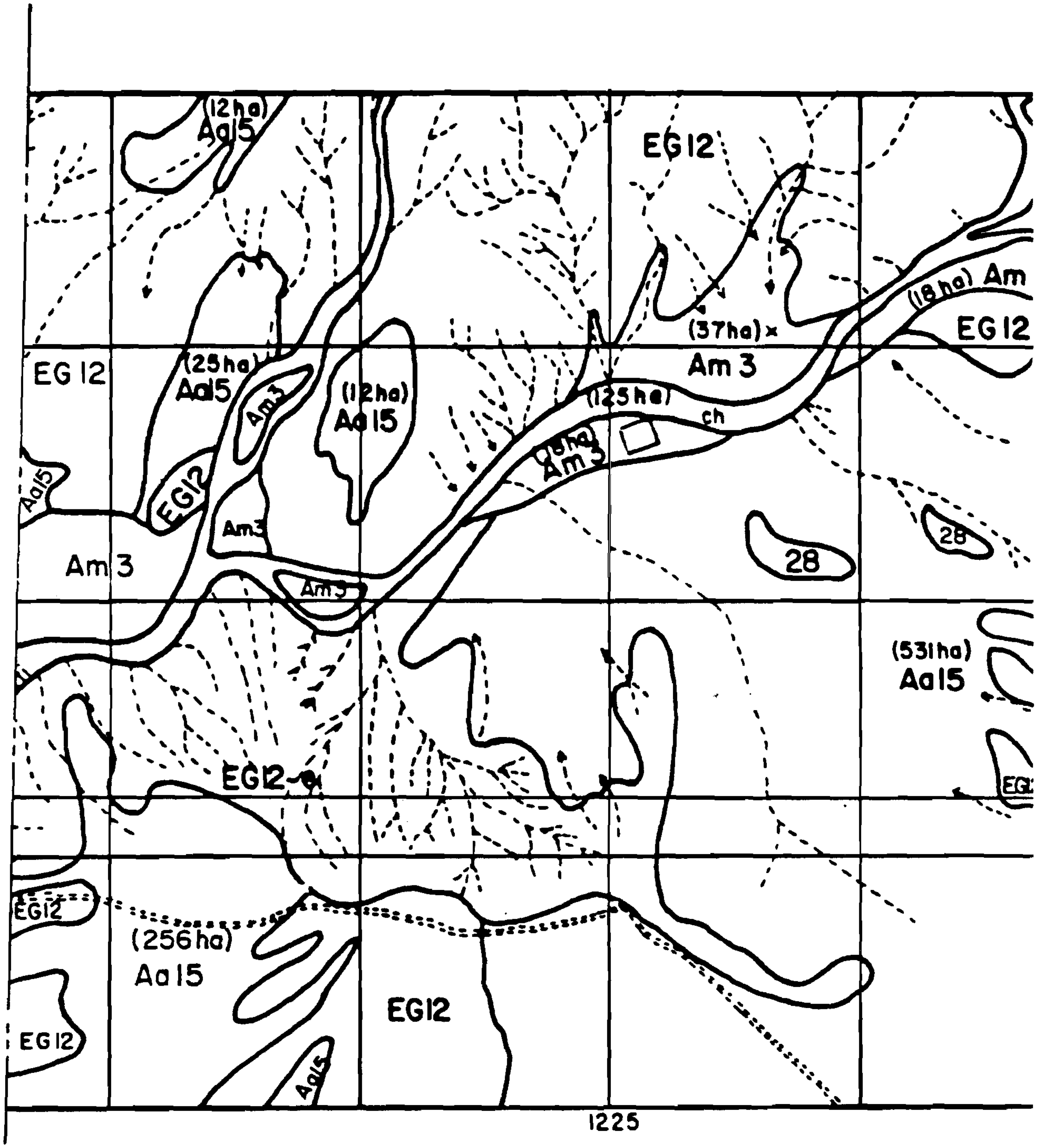
Legende

Aa15	Aada (1058 ha)
Am3	Houmbouli (363 ha)
Di 15	Didjan Der
EG12	Eado Gafan
EG12-e	Eado Gafan erodé
ch	lit d'oued
x	forage proposé
⁄ ⁄	oued (125 ha)
∴	piste
□	jardin actuel
28	Dépouillé

Echelle 1:25.000

Dr. Joseph E. Goebel et Mr. Aboubaker Douale
Laboratoire d'analyse des sols et des eaux

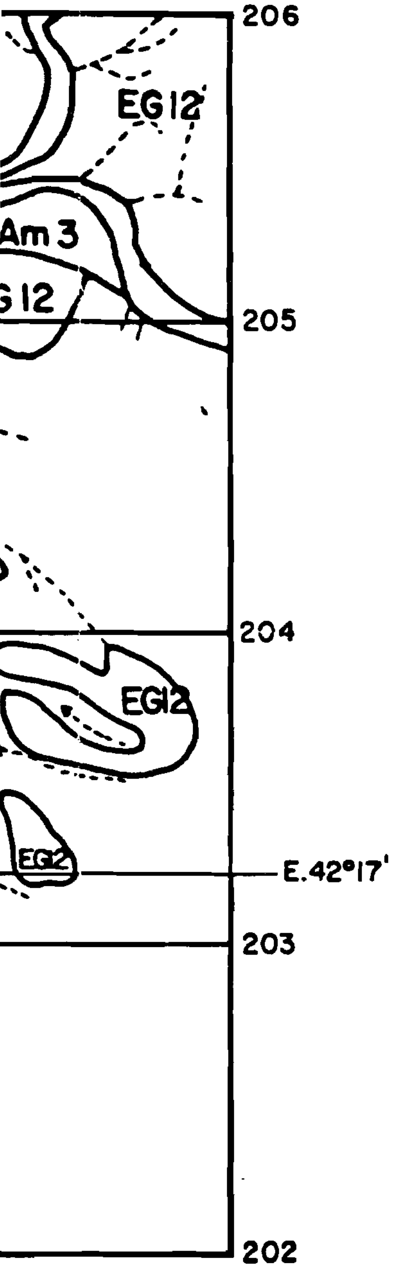
Feuille 2


(12ha)
Aa15
EG12
(18ha) Am
EG12
(37ha)
Am 3
EG 12
(25ha)
Aa15
Am3
(12ha)
Aa 15
(125ha)
ch
Am3
Aa15
EG12
Am3
28
28
Am 3
Am3
(531ha)
Aa15
EG12-e
EG12
(256ha)
Aa 15
EG12
EG 12
Aa15
1225

Esquisse de Carte Pédologique
Region de Chekheyti

Octobre 1981

Feuile 3 de 3



Legende

Aa15	Aada (1058 ha)
Am3	Houmbouli (363 ha)
Di 15	Didjan Der
EG12	Eado Gafan
EG12-e	Eado Gafan erodé
ch	lit d'oued
x	forage proposé
	oued (125 ha)
	piste
□	jardin actuel
28	Dépouillé

0 — 1 Km — 2 Km

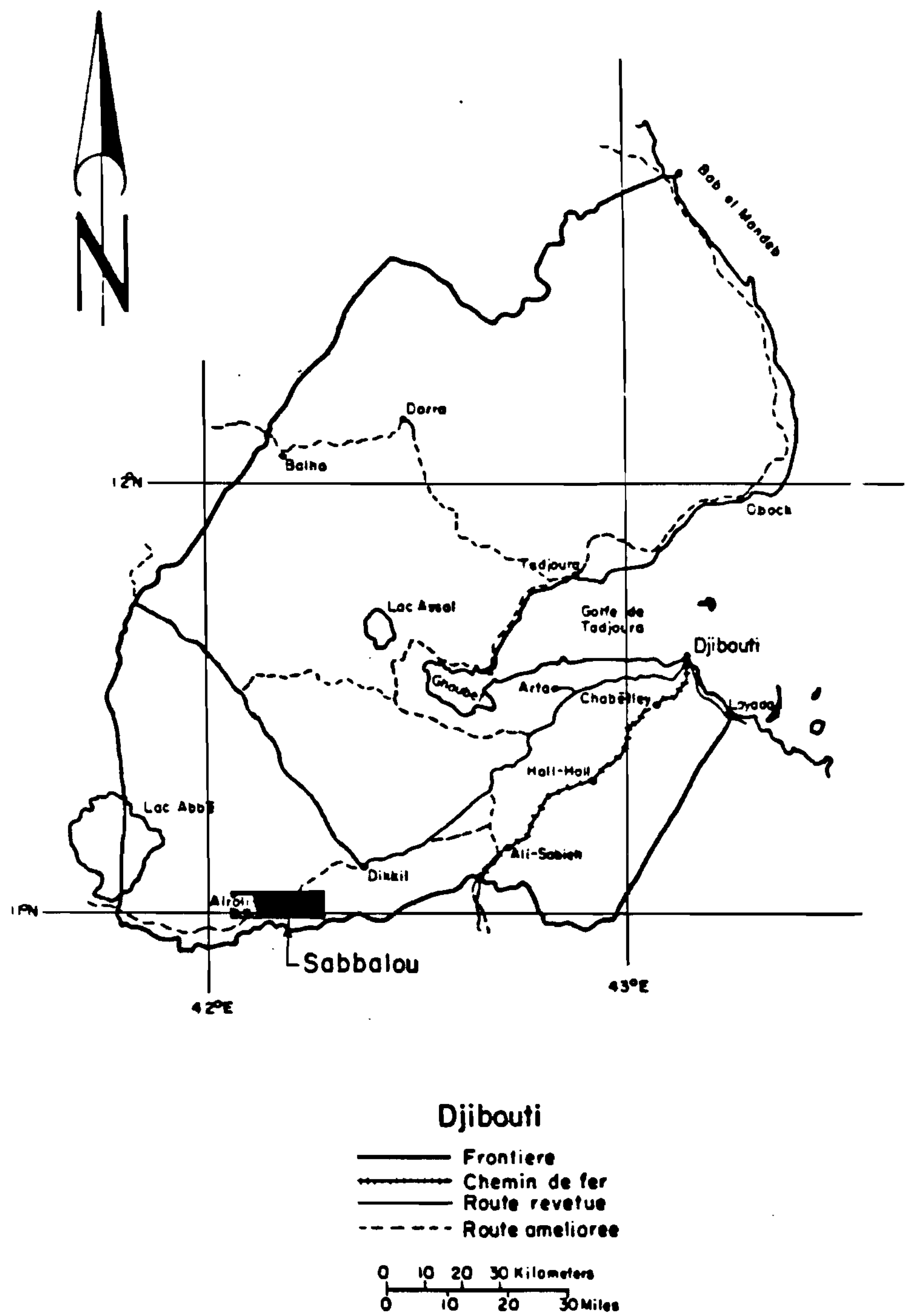
Echelle 1:25.000

Dr. Joseph E. Goebel et Mr. Aboubaker Douale
Laboratoire d'analyse des sols et des eaux

Esquisse de Carte Pédologique
Region de Sabbalou

Octobre 1981

Feuile 1 de 4



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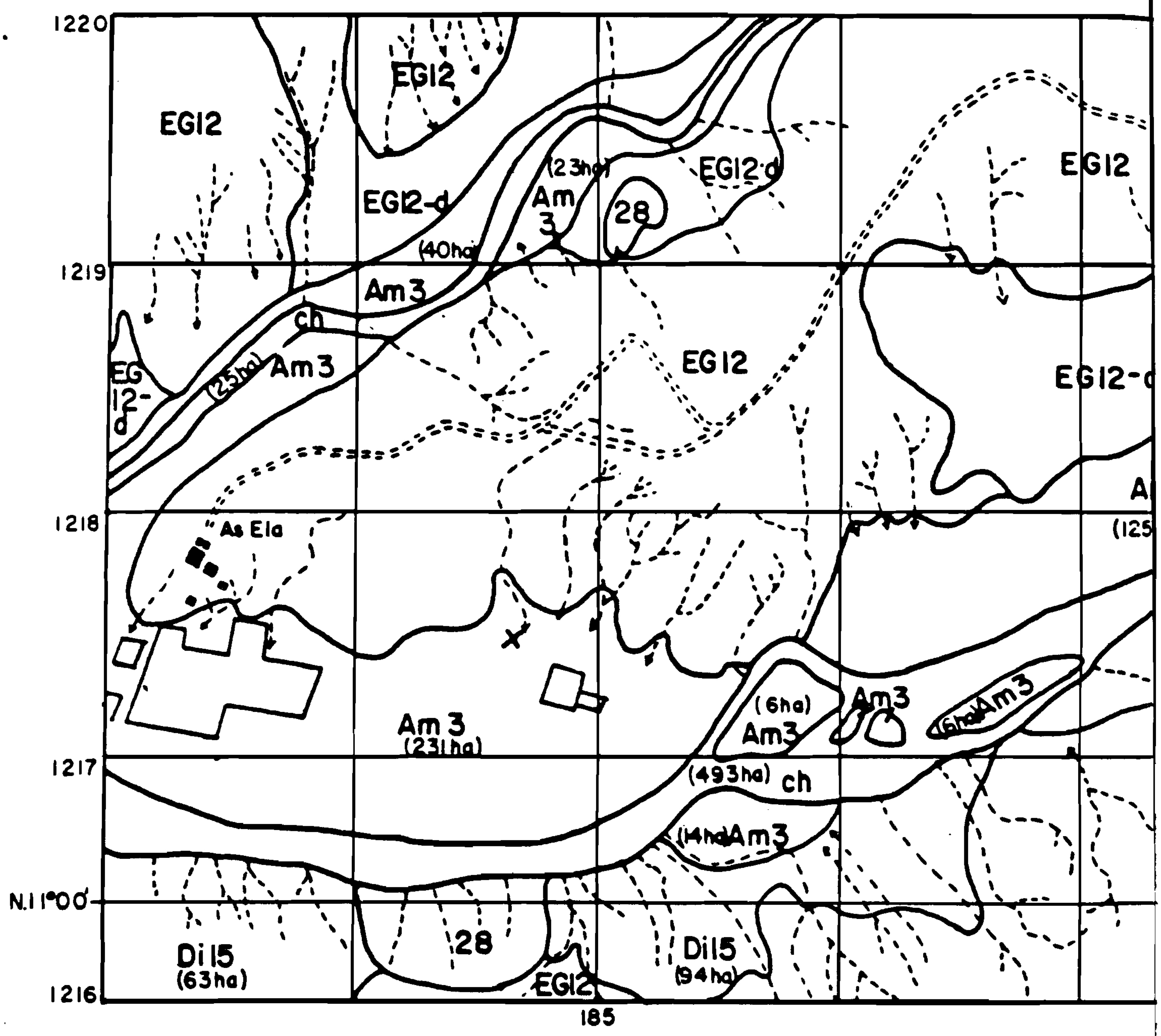
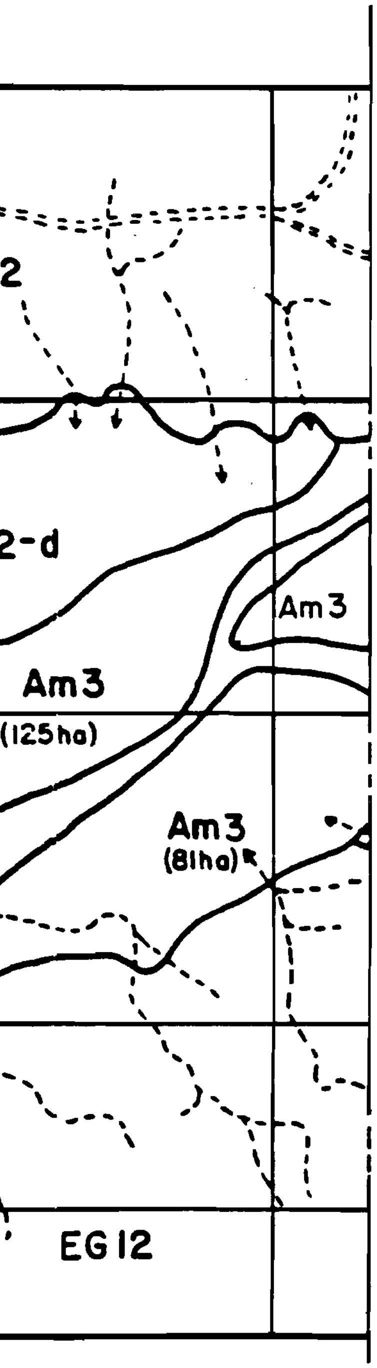

1220
1219
1218
1217
N.11°00'
1216
185
EG12
EG12
EG12-d
(23ha)
Am
3
28
EG12-d
EG12
(40ha)
Am3
ch
EG
12-
d
(25ha)
Am3
EG12
EG12-d
As E1a
Am 3
(231ha)
(6ha)
Am3
Am3
(6ha) Am3
(493ha)
ch
(14ha) Am3
Di15
(63ha)
28
EG12
Di15
(94ha)



Feuile 3

Esquisse de Carte Pédologique
Region de Sabbalou

Octobre 1981

Feuile 2 de 4

Legende

Aa 15	Aada (274 ha)
Am 3	Houmbouli (940 ha)
Ba 16	Balambal
Di 15	Didjan Der (387 ha)
EG12	Eado Gafan
EG12-d	Eado Gafan avec dunes
Ou 9	Oueah
WD17	Wanni Dacar
ch	lit d'oued
*	forage proposé
⊗	limnigraphe
	oued
	piste
□	jardin actuel
28	Dépouillé

0 1 Km 2 Km

Echelle 1:25.000

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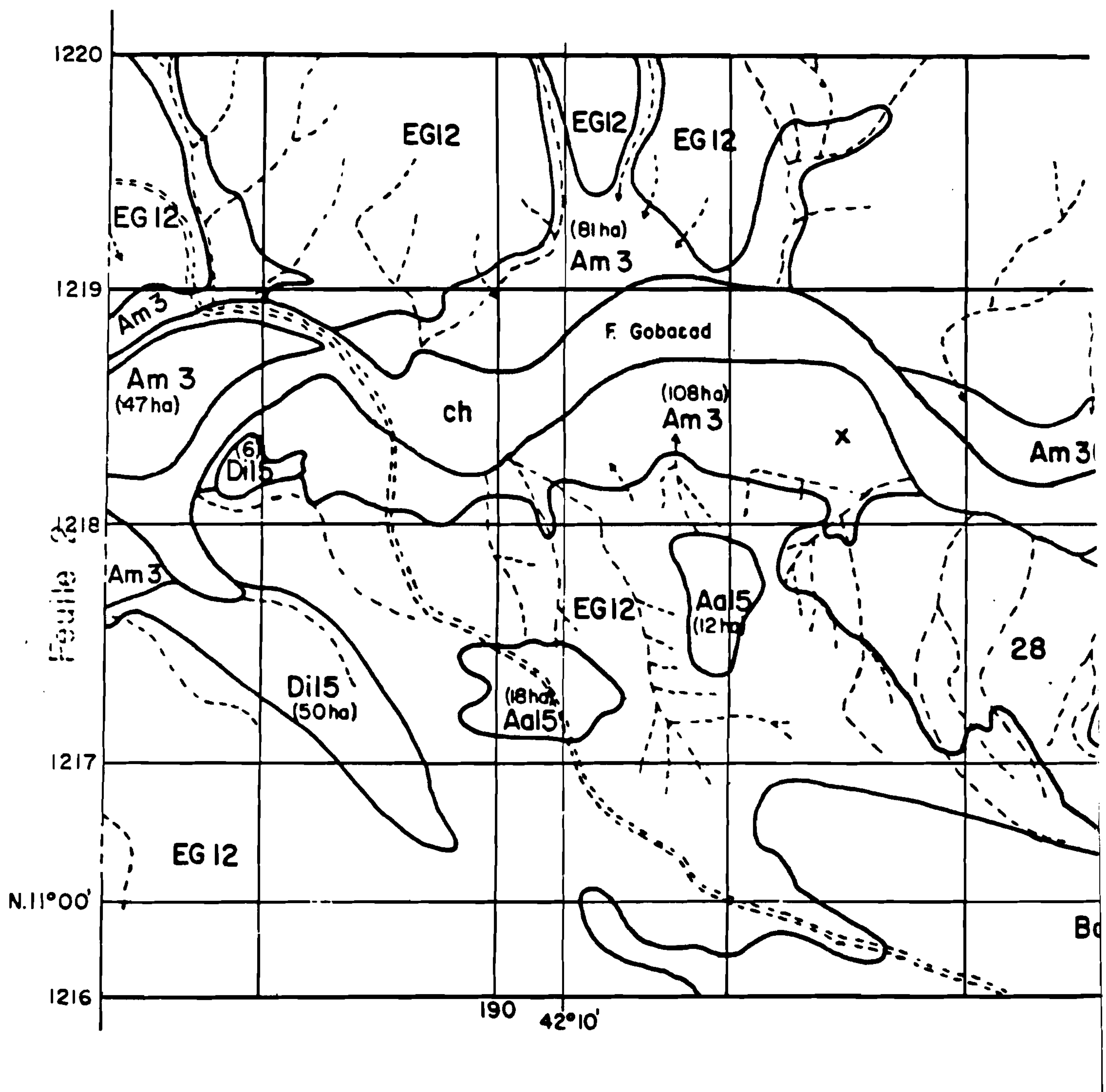
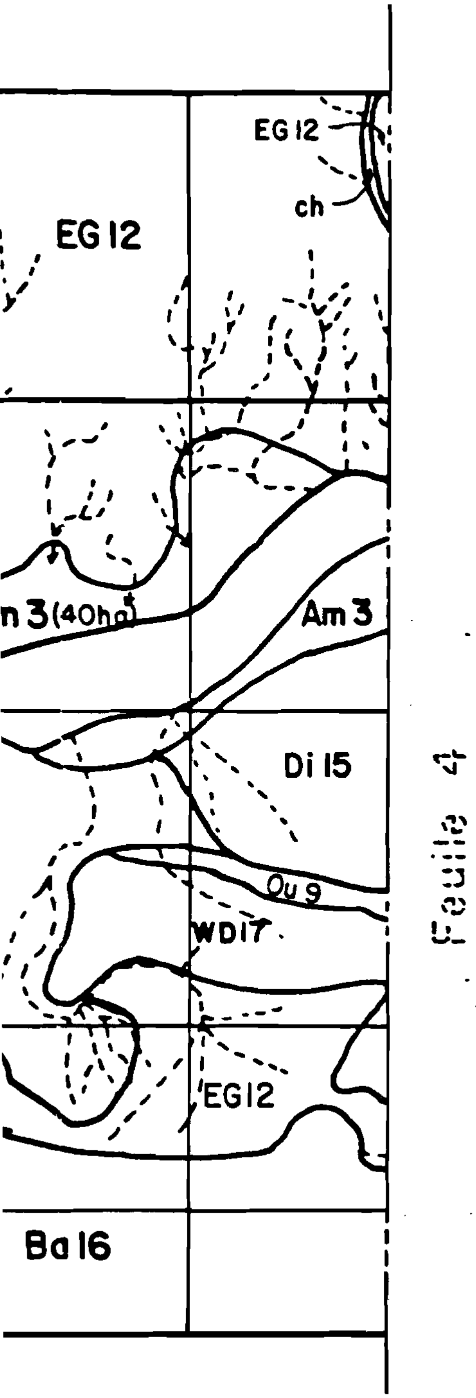

1220
1219
1218
1217
N.11°00'
1216
190
42°10'
EG12
EG12
EG 12
EG 12
(81 ha)
Am 3
Am 3
Am 3
(47 ha)
F. Gobacad
ch
(108 ha)
Am 3
x
Am 3
(6)
Di15
Am 3
EG12
Aa15
(12 ha)
28
Di15
(50 ha)
(18 ha)
Aa15
EG 12
Feuille 2

741



Esquisse de Carte Pédologique
Region de Sabbalou

Octobre 1981

Feuile 3 de 4

Legende

Aa 15	Aada (274 ha)
Am 3	Houmbouli (940 ha)
Ba 16	Balambal
Di 15	Didjan Der (387 ha)
EG12	Eado Gafan
EG12-d	Eado Gafan avec dunes
Ou 9	Oueah
WD17	Wanni Dacar
ch	lit d'oued
×	forage proposé
⊗	limnigraphe
	oued
	piste
□	jardin actuel
28	Dépouillé

0 1 Km 2 Km

Echelle 1:25.000

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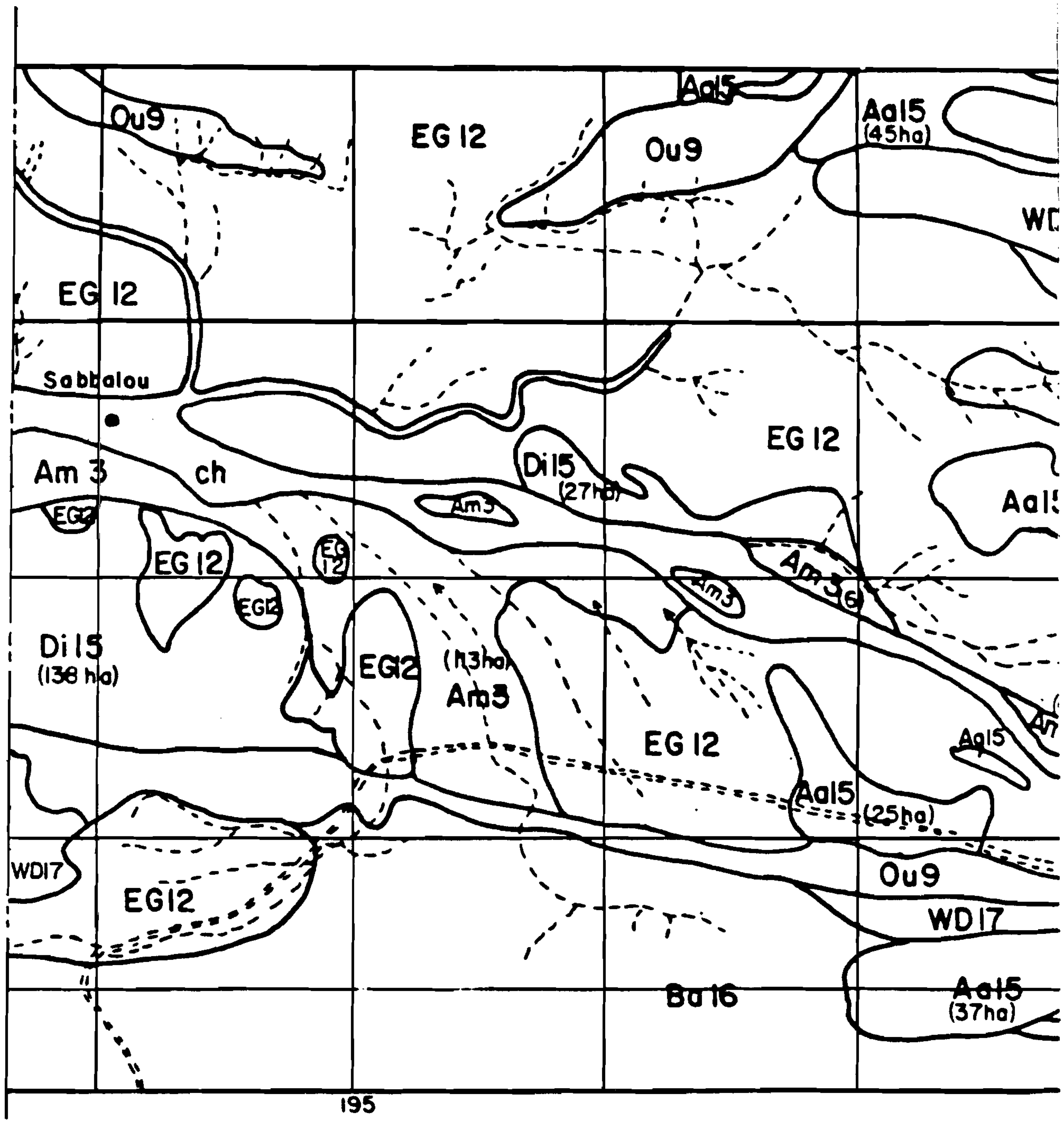
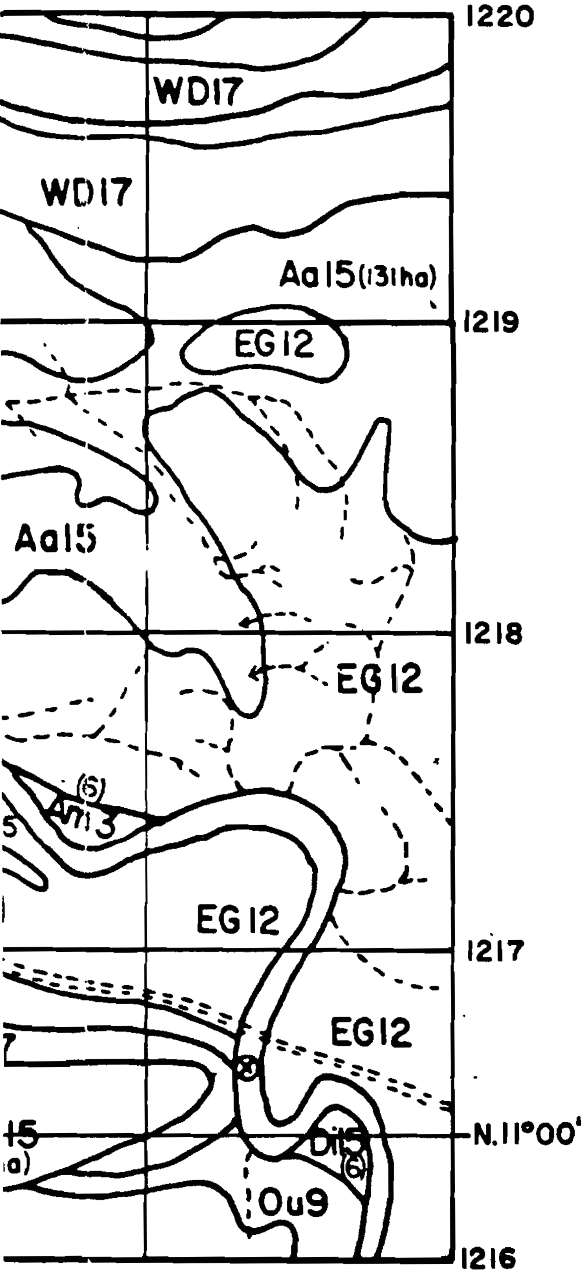


Feuille 3

BEST AVAILABLE COPY

743



Esquisse de Carte Pédologique
Region de Sabbalou

Octobre 1981

Feuile 4 de 4

Legende

Aa 15	Aada (274 ha)
Am 3	Houmbouli (940 ha)
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EG12	Eado Gafan
EG12-d	Eado Gafan avec dunes
Ou 9	Oueah
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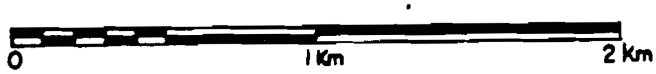
ch	lit d'oued
*	forage proposé
⊗	limnigraphe
	oued
	piste
□	jardin actuel
28	Dépouillé



Echelle 1:25.000

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Laboratoire d'analyse des sols et des eaux

LABORATOIRE D'ANALYSE DES SOLS ET DES EAUX

RÉPUBLIQUE DE DJIBOUTI

APPENDIX K

EXHIBIT

DEY DEY WATERSHED SOILS MAP

SOILS DESCRIPTIONS AND INTERPRETATIONS

APPENIDX K

DEY DEY WATERSHED SOILS MAP

SOILS DESCRIPTIONS AND INTERPRETATIONS

1.0 INTRODUCTION

This medium scale soils map was made of the Dey Dey and Domerjog watersheds because of their proximity to the city. Figure 1 shows the location of these watersheds. They were also chosen for their size. It was important to learn more about the soils and water near the city of Djibouti to help answer development questions. The Houmboul watershed was too large for this project. The information will be helpful for water development for the farms of Atar.

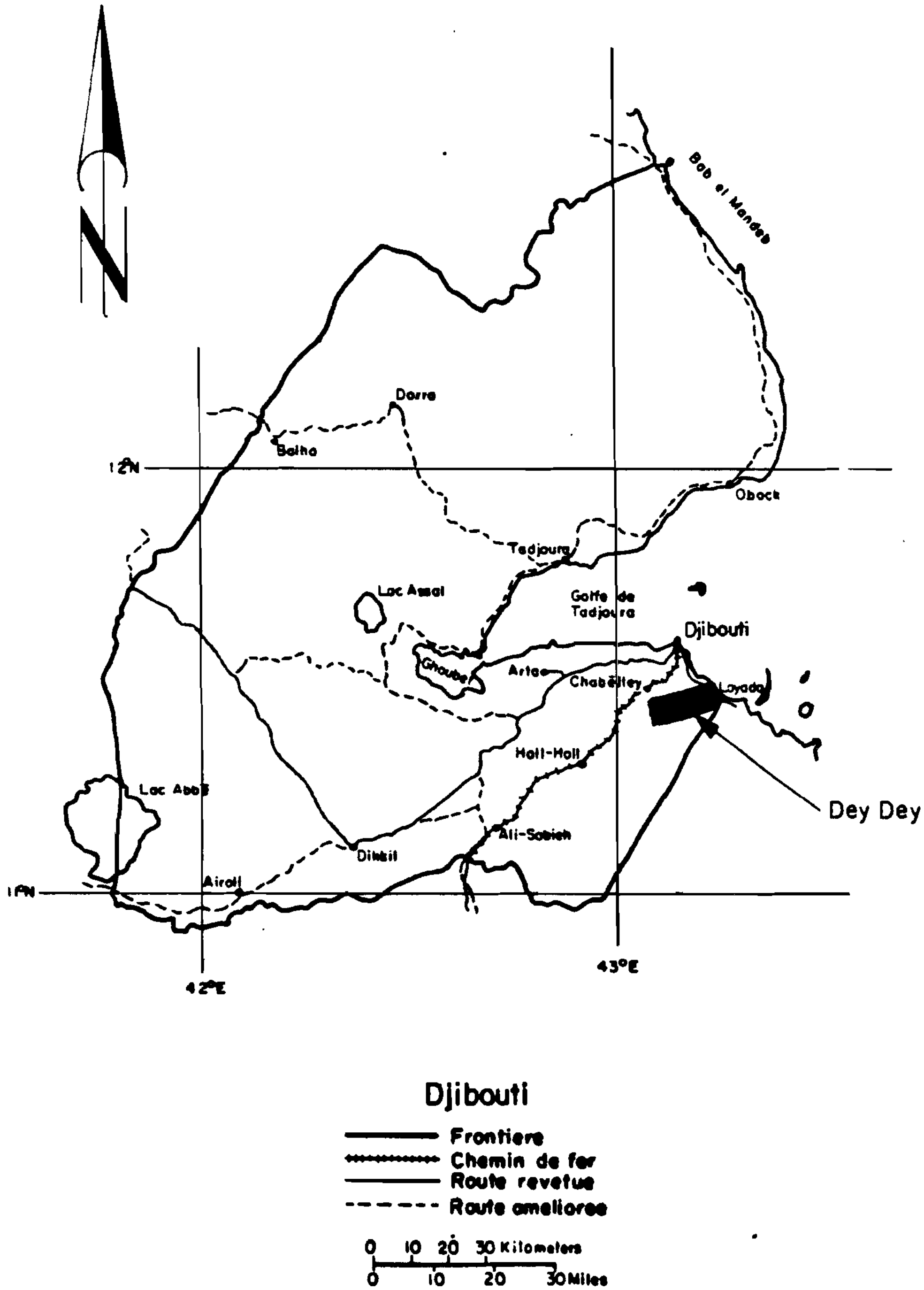
It is recommended that the soils mapping proceed on the watershed basis because all development in Djibouti is dependent upon water resources which are only available from rainfall. Since a watershed is the catchment basin for rainfall runoff, it becomes the logical working basis. Djibouti has no fences or other features to locate political boundaries nor maps to substantiate these, but the crest of the hill that divides the rain water between two valleys is real, everyone can see it and it can be agreed upon in most cases.

There is room for some agricultural development near Domerjog based on excess flood water seeping into the channel. A boulder back filled trench in the Dey Dey Wadi would supply better water for the Atar Agricultural Project and its neighbors. There is probably enough water for one square kilometer of vegetables.

Section 2.0 of this appendix discusses the procedures for mapping the watersheds. Section 3.0 contains a list of Dey Dey and Damerjog watershed soil mapping untis and their descriptions. Section 4.0 then covers the actual interpretation of the soils in the Dey Dey and Damerjog areas.

Esquisse de Carte Pėdologigue
Region de Dey Dey et Damerjog

Juin 1982



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2.0 PROCEDURES FOR MAPPING WATERSHEDS

1. Make 1:100,000 scale map of the watershed for slopes, contours. drainage network and national soils map to serve as guidance; also locate the 5% random sample sites that occur in the watershed.

2. Acquire the 1973 aerial photographs that cover the watershed (scale approximately 1:25,000).

3. Match the photos by establishing a common line on alternate photos for the flight line and adjacent photos between flight lines. Establish north and indicate this on the photo. Write the number of the matching photo.

4. Locate at least 3 UTM coordinates for each photo to be used in mapping. Select those with the best certainty of identifying the spot on both the photo and the map. This will establish the UTM grid on the photographs and provides ground control and orientation. Write the grid coordinate numbers on the photo.

5. Take a large sheet of paper. Pick one photo near the center of the watershed and place it in underneath the center of the paper and trace the matching lines. Write the number of the photo in the upper left corner of this square. Trace the UTM coordinates on the map and give them their proper number. Place the matching photo on the matching line under the paper, after removing the other photo. If possible, it is good to have all the photos spread to make a rough mosaic. Copy the same information, matching lines and coordinate numbers, pencile on the paper. Do this for all of the photos to the edge of the watershed. The photos will not fit exactly.

6. Establish the scale of the map by measuring between 2 grid coordinates. The further apart the better. You may check several photos for the scale in the same manner.

7. Draw a UTM grid on the new map by passing through the most UTM grid points possible with a east-west line through the middle. Then establish perpendicular lines near both east and west ends passing closest to the same row of coordinate points. Armed with the scale and orientation east-west and north-south, mark off one kilometer units on all these lines. This requires patience because when connecting the lines to make the grid the intersection often will not coincide with those associated with the photos. That's due to distortion in the photos.

8. Locate the random sample sites on the map.

9. Punch register clear acetate to the photos and trace the information on the photo. Now with the scaled grid place the intersects on the sites identified between the photo and the 1:100,000 map. Establish the location of the random sample sites and ink them on the acetate and lable them.

10. Take the photos to the field and describe and sample the soils in the random sites. Map features as needed aerial support for field work is necessary.

11. Return to the office and proceed to map the remaining photos and label the soil units.

12. Establish as many soil series as occur and develop description and interpretation of the series.

13. Write up the mapping unit description.

14. Use the vertical sketchmaster to take out photo distrotion and put the soils map at exactly 1;25,000 scale on a transfer sheet of paper. Be sure to transfer the UTM grid coordinate intersects and their number. Also trace the drainage channels, roads, and watershed boundaries -- each in a different color. Be sure the same areas match between photos.

15. Cut the 1:25,000 scale transfer sheets out and attach them together. This map is placed over and registered to a 100 square kilometer grid in clear acetate, by matching as many coordinates to the grid as possible.

16. Place a clean sheet of clear acetate over the paper-constructed map and trace the soils, drainage channels, roads, watershed boundaries, and other important information. The map is ready for reproduction.

17. Be sure the soils classifications are consistent between adjoining watersheds.

18. Measure the watershed and each of the soil areas.

19. Complete the report including the site descriptions, the soil series descriptions, the soils interpretations, the mapping unit descriptions, list of mapping units, list of soils series encountered and their classification.

20. Make a reduced, convenient map for general distribution and correct the national map accordingly.

3.0 DEY DEY WATERSHED LIST OF SOIL MAPPING UNITS AND MAP SYMBOLS

AO27	Arrana Omanae
At1	Atar
At35	Atar eroded
Ba16	Balambal
DA16	Daba Eabdalle
DD10	Dagan Dere
Da9	Damerakaddae
Di5	Didjan Dere
Dt10	Dita
Eo4	Eoulma
Eo34	Eoulma - dunes
Gu16	Guistir
Gu35	Guistir, eroded
GB12	Gran Bara
JA16	Jaban Eas
Ou9	Oueah
19	Wadi channel
20	Beach
30	Volcanic cone

3.1 MAPPING UNIT DESCRIPTIONS

Symbol: AO27

Name of principal soil: Arraha Ommane

Location and distribution: along the canyons, beside wadis in the eastern 3/4 of the area.

Climate: hot and humid

Predominance in the watershed: limited extent

Composition of Mapping Units:

1) Name of the soil series: Arraha Ommane

Classification: loamy, skeletal mixed hyperthermic, Lithic Camborthid.

Brief description: shallow soil, less than 50 cm thick, dark brown gravelly loam, thick $CaCO_3$ coatings on rocks, may have very thin gravelly sand overburden.

Percentage in the mapping unit: 50%

Geomorphic position: canyon side slopes

Parent material: eolian deposits and collivium

Slope: 3-20%

Dominant uses: watershed

Minor inclusions: 15% Holl-Holl, 10% wadi channels, 10% outcrop.

Symbol: At 1

Name of principal soil: Atar - Eoulma

Location and distribution: along the southern coast.

Climate: hot and humid

Predominance in the country: minor soil in the country.

Composition of Mapping Unit:

1) Name of the soil series: Atar

Classification: fine loamy, mixed hyperthermic, Typic Calciorthid.

Brief discription: Thick soil, over 150 cm. thick, dark brown to strong brown, sandy loam over a silt loam, calcium carbonate and calcium sulfate in the lower part of the profile.

Percentage of the mapping unit: 60%

Geomorphic position: coastal plain

Parent Material: recent marine sediments.

Slope: 1-3%

Dominate uses: range and limited irrigated agriculture.

2) Name of soil series: Eoulma

Classification: sandy, mixed hyuperthermic, Typic Torriorthent.

Brief description: sandy soil with a pale brown sandy clay loam or sand over a dark brown sand, thick soil.

Percentage of the mapping unit: 30%

Geomorphic position: recent alluvium or eolian sands from nearby alluvial deposits.

Symbol: At 1 (continued)

Parent Material: eolian sand

Slope: 1-2%

Dominate uses: Irrigated agriculture and range.

Symbol: At 35

Name of principal soil: Atar

Location and distribution: along the coastal plain.

Climate: hot and humid

Predominance in the watershed: limited

Composition of Mapping Unit:

1) Name of the soil series: Atar

Classification: fine loamy, mixed hyperthermic, Typic Calciorthid.

Brief description: thick soil over 150 cm., dark brown to dark reddish brown sandy loam over a strong brown silt loam, calcium carbonate and calcium sulfate occur over the lower part of the profile.

Percentage of the mapping unit: 75%

Geomorphic position: on the coastal plain near major streams.

Parent material: recent marine sediments

Slope: 1-3%

Dominant uses: range

Minor inclusions: 15% eroded phase of the same soil.

Symbol: Ba 16

Name of principal soil: Balambal - Derokkoma

Location and distribution: all over the country west of the mountain ranges, and the plateaus.

Climate: warm and dry
Predominance in the country: one of the major soils in the country.

Composition of Mapping Unit:

1) Name of the soil series: Balambal

Classification: fine loamy, mixed hyperthermic, Typic Calciorthid.

Brief description: between 50-75 cm. thick, yellowish-red to dark reddish-brown, stony clay loam.

Percentage of the mapping unit: 40%

Geomorphic position: eolian material on the lava plateau.

Parent Material: Eolian silt and sand

Slope: 1-3% sometimes up to 5%

Dominate uses: range

2) Name of the soil series: Derokkoma

Classification: fine loamy, mixed hyperthermic. Typic Torriorthent.

Brief description: 75-125 cm. thick, dark reddish-brown, stony sandy clay loam B horizon.

Percentage of the mapping unit: 30%

Geomorphic Position: on the lava plateau

Parent Material: eolian mantle

Slope: 1-5% mostly 1-2%

Dominate uses: range.

Minor inclusion: 20% wadi channels, 15% colluvial delats; up to 10% lava outcrop.

Symbol: DA 16

Name of principal soil: Daba Eabdalle

Location and distribution: on the plateaus in the mountains of the western part of the watershed.

Climate: moderate and dry

Predominance in the watershed: limited soil

Composition of Mapping Unit:

1) Name of the soil series: Daba Eabdalle

Classification: fine loamy skeletal mixed hyperthermic, Aridic Calcuistoll.

Brief description: moderately thick 50-100 cm, reddish broan and dark reddish brown silt loam, many stones, weak mollir epipedon in the surface over yellowish red silty clay loam ald gravelly silty clay loam.

Percentage in the mapping unit: 50%

Geomorphic position: lava plateau

Parent material: eolian mantle

Slope: 1-3%

Dominant uses: range

Minor inclusions:

2) Name of the soil series: Minkille

Classification: fine loamy, mixed hyperthermic, Pachi Calciustoll

Brief description: 50 cm thick, brown dark grayish brown gravelly loam, stonly loam or stonly clay loam.

Percentage in the mapping unit: 20%

Geomorphic position: plateau

Parent material: eolian mantle sometimes local alluvium

Slope: 1-2%

Dominant uses: range

Minor inclusions: Balambal soil up to 10%, 10% of Talus and rock outcrop with slopes of less than 10%.

Symbol: DD 10

Name of principle soil: Dagah Dere-Goendale Madobe

Location and distribution: Eli Sabieh region and mountainous region of Obock.

Climate:

Predominance in the country: minor soil.

Composition of Mapping Unit:

1) Name of the soil series: Dagah Dere

Classification: loamy skeletal, mixed hyperthermic, Lithic Torriorthent.

Brief description: less than 50 cm. thick, yellowish brown, vewry gravelly sandy loam over bedrock.

Percentage of the mapping unit: 50%

Geomorphic position: on rolling hills.

Parent Material: rhyolite

Slope: 8-15%

Dominant uses: watershed and range.

2) Name of the soil series: Goeondale Madobe

Classification: Loamy skeletal, mixed hyperthermic, Typic Calciorthid.

Brief description: less than 40 cm. thick, yellowish brown, dark brown, and light yellowish loam, gravelly sandy clay loam with a calcic horizon. Surface few cm may be sandy loam.

Percentage of mapping unit: 30%

Geomorphic position: Talus or mountain slopes

Parent Material: rhyolitic sandstone

Slope: 15-20%

Dominate Uses: watershed and range.

Symbol Da 9

Name of principal soil: Damerkaddae - Afnaba Daba

Location and distribution: in the ryolitic mountain zones throughout the country near Eli Sabieh and north of Tadjoura

Climate: Usually warm and dry

Predominance in the country: moderately dominant soil in the country.

Composition of Mapping Units:

1) Name of the soil series: Damerkadda

Classification: sandy skeletal, mixed hyperthermic, Typic Torriorthent.

Brief description: thick, yellowish brown to strong brown very gravelly sand and very gravelly sandy loam.

Percentage of the mapping unit: 40%

Geomorphic position: mountain side slope and Talus

Parent Material: Colluvium

Slope: 15-20%

Dominant uses: range and watershed.

2) Name of soil series: Afnaba Daba

Classification: loamy skeletal mixed hyperthermic, Typic Torriorthent.

Brief description: very thin soil, less than 25 cm. dark brown very gravelly sandy loam.

Percentage of the mapping unit: 40%

Geomorphic position: on high slopes of the mountain above the Talus.

Parent Material: thin talus or colluvium

Slope: 20-50%

Dominant uses: watershed and range

Minor inclusions: other soils included: Arraha Ommane 10%, Da Le Dola 10%.

Symbol: Di 5

Name of principal soil: Didjan Der

Location and distribution: along streams and terraces throughout the country.

Climate: hot and dry or warm and dry

Predominance in the country: minor

Composition of Mapping Unit:

1) Name of the soil series: Didjan Der

Classification: loamy skeletal, mixed hyperthermic, Typic Torriorthent.

Brief description: thick stony and very gravelly soil with a dark brown sandy clay loam, has a calcium carbonate layer over 200 cm. thick.

Percentage of the mapping unit: 70%

Geomorphic position: terraces

Slope: 1-3%

Dominant uses: irrigated agriculture and range land.

Minor inclusions: about 15% stream channels 10% side slopes and the Eoulma soil.

Symbol: Dt 10

Name of principal soil: Dita

Location and distribution: in and along coastal mountains.

Climate: hot and humid.

Predominance in the country: minor soil.

Composition of Mapping Units:

1) Name of the soil series: Dita

Classification: loamy skeletal, mixed hyperthermic, Lithic Calciorthid.

Brief description: less than 50 cm. thick, pale brown and pinkish gray gravelly sandy loam and gravelly loam with a Ca CO3 layer.

Percentage of the mapping unit: 70%

Geomorphic position: rolling hills.

Parent Material: coluvial side slopes or pediment sediments.

Slope: 3-10%

Dominant uses: watershed and range.

Minor Inclusions: 15% waterways; 10% rock outcrop.

Symbol: Eo 4

Name of principal soil: Eoulma

Location and distribution: on the coastal side of the country in association with the colluvial fans.

Climate: hot and humid

Predominance in the country: minor soil

Composition of Mapping Units:

1) Name of the soil series: Eoulma

Classification: sandy mixed hyperthermic, Typic Torriorthent.

Brief Description: thick soil, over 200 cm. of pale brown or brown sand, essentially no structure of character.

Percentage of the mapping unit: 60%

Geomorphic position: alluvial plains, alluvial terraces.

Parent Material: alluvium

Slope: 0-35%

Dominant uses: irrigated agriculture and rangeland.

Minor inclusions: 15% waterways, 20% of the area is covered with dunes up to 30 cm. high.

Symbol: Eo 34

Name of principal soil: Eoulma

Location and distribution: on the coastal plains near major streams.

Climate: hot and humid

Predominance in the watershed: limited extent

Composition of Mapping Unit:

1) Name of the soil series: Eoulma

Classification: sandy, mixed hyperthermic, Typic Torriorthent

Brief description: thick soil, over 200 cm., brown or pale brown sand with essentially no structure or character. May have thin sandy clay loam overburden.

Percentage of the mapping unit: 60%

Geomorphic position: alluvial terraces along major streams.

Parent material: alluvium

Slope: 0-3%

Dominant uses: irrigated agriculture and range land.

Minor inclusions: 5-15% sand dunes of 20-200 cm. high; 15% waterways.

Symbol Gu 16

Name of principal soil: Guistir

Location and distribution: in the eastern two-thirds of the area.

Climate: hot and humid

Predominance in the watershed: moderately extensive

Composition of Mapping Unit:

1) Name of soil series: Guistir

Classification: fine loamy, mixed hyperthermic, Typic Camorthid

Brief description: thick, over 120 cm, dark brown to reddish brown clay loam with subangular blocky structure, below 30 cm, it has $CaCO_3$ and $CaSO_4$ deposition.

Percentage of the mapping unit: 60%

Geomorphic position: lava plateau

Parent material: eolian or marine sediments

Slope: 0-3%

Dominant uses: rangeland

Minor inclusions: 10% drainage ways, 10% rock outcrop, 10% minor amounts of Arraha Ommane.

Symbol Gu 35

Name of principal soil: Guistir

Location and distribution: throughout the eastern two-thirds of the area.

Climate: hot and humid,

Predominance in the watershed: major soil area

Composition of Mapping Unit:

1) Name of the soil series: Guistir

Classification: fine loamy, mixed hyperthermic, Typic Camorthid.

Brief description: thick over 120 cm, dark brown to reddish brown clay loam with subangular blocky structure below 30 cm, it has $CaCO_3$ and $CaSO_4$ deposition.

Percentage of the mapping unit: 45%

Geomorphic position: lava plateau

Parent material: eolian or marine sediment

Slope: 1-5%

Dominant uses: range

Minor inclusions: 15% Jaban Eas soil 10% rock outcrop, 15% waterways, 10% Afnaba Daba.

764

Symbol: GB 12

Name of principal soil: Grand Bara

Location and distribution: mountainous areas throughout the country on large playas, well distributed.

Climate: hot and dry with local dust twirls during the day and rapid colling at night.

Predominance in the country: moderate extent.

Composition of Mapping Unit:

1) Name of the soil series: Grand Bara

Classificatin: fine loamy, mixed hyperthermic, Typic Camborthid.

Brief description: thick soil, over 150 cm thick, brown or dark brown, clay or sandy clay loam with a B horizon with some ferromanganese and gypsum crystals below 75 cm.

Percentage of the mapping unit: 80-90%

Geomorphic position: playa basin

Parent Material: lacustrine sediments

Slope: 0-1%

Dominant uses: water catchment

Minor inclusions: some gullies, small inclusions of Aada soil.

765

Symbol JA 16

Name of principal soil: Jaban Eas-Guistir

Location and distribution: principally on the coastal plains in the southern part of the country.

Climate: humid, hot climate.

Predominance in the country: moderate extent.

Composition of Mapping Unit:

1) Name of the soil series: Jaban Eas

Classification: fine loamy, mixed hyperthermic, Typic Calciorthid.

Brief description: thick, over 150 cm., red or yellowish red clay with a B horizon, accumulations of calcium sulfate with accumulations of sodium carbonate.

Percentage of the mapping unit: 35% at 25-50 cm.

Geomorphic position: lava flows on the coastal plain.

Parent Material: eolian mantle.

Slope: 2-4% some areas up to 8%.

Dominant uses: range.

2) Name of the soil series: Guistir

Classification: fine loamy, mixed hyperthermic, Typic Camborthid.

Brief description: thick over 150 cm. thick of reddish-brown or dark reddish brown clay or sandy clay loam with a B horizon, a gypsum calcium carbonate below 75 cm.

Percentage in the mapping unit: 25%

Geomorphic position: lava flow on the coastal plain.

Parent Material: eolian mantle.

Slope: 2-4%

Dominant uses: range

Minor inclusions: 20% of areas of 5-8% slopes and areas also 15% water channels.

Symbol: Ou 9

Name of principal soil: Oueah-Degamankal

Location and Distribution: distributed throughout the country in the mountainous region.

Climate: warm to hot dry areas.

Predominance in the country: moderate extent.

Composition of Mapping Unit:

1) Name of the soil series: Oueah

Classification: loamy skeletal, mixed hyperthermic, Typic Torriorthent.

Brief description: medium deep soil, grayish brown and brown, very gravelly sandy loam.

Percentage of the mapping unit: 45%

Geomorphic position: steep mountain slopes.

Parent Material: colluvium and Talus.

Slope: 25-40%

Dominant uses: watershed.

2) Name of soil series: Degamankal

Classification: sandy, mixed hyperthermic, Lithic Torriorthent.

Brief description: thin soil less than 25 cm. thick, dark yellowish brown, very gravelly sandy loam with some calcium carbonate coatings on the gravel.

Percentage of the mapping unit: 35%

Geomorphic position: upper mountain slopes.

Parent Material: Colluvium.

Slope: 8-25%

Dominant uses: watershed.

Minor inclusions: 10% Talus, 20% rock outcrop.

Symbol: 19

Name of the Unit: Wadi Channel

Location and distribution: throughout the entire country.

Climate: often hot and dry

Predominance in the country: limited extent.

1) Precentage of the mapping unit: 70-75%

Geomorphic position: Wadi Channel

Parent Material: Stream sediment

Slope: 1-3%

Dominant uses: water storage

Minor inclusions: 10% of Didjan Der soil, 10% of Eoulma soil.

Symbol: 20

Name of the Unit: Beach

Location and distribution: along the coastal region.

Climate: hot and humid.

Predominance in the country: limited extent.

Brief description: sand

Geomorphic position: beach

Parent Material: sand

Dominant uses: recreation

Symbol: 30

Name of miscellaneous land type: Volcanic cone

Location and distribution: throughout the area

Climate: hot and humid

Predominance in the watershed: very limited

Miscellaneous land type: Volcanic cone

Percentage of the mapping unit: 100%

Geomorphic position: volcanic cone

Parent material: volcanic ash and rubble

Slope: 5-20%

Dominant uses: watershed and range

Minor inclusions: up to 15% Holl-Holl

4.0 INTERPRETATION

What follows is a list of the soils series in the Dey Dey wastershed and a key to the soils interpretation as well as the interpretations themselves. Finally it contains an example of the actual soils map (scale 1:100,000) which was developed.

4.1 LIST OF THE SOIL SERIES IN THE DEY DEY WATERSHED

Afnaba Daba

Arrah Ommane

Atar

Balambal

Daba Eabdalle

Daga Dere

Damerkaddae

Didjan Dere

Dita

Eoulma

Gran Bara

Guistir

Holl-Holl

Jaban Eas

Oueah

4.2 Key to Soil Interpertations Symbols

Land Capability Classification

The Soils are divided into 8 (I-VIII) categories depending on the intensity of land use (see Buchman and Brandy) from well tilled row crops to watershed and wildlife habitat. For all categories, except I, there is a limitation to the use of that soil for agriculture. All of Djibouti is too arid for class I land because these soils require irrigation for agricultural production. Therefore, the arid limitation is assumed for all soils of the country. The following list of letters which follow the Roman Numerals of this classification system indicate the important specific restraint:

w = available water capacity
r = rooting zone depth in less than one meter
s = slope is greater than 5 percent
d = drainage for leaching salts
c - susceptibility to water overflow
a - alkalinity
g - stoniness
v = wind erosion and blowing
e = erosion susceptibility

Irrigation Suitability Classification

The code for irrigation suitability is the same for all 8 (I through VIII) categories of the land capability classification without the aridity limitation as a constraint. The same symbols of limitation are indicated as they affect irrigation agriculture. Therefore, irrigation is assumed for all these soils and no additional symbol is used.

Internal Drainage Classification

Here the land capability categories are:

I no limits to internal drainage practices
II moderate limits
III severe limits

The limits considered to affect internal drainage are:

t = permeability, texture and structure
r = depth to bedrock
w = depth to the water table
i = steepness of slope
b = ditch bank stability
c = flooding or ponding
a = salinity or alkalinity
s = available outlets

Terraces and Diversions Suitbility Classifications

The categories here are:

- I no limits to building terraces
- II moderate limits
- III severe limits

The factors determining the suitability for terraces are:

- p = slope, steepness and length
- r = depth to bed rock
- f = stones and outcrops
- w = wind hazard
- t = texture and permeability
- c = channel siltation
- s = outlet availability
- e = flooding hazard

Embankments Suitability Classification

The major categories are:

- I no limits to construct embankments
- II moderate limits
- III severe limits

The factors determing suitability are:

- r = depth of the soil
- t = soil texture
- e = Soil erodability
- p = percent and length of slope
- g = presence of gypsum or salt
- c = stones

Pond Reservoir Suitability Classification

The major categories are:

- I no limits to pond construction
- II moderate limits
- III severe limits

The factors determing suitability are:

- t = permeability
- w = depth to the water table
- r = depth to bedrock, less than 2 meters
- p = slope
- e = flooding hazard

Rangeland Classification, Estimated Production

I good production of 200-500 K per Ha
II limited production of 50-200 K per Ha
III non-usable production 0-50 K per Ha

8/12/81 A.D/J.G./F.O.

AFNABA DABA

Location: 289.7 E
1391.0 N

0-10+ cm: C horizon; 7.5 YR 5/4 brown (dry), 7.5 YR 3/4 dark brown (moist); very gravelly sandy loam; structure: none; loose, very friable, nonsticky; strongly effervescent.

Surface: 10% cobbles and 90% gravel

Inclusions: 50% rock outcrop

Slope: 18%

Position: talus slope

Parent Material: metamorphised rhyolite

Vegetation: barren

Classification: loamy skeletel (shallow) mixed hyperthermic Typic Torriorthent.

Soil Interpretation:

Land Capability Classification: VIIs

Irrigation suitability classification: none

Range: III 2% bush

Internal drainage: IIIi

Terraces and diversions: III p;r

Embankments, dikes and levees: IIIr;p

Pond reservoir: III r;p

775

1/3/82 A.D./J.G.

ARRAHA OMMANE

Location: 272.4 E
1256.3 N

0-5 cm: A horizon; 10 YR 4/3 brown (dry), 10 YR 3/4 dark yellowish brown (moist) gravelly sand; weak medium to fine subangular blocky structure; firm, friable, nonsticky; strongly effervescent; 20 to 25% 2 to 20 mm gravel; few fine fibrous roots; $CaCO_3$ coatings on stones; clear and irregular boundary;

5-30 cm: B horizon; 7.5 YR 3/4 dark brown (dry), 7.5 YR 3/2 dark brown (moist); very gravelly loam; structureless; loose, friable, slightly sticky; strongly effervescent; thick $CaCO_3$ coatings on rocks and gravel; 60% stones cobbles and gravel; common medium woody roots; abrupt irregular boundary;

30+ cm: R unfractured rock.

Surface: 90% gravel and stones

Inclusions: 5 to 10% outcrop, 10-20% thicker soil at footslopes, 10% wadi channels.

Slope: 13% (10-20%)

Position: side slope

Parent Material: rhyolite colluvium or rhyolite mountain

Vegetation: 5% grass 3 to 6 cm, 5% herbs 10 to 30 cm, and 2 to 3% 1 m acacia

Erosion: severe water

Temperature: 26.6 °C

Classification: loamy skeletal mixed hyperthermic Lithic Camborthid

Soil Interpretation:

Land Capability Classification: V s;g

Irrigation Suitability Classification: None

776

ATAR

Location: 301.6 E
1274.3 N

0-10 cm: A horizon; brown 7.5 YR 5/4 (dry), dark brown 7.5 YR 3/4 (wet); sandy loam; structureless; loose; (dry); pH=7.5-8; wind deposited sand, no relationship with the sub-soil; abrupt contact.

10-110 cm: B horizon; strong brown 7.5 YR 4/6 (dry), and dark brown 7.5 YR 3/4 (wet); silt loam; moderate large angular blocky breaking to moderate medium and fine angular blocky structure; firm (dry) and friable (moist); 50% of 5-25 mm 10 YR 8/1 carbonates; many pressure faces (sand on faces of large fine vertical cracks; few fine and medium roots; pH=8.5; gradual and smooth boundary;

110-130+ cm: strong brown 7.5 YR 4/6 (dry), dark brown 7.5 YR 3/4 (wet); silt loam texture; weak medium subangular blocky structure; 5% of 5 to 10 mm $CaCO_3$, pH=8.5.

Inclusions: Few 20 cm sand dunes

Slope: flat area; near the sea;

Vegetation: 20% vegetation cover (90% acacia and 10% kulan)

Comment: 1 km NE of Damerjog at the junction of the roads to Loyada and irrigation water line to AtAR.

Classification: fine loamy mixed hyperthermic Typic Calciorthid.

Soil Interpretation:

Land Capability Classification: III b

Irrigation Suitability Classification: II d;c;v

Range: I 20% bush

Internal Drainage: II t

Terraces and Diversions: II p

Embankments, dikes and levees; II p;g

Pond reservoir: II t;w

BALAMBAL

Location: 251 E
1260 N

-15-0 cm: volcanic bombs of 5 to 30 cm covering 75% of the area.

0-2 cm: A horizon; 5 YR 4/6 yellowish red (dry), 5 YR 3/4 dark reddish brown (wet); stony clay loam; moderate medium and fine subangular blocky structure; friable (dry and moist); common pores (1-2 mm); thin discontinuous CaCO3 layer on rocks below the soil surface; strongly effervescent, fine disseminated CaCO3; pH 7.5; abrupt boundary;

2-35 cm: B horizon; 5YR 4/6 yellowish red (dry), 5YR 3/4 dark reddish brown (wet); stony clay loam; firm, friable, nonsticky; medium and large strong subangular blocky structure; strongly effervescent, finely disseminated CaCO3; pH 7.5; few coarse woody trees roots; clear and wavy boundary;

35-45+ cm: Cca horizon; many continuous white CaCO3 coatings on gravel uncemented; loose.

Slope: Slope of 2 to 3%

Position: on a plateau, flat top

Vegetation: 2 to 3% cover; "bilcin," "Ibateys"

Classification: fine loamy mixed hyperthermic Typic Calciorthid.

Soil Interpretation:

Land Capability Classification: VII r;g

Irrigation Suitability Classification: none

Range: III 5% bush

Internal Drainage: III r

Terraces and Diversions: III r;f

Embankments, dikes and levees; III r;c

Pond reservoir: III r

778

DABA EARDALLE

Location: 220.3 E
1220.6 N

0-14 cm: A11 horizon; 5YR 4/3 reddish-brown (dry), 5YR 3/3 dark reddish-brown (moist); silt loam; moderate medium to fine angular blocky structures; firm, friable nonsticky; many fine fungus traces; many fine pores; strongly effervescent; clear and irregular boundary;

14-34 cm: A12 horizon; 5YR 3/3 dark reddish-brown (dry and moist); silt loam; moderate coarse tomedium subangular blodky structure; firm friable, nonsticky; many fine fungus traces; many fine fibrous roots; strongly effervescent; clear and irregular boundary;

34-40 cm: B horizon; 5YR 3/4 dark reddish-brown (moist), silty clay loam; moderate coarse to medium subangular blocky structure; firm, friable slightly sticky; strongly effervescent; common fine fibrous roots; clear and irregular boundary;

40-62 cm: Cca horizon; 5YR 4/6 yellowish-red (dry), 5YR 3/4 dark reddish-brown (moist); gravelly silt clay loam; structure: none; loose, friable, slightly sticky; strongly effervescent; 35% gravel; thin CaCO3 coating on all faces of the gravel; abrupt and smooth boundary;

62-70+ cm: R horizon; solid lava, basaltic rock.

Surface: On the surface 90% cobbles and boulders of volcanic bombs.

Parent Material: Lava flow plateau with 1-8% long slopes loess covered.

Vegetation: Vegetation cover of 15% (bilcin, Aousdameir, kulan 1 to 1.5 m high and dacar).

Temperature: Moderately cool.

Comment: Extensive soil

Classification: loamny mixed hyperthermic Aridic Calciustoll

Soil Interpretation:

Land Capability Classification: VI g

Irrigation Suitability Classification: None g;d

DABA EABDALLE

(Continued)

Range: 5% bush; 10% grasses and herbs; 400K/Ha

Internal drainage; III r

Terraces and diversions: III r;p;f

Embankments, dikes and levees: III r;t

Pond reservoir: III t;r

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DAGAH DERE

Location: 267.1 E
1240.1 N

-2 to 0: Fine gravelly desert pavement.

0-25 cm: A horizon; 10YR 5/4 yellowish-brown (dry); 10YR 4/3 brown (moist); common fine fibrous roots; fine weak granular structure; 0-1.5 mm leached of CaCO3; very gravcelly sandy loam; loose, friable; fine disseminated and 1-2 mm CaCO3; strongly effervescent; 65% 2-10 mm gravel from fractured rock; irregular and diffused boundary;

15-40+ cm: Rhorizon; 10-40 mm fractured rock; strongly effervescent; 2-5 mm CaCO3;

Inclusions: 10-15% rock outcrop

Slope: Slope of 8-15% and strongly rolling slope.

Vegetation: 2-5% vegetation cover of Aurdawad and Aousdamer

Classification: loamy skeletal mixed hyperthermic Lithic Torriorthent.

Soil Interpretation:

Land Capability Classification: VI r;s;g;

Irrigation Suitability Classification: none

Range: II 5% bush; 5% grass

Internal Drainage: III r;i

Terraces and Diversions: III p;r;f;

Embankments, dikes and levees: III r;t;p

Pond Reservoir: III t;r;p

DAMERKADDAE

Location: 247.3 E
1234.0 N

0-15 cm: A1 horizon; 10YR 5/4 yellowish-brown (dry); 10YR 5/6 yellowish-brown (moist); very gravelly sand; weak medium to fine subangular blocky structure; loose; loose, 50% gravels; strongly effervescent; common fine 1-4 mm indurated CaCO3; irregular diffused boundary;

15-55 cm: C11ca horizon; 7.5YR 5/6 strong brown (dry), 7.5YR 4/4 brown (moist); very gravelly sand; 50% fractured pebbles and cobbles; weak fine angular blocky structure; loose, loose; many 1-10 mm indurated CaCO3; strongly effervescent; irregular, diffused boundary;

55-140 cm: C12ca horizon; 7.5YR 5/6 strong brown (dry), 7.5YR 4/4 brown (moist); very gravelly sandy loam; 50% fractured pebbles and cobbles structureless; loose, loose: common 1 to 5 mm indurated CaCO3; strongly effervescent; irregular diffused boundary;

Inclusions: This soil represents 40% of the area; 35% of the area consists of a loamy skeletal mixed hyperthermic Lithic Torriorthent, 25% rock outcrop.

Slope: 40 to 70% slope;

Parent Material: Rhyolthic rocks moderately fractured

Vegetation: Sparse vegetation (compobogon), "galan, gubac, bilcin, ibateys."

Comment: Location at 247.3 E 500 mmon the road to post control 1234.0 N at Ali-Sableh; west of the road;

Classification: Sandy skeletal mixed hyperthermic Typic Torriorthent.

Soil Interpretation:

Land Capability Classification: VII w;r;g;e

Irrigation Suitability Classification: none

Range: II 5% brush; 150K/Ha

DAMERKADDAE

(Continued)

Internal Drainage: III r;i;b;

Terraces and Diversions: III p;r;f;t

Embankments, dikes and levees: III r;t;p;c

Pond Reservoir: III t;r;p

DIDJAN DER

Location: 258.8E
1265.2 N

0-15 cm: A horizon; 7.5YR 5/4 brown (dry), 7.5YR 3/4 dark brown (moist); very gravelly sandy clay loam; weak medium subangular blocky structure; loose, friable nonsticky; few fine roots; 65% of 2 to 4 mm gravels; moderately effervescent; irregular diffused boundary;

15-85 cm: Cca horizon; 10YR 8/1 white (dry) 10YR 5/3 brown (moist); very gravelly sandy clay loam; structureless; thick coating of CaCO3 on all rock surfaces, abundant fine fraction; 40% gravels, 20% cobbles, 10% stones; extremely effervescent; irregular diffused boundary;

85-200 cm: IICca horizon; 10YR 6/4 light yellowish (dry), 10YR 6/3 pale brown (moist); stony sandy clay loam; firm friable, nonsticky; 15% soft powdery 1 to 5 mm CaCO3; irregular diffused boundary;

200-350 cm: IIICca horizon; boundery alluvium;

Surface: Between 40-80% gravel and about 30% cobbles and stones.

Slope: 0-3% dissected (slightly)

Vegetation: About 20% vegetation cover (balanits aegyptioca, acacia...)

Comment: 100 m west of the road, on the west bank of the wadi.

Classification: Loamy skeletal mixed hyperthermic Typic Torriorthent.

Soil Interpretation:

Land Capability Classification: IV g

Irrigation Suitability Classification: II g

Range: 5% bush

Internal drainage: I

Terraces and Diversions: II f

Embankments, dikes and levees: II c

Pond reservoir: II t

15/3/82 J.G./A.D.

DITA

Location: 284.4 E
1369.4 N

0-8 cm: A horizon; 10YR/6/3 pale brown (dry), 10YR/4/4 dark yellowish brown (moist); gravelly loam; structureless; loose, friable, nonsticky; strongly effervescent; abrupt irregular boundary.

8-40+ cm: Cca horizon; 7.5YR/6/2 pinkish gray (dry), y.5YR/5/4 brown (moist); gravelly sandy loam; soft disseminated $CaCO_3$ and continous thick $CaCO_3$ coatings on rocks; structureless; loose, friable, nonsticky; strongly effervescent.

Surface: 80% gravel, 20% cobbles

Inclusions: 15% waterways; 10% rock outcrop

Slope: 3%

Position: colluvial valley; pediment slope

Parent material: rhyolite colluvium

Vegetation: barren except waterways

Erosion: moderate sheet erosion

Temperature: 31.7 °C at 30cm

Classification: loamy skeletal mixed hyperthermic Lithic Calciorthid

Soil Interpretation:

Land Capability Classification: VI w;r;g

Irrigation suitability classification: none

Range: III 2% bush

Internal drainage: III r;i

Terraces and diversions: iii p;r;f;t

Embankments, dikes and levees; III r;t;c

Pond reservior: III t;r;p

EOULMA

Location: 307.1E
1339.1 N

0-20 cm: IC horizon; 10YR 6/3 pale brown (dry), 10YR 3/4 dark yellowish-brown (moist); sandy clay loam; structure: none; loose, friable, slightly sticky; strongly effervescent; few fine woody roots; clear smooth boundary;

20-40+ cm: IIC horizon; 7.5YR 4/4 brown (dry), 7.5YR 3/4 dark brown (moist); sand; structure: none; weakly cemented, friable, nonsticky; strongly effervescent; fine disseminated $CaCO_3$;

Surface: 50% gravel;

Inclusions: 15% waterways with 20-30 cm of eolian sand

Slope: 0-1%

Position: Outer edge of an alluvial fan

Parent Material: Mixed alluvium

Vegetation: 20% grass and woody tuft and 5% acacia in the waterways.

Temperature: 6 ^{o}C

Classification: Sandy mixed hyperthermic Typic Torriorthent.

Soil Interpretation:

Land Capability Classification: VI w;v

Irrigation Suitability Classification: II c;v

Range: I 20% grass; 5% bush

Internal Drainage: I

Terraces and Diversions: II t

Embankments, dikes and levees: II t

Pond reservoir: III t

GRAND BARA

Location: 240 E
1246 N

All 0-0.5 cm: Pink 7.5YR/7/4 (dry); brown 7.5YR/4/4 (moist); silty clay loam; laminar; hard (dry); friable (moist); slick (wet); moderately effervescent; pH 7.3; abrupt boundary.

A120.5-10 cm: Pink 7.5YR/7/4 (dry), brown 7.5YR/4.4 (moist); clay loam; strong medium to fine angular blocky structure; firm (dry), friable (moist), slightly sticky (wet); moderately effervescent: gradual boundary,

B1 10-30 cm: Brown 7.5YR/5/4 (dry, dark brown 7.5YR/ 3/4 (moist); clay loam; moderate medium to fine angular blocky structure; firm (dry), friable (moist); slightly sticky (wet); moderately effervescent; gradual and irregular boundary

B2 30-70 cm: 10YR/6/2 light brownish gray on ped faces; 7.5YR/3/4 dark brown (dry); 7.5YR/3/4 dark brown (moist); sandy clay loam; strong large to medium angular blocky structure; firm (dry), friable none sticky (moist); common fine 1 to 2 mm faint dark brown feromanganese concretions; few fine gypsum crystals; thin alluviated silty coating on ped faces; moderately effervescent.

Surface: Absoutely flat, surface covered with polyhedrons (4-10 cm, 1-3 mm wide and 2-10 mm deep)

Comment: Location - 7 km from the east of the road to the west in the middle of Grand Bara

Classification: fine loamy mixed hyperthermic Typic Camborthid

Soil Interpretation:

Land Capability Classification: VIII c

Irrigation suitability classification: II c;v

Range: barren

Internal drainage: II s

GRAND BARA

continued

Terraces and diversions: II p

Embankments, dikes and levees: II p

Pond reservior: II w

29/12/80 A.D./J.G./F.O.

GUISTIR

Location: 274.3 E
1220.3 N

0-15 CM: A1 horizon; 7.5YR 4/4 dark brown (dry), 7.5YR 3/4 dark brown (moist); clay loam; weak medium to fine subangular blocky structure; soft, friable, nonsticky; 20% fine gravels; common fine roots; strongly effervescent; clear and irregular boundary;

15-30 cm: B1 horizon; 5YR 4/4 reddish brown (dry), 5YR 3/4 dark reddish brown (moist); clay loam; strong large to medium subangular blocky structure; firm, friable, nonsticky; fine disseminated and indurated $CaCO_3$; strongly effervescent; clear boundary;

30-70 cm: B2 horizon; 5YR 4/4 reddish brown (dry), 5YR 3/4 dark reddish brown (moist); clay loam; strong large to medium subangular blocky structure; hard, friable, slightly sticky; small cracks of 1 to 3 mm from 10 cm to 100 cm with 20 cm spacing and common medium pressure faces and common medium discontinuous slick sides; strongly effervescent; few rose gypsum of 2 to 4 mm; clear boundary;

70-120 cm: B3 horizon; 5YR 4/4 reddish brown (dry) 5YR 3/4 dark reddish brown (moist); clay loam; moderate large to medium angular blocky structure; hard, friable, nonsticky; many 1 to 4 mm rose gypsum; strongly effervescent.

Surface: 50% 5 to 15 cm gravel and cobbles on the surface

Inclusions: Eolian mantle over lava flow; 2 to 3 mm thick loess;

Slope: 2% slope

Position: Little erosion and very long straight slope

Vegetation: 10% cover of sarman

Comment: 4 Km from Guistir on the road to Ali-Adde stream bank on the north side of the road.

Classification: Fine loamy mixed hyperthermic Typic Camborthid.

Soil Interpretation:

Land Capability Classification: VI a;g

Irrigation Suitability Classification: VI a;g

GUISTIR

(Continued)

Range: II 10% bush; 10% grass and herbs

Internal drainage: II t;a

Terraces and Diversions: II p;r;f

Embankments, dikes and levees: II p;c;g

Pond Reservoir: III w;r

790

30/12/80 A.D./J.G./F.O.

HOLL-HOLL

Location: 273.6 E
1250.7 N

0-20 cm: A horizon; 10YR 5/4 yellowish brown (dry); 7.5YR 3/4 dark brown (moist); very gravelly; sandy clay loam; weak fine subangular blocky structure; loose, friable, slightly sticky; many fine roots; 60% 3 to 10 cm gravels; 1 to 4 mm fine powdery disseminated and indurated $CaCO_3$; medium coating of $CaCO_3$ on the gravels and the stones; strongly effervescent; irregular and diffused boundary;

20-50 cm: Cca horizon; 10YR 5/3 brown (dry), 10YR 3/4 dark yellowish brown (moist); very gravelly sandy clay loam; weak fine granular structure; soft, friable, slightly sticky; 80% gravels; soil filling interstices; common fine and a few coarse roots; 1 to 4 mm fine powdery disseminated and indurated $CaCO_3$ on all parts of the rocks; strongly effervescent; irregular and diffused;

50-200+ cm: IICa horizon; 10YR 5/4 yellowish brown (dry), 7.5YR 4/6 strong brown (moist); gravelly sandy clay loam; 30% volcanic colluvium gravel plus 20% 1 to 15 mm of indurated $CaCO_3$; from 120 cm to the bottom 10% 1 to 10 mm of soft powdery $CaCO_3$ reprecipitated from above; few $CaCO_3$ coating on the rock faces; strongly effervescent.

Surface: 70% boulders and cobbles on the surface;

Inclusions: Thin soil occupies 35% of the area and a thinner soil occupies 30% of the area;

Slope: 45 to 70% slopes

Parent Material: Lava outcrops 30%

Vegetation: 20% vegetation cover on this soil and the other soil about less than 5% vegetation;

Comment: On the south side of the road and the south bank of the Holl-Holl river and at 150 m west of the military school;

Classification: Loamy skeletal mixed hyperthermic Typic Calciorthid.

Soil Interpretation:

Land Capability Classificatin: VIII s

HOLL-HOLL

(Continued)

Irrigation Suitability Classification: none

Range: II 10% bush

Internal Drainage: III i;r

Terraces and Diversions: III p;f

Embankments, dikes and levees: III r;t;e;p

Pond Reservoir: III r;p

13/11/80 A.D./J.G./F.O.

JABAN EAS

Location: 290.3 E
1277.8 N

0-5 cm: A horizon; yellowish red 5YR 5/6 (dry) red 2.5YR 4/6 (wet); loose, 90% cobbles and boulders; clear boundary;

5-19 cm: B1 horizon; yellowish red 5YR 5/6 (dry) and red 2.5YR 4/6 (wet); clay loam; very fine, weak granular structure; friable (wet) and loose (dry); very fine roots; pH 8.4 clear boundary;

19-49+ cm: B2ca horizon; red 2.5YR 4/8 (dry) red 2.5YR 3/6 (wet); gravelly clay loam; fine subangular moderate structure; loose; 10% 7.5YR 8/1 powdered 1 to 5 mm secondary $CaCO_3$; very fine roots;

Inclusions: Big rock outcrops of basalt (2%)

Slope: 2 to 3%

Vegetation: Acacias 5% cover

Classification: Fine loamy, mixed hyperthermic, Typic Calciorthid.

Soil Interpretation:

Land Capability Classification: VII a;g

Irrigation Suitability Classification: none a;g

Range: II 5% bush; 200K/Ha

Internal drainage: III t;a;b

Terraces and Diversions: II p;t;c

Embankments, dikes and levees: II p;g

Pond Reservoir: III w;r

2/12/80 A.D./J.G./F.O.

OUEAH

Site No. 68

Location: 266.4 E
1274.8 N

-25 cm to 0: Rock fragments on the surface (10% boulders, cobbles and stones 40%, gravels 40%);

0-12 cm: Al horizon; 10YR 5/2 grayish brown (dry), 10YR 3/3 dark brown (moist); very gravelly sandy loam; weak medium to fine subangular blocky structure; loose (dry); friable (wet); nonsticky (moist); many fine and few coarse fibrous roots; fine disseminated and 1 to 4 mm indurated CaCO3; strongly effervescent; 60% gravels and about 10% cobbles and stones; clear and diffused boundary;

12-50+ cm: C horizon; 10YR 5/3 brown (dry), 10YR 3/4 dark yellowish brown (moist); very gravelly sandy loam; weak fine angular structure; loose, friable nonsticy; 70% gravels, fine disseminated 1 to 4 mm indurated CaCO3, continuous CaCO3 coating on the rocks surface; strongly effervescent; common fine roots;

Inclusions: 20% rock outcrop

Slope: 45% of the slopes are occupied by this soil

Similar Soil:35% similar lithic entisol

Vegetation: 20% of bilcin and qudac cover

Comment: Colluvial slope mixed ignious rocks, 25 to 40% of slopes on the mountainhs,

Location: Military firing range at 500 m west of the road at Oueah,

Classification: Loamy skeletal mixed hyperthermic Typic Torriorthent (about 45% of the area); loamy skeletal mixed hyperthermic Lithic Torriorthent (about 35% of the area).

OUEAH

(Continued)

Soil Interpretation:

Land Capability Classification: VII s;g;e;r;w

Irrigation Suitability Classification: none

Range: I 20% bush

Internal drainage: III r;i

Terraces and Diversions: III p;r;f

Embankments, dikes and levees: III r;t;p;c

28/1/82 A.D./F.O.

DJADJABOD

Site No. 281.6 - 1256.2

Location:

1-10 cm: C1 horizon; 10Yr 5/4 yellowish-brown (dry) 10YR 3/4 dark yellowish brown (moist); loamy sand; weak medium to fine subangular and angular blocky structure; weakly cemented brittle nonsticky; strongly effervescent; many fine fibrous roots; clear and smooth boundary;

10-20 cm: C2 horizon; 10YR 3/3 dark brown (moist); very gravelly loamy sand; weak medium to fine subangular blocky structure; firm, friable, nonsticky; strongly effervescent; many fine fibrous roots; many fine white filaments; clear and wavy boundary; 50% gravel and stones;

20-50+ cm: C3 horizon; 10YR 5/4 yellowish-brown (moist); very gravelly sand; structureless; loose, friable, nonsticky; 50% watershed gravel and stones, strongly effervescent; few medium woody roots and many fine while filaments.

Surface: 20% boulders, cobbles and stones.

Inclusions: 20% wadi channels

Slope: 3%

Position: Old terrace

Parent Material: Colluvium and loess

Vegetation: 80% "cagar" and dabayey, 5% "saraman" and "cadad"

Erosion: Moderate water erosion

Comments: Altitude 300 m

Classification: Sandy skeletal mixed hyperthermic Typic Torriorthent.

HAGARRE

Site No. 276-1261

Location: 276.0 E
1261.7 N

0-5 cm: A horizon; 10YR 5/2 grayish brown (dry), 10YR 3/2 very dark grayish brown (moist); sand; structureless; loose, friable, nonsticky; strongly effervescent; common fine fibrous roots; thin irregular CaCO3 coatings on rocks; 10% fine and medium gravel;

5-50 cm: C horizon; 10YR 4/3 brown (dry), 10YR 3/3 dark brown (moist); sand; weak medium to fine subangular blocky structure; 10% fine and medium gravel; very thin CaCO3 coatings on rocks; soft powdery less than 1% 1 to 2 mm CaCO3; firm, friable, nonsticky; strongly effervescent; common fine woody roots.

Surface: 90% gravel and stones

Inclusions: 50% rock outcrop 20% lithic variant

Slope: 17%

Position: Colluvial talus slope

Parent Material: Colluvium (basalt) of stratified lavas

Vegetation: 10% 10 cm grass, 5% herbs, 10% brush and 1 to 3 m high acacia tortilis

Erosion: Severe water

Temperature: 26.4 ^{o}C 50 cm

Classification: Sandy mixed hyperthermic Typic Torriorthent.

797

GOUMBOURTA EAD

Site No. 269-1254

Location: 269.3 E
1254.6 N

o-5 cm: All horizon; 10YR 4/2 dark grayish brown (dry), 10YR 2/2 very dark brown (moist); gravelly loam; weak fine subangular blocky structure; loose, friable, slightly sticky; strongly effervescent; thick coating of $CaCO_3$ on gravel; common fine fibrous roots; 40% fine and medium gravel; clear wavy boundary;

5-40 cm: A12 horizon; 10YR 3/3 dark brown (dry), 10YR 3/2 very dark grayish brown (moist); very stony loam; structureless; loose, friable, slightly sticky; thin $CaCO_3$ coatings on gravel and stones; 80% stones, cobbles and gravel; gradual irregular boundary;

40+ cm: Fractured rock.

Surface: 90% gravel, stones and cobbles

Inclusions: 10 to 15% rock outcrop, 20% toeslope variant

Slope: 17%

Parent Material: Basalt

Vegetation: 10% 6 cm grass, 2% herbs (20 cm tall), 20% brush (20 cm - 2 m)

Erosion: Severe water

Temperature: 29.2 ^{o}C 40 cm

Classification: Loamy skeletal mixed hyperthermic Lithic Torriorthent.

198

1/3/82 J.G./A.D.

DJALAF

Site No. 275-1261

Location: 275.6 E
1261.8 N

0-5 cm: A11 horizon; 10YR 5/3 brown (dry), 10YR 3/3 dark brown (moist); gravelly sandy loam; weak fine and medium subangular blocky structure; loose, friable, nonsticky; few medium roots; strongly effervescent; $CaCO_3$ coatings on the peds; 25% coarse gravel and stones;

5-50 cm: A12 ca horizon; 10YR 5/3 brown (dry), 10YR 4/3 brown (moist); gravelly sandy loam; 30% fine and medium gravel; continuous $CaCO_3$ coatings on rocks; common fine fibrous roots; wavy and irregular boundary;

50-90 cm: Cca horizon; 90% cobbles, stones and coarse gravel; continuous $CaCO_3$ coatings;

Surface: 75% medium gravel, 5% stones and boulders

Inclusions: 20% wadi channels, 10-15% colluvial delta and colluvium

Slope: 1%

Position: Terrace

Parent Material: Alluvium

Vegetation: 20% 10 cm grass and herbs, 10% acacia

Erosion: Slight infrequent inundations

Temperature: 26.7 ^{o}C 50 cm

Classification: Loamy skeletal mixed hyperthermic Typic Calciorthid.

799

1/3/82 J.G./A.D.

MIDGAEOUNE

Site No. 303-1265

Location: 303.3 E
1265.9 N

0-20 cm: A horizon; 5YR 5/6 yellowish red (dry), 5YR 4/6 yellowish red (wet); clay loam; weak very fine subangular blocky structure; slightly loose, friable, slightly sticky; 5% 11 to 5 mm soft powdery $CaCO_3$; about 10% medium gravel coated with $CaCO_3$; common very fine fibrous roots; extremely effervescent; pH 8.5; gradual wavy boundary;

20-30 cm: B21 horizon; 7.5YR 6/4 light brown (dry), 7.5YR 4/6 strong brown (wet) gravelly clay loam; weak and moderate medium and fine subangular blocky structure; slightly firm, friable, slightly sticky; many fine fibrous roots; 25% gravel, cobble s and stones from 5 to 100 mm coated with $CaCO_3$; strongly effervescent; gradual smooth boundary;

30-60 cm: B22 horizon; 7.5YR 6/4 light brown (dry), 7.5YP 4/6 strong brown (wet); clay loam; 10 to 15% fine and medium gravel; structureless; slightly firm, friable, slightly sticky; common medium ($CaCO_3$ on rocks and gravel; strongly effervescent; fine disseminated $CaCO_3$;

Surface: Small accumulation zone with 60% gravel cover

Inclusions: Included in Holl-Holl mapping units

Slope: 1%

Position: Lava plateau (at its shoulder)

Parent Material: Eolian and slope wash

Vegetation: Less than 1% grass, 1% bushes

Erosion: Slight

Temperature: $7^{o}C$ 50 cm

Classification: Loamy mixed hyperthermic Typic Calciorthid.

1/3/82 A.D./J.G.

EOBOLLEY WEYN

Site No. 289-1259

Location: 289.1 E
1259.7 N

0-20 cm: A horizon; 7.5YR 5/4 brown (dry); 7.5YR 3/4 dark brown (moist); gravelly clay loam; structureless; loose, friable, slightly sticky; 50% gravel; strongly effervescent; few fine roots; CaCO3 deposits on gravel; gradual wavy boundary;

20-40 cm: B horizon; 5YR 4/4 reddish brown (dry), 5YR 3/3 dark reddish brown (moist); gravelly loam; loose, friable, slightly sticky; strongly effervescent; 20% gravel and stones covered with CaCO3;

Surface: 70% cobbles and stones

Inclusion: 5% drainage ways

Slope: 1%

Position: Shoulder of lava plateau

Parent Material: Eolian and volcanic rubble

Vegetation: 1% grass (10 cm), 4% acacia

Erosion: Water (slight)

Temperature: 30.7 ^{o}C 40 cm

Classification: Loamy skeletal mixed hyperthermic Lithic Camborthid.

801

1/3/82 J.G./A.D.

HINDI

Site No. 273-1257

Location: 273.8 E
1257.6 N

0-15 cm: A horizon; 10YR 4/3 brown (dry), 7.5YR 3/4 dark brown (moist); very gravelly loamy sand; structureless; loose, friable, nonsticky; 60% gravel, cobbles and stones; thin $CaCO_3$ coatings on all rock fragments; extremely effervescent; few fine fibrous roots; clear wavy boundary;

15-40 cm: B21 horizon; 10YR 5/2 grayish brown (dry), 10YR 3/3 dark brown (moist); very gravelly loamy sand: 80% gravel and stones; structureless; loose, friable, nonsticky; $CaCO_3$ coating on all rock fragments; common fine fibrous roots; extremely effervescent; gradual wavy boundary;

40-150+ cm: B22 horizon; 10YR 7/2 light gray (dry), 10YR 5/4 yellowish brown (moist); gravelly loamy sand; slightly cemented; structureless; hard, very firm, nonsticky; 10 to 15% $CaCO_3$; $CaCO_3$ deposits on rock fragments and disseminated fine $CaCO_3$: 50 to 60% gravel; extremely effervescent;

Surface: 60% gravel cover and 20% stone cover

Inclusions: Wadi channel and dark colluvial deltas and colluvium

Slope: 1%

Similar Soil: DIJAN DER

Position: Terrace

Parent Material: Alluvium

Vegetation: 20% to 10 cm grass, 2% herbs, 50 to 60% acacia cover near the wadi

Erosion: Slight water; infrequently inundated

Temperature: 30.3 $^{\circ}$C 40 cm

Classification: Sandy skeletal mixed hyperthermic Typic Calciorthid

802

GOUMBOURTA EATAR

Site No: 300-1267

Location: 300.8 E
1267.2 N

0-10 cm: A horizon; 2.5YR 3/2 dusky red (dry), 2.5YR 3/4 dark reddish brown (moist; clay; moderate medium to fine subangular blocky structure, firm, friable, sticky; strongly effervescent; 5 to 10% 2 to 5 mm gravel; clear smooth boundary;

10-35 cm: B21 horizon; 2.5YR 3/2 dusky red (dry), 2.5YR 5/4 dark reddish brown (moist); clay loam; hard coarse to medium subangular blocky structure; firm, friable, slightly sticky; soft masses of 2 to 4 mm secondary $CaCO_3$ (3 to 4%); strongly effervescent; gradual smooth boundary;

35-70 cm: B22 horizon; 5YR 4/6 yellowish red (dry), 2.5YR 3/4 dark reddish brown (moist); clay loam; weak medium to fine suibangular blocky structure; firm, friable, slightly sticky; strongly effervescent; gradual smooth boundary;

70-85 cm: B23 horizon; 2.5YR 3/4 dark reddish brown (dry and moist); clay loam; (auger sample); firm, friable, slightly sticky; strongly effervescent; 3 to 4% fine $CaSO_4$; gradual smooth boundary;

80-100+ cm: B24 horizon; 2.5YR 3/4 dark reddish brown (dry and moist); clay loam; (augar sample); 15% weak pusmic rock; 1% $CaSO_4$; strongly effervescent.

Surface: 90% cobbles and stones

Inclusions: 10% lava outcrop

Slope: 2%

Position: Side slope

Parent Material: Eolian deposit

Vegetation: 5% acacia, 2 to 3% fine grass 10 cm tall

Erosion: Moderate

Temperature: 31.2 ^{o}C 50 cm

Classification: Fine loamy mixed hyperthermic Typic Camborthid

1/3/82 J.G./A.D.

HAMACH-HAMACH

Site No. 271-1255

Location: 271.7 E
1255.9 N

0-12 cm: A horizon; 10YR 6/4 yellowish brown (dry), 10YR 4/4 dark yellowish brown (moist); loam; weak fine and medium subangular blocky structure; fragile, friable, nonsticky; few fine woody roots; strongly effervescent; 15% fine and medium gravel; clear irregular boundary; $CaCO_3$ coatings on the vock fragments;

12-50+ cm: B horizon; 7.5YR 6/4 light brown (dry), 7.5YR 5/4 brown (moist); stony clay loam; weak medium and fine subangular blocky structure; fragile, friable, slightly sticky; strongly effevescent; patches from 1 to 3 cm with soft powdery $CaCO_3$; $CaCO_3$ coating on gravel; common medium and fine woody roots; about 30% stones, cobbles and gravel.

Surface: 80% gravel, stones and boulders

Inclusions: 30 to 50% lava outcrop

Parent Material: Talus

Vegetation: 10 to 15% Jirme, cadad, 10% grass

Erosion: Severe water erosion

Temperature: 26.2 ^{o}C 50 cm

Classification: Fine loamy mixed hyperthermic Typic Camborthid.

DIKO

Site No. 302-1268

Location: 302.4 E
1268.4 N

0-5 cm: A horizon; 7.5YR 5/4 brown (dry), 2.5YR 3/6 dark red (moist); clay loam; weak fine subangular blocky structure; firm, friable, slightly sticky; 5 to 10% medium gravel; clear smooth boundary; strongly effervescent;

5-30 cm: B21 horizon; 5YR 3/4 dark reddish brown (dry and moist); gravelly clay loam; 20% fine gravel, moderate medium breaking to fine subangular blocky structure; firm, friable, slightly sticky; many fine mycelia; strongly effervescent; 1 to 3% 1 to 2 mm soft $CaCO_3$; gradual wavy boundary;

30-50+ cm: B22 horizon; 5YR 4/6 yellowish red (dry), 5YR 3/4 reddish brown (moist); gravelly clay; 20% fine gravel; few fine $CaSO_4$ crystals; strongly effervescent (auger sample);

Surface: 80% cobbles, stones and boulders

Inclusions: 10% drainage ways with thin fluvial cover, 10% steep Holl-Holl soil

Position: On lava plateau

Parent Material: Eolian material on lava flow

Vegetation: Rare, "binin" and "arman" (10%) in waterways; sparse grass

Erosion: Slight

Temperature: 33 ^{o}C 50 cm

Classification: Fine loamy mixed hyperthermic Typic Camborthid

805

3/1/82 J.G/A.D./F.O.

Site No. 283-1259

Location 283.6 E
1259.9

0-8 cm: A horizon; 5YR 5/6 yellowish red (dry), 2.5YR 5/6 red (moist); loam; weak fine subangular blocky structure; loose, friable, slightly sticky; few fine roots; moderately effervescent; clear and wavy boundary;

8-50 cm: B21 horizon; 2.5YR 3/6 dark red (dry and moist); silty clay loam; moderate medium and coarse subangular blocky structure; hard, friable, slightly sticky; 5% fine gravel; few fine roots; moderately effervescent; slightly salty in the lower part of the horizon; few small slicksides; gradual and smooth boundary;

50-100+ cm: B22 horizon; 10YR 4/6 red (dry), 10YR 3/6 dark red (moist); sandy clay loam; 15% fine gravel; moderate and weak medium subangular blocky structure; hard, friable, slightly sticky; 3-5% 1 to 3 mm $CaSO_4$ crystals; moderately effervescent.

Surface: 60 to 70% cobbles and stones

Inclusion: Jaban Eas

Slope: 3%

Similr Soil: Guistir

Position: Lava flow

Vegetation: 2% "sarman" in the waterways

Erosion: Wind and water erosion

Temperature: 30.3 ^{o}C 50 cm

Comment: Silt crust from the rain at the surface

Classification: Fine loamy mixed hyperthermic Gypsic Camborthid

3/1/82 A.D./J.G./F.O.

Site No. 286-1261

Location: 286.3 E
1261.9 N

0-10 cm: A horizon; 5YR 4/6 yellowish red (dry), 2.5YR 3/6 dark red (moist); loam; weak fine subangular blocky structure; loose, friable, nonsticky; mildly effervescent; clear and wavy boundary;

10-110+ cm: B2 horizon; 5YR 4/6 yellowish red (dry), 2.5YR 3/6 dark red (moist); sandy clay loam; moderate medium and coarse subangular blocky structure; very hard, friable, slightly sticky; few fine white filaments; 5% fine gravel; few slicken-sides; seems to have faint salt taste; mildly effervescent.

Surface: 60% cobbles, stones and boulders

Inclusions: Guistir or Jaban Eas

Slope: 1%

Position: Lava flow (loess covered) on the coastal side

Vegetation: Rare (2 m high "bilcin" and 1% herbs)

Erosion: Wind and sheet

Temperature: 31 ^{o}C

Comment: Silt crust from the rain at the surface

Classification: Fine loamy mixed hyperthermic Typic Camborthid

30/12/81 F.O./A.D./J.G.

DAGAHDAMER

Site No. 306-1263

Location: 306.3 E
1263.8 N

0-15 cm: A horizon; 10YR 5/3 brown (dry), 7.5YR 4/4 dark brown (moist); very gravelly loamy sand; weak medium to fine subangular blocky structure; loose, friable, nonsticky; strongly effervescent; 30% gravel and 30% stones; common fine woody roots; clear and wavy boundary;

15-40+ cm: Cca Horizon; 10YR 5/3 brown (dry), 7.5YR 4/4 dark brown (moist); very gravelly sandy loam; weak fine subangular blocky structure; loose, friable, slightly sticky; strongly effervescent; 1 to 10 mm hard pitted $CaCO_3$ and fine disseminated soft powdery and thick coatings on the gravel and the stones; few fine woody roots.

Surface: 80% gravel and 20% cobbles and stones

Inclusions: 15% rock outcrop and 15% typic Calciorthid

Slope: 15%

Position: Colluvial slope

Parent Material: Loess and mixed igneous rocks

Vegetation: 10% bushes and grass

Erosion: Water erosion (sheet and gully)

Temperature: 30.1 ^{o}C 40 cm

Classification: Loamy skeletal mixed hyperthermic Lithic Calciorthid

808

4/1/82 A.D./F.O./J.G.

Site No. 282-1259

Location: 282.4 E
1259.7 N

0-20 cm: A horizon; 10YR 5/3 brown (dry), 10YR 3/4 dark yellowish brown (moist); very gravelly sand; weakly cemented, friable, nonsticky; strongly effervescent; 50% gravel; thin coating of $CaCO_3$ on the gravel and stones; clear and wavy boundary;

20-70 cm: Cca horizon; 10YR 6/2 light brownish gray (dry), 10YR 3/2 very dark grayish brown (moist); very gravelly sand; hardly cemented, brittle, nonsticky; strongly effervescent; 70% gravel and stones; diffused boundary;

70-150+ cm: C horizon; stratified gravel and stones.

Surface: 40% cobbles and stones

Inclusions: Wadi channel

Slope: 1%

Similar Soil: Didjan Der

Position: Terrace

Vegetation: Acacia and bushes

Erosion: Occasional flooding and wind erosion

Temperature: 30.6 $^{\circ}$C 50 cm

Clssification: Sandy skeletal mixed hyperthermic Typic Calciorthid

A.D./F.O./J.G.

Site No. 280-1253

Location: 280.5 E
1253.1

0-10 cm: A horizon; 7.5YR 5/4 brown (dry), 7.5YR 3/4 dark brown (moist); sandy loam; moderate medium subangular blocky; firm, friable, slightly sticky; 10% gravel; strongly effervescent; few fine roots; clear and wavy boundary;

10-50+ cm: C horizon; 10YR 5/3 brown (dry), 10YR 4/3 dark brown (moist); very many cobbles/sandy loam; structureless; weakly cemented, friable, nonsticky; strongly effervescent; thin $CaCO_3$ coating on the cobbles and gravel; common fine roots; 50% cobbles and gravel.

Surface: 75% gravel, 20% cobbles and boulders

Inclusions: Wadi channel and Jaban Eas complex

Slope: 1%

Similar Soil: DIDJAN DER

Position: Old Terrace

Parent Material: Alluvium

Vegetation: 3% bushes and grass

Erosion: Sheet erosion and wind erosion

Temperature: 29PToPTC 50 cm

Classification: Loamy skeletal mixed hyperthermic Typic Torriorthent

2/1/82 A.D./F.O./J.G.

Site No. 304-1271

Location: 304.7 E
1271.2 N

0-17 cm: C21 horizon; 10YR 5/3 brown (dry), 10YR 3/3 dark brown (moist); sand; laminar; structureless; loose; effervescent; clear and wavy boundary;

17-60 cm: C22 horizon; 7.5YR 4/4 brown (dry), 7.5YR 3/4 dark brown (moist); sandy clay loam; weak medium and fine subangular blocky structure; slightly firm, slightly friable, slightly sticky; strongly effervescent; less than 1% 2-15 mm $CaSO_4$; gradual wavy boundary;

60-80+ cm: C23 horizon; 7.5YR 4/4 brown (moist); sandy clay loam; weak medium and fine subangular blocky structure; slightly firm; slightly friable, slightly sticky; strongly effervescent; 5% 2-20 mm $CaSO_4$.

Surface: Eolian sand, 1 mm weak crust

Inclusions: Sand dunes (20-100 cm)

Slope: Less than 1%

Similar Soils: ATAR

Position: Coastal plain

Parent Material: Recent marine sediment

Vegetation: 2% Prosopis juliflora and acacia

Erosion: Eolian and rill erosion

Temperature: 31.7 ^{o}C 50 cm

Classification: Fine loamy mixed hyperthermic Typic Torriorthent

811

4/1/82 A.D./F.O./J.G.

Site No. 278-1254

Location: 278.3 E
1254.8 N

0-10 cm: A horizon; 10YR 6/4 light yellowish brown (dry), 10YR 4/3 brown (moist); loam; moderate medium to fine subangular and angular blocky structure; firm, friable, slightly sticky; strongly effervescent; 5% gravel; few fine roots; clear and wavy boundary;

10-50+ cm: C horizon; 10YR 5/3 brown (dry), 10YR 3/3 dark brown (moist); very gravelly loam; weakly cemented, friable, slightly sticky; strongly effervescent; 50% gravel and cobbles; thin $CaCO_3$ coating on the gravel and cobbles.

Surface: 60% stones and boulders

Inclusions: 10% lava outcrop

Slope: 1%

Similar Soils: "Balambal"

Position: Lava plateau

Parent Material: Volcanic ash ejecta

Vegetation: 15% 600150 cm high "binin"

Erosion: Sheet erosion and wind erosion

Temperature: 20PToPTC 50 cm

Classification: Loamy skeletal mixed hyperthermic Typic Torriorthent

812

2/1/82 J.G./F.O./A.D.

Site No. 305-1271

Location: 305.7 E
1271.4 N

0-4 cm: A horizon; 10YR 4/3 brown (dry), 10YR 3/4 dark yellowish brown (moist); loamy sand; structureless; loose, very friable; common fine roots; effervescent; clear wavy boundary;

4-30 cm: C21 horizon; 7.5YR 3/4 very dark brown (moist); sandy loam; weak moderate and coarse subangular blocky structure; few fine white filaments; firm, friable, nonsticky; few fine roots; strongly effervescent; many fine pores; clear wavy boundary;

30-60+ cm: C22 horizon; 7.5YR 4/4 brown (moist); loamy sand; weak medium subangular blocky structure; firm, friable; few fine pores; few fine crystals; effervescent; stratified loam, sands and gravels (5-20 cm layers).

Surface: Eolian sand and crusty patches of saline silt

Inclusions; Torrifluvents and Torriorthents

Slope: 0%

Similar Soils: No. 11

Position: Flood terrace

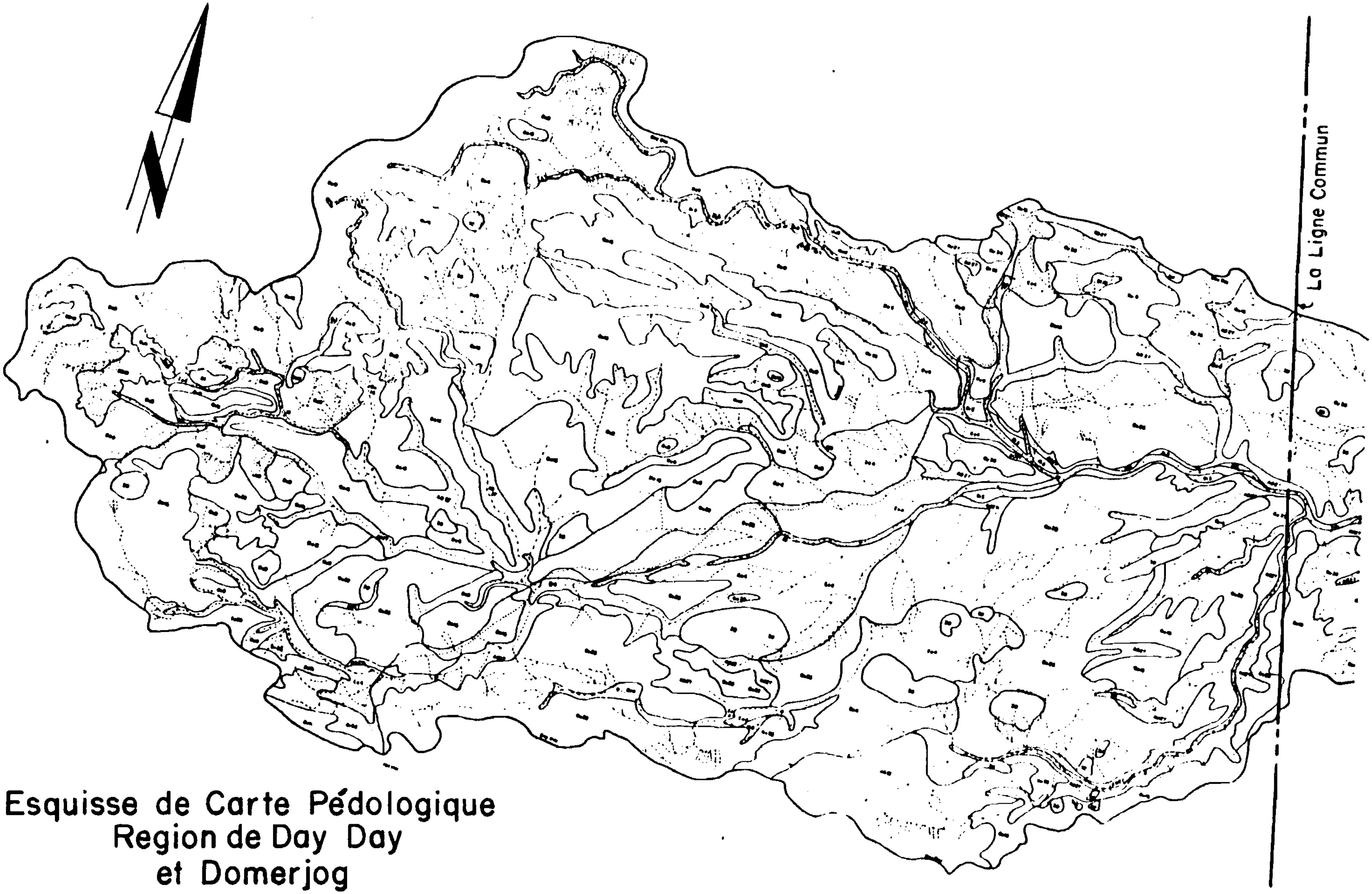
Parent Material: Stratified fluvial deposits

Vegetation: 40% acacia and prosopis Juliflora

Erosion: Flood and wind erosion

Temperature: 33.0PToPTC 50 cm

Classification: Coarse loamy mixed hyperthermic Typic Torriorthent



Esquisse de Carte Pédologique Region de Day Day et Domerjog

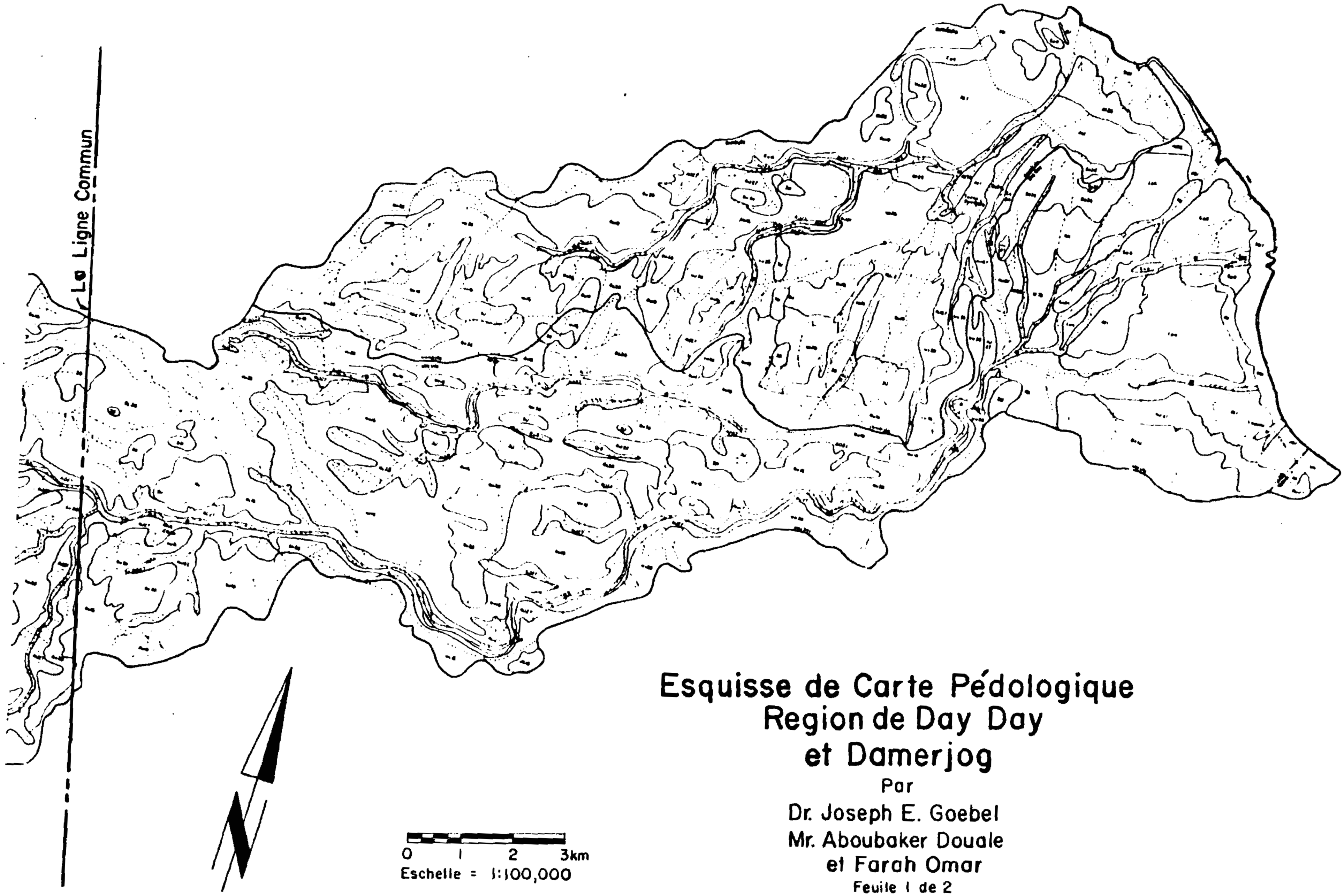
Par

Dr. Joseph E. Goebel
Mr Aboubaker Douale
et Farah Omar

Feuile 2 de 2

0 1 2 3 km
Eschelle = 1:100,000

814



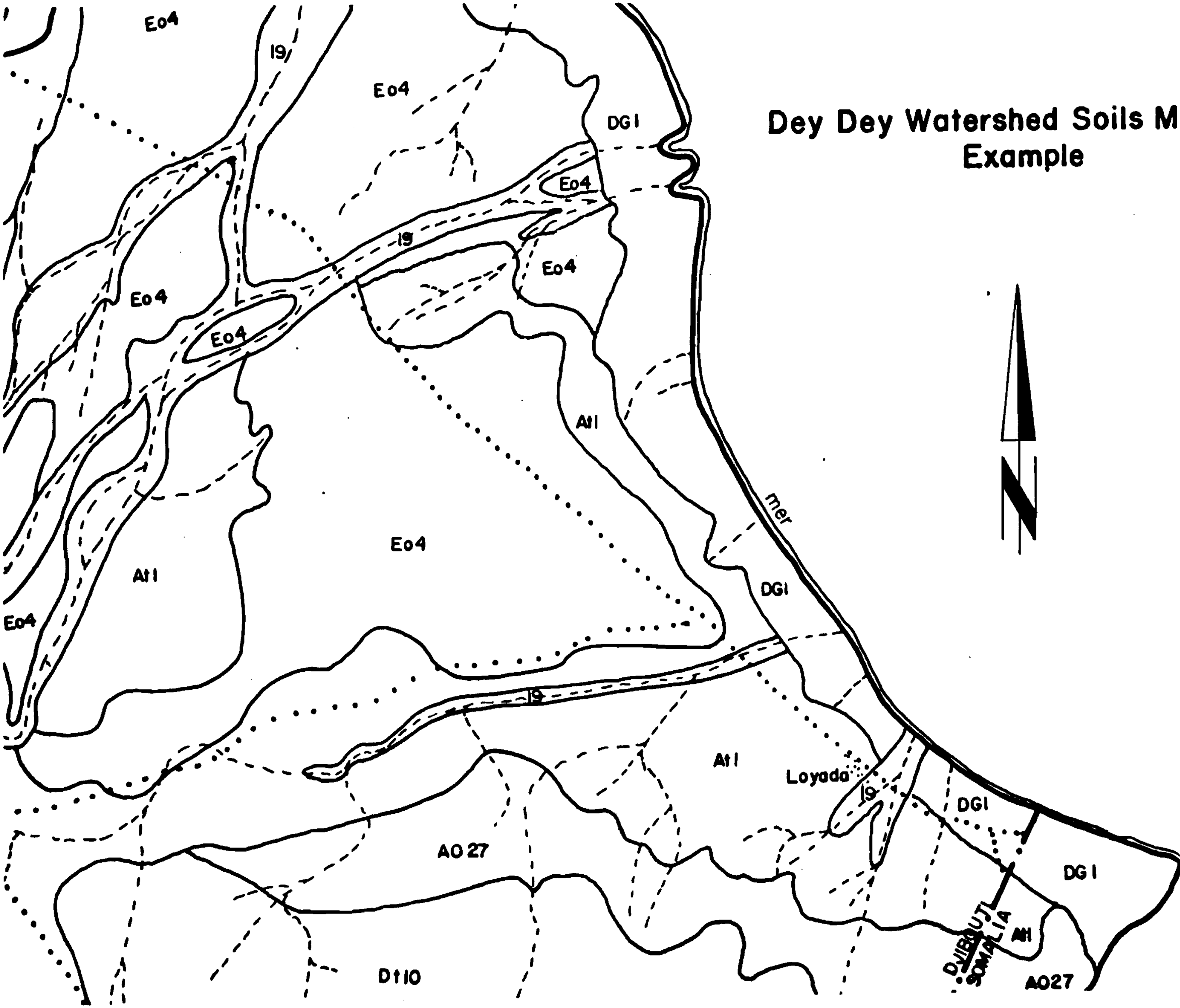
Esquisse de Carte Pédologique Region de Day Day et Damerjog

Par

Dr. Joseph E. Goebel
Mr. Aboubaker Douale
et Farah Omar

Feuile 1 de 2

Dey Dey Watershed Soils Map Example



LABORATOIRE D'ANALYSE DES SOLS ET DES EAUX
RÉPUBLIQUE DE DJIBOUTI

APPENDIX L

LAND OWNERSHIP MAP

APPENDIX L
LAND OWNERSHIP MAP

1.0 INTODUCTION TO LAND OWNERSHIP MAPPING

Due to the small size of the agricultural fields in Djibouti, it is necessary to establish a mapping capability at 1:5,000 scale which is five times larger than the largest scale photography available and twenty times larger than the only serviceable topographic map.

Therefore, Beverly Rollins, a volunteer with the Agricultural Service, learned how to locate detail from the 1:100,000 topographic map to the 1:25,000 aerial photos. She then located the farm boundaries and other topographic detail for the Houmbouli and Douda agricultural area (See Figure 1). The information of the black-and-white photos were enlarged and compared to some hand-held 35 mm color slides of the present condition in these two areas. The distortion was removed and a 1:5,000 scale map was established using the Universal Transverse Mercator (UTM) kilometer grid as a base for placing and locating features. This presents a large enough scale to begin to locate the agricultural inventory on the map. It is expected that this procedure can be expanded to other areas such as Asala, Hanle, Tadjorah, Obock, etc.

2.0 PROCEDURE FOR MAKING THE 1:5000 SCALE LAND OWNERSHIP MAP

In making a map it is important to have a base map which establishes the location of features to be identified on the ground. Since Djibouti has few roads, fences and channels as well as large-scale maps, the best maps available are the 1:100,000 scale topographic map. Since there is no large-scale that covers the country, this project has used the UTM, one-kilometer grid base of the 1:100,000 map as the specific base map. The intersection of the north-south lines with the east-west ones need only then to be established for each larger scale and a serviceable map can be made.

Therefore, in this project, we compared the features of the 1:100,000 scale map to those of the 1:25,000, 1973, aerial photographs. Several UTM grid locations are placed on an acetate overlay, punch registered to the aerial photo. The scale is established and a full grid made by scratching the acetate to avoid obliterating the photo.

At this time the selected features are traced on separate overlays to facilitate updating. This map is then transferred, using vertical sketchmaster, a grid at exactly 1:25,000. Figure 2 shows the resultant 1:25,000 base map.

In the meantime, we took 35 mm slides of the present agriculture in Houmbli and Douda from about 500 meters elevation. Care must be taken in this stip to hold the camera vertical to the ground and get overlap on all sides.

At this point the 1:25,000 map of 1973 features are merged with the 1982 slides. The aerial photos enable one to locate the features on the 1:100,000 scale map in sufficient detail to recognize its placement on the 1:5,000 scale map (in this case the color slides). To facilitate this transfer a perpendicular is established between those points recognized on both the 1:25,000 scale map and the color slide. The 1:25,000 scale map is then placed on a board and moved to/from the projector to accomplish scale and filtered to compensate for distortion. Then the new features are traced on a sheet of paper placed over the 1:25,000 scale map.

The new map, with the placement of fences, channels, roads and buildings is then enlarged to 1:5,000 scale. The final map is comprised of a sheet for each square kilometer of the UTM grid (10 cm x 10 cm). Figures 3-7 show the final 1:5,000 scale maps. The mylar sheets are punched. The grid is divided into 100 parts. Each type of feature is placed on a separate sheet of mylar.

A single photocopy is made and taken to the field for adjustment, verification and logging ownership. The fields are measured with a planimeter and the size of the fields are assigned to the appropriate proprietor.

Esquisse des Carte des Propriétés
Region de Douda Weyn

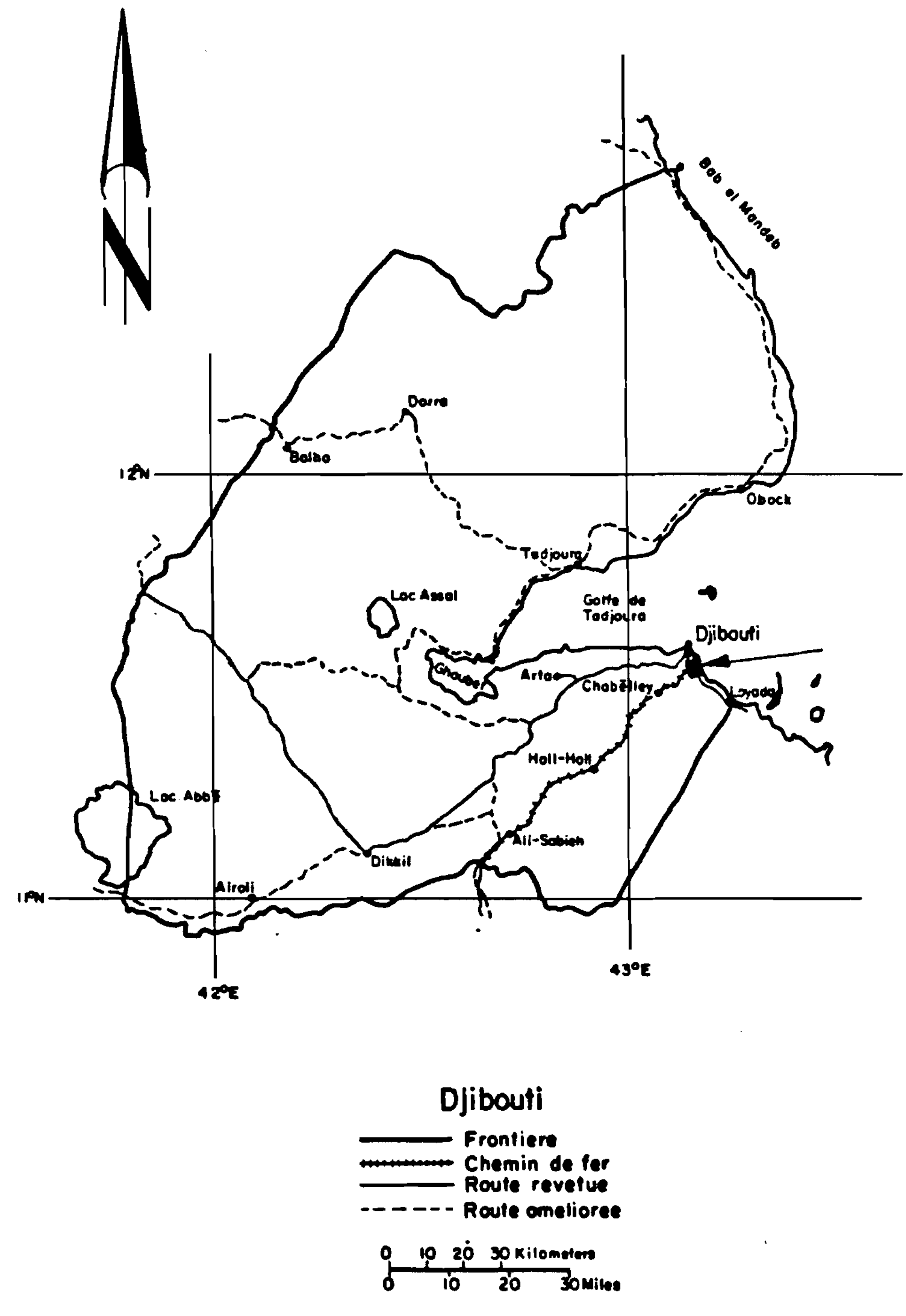


FIGURE 1

BEST AVAILABLE COPY

820

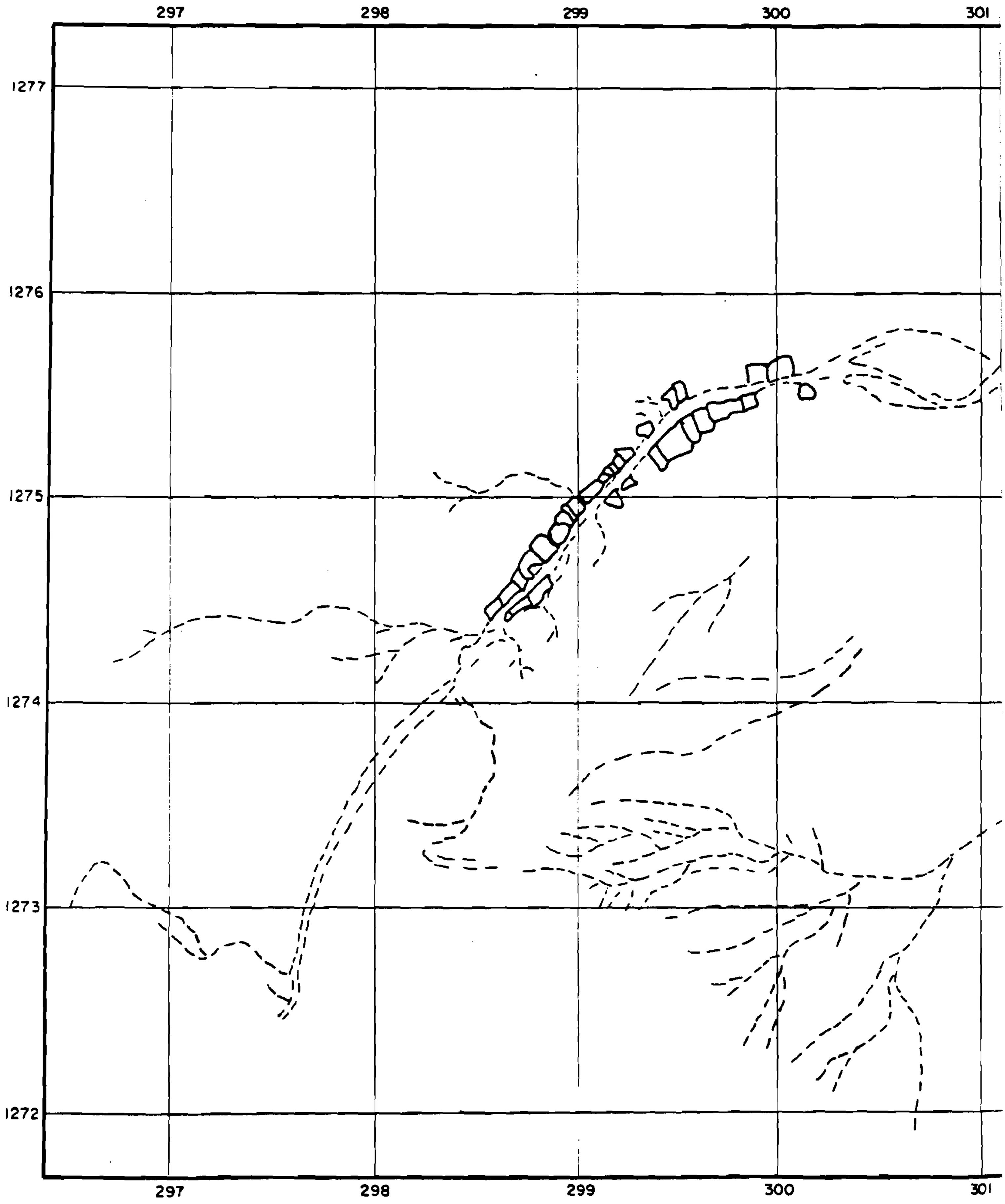
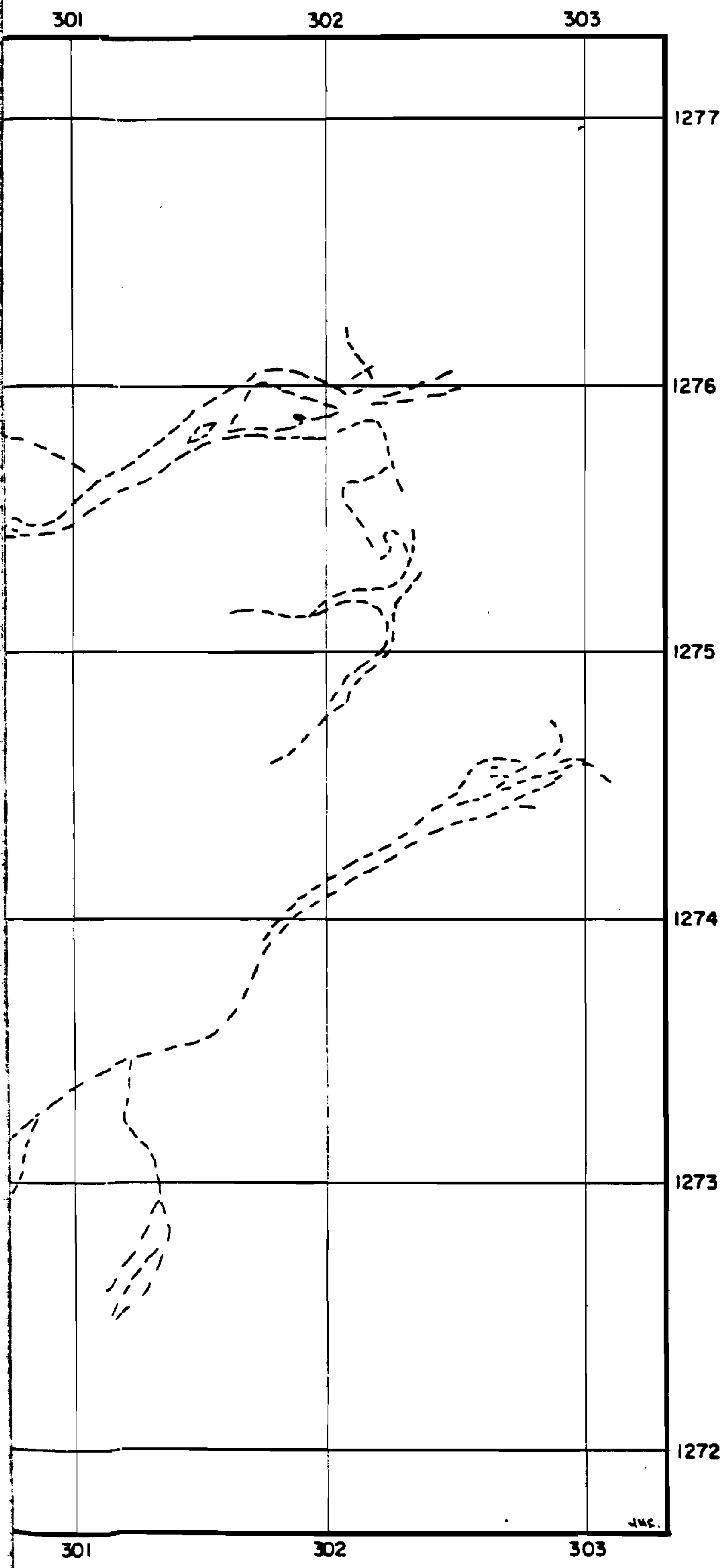


FIGURE 2

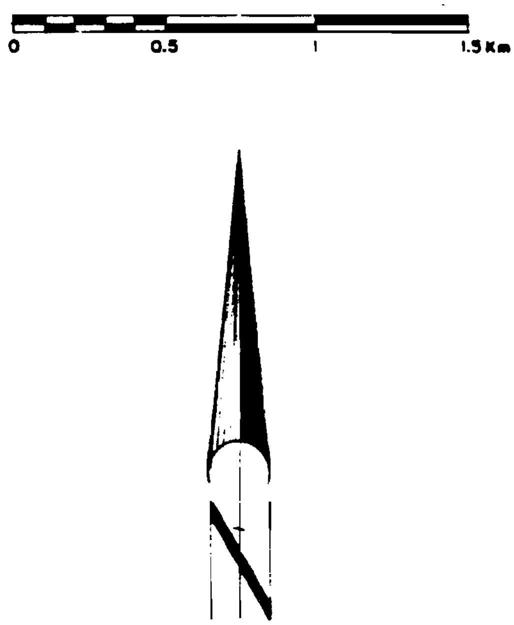
821



Propriétés de la Region de Douda Weyn

Fait par Foto Arien de 1973

Eschelle = 1:25,000



822

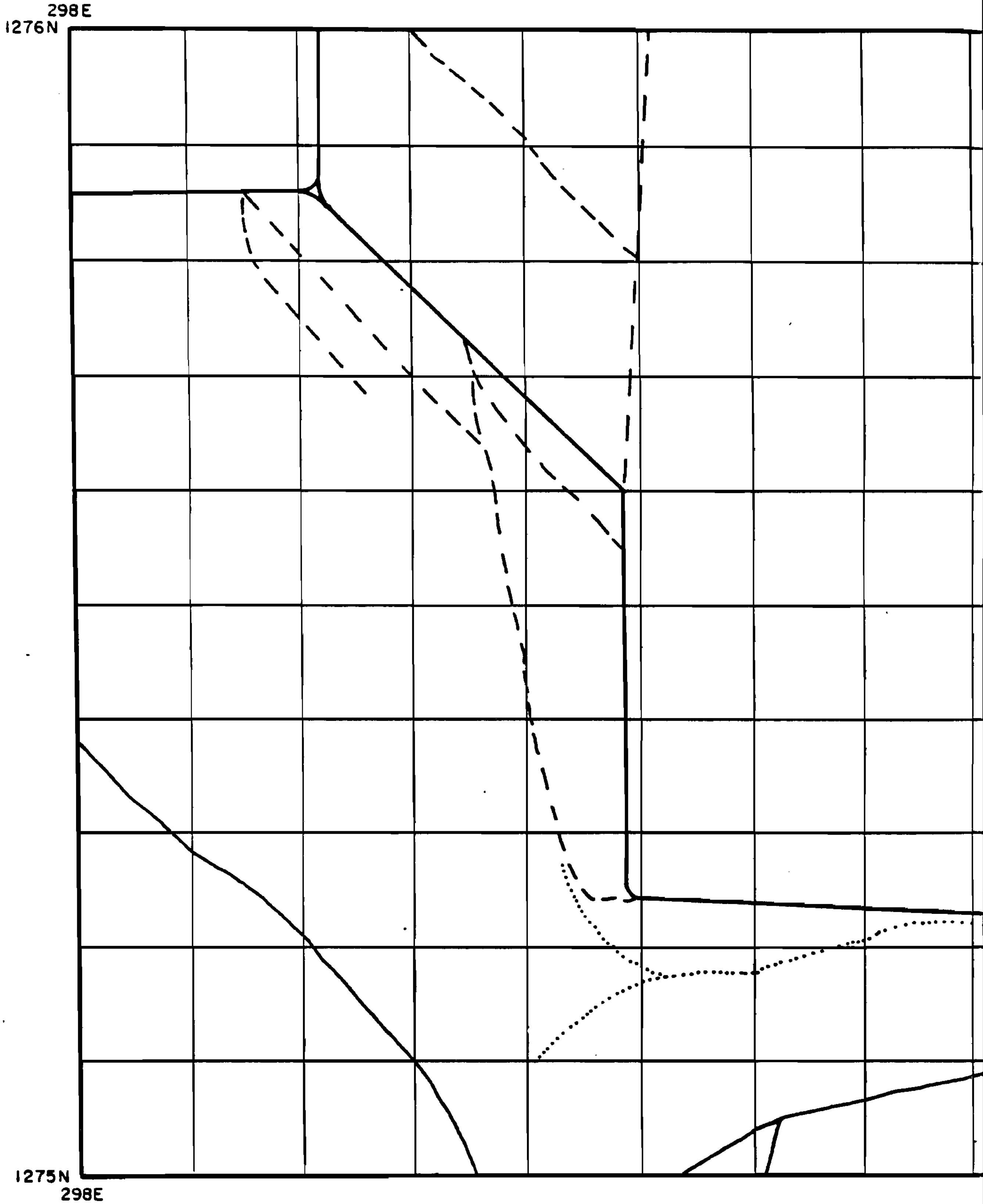
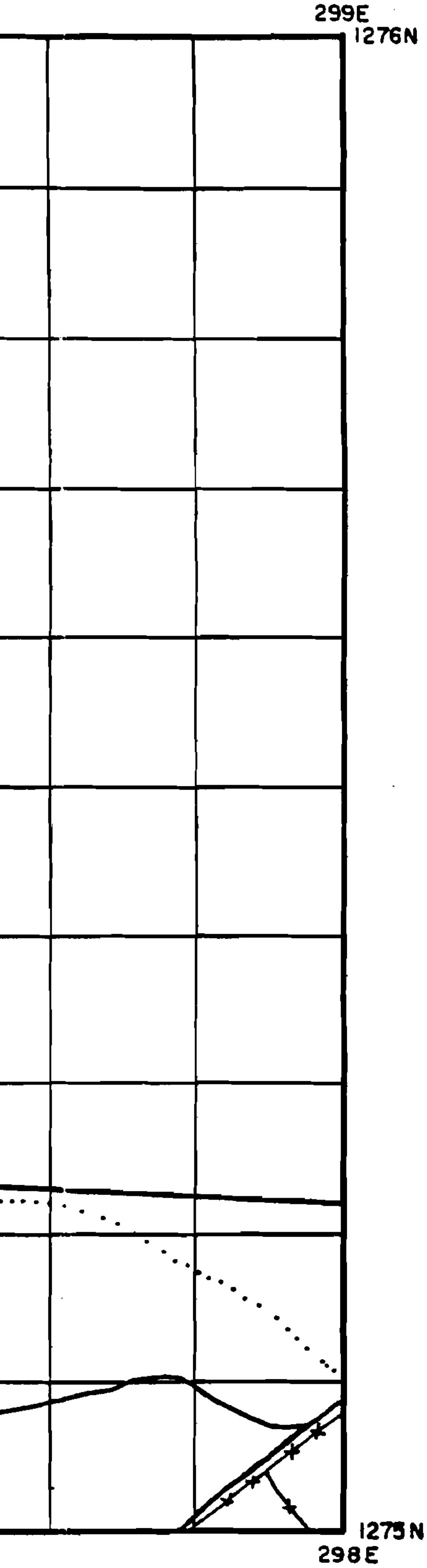


FIGURE 3

823



Propriétés de la Region de Douda Weyn

Eschelle = 1: 5,000

824

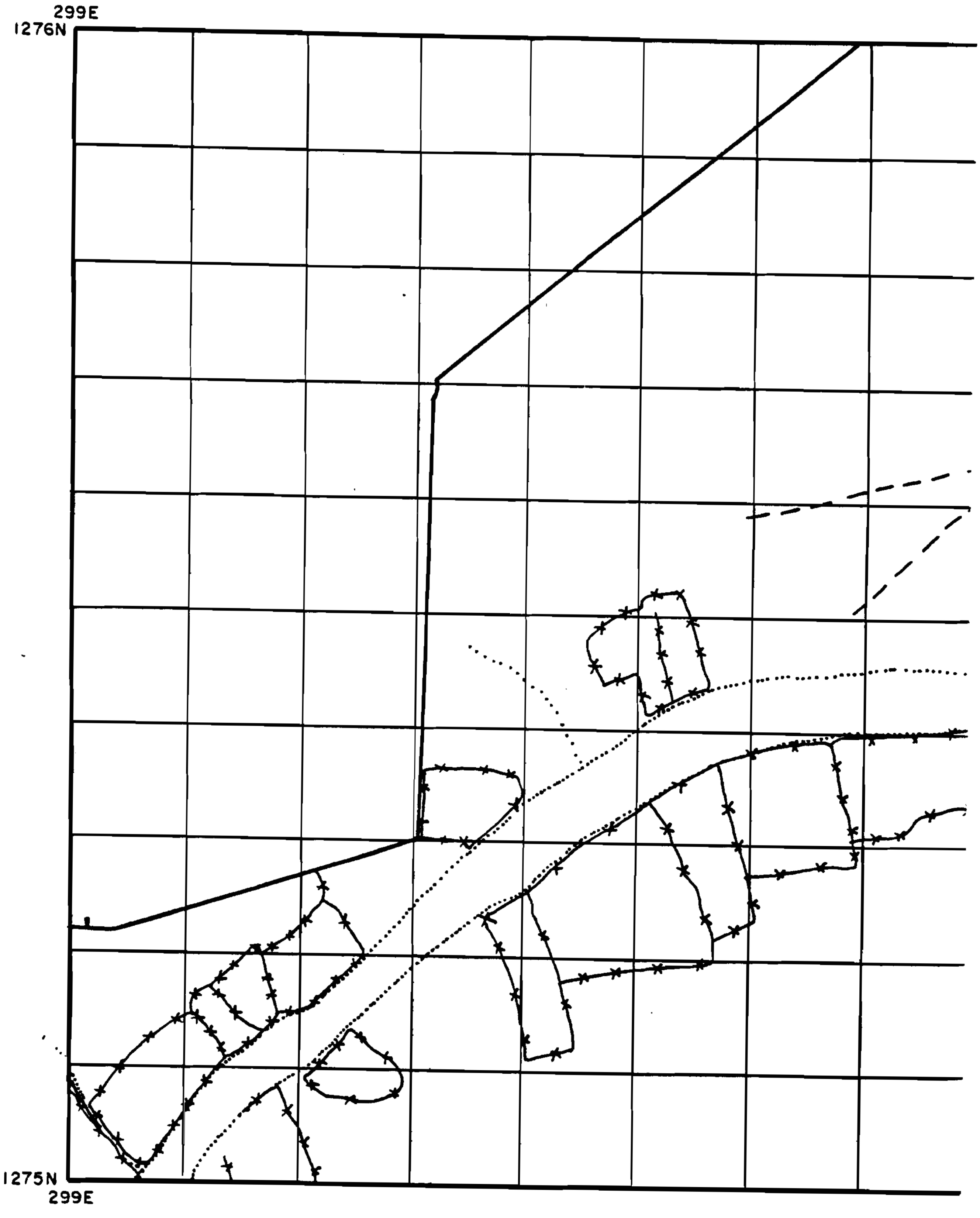
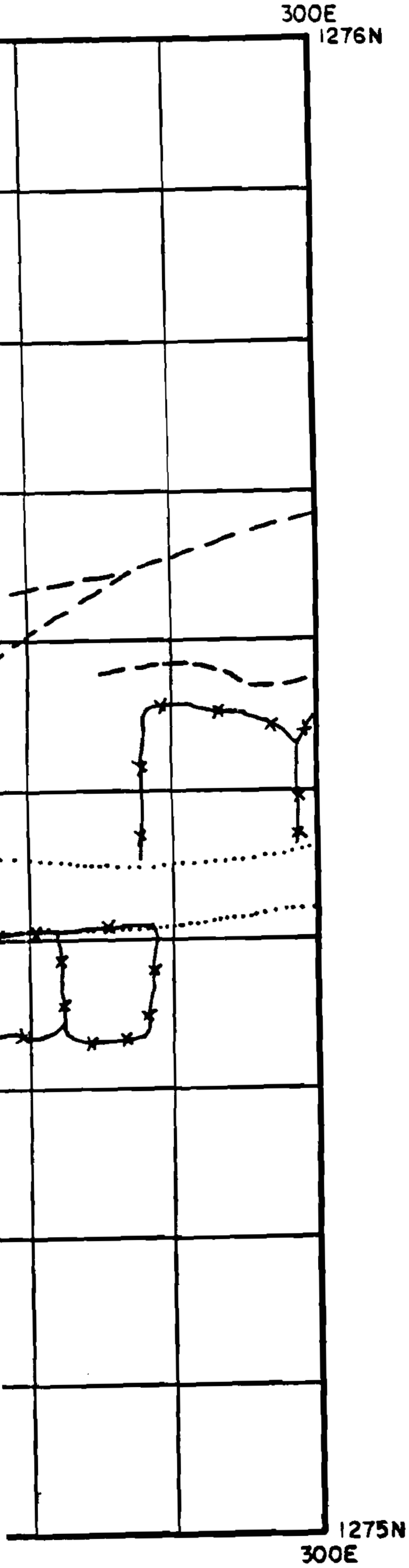
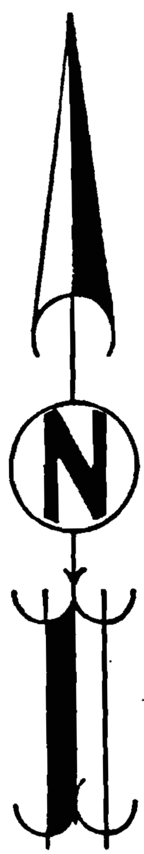


FIGURE 4



Propriétés de la Region de Douda Weyn

Eschelle = 1: 5,000



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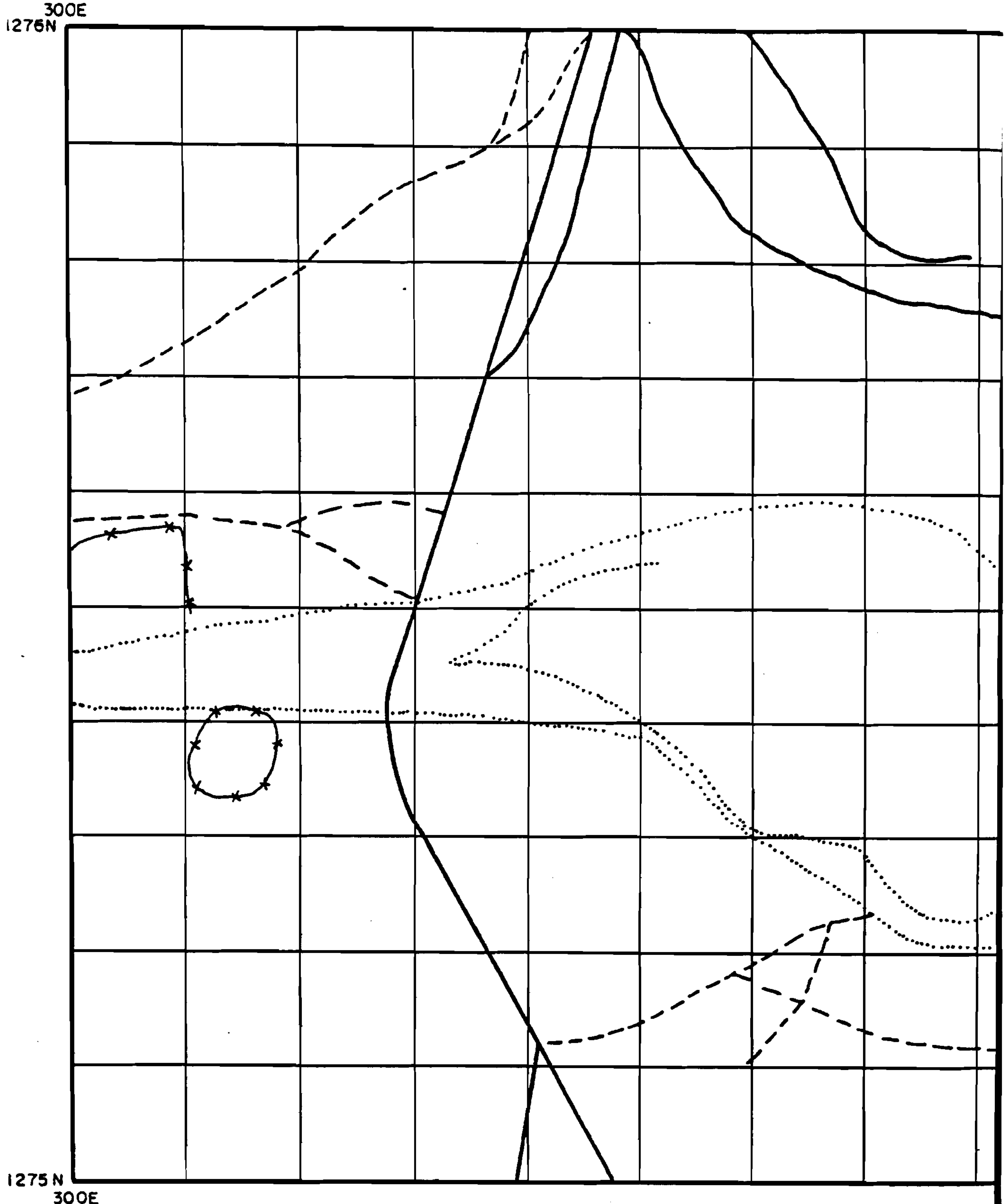
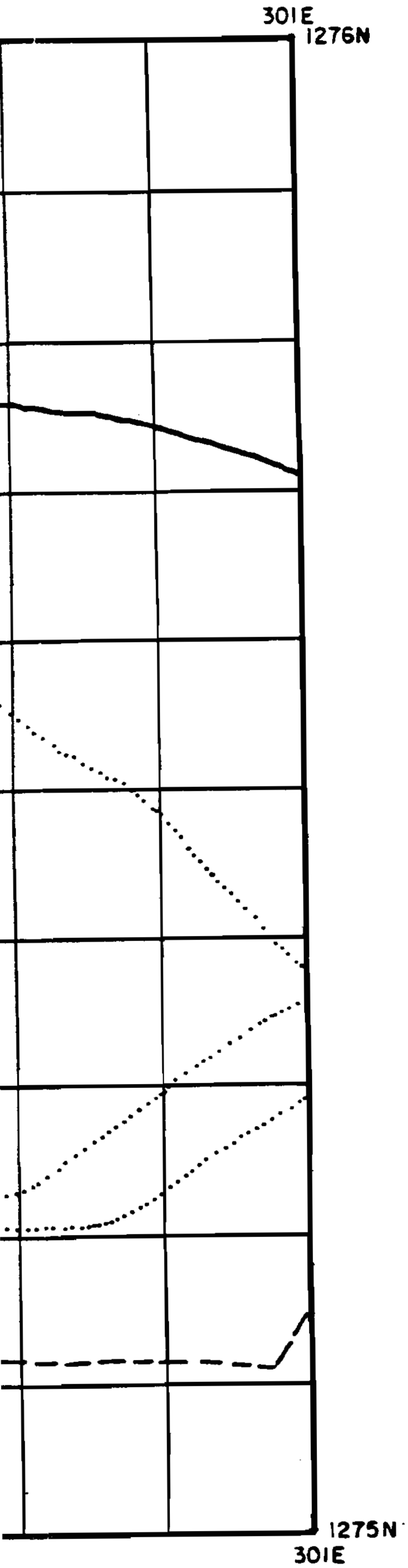
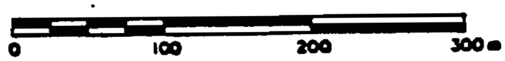


FIGURE 5



Propriétés de la Region de Douda Weyn

Eschelle = 1: 5,000



828

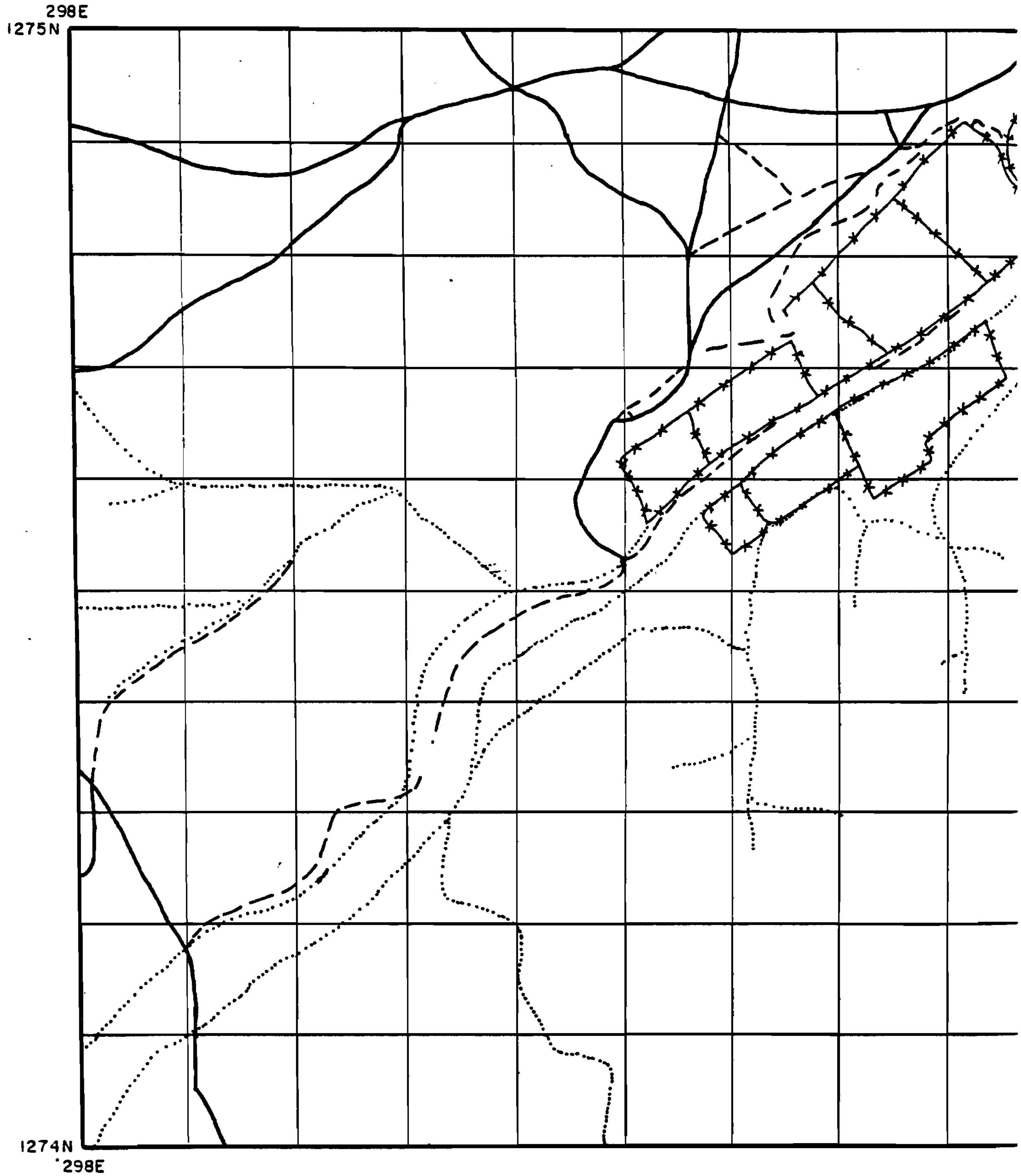
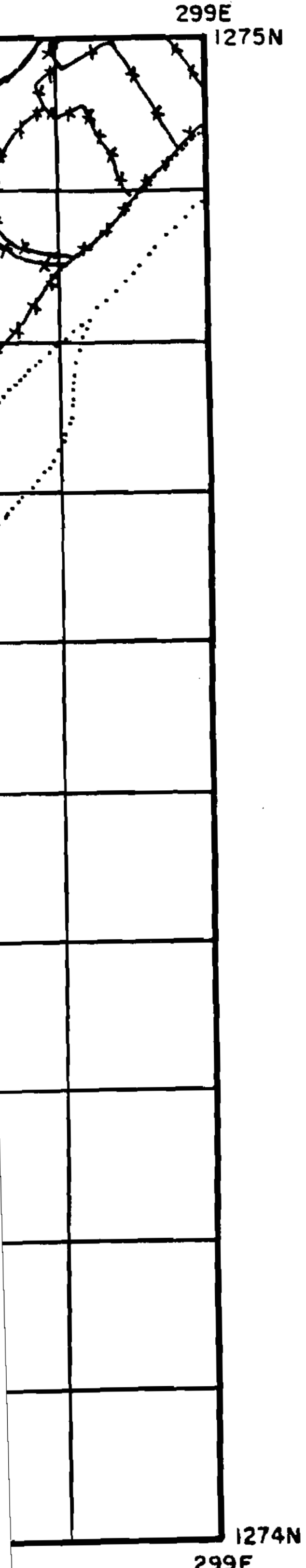


FIGURE 6



Propriétés de la Region de Douda Weyn

Eschelle = 1: 5,000

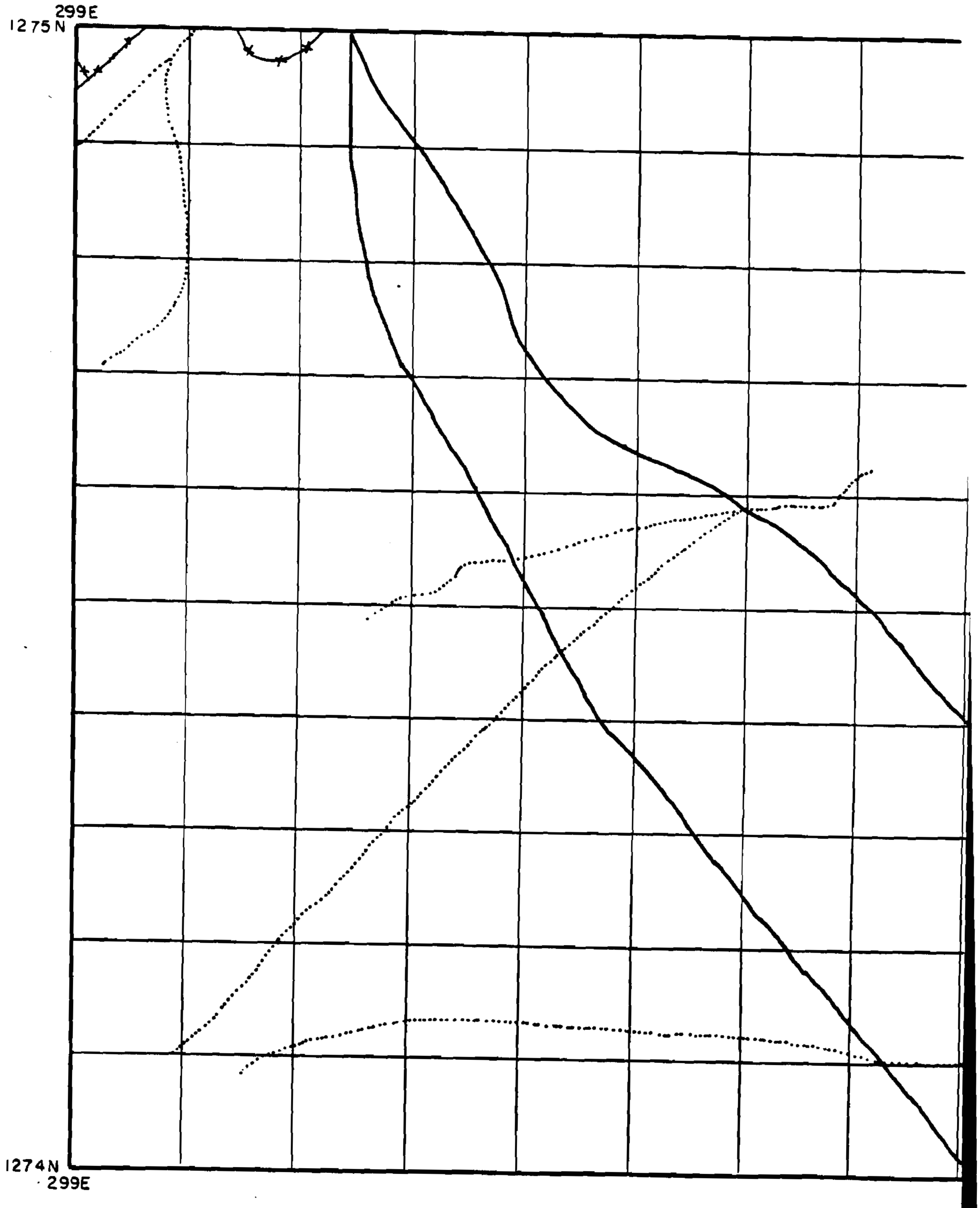
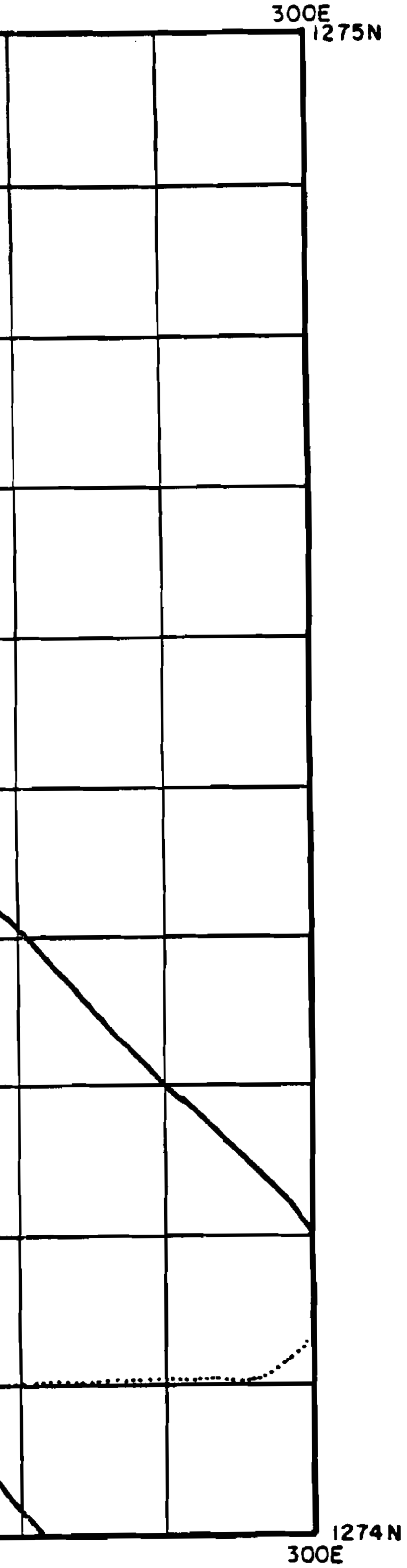


FIGURE 7



Propriétés de la Region de Douda Weyn

Eschelle = 1: 5,000

LABORATOIRE D'ANALYSE DES SOLS ET DES EAUX

RÉPUBLIQUE DE DJIBOUTI

APPENDIX M

THE SOILS AND WATER LABORATORY LIBRARY

APPENDIX M

The Soils and Water Laboratory Library

1.0 INTRODUCTION

Many books in both French and English have been received by the laboratory to maintain as a repository of reference material to serve as back-up for the technicians. The titles have been selected carefully to include basic information on more than just laboratory references.

Since the Djiboutian technicians will have no access to a major library, the subject matter of the library deals with all facets of soils and agronomic investigations, agricultural practices and implementation as well as related fields in chemistry, geology, engineering, etc.

GROUP A
McGraw-Hill Book Company
1221 Avenue of the Americas
New York, New York 10020 U.S.A.

BASIC for Beginners
Gary & Bitter
1978 176p.

Clay Mineralogy
Ralph E. Grim
1968

Engineering Properties of Soils and Their Measurement
Joseph E. Bowles
1978 368p.

Environment and Plant Response
Michael Treshow
1970 416p.

Field Geology
Frederic Lahee
1961 880p.

Fundamentals of Horticulture
J.B. Edmonal
1975 576p.

Groundwater Hydrology
Herman Bauwer
1978 480p.

Geology: Principles and Processes
William H. Emmons
1940 491p.

Handbook of Meteorology
F.A. Beroy Jr.
1945 1116p.

Introduction to Plant Pathology
Cale, Leon J. Editor
Heald, U. D. Author
1943 601 p.

Lange's Handbook of Chemistry, 12th Edition
John A. Dean
1978
07016191-7

835

Optical Mineralogy
Kerr, P. F.
1959 442p.

Photogeology
Victor C. Miller
1962 268p.

Plant and Soil Water Relationships
Paul J. Kramer
1969 416p.

Production of Field Crops
Michael S. Kipps
1970 790p.

Range Land Management
Harold F. Heady
1975 460p.

Range Management
Arthur Smith
1975 532p.

Rural and Regional Planning
William R. Lassey
1977 256p.

Soils and Soil Fertility
Thompson and Troek
1972

Vegetable Crops
Thompson Kelly
1957 611p.

Weed Biology and Control
Thomas J. Muzick
1970 256p.

836

GROUP B

American Society of Agronomy
and
Soil Science Society of America
677 Segoe Road
Madison, Wisconsin, 53711 U.S.A.

Agricultural Anhydrous Ammonia
Technology and Use
M.H. McVihar
1966 314p.

Chemistry in the Soil Environment
Special Publication #40 ISBN 0-89118-065-6
Robert H. Dowdy et. Al
1981 259p.

Crop Tolerance to Suboptimal Land Conditions
Gerald A. Jung
1978 343p.

Drainage of Agricultural Lands
W.W. Bution
1957

Drainage for Agriculture
J. Van Schilfgovade
1974 736p.

Fertilizer Technology and Use
R.A. Olson
1971 411p.

Forage Fertilization
D.A. Mays
1973 621p.

Introduction to Crop Publication
W.B. Ennis Jr.
1979 524p.

Instrumental Methods of Analysis of Soils and Plant Tissue
L.M. Walsh
1971 222p.

Irrigation of Agricultural Lands
R.M. Hagen
1947 1180p.

837

Methods of Soil Analysis Vol I and Vol II
C.A. Black
1965 2 volumes 1572p.

Micronutrients in Agriculture
J.J. Montvedt
1972 666p.

Mineralogy in Soil Science and Engineering
Kunze, G.W., Chairman
1968 106p.

Minerals in Soils Environments
J.B. Dixon
1977 972p.

Multiple Cropping
R.I. Papendid
1977 384p.

Nitrification Inhibitors - Potentials and Limitations
J.J. Meisinger et. al.
ASA Special Publication No.38

Nutrient Mobility in Soils: Accumulation and Losses
Orvis P. Engelstad
1970 81p.

Pesticides in Soil and Water
W.O. Guenzi
1974 576p.

Plant Environment and Effective Water Use
W.H. Pierre
1966 295p.

The Role of Biological Nitrogen Fixation in Forage Livestock Systems
Carl S. Haveland
1976 133p.

The Role of Phosphorous in Agriculture
F.E. Khasawneh
1980 928p.

The Role of Potassum in Agriculture
W.S. Kilmer
1968 509p.

Soil Conditioners
W.C. Maldenhauer
1975 186p.

Soil for Management of Organics
Wastes and Waste Water
1977 627p.

Soil Nitrogen
W.V. Bartholomew
1965 615p.

Soil Surveys and Land Use Planning
L.J. Bartelli
1966 196p.

Soil Testing: Correlating and Interpreting the
Analytical Results
T.R. Peck
1977 127p.

Soil Testing and Plant Analysis
Leo Walsh
1973 491p.

Soil Water
D.R. Nielson
197 175 p.

Transferring Technology for Small Scale Farming
Noble R. Usherwood et.al.
ASA Special Publication No.41
ISBN 0-89118-066-4

Water Potential Relations in Soil Microbiology
J.F. Parr et.al
SSSA Special Publication No.9
ISBN 90-89118-767-7

Universal Soil Loss Equation: Past, Present
and Future
A.E. Peterson
1979 54p.

839

GROUP C
John Wiley and Sons, Inc.
New York, New York U.S.A.

Dana's Manual of Mineralogy
Hurlbut, C.S.
1971 579p.

Historical Geology
Dunbar, C.O.
1969 566p.

Mineral Nutrition of Plants: Principles and Perspectives
Epstein, E.
1972 412p.

The Physical Chemistry and Mineralogy of Soils Vol. II Soils in Place
C. Edmund Marshall
1977 313p.

GROUP D
Prentice-Hall Inc.
Englewood Cliffs, New Jersey U.S.A.

Farm Management Economics
Heady, E.O.
1961 645p.

Introduction to Petrology
Boyly, B.
1968 391p.

Physical Geology
Leet, L.D.
1971 687p.

841

GROUP E
Iowa State University Press
So. State Avenue
Ames, Iowa, 50010 U.S.A.

A Manual of Soil Fungi
Joseph C. Gilman
1957 450p.

Erosion and Sediment Pollution Control
R.P. Beasley
1972 320p.

Introduction to Soil Mechanics
M. Das Braja
1979 270p.

Soil Genesis and Classification
S.W. Buol
1980 404p.

842

GROUP F
The McMillan Company
New York, New York U.S.A.

Soil Fertility and Fertilizers
Samuel Tisdale
1966

The Nature and Properties of Soils
Buckman, H.O.
1960 567p.

GROUP G
W.H. Freeman & Company
600 Market Street
San Francisco, CA 94104 U.S.A.

Applied Animal Nutrition: The Use of Feedstuffs
E.W. Crampton
1967 753p.

The Climate Mandate
W.O. Roberts
1979 197p.

Crop Production: Principles and Practices
S.R. Chapman
1976 566p.

Elements of Mineralogy
Brian Mason
1972 344p.

Fluvial Processes in Geomorphology
L.B. Leopold
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1818 H. Street N.W.
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LABORATOIRE D'ANALYSE DES SOLS ET DES EAUX

RÉPUBLIQUE DE DJIBOUTI

APPENDIX N

PAPERS PRESENTED AT A CONFERENCE ON "REMOTE SENSING OF ARID AND SEMI-ARID LANDS", CAIRO, EGYPT, NOVEMBER 1981

INTRODUCTION

In the middle of this project, an opportunity arose which permitted Aboubaker Douale and Joseph Goebel to present the results of their applications of remote sensing in doing the soils investigations for agricultural assessment.

These papers were both presented in Cairo, Egypt in January 1982, at the International Symposium on Remote Sensing of the Environment.

APPENDIX N-1

NATURAL WATER CONTAINMENT SITE IDENTIFICATION IN THE ARID MOUNTAINS OF DJIBOUTI

Dr. Joseph E. Goebel

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ABSTRACT

Djibouti is young, arid and dependent on outside resources. It desires to establish an agricultural capability. It is searching for water in aquifers and as surface runoff.

The purpose of this study was to evaluate a method for identifying natural water containment sites in wadi channels through synergistic relationships of remote sensing techniques and traditional information resources. Watersheds could then be evaluated for their producing and water holding capacities. We looked for sites to store water in the wadi gravels upstream from natural dam sites of resistant impermeable rock.

The three sources of information used in this study were: a 1:100,000 scale topographic map series; two Landsat scenes of different moisture conditions; and aerial photographs. The three steps used in this investigation were: (1) locating potential sites on the topographic map; (2) locating and recognizing containment sites on Landsat imagery; (3) the most desirable sites were confirmed by aerial photograph interpretation.

The best results in this study were obtained by using the topographic map in conjunction with a Landsat scene taken in the dry season and combining bands 5-7 and 5-4.

Agricultural decisions will be made quickly and economically because of the speed, accuracy and dependability that is achieved by applying synergistic methods to the interpretation of aerial photographs, topographic maps and multispectral imagery.

*Presented at the International Symposium on Remote Sensing of Environment, First Thematic Conference: "Remote Sensing of Arid and Semi-Arid Lands" Cairo, Egypt, November, 1981.

INTRODUCTION

Djibouti is a young arid country faced with locating and establishing an agricultural resource to reduce its dependence on imported foodstuffs. As in most arid areas, an adequate amount of good quality water is the limiting factor in agricultural development. This study was undertaken to identify natural water containment sites on water courses of the wadis (temporary river beds). This should lead to developing subsurface water storage of surface drainage waters which can be connected with downstream proposed agricultural projects. The Said watershed was selected for this study because it is representative of the area.

An active program of aquifer investigation is in process in Djibouti. To date most of the aquifers have shown high concentrations of sodium and other elements which restrict its use for irrigation. Further, these aquifers have somewhat low recharge rates and they are employed mostly for urban and industrial water. The known aquifers often are limited in extent, often not near agricultural land and often very deep. If agriculture is to be implemented, supplemental sources of good quality water will be needed.

The other source of water is surface runoff. Because of the mountainous and youthful terrain coupled with high intensity storms, typical of arid regions, and the thin soils with sparse vegetation, Djibouti has a potentially high percentage of rainwater runoff. What is desired is rapid surface water containment without high evaporation losses due to water surface exposure and subsequent timely distribution to irrigated fields.

Part of the answer of surface water storage lies in the natural drainage system. All of the country's streams have intermittent surface flows, and many of them, in part or in whole, have permanent water flow in the gravelly wadi sediments. Local subsurface water containment sites occur in the wadi whenever a sufficiently resistant impermeable rock unit crosses the channel and creates a knick-point which establishes a base level for the water flow characteristics upstream. This often results in reducing the gradient upstream causing the stream to unload and fill the valley with coarse sediments. This then becomes a high-capacity water retaining basin if the floor of the valley has low permeability. Photos N-2 and N-3 show a typical natural dam site.

The coarse sediments and reduced gradient increase the water infiltration during periods of runoff. A resistant impermeable knick-point serves as a natural dam. After a flood, as the water continues flowing through the gravels, the water breaches the knick-point and supports water flow in the wadi subsurface. The actual knick-point can be deeply grooved or covered by some meters of stream lag.

Photo N-1: Banhuale is a natural dam site. Its spring results from flood water entering the wadi channel.

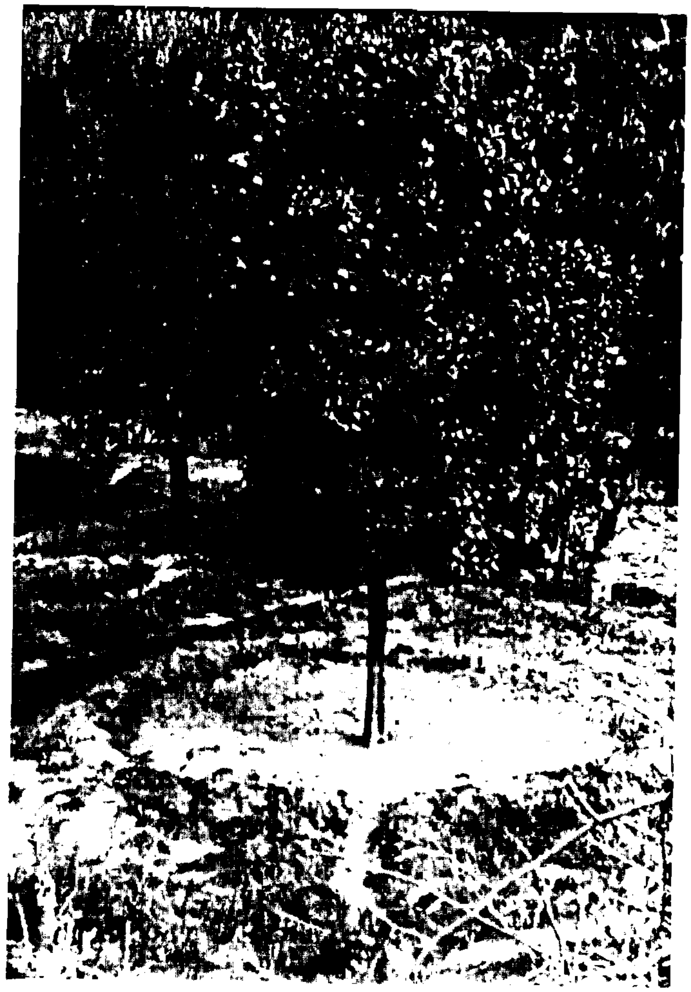

Photo N-2: This is an orange tree along the wadi channel. It is irrigated with water from the Banhuale spring.

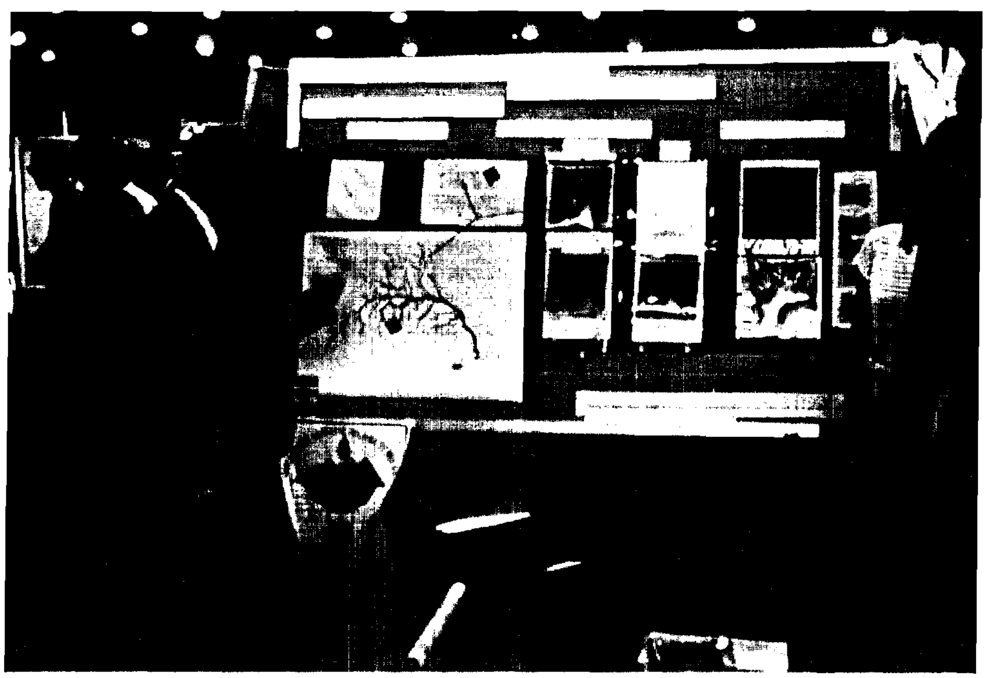

Photo N-3: Dr. Goebel of Resources Development Associates, on the left is presenting the professional paper on natural dam sites in Djibouti at a remote sensing symposium in Cairo, Egypt.

This same configuration of geology and stream dynamics is the only cause and effect for permanent and intermittent springs in Djibouti. As would be expected in this arid country, the available water is local, temporal and limited. Runoff thus represents a serious loss of large quantities of good quality water.

The Djiboutian nomads have learned to avail themselves of these geologic conditions for water sources. Where the local wadi watertable occurs within two meters they have established traditional hand-dug well sites. Where they have located more permanent springs, they have irrigated fruit tees and established tribal headquarters. The cartographers who made the 1:100,000 scale topographic map of the country, recorded these water sources and identified trees distinguishing them from bush. They also delineated the valley floor from the surrounding mountains. Thus, valuable field evidence has been accumulated and recorded to support a decision about the occurrence of natural water conatinment basins.

The purpose of this study was to evaluate a method for identifying natural water containment sites in wadi channels so watersheds could be evaluated for their water producing and water holding capabilities. This kind of problem is suitable to multispectral analysis. It is also suitable for a synergistic method of investigation. A synergistic method involves a study where the objective of the investigation cannot be assured or verified by any single source or type of information. The use of multiple sources, each with its unique contribution, will clarify the objective enough to define it. This is often a method employed when doing multispectral analysis.

MATERIALS

In this case, there were three synergistic sources of information. One source was Landsat images with their pictoral quality and spectral resolution. Comparing spectral bands permits the recognition of growing vegetation and its implied water presence in the root zone. The larger the vegetation presumably the deeper the root zone and the longer the availability of water. The pictoral quality enhanced the wadi configuration. Further, two temporal periods, wet versus dry conditions, were employed to better define vegetation and geomorphology needed for site interpretations.

Two Landsat scenes were used. One was taken on 27 July 1973 (1369-06563), which represented the dry period. The other scene was 4 November 1978 (39244-06460), which represented the wetter period. Both the positive and negative, 1:100,000 scale, black-and-white films were acquired for all four bands on both scenes. The standard false color composite paper print, at 1:1,000,000 scale, was also used. Color diazo prints of red for band 5 and blue for bands 6 and 7 were produced for color visual enhancement. Band 4 was used in black-and-white.

Another information source used was the 1:100,000 scale topographic map of the region. This map supplied evidence of actual water within two meters of the surface at well sites and springs. It also indicated groves of trees in a nearby treeless area. This is important because trees can tap water deeper than most plants. Evidence of vigorous trees in the wadis during the dry season would be evidence of water availability and thus confirmation of an active water confinement basin. This map series also has the wadi bed configuration. This is helpful in recognizing the channel dynamics and valley floor configuration broadening and constricting on a map where the countour interval is 100 meters. The contractions in the channels occur between the steeper gradient below the knick-point, or point of greatest resistance to erosion, and the broad area of lesser gradient upstream which contains thick deposits of sands and gravels. These sands and gravels fill the potential natural water containment basin and serve as an aquifer. Further the landforms are represented by the elevation contour line configurations. The recognition of the shape of the hills assist in identifying resistant rock which are probably causes of the knick-point that creates the water conatinment sites. This kind of evidence for a natural dam at the knick-point is also produced by geologic conditions which are not sufficient to produce a barrier to subsurface wadi flow that can result in a containment basin. Other evidence is needed to verify the long-term existence of water in the containment basin.

The map used was a Carte De La Cote Francaise de Somalis au 1:100,000; Territorie Francaise Des Afars et Des Issas; Institute Geographic national, 136 bis, Rue de Grenelle, Paris (VII3). Those parts of the map specifically addressed were: the hand-dug well symbols, the spring symbols, the tree type vegetation symbols, the drainage network and the elevation contours. Each part made its synergistic contribution to the identification of natural water containment sites.

A third source of information was aerial photographs at 1:25,000 scale. These were used to verify the evidence previously used to establish selected sites. These stereo photographs permitted recognition of vegetation, land form and stream configuration used to establish a water containment site. As a result, the number of places selected for on-site investigation for geological and engineering characterists are appropriately reduced.

METHODS

Three steps were used in this investigation. First, potential sites were located by interpretation of the topographic map. Second, these sites were located on the Landsat imagery for confirmation by evidence on the images and projected to previously unidentified sites. Third, the most desirable sites were confirmed by aerial photograph interpretation.

Potential water containment basins were located on a map derived at the same scale as the topographic map. The hand-dug wells and springs, drainage configurations and the natural dam sites at knick-points were identified and located on this map. This map was reduced to the scale of the images.

The Landsat images were interpreted based on the pictoral conditions of the sites located by the topographic map. This same pictoral evidence was then projected to the rest of the image to locate other sites not identified on the topographic map.

Several combinations of MSS bands for two seasons were systematically compared to the sites established by the information from the topographic map. The image combinations used in this study were as follows: for Band 5 a red positive diazo print was used. For Band 4 a standard black positive film print was used. For Bands 6 and 7 a blue positive diazo print was used. The November 4, 1978 scene was considered the wetter of the two scenes. Band 5 red positive diazo was evaluated alone with discouraging results and no other single bands were evaluated. A Band 4 black negative was introduced into combination with Bands 5 and 7 and was too dark to interpret. The results are no included. We also used a standard FCC paper print.

Band 5 of July was combined with Band 4, 6 and 7 of July and 4, 6 and 7 of November. Band 5 of November was combined with Bands 4, 6 and 7 of November and Bands 4, 6 and 7 of July. The most useful band combination were determined by their high predictability of water containment basins.

A 1:100,000 scale map was made of the sites located by the most predictive band combinations.

Aerial photographs of the selected sites were interpreted to determine the final site selection for field investigation.

RESULTS

The evaluation of Landsat images for two seasons, supported by information on the topographic map, resulted in selecting the best remote sensing materials for natural water containment site identification and established the most likely sites for development.

Table I tabulates the results of the interpretations. Figure 1 is a photointerpretive map of the channels and terraces associated with the dam sites. The sites located by the topographic map and recognition of a site three or more times on the imagery established the standard for comparison between band combinations. A total of 165 sites were recognized. The topographic map had 125 sites and 6 sites were never recognized in any image interpretation. This left 119 ground truth sites. There were 159 sites interpreted on the images including 40 sites

Information Source	Topo Map	Jb5-Jb4	Jb5-Nb4	Nb4-Jb4	NB5-Nb4	Jb5-Jb6	Jb5-Nb6	Nb5-Jb6	Nb5-Nb6	Jb5-Jb7	Jb5-Nb7	Nb5-Jb7	Nb5-Nb7	FCC	Jb5	Nb5-Nb4 + Nb5-Jb7	Nb5-Nb4 + Nb5-Nb7
Total per Source	125	19	46	13	69	21	37	47	60	28	36	70	55	51	7	96	92
Sites Associated with hand dug wells	60	2	10	8	28	1	10	21	34	5	9	28	19	12	2	42	51
Sites associated with natural dam structures	65	15	32	5	33	18	22	21	31	20	25	24	2	38	5	29	31
Sites not identified on the topographic map	0	2	4	0	8	2	5	5	0	3	2	18	4	1	0	15	10
Sites occuring 1 or 2 times on landsat	29	5	11	0	11	4	8	10	5	4	4	20	19	5	1	27	18
Sites occuring three or more times on landsat	90	14	35	13	58	17	29	37	55	24	32	50	36	46	6	69	74

Note : J = July 27, 1973; N = November 4, 1978; b = band.

Natual Water Containment Site

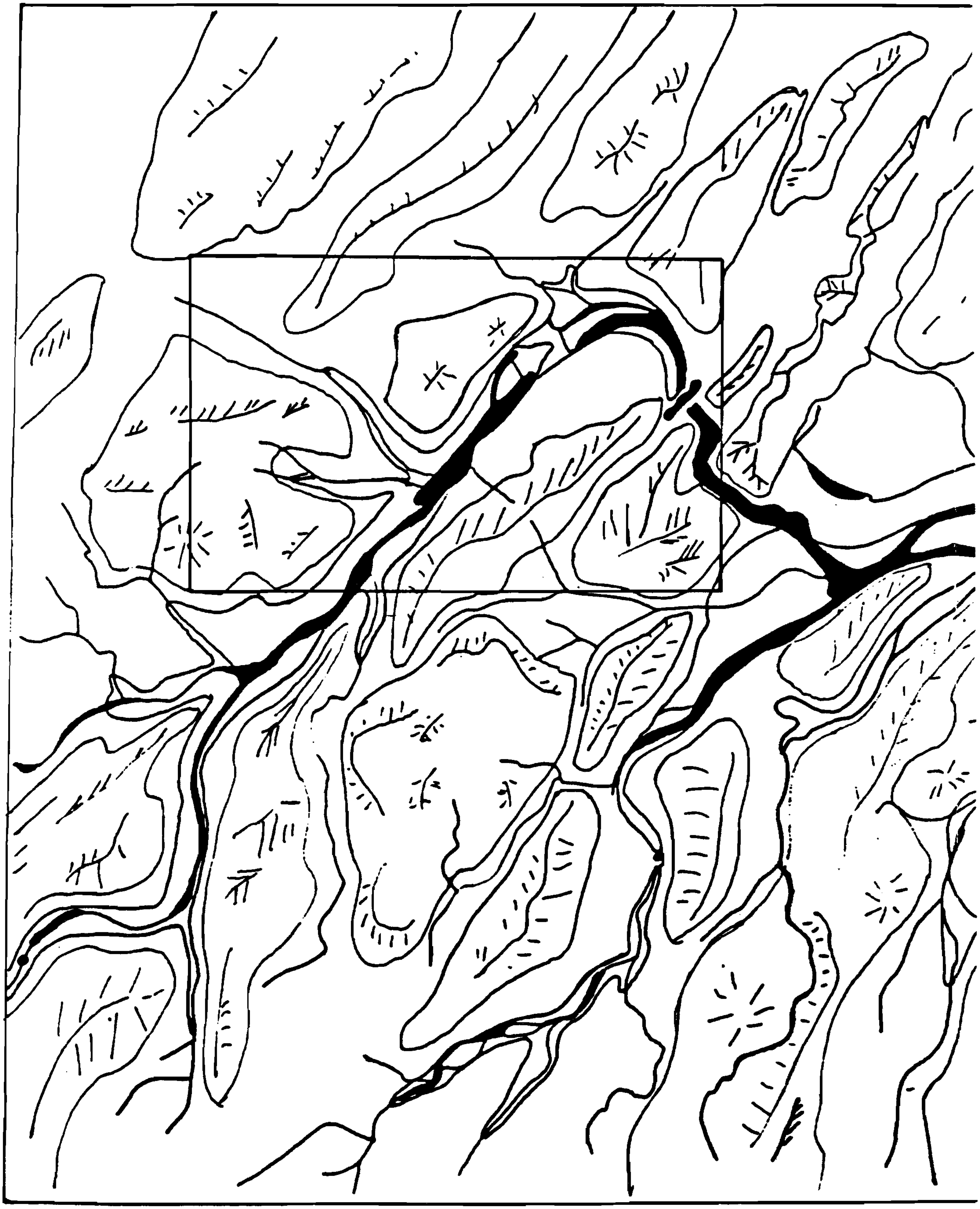

FIGURE 1

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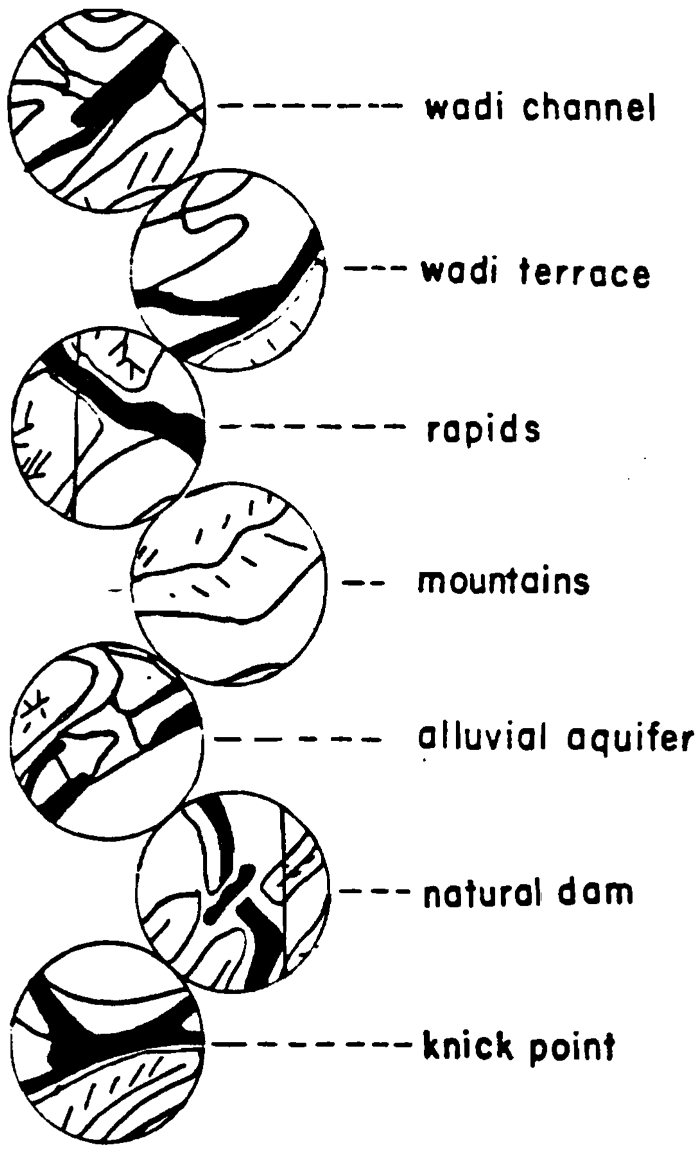
Photo Interpretation of Channels and Terraces Associated with Natural Dam Sites

Legend



not identified on the topographic map. There may have been untapped water sources occurring too deep or not needed for livestock water. There were 60 natural dam sites predicted. There were 65 hand-dug well sites recorded. The number of sites occurring only once or twice was 69. The number of sites occurring more than three times was 90.

The November Band 5 and the July Band 7 (Nb5-Jb7) was the most successful combination in predicting natural water containment sites. This combination identified 70 sites with 50 occurring more than three times and 52 corresponding to hand-dug wells and natural dam sites.

These results were closely followed by November Band 5 and November Band 4 (Nb5-Nb4). This combination identified 69 sites having 61 sites in common with the topographic map and 58 sites recognized more than three times in the study. Combining these three bands (Nb5-Jb7 and Nb5-Nb4) 92 sites were identified with 82 sites confirmed by the topographic map and 74 sites occurred more than 3 times in the study. This represents 75% of the sites on the topographic map and 58% of all of the sites. Combining three bands is better than combining two bands. But in this case, it results in the use of two scenes taken at different times and requires temporal registration which is complex and expensive.

If November Bands 4, 5 and 7 are combined in the groups Bands 5 and 4 compared to Bands 5 and 7 (Nb5-Nb4 and Nb5-Nb7) 96 sites, or 58% of the total are identified. These include 71 sites occurring on the topographic map, or 57%, and 69 sites occurring more than three times in the study. This requires only one scene and combining three bands.

A standard paper FCC image of the July 27, 1973 scene was evaluated with favorable results. Its interpretation yielded from one-half to two-thirds the best results of their band combinations.

CONCLUSIONS

The visual interpretation of the Landsat imagery assisted in the geomorphic and geologic interpretation. This confirmed or denied similar sites identified on the topographic map. Combining the information about hand-dug well sites, springs, vegetation and landform obtained from the topographic map with selected MSS bands from Landsat significantly increased the number of sites and the accuracy of their identification compared to the use of these materials singularly. The number of possible water containment sites was greatly reduced in this procedure. Thus fewer sites required aerial photographic interpretation.

Now that this procedure has been established, it will be applied to a nearby watershed where a project is being considered to modify the natural subsurface water flow in order to increase the subsurface water storage capacity of the natural water containment basins. This water will then be used for local irrigation or channeled downstream to more appropriate agricultural soils.

Agricultural development decisions will be made by the Republic of Djibouti quickly and economically because of the speed, accuracy, and dependability that is achieved by applying synergistic methods to the interpretations of aerial photographs, topographic maps and multispectral imagery.

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APPENDIX N-2

AGRICULTURAL RESOURCE ASSESSMENT IN TROPICAL ARID DJIBOUTI

Mr. Aboubaker Douale
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Djibouti, Djibouti, Africa

ABSTRACT

Djibouti is a new small country on the coast of hot arid northeast Africa. The geology is mostly eruptive volcanic rocks and sandy and gravelly soils. The government established a soil and water analysis laboratory for the analysis and inventory of the soils and water resources and to provide technical assistance to range and agricultural development. Field information was gathered on the basis of random sample sites of one square kilometer each. Each site was visited, described and sampled to provide the field evidence of the soils to make a soils map. This information was transferred onto the 1:100,000 scale topographic map and a more detailed soil map was generated. The use of Landsat imagery successfully expedited the production of an accurate soils map for making predictions and plans for establishing an agricultural capability and good range management practices in the country.

*Presented at the International Symposium on Remote Sensing of Environment, First Thematic Conference: "Remote Sensing of Arid and Semi-Arid Lands: Cairo, Egypt, November, 1981.

ENVIRONMENT

GEOLOGY

The Republic of Djibouti is located in the northeast horn of Africa between Latitudes 11 degrees and 12 degrees North and Longitudes 42 degrees and 42 degrees 30' East. It lies in the Afar triangle and is part of the African Ritt Valley. Most of it is composed of basic ingneous rocks, except for a narrow coastal plain in the east. Most uplands are covered with coarse desert pavements which often overlie friable soils.

CLIMATE

The whole territory of Djibouti is aridic. On the coastal plain the annual rainfall is 100-150 mm per year mostly occurring in the winter. Elsewhere precipitation occurs during the summer as heavy showers. There is a topographic rise in the northern part of the country where rainfall increases with elevation up to, but does not exceed 350 mm per year. It should be noted that on similar land in North Yemen, dryland agriculture is practiced only where precipitation exceeds 40 mm per year.

During all the months of the year, evaporation far exceeds potential rainfall. Irrigation, without proper washing, will always cause salt accumulation.

SOILS

Most data available, including this survey, show the soils are generally impregnated with carbonates. Permeability, slope, texture and depth will be the major criteria to evaluate the capability of the soils to support irrigated agriculture. There are presently a few scattered irrigated gardens indicating that irrigated agriculture is technically possible in Djibouti. This soil survey will have to indicate sites where optimum utilization of the scarce water resources can be achieved. Photos N-4 through N-11 show some of the agricultural conditions of Djibouti.

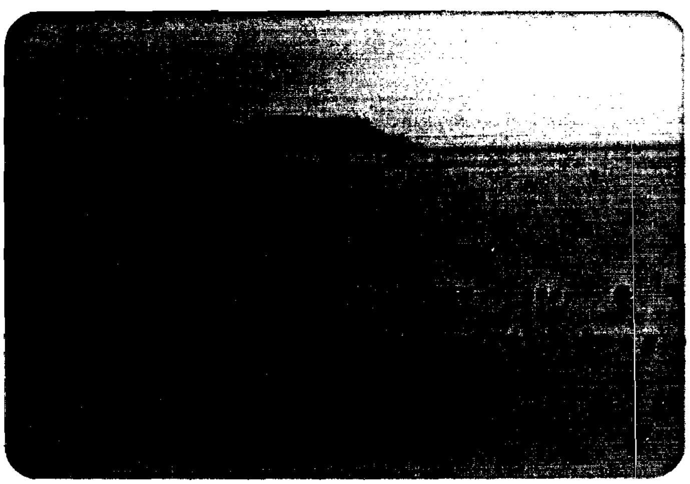
SOILS AND WATER LABORATORY

Many people of the Republic of Djibouti are nomadic and live from the products of herds of goats and sheep. Around shallow hand-dug wells many areas are overgrazed and hunger, not thirst, has devastated many communities in the past.

Djibouti relies on neighboring countries for agricultural products. Land evaluation and mapping at an appropriate scale will assist in the determination of the agricultural capacity and rangeland carrying capacity of all of the soils. It will also assist in the selection of sites and the spacing of drilled dug wells.

hoto
-4: This study was done to improve and expand Palm ardens like this one in Houmbouli

Photo N-5: This is the beginning of the Houmbouli delta recognized on space imagery



ıoto
·6: Soils like this flooded Grand Bara soil was found o be suitable, with proper management, ɔr agriculture. The extent of this ıil is determined accurately on space ımagery.

Photo N-7: The natural dam in the background contains the white gravels which store water after flooding

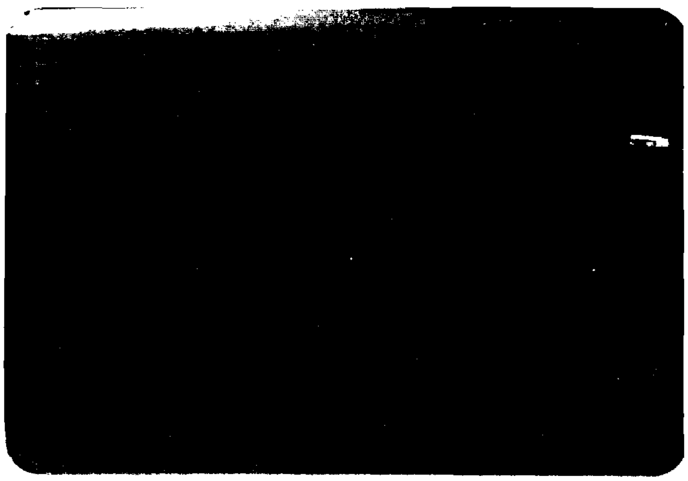


Photo N-8: This is the Atar project started to relocate the dispossessed. The well water is salty and high in boron.

Photo N-9: This soil is not salty as was suspected for years before this study.

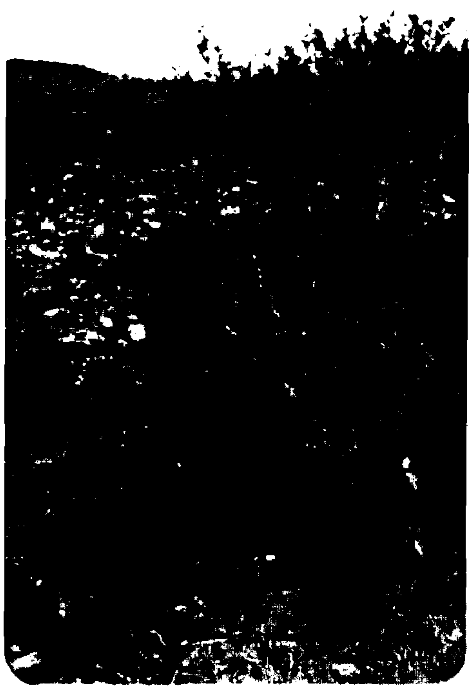


Photo N-10: When it rains the vegetation is lush. This is what supported the nomads.

Photo N-11: This is a small garden in Houmbouli built by an ambitious nomad by hand. Note the well right of center.

Upon independence Djibouti found it necessary to have more independent agricultural capability and decided to assess national agricultural and water potential. A soils and water laboratory was established to identify, locate and evaluate suitable agricultural areas. We used remote sensing techniques to reach our objectives quickly and accurately.

GENERAL APPROACH

At the beginning of this project, before any field work, we made a preliminary soils map based on the 1:200,000 scale geological map and the topographic map at the same scale. This map guided us in the determination of the soils in the field. Then we drew a half percent random sample to establish ground truth and describe and sample the soils to define general soil resources. Each sample site was one square kilometer established by the mercator grid system. We visited each sample site. We described and sampled the jabor soils. At the laboratory we located each site in the kilometer grid system on the 1:250,000 FCC Landsat images of the country. We proceeded to map the soils according to the information obtained when we visited the field and the information on the Landsat images as established at each sample site. This map was then combined with the topographic information on the 1:100,000 scale topographic map to create a reconnaissance soils map.

This reconnaissance soils map, in conjunction with hydrological data from a collateral project, was used to select appropriate watersheds for semidetailed soils mapping on aerial photographs at a scale of 1:25,000. For semidetailed mapping, we used a random sample of five percent (5%) of the area to collect the basic field data. Following this procedure, specific agricultural sites are determined and limited in extent to the water potential of the area.

RESULTS

Crossing the country describing the soils at the sample sites, we acquired first-hand knowledge of each of the soils in the country. The Djiboutian technicians were trained to describe, sample, classify and map the soils. We made a 1:250,000 general soils map of Djibouti. We described and evaluated the major soils of the country. We also made a 1:100,000 scale reconnaissance soils map of the country. We proceeded to do semidetailed soils maps of selected watersheds with the organized soil legend developed in making the reconnaissance soils map. We accepted and rejected soil types for their utility in range or agriculture. We located and identified the potential agricultural and range sites.

We described, classified and interpreted the major soils in Djibouti for planning purposes. Agriculture in Djibouti is in its first phase. Djibouti needs new and appropriate technology to re-establish rangeland and establish agricultural production. We don't know the fertility status of the soils. The saline status of the soils require further investigation. To help our farmers and to give them scientific recommendations for farming and ranching, we established laboratory facilities to test the soils and water and properly inform the land user.

The following is a legent for the general soils map listing the general soil characteristics described at the sample site; a description of the appearance of the major soil areas on the FCC image and the indicative map symbol.

MAJOR SOILS OF DJIBOUTI

Aal5 - Playa basin with colluvial sand.
Appeared as long narrow bluish gray areas on Landsat image.
Texture sandy over silt, slope 0-2%; depth more than 200 cm; rock fragment-free; 10% shrub cover.

AF 9 - Steep slopes of basaltic plateaus.
Appeared as long narrow dark brown areas streaked with green on the Landsat image.
Texture gravelly sand; slope 40-70%; depth 50 cm; 90% cobbles and stones; vegetation 1% shrubs and grass.

At 1 - Recent marine sediment.
Appeared as moderate areas of bluish gray near the sea.
Texture silt loam; slope 1-2%; depth more than 200 cm; few 2-7 meter sand dunes; vegetation 20% brush and shrubs.

Bal6 - Thin silt sediment on lava flows.
Appeared as very dark brown with common green spots on the Landsat images.
Texture clay loam; slope 2-5%; depth 50 cm; 75% stones and boulders; vegetation 2-3% shrubs.

Da9 - Steep ryolitic mountains.
Appeared as broad areas of very light brown mottled with light green and brown on the Landsat images.

DA16 - High lava plateaus.
Appeared as dark brown mottled with very dark brown or bluish gray and fine light green spots on the Landsat images.
Texture gravelly loam; slope long 1-8%; depth 50 cm; 90% cobbles and boulders; vegetation 15% brush, shrubs and grass.

DI 5 - Wadi delta.
Appeared as long narrow areas of light bluish gray on Landsat images.
Texture sand; slope 0-2%; depth 75 cm; 3-4 meter sand dunes; vegetation 5% grass.

EG12 - Basin playa with sand dunes.
Appeared as broad areas of blue and light blue mottled with dark blue and green on Landsat images.
Texture sand; slope 1-2%; depth 75 cm; 3-4 meter sand dunes; vegetation 5% grass.

GB12 - Basin playa - barren.
Appeared as broad smooth areas of white and light blue on Landsat images.
Texture loam; slope 0-1%; depth more than 200 cm; rock fragment-free; vegetation barren.

GM9 - Steep sandstone mountains.
Appeared as blue with verigated dark blue on Landsat images.
Texture gravelly sandy loam; slope 24-35%; depth 50 cm; 80% gravel and cobbles; vegetation 1% shrubs.

Ha10 - Weathered granite basin floor.
Appeared as irregular areas of grayish blue on Landsat images.
Texture sandy clay loam; slope 2-8%; depth 60 cm; rock fragment-free; vegetation 3% brush and shrubs.

HH27 - Steep slopes of lava flow.
Appeared as long narrow very dark brown and bluish gray areas on Landsat images.
Texture bouldery loam; slopes 70%; depth 100 cm; 70% boulders; vegetation 20% brush.

JA16 - Thick silt mantle on lava.
Appeared as extensive broad areas of mottled light green and light greenish blue on Landsat images.
Texture silty clay loam; slope 0-2%; depth 150 cm; 50-80% cobbles and boulders; vegetation 10% shrubs.

Ko 3 - Wadi channel.
Appeared as long narrow white or light gray areas on Landsat images.
Texture gravelly sandy clay loam; slope 0-3%; depth more than 200 cm; 40-80% gravel; vegetation 20% brush and shrubs.

Ma12 - Basin playa delta.
Appeared as broad purple areas streaked with light blue and brown on Landsat images.
Texture loam; slope 5-25%; depth 120 cm; 60% cobbles and stones; vegetation 1-2% bushes.

Du 9 - Faulted lava flow mountains.
Appeared as dark brown broad areas mottled with very dark brown on Landsat images.
Texture gravelly loam; slope more than 65%; depth 75% cm; 70% stones and boulders; vegetation 10% brush and shrubs.

RD12 - Saturated basin playa.
Appeared as broad areas of green and brown on Landsat
Texture clay loam; slope 0-1%; depth more than 80% cm;p rock free; vegetation rare.

WD17 - Basaltic plateau.
Appeared as broad areas of brownish green mottled with very dark brown and light green on Landsat images.
Texture silt loam; slope 5-25%; depth 25 cm; 80% stones and boulders; vegetation 5% shrubs and grass.

6 - Colluvial gravel.
Appeared as moderately wide long grayish blue areas with small brown blotches on the Landsat images.
Texture silt loam; slope 5-25%; depth less than 100 cm; 70% cobbles and stones; vegetation 1% shrubs.

22 - Salt.
Appeared as brilliant white on Landsat images.

25 - Lacustrine mud.
Appeared as broad areas mottled with light blue and blue on Landsat images.

28 - Lacustrine marl.
Appeared as white and light blue on Landsat images.

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29 - Coral islands.

30 - Volcanic cones.
Appeared as small areas of very dark brown on Landsat images.

CONCLUSIONS

A three-man team mapped 10,000 square kilometers of southern Djibouti in one year. We produced 1:250,000 scale soil maps and 1:25,000 scale maps of selected watersheds. We established soil series for the major soils and their interpretation. We also developed the capability to establish the chemical status of the soils and water of Djibouti. We identified and located potential agricultural sites and rangelands. Remote sensing techniques helped us attain our objectives.

LABORATOIRE D'ANALYSE DES SOLS ET DES EAUX

RÉPUBLIQUE DE DJIBOUTI

APPENDIX O

FIELD TRIP GUIDE

APPENDIX O

DJIBOUTI - ATAR

FIELD TRIP GUIDE

0 Km TOTAL service station on Charles De Gaulle:

1 Km Turn to the left to go to the Atar project. Here we see an old delta of the Ambouli River. It's quite gravelly. The river has changed course and cut through the deltaic deposit back to the marine sediments that underlie these sediments. The volcanic cones are all along to the front. We put them in miscellaneous land type because they are too limited in area. It is of interest to know they are there but they are too limited in extent. The soils are actually better on the cones than they are on the surrounding territory. The railroad on the right goes to Addis Abba. The road we're taking is the one to Somalia. It is about 18 Km to Layada. Djibouti has been inhabited actively for the last 1,200 years. There is evidence of prehistoric peoples here too but active habitation has been about 1,200 years.

6 Km Police training Center.

7.5 Km We see the stony covered areas to the right are lava. Here we're still on some of the deltaic deposits with the fine sediments underneath old marine sediments. This is a sort of eroded phase coming up ahead before the Atar soil. It's probably eroded because again this is still part of that deltaic complex that was a little higher and it has more run-off in this region than you'll see later.

8 Km To the right we can see some of the farms on the Douda wadi. this is the Douda Wein agricultural section. The Yemeneese were doing agriculture here at least 15 years ago. 1973 photos show the land ownership then and now to be approximately the same. There have been only a few farmers added to this complex. These are formed in the Yemeneese style. All these people were pumping water by hand when I came. This project has the old Egyptian teeter-bucket system for irrigation but now they've been installing pumps. There is one of the old poles sticking up to the right. A French volunteer came to this site and organized these people into a cooperative for selling their vegetables. This is one of the more successful agricultural areas in terms of market development and production. The water quality is better on this wadi than the other one principally because the people have dug their wells closer to the wadi.

9 Km The Atar type soils. The flat may have a few centimeters of small sand dunes on them. They are kind of a silty clay loam. They have a rose gypsum impregnated layer at about 75 cm. The problem with this soil for agriculture is there is a textural

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contrast between the upper sands and a silty clay and they will probably have a lot of problems with salt deposition on that textural contrast. So if they are going to use it it is best that they plow deep and mix it and get a more gradual textural increase with depth. Actually, we won't get much development on this soil. Originally the people looked at this flat soil and were quite interested in it, but we do not have the water for it. As you look to the right and again see the volcanic cones we see some white buildings. That is where the wells are that supply Djibouti city water. The water from those wells is coming from the fractures in the rocks up to the mountains to the south. All of that water from there is necessary to the city. So the only water that is available for agriculture on this plain is that which passes that line of wells and infiltrates into the wadi bed on this side. We probably have enough water here for one or two square kilometers of agriculture. The hill over here is an old island. It is a volcanic deposit, not a coral island.

10 Km On the left you see an abandoned sunken ship. Many people like to go there and fish. As you notice, we are within a kilometer off the coast and we are just a few meters above sea level. On the right is a row of trees that mark the Douda Yar (Yar means small in Somali and Wein means big). There is another small agricultural project here. They are able to use the water all year long that infiltrates the wadi bed. So far they do not seem to have much trouble with water supply through the year for the number of farmers that are there. You see some large palms in there. Those were established by the Yemeneese some years ago. They are quite salt tolerant so they manage to survive. I think they are also fairly drought tolerant. At least their roots may get some water from the wadi as a result they have survived the years of abandonment. The palmate palm is bled for its sap, they make a type of beer out of it. The date palm, the rather long leafed palm is kept for its fruit. Here we see a rather typical garden. This garden is an earlier more traditional version of the type of gardening that was done in Djibouti; probably the type that was introduced by the Yemeneese with some modification by the French tradition.

19 Km Eastern route to the EEC Agricultural Project. Turn right at the military sign post. One of the things to get out of the Atar project in terms of soils and water is that they should go over to the Dey Dey wadi and also to the Damerjog wadi to bring in channel water. Damerjog does not extend up to the mountains. The Dey Dey does and it should have enough water to irrigate one square kilometer after it leaves the line of wells for the city. There is just a little bit of agriculture on the Dey Dey. If they would put in a drainage field under the Dey Dey wadi, they could bring that water over to this project and save the soils from salt. They would have clean enough water to wash the soils. Then they would have a permanent operation here. It would not salt up on them. The Atar project is about 2 Km from Damerjog to the S.E. This area is used as range. We are quite distant from the mountains here and the

better range occurs on the mountains toward the sea. One year ago, when the first rains came after the three year dry spell, the rains did not get this far and this region remained quite dry. But the next year got the rains. You can see the herbs. There was a grass out here that sprouted up in the spring. The livestock they use here are brush eaters. Camels, goats, sheep and donkeys are browsers, not grazers, so they eat the acacia we see here too. This area was grazed traditionally, I believe, only when the rains came far enough for them to leave Ethiopia and get all the way out here to use these plants. There is a little fine grass that will show up temporarily.

21 Km Leave Damerjog. There is a thin desert pavement on these soils because of the wind. I do not know what the source of the little gravel is. The desert pavement here is unusually large. Fencing is done with brush. In fact the agriculture will probably put a severe pressure on the brush. Traditionally the people put this brush around their houses to keep the hyneas and jackals out, and to protect their livestock. They would do that more generally when they were going to be there for a few weeks. In fact the houses in town still have the small courtyard with the little house in the center. Now they use the bushes to keep the goats out of the gardens. It takes quite a few hectares of acacia to put up a fence around a garden. It is not very good for keeping out the small animals like the rabbits, skunks, etc. Economical fencing is a serious question here as well as fencing that will last longer. The thorn brush fence is probably good for only 3 to 5 years. They are going to have to fence out the livestock. The agriculture has so much less area than the range that the livestock will have to be fenced out. So the fencing will be the responsibility of the farmer. This is a good trip to take first. We have soils that correlate with the soils of Nevada, parts of the dryer parts of California, western Texas regions around the Big Bend country, parts of New Mexico and Arizona. We are correlating with the thermic soils. But we have hyper-thermic soils here. We have a lot of entisoils. The whole country is quite young geologicaly although during the Pliestocene, there must have been a wetter epoch. We know this from the lake beds in the interior. There was some fair soil development. This Atar soil has a B horizon in it. Out into the interior we can see on some of the flat playas and in fact right here on this coastal plain, we see some good strong B horizons, even a little accumulation of clay in the B horizons. The problems is, they have been impregnated with gypsum and sodium, potasium and calcuim carbonates.

25 Km Douda Wein. We came back on the western fork of the road instead of the eastern fork we took on the way out. You can see here on the Douda Wein, that the trees do quite well right next to the wadi. Those could have been fruit trees because they probably would be able to survive. In this soil we would want a more draught tolerant species than we would consider in the north part of the country. Here in Djibouti, they should move to regular range management, rather than herding the

livestock. They could control them by opening and closing the water holes and distributing salt. This way they will not have to spend their time out there. They are spending far too much time for the return on their livestock. Whoever is left with the livestock will need larger range management practices like those practiced in western United States and Australia. Djibouti is lucky in the sense that because of the high infiltration in the wadi, and the fact that even though the rains are sporadic, the water is stored in the wadis, they have good distribution of water holes so they will not have to build ponds or farm tanks to distribute grazing across the land. Because of the sparse vegetation here and because of the type of livestock and its tolerance to dry conditions, I think they probably have adequate distribution now to naturally rotate their grazing. One soils map of the entire country was made because of the range requirements. There is a real assortment of wild life here in Djibouti also. Cheetahs ostriches, hyenas, jackals, fox, chipmunks, squirrels, skunks, porcupines, various kinds of birds, lizards, turtles, snakes, baboons, aquatic and land birds.

AMBOULI GARDEN

FIELD TRIP GUIDE

0 Km We will see a private investment in agriculture here in Ambouli. There has been no governmental assistance at all. These people buy their own equipment and do their own land leveling. These are the upper-middle class, the military officers, doctors, new government people who are looking for a place to invest and there are not many resources. Investing like an esquire into the land is appealing.

1 Km Immediately here on the left we see an old well that has washed out. Since the river changed its channel, that piece back there with the palm in it is a well that was excavated since the river changed its course. We just found out that this channel is less than 60 years old. It originally was dumping right into the Gulf of Aden instead of dumping into the Gulf of Tadjoura. Now you can see the mango tree on the right just as we came out of the channel. These are new gardens. There are about 120 now. There were about 60 in 1980. These are on very gravelly, coarse, sandy, highly permeable soils. There is no calcic horizon here. This is an entisoil. Turn right at the first opportunity. The bushes and trees we have seen are mangoes, dates, guava and oranges. For crops we see eggplant, okra, watermelon, muskmelon, onions, peppers, radishes, corn, sorghum and a little millet. There is quite a business in dry forage for the livestock in town, especially for the goats. Djibouti also sells wood to Yemen, so there is a forestry industry here. Salt content in this well runs between 1,500 and 2,000. That is generally the case for the wells in this area. There is one near here that runs up to 6,000 parts per million, which is why you see a lack of vigor in the plants. They also grow some flowers in this area. We are going to turn left before the channel and follow the channel on this side over to the Arta road. Right here in the junction of roads, flowers are grown. The fall is when the vegetables are planted. They start planting around the first part of October. Some are plant into January. Those crops are finished between March and June. In June they go into melons and heat tolerant crops. We see some cotton over there. This is the largest agricultural area in the region. It represents between 2 to 2 1/2 square kilometers. As you notice, the density of plants is down. They are covering at best about 25% of the area. Oftentimes they may not be covering more than 10% of the area with crop. One of the ways to reduce water loss is to get more plants in the ground to get more production for the water put on a given area. That way, you do not lose so much to evaporation. One woman has been farming and supporting her family here for 30 years.

DJIBOUTI ELI SABIEH
FIELD TRIP GUIDE

0 Km The Atar road at the crossing of the Amboule wadi. The agricultural region extends west of the road here and goes on toward the mouth of the river. These farmers are doing a little better because their water is of better quality. They have gotten closer to the wadi and their crops show the results of that. Near Balbala you cross the top of a lava dome.

2 Km Here is the livestock market. They buy and sell the sheep and camels here. We also see the milkweed. It is not a happenstance plant. The nomads kept the milkweed for its fiber. They would strip the stem and get the fine fiber to make rope, a very silky rope. They always had it along their pathways so they could get it as they moved along. This area is devoid of vegetation because the people have chopped it all off. Here the Labanese gave them a reservior. This was put in specifically to give these people water.

3 Km When you look off to the left you begin to see the great coastal plains and the large lava flows. This is the thin eolian or marine sediments laid over lava flow. It has basically two different slope groups. A rather flat area of A and B slopes and then slopes up to about 8%. It extends from here way into Somalia. The coastal plain in the northern part of the country is quite different. There the plain is really colluvial fans associated with the mountains, but the climatic condition turns out to be about the same. Those are sandy and consequently do not have the sodium and potassium carbonate deposition within a meter. They are also dry.

4.7 Km Weather station. This is an official and complete one with the appropriate grass lawn. To the left we see the Ambouli river valley. The Ambouli comes through this low span. On the right you can look down on the Gulf of Tadjoura. On a clear day you can see the mountains on the other side. In front of us as we come down the hill from Balbala, we see the Jaban As soils. Jaban As means red soil in Somali. This soil is a bit controversial because another project selected this one for a 60 hectares agricultural development. The soil is a silty clay or clay. It is between 1 and 2 meters deep and has a B horizon. At about 1 meter we have a very dominant deposition in the fabric of rose gypsum. At about 20 to 50 cm we have a high concentration of bicarbonate salt, which I believe comes from light dew. We have a kind of dew here in the winter time. The salt comes from the salt air of the sea. When the gentle misty rains come they take the salt into the soil. This can get leached out on the rainy years but on the drier years it accumulates, apparently because of the heavy texture and salt content of the soil, it sheds the water rather quickly so the penetration is not much over 20 to 30 cm. Between 20 and 50 cm there is a sodium or at least a salt horizon of about 10 to 20 cm thick. We can actually find crystalized salt tasting salty.

It tastes like sodium chloride, but the test did not show that much chlorine so it must be potassium carbonate. We are not recommending this for agriculture. It is too erosive and you would loose the structure that you have, so you would have a serious permeability problem. The only water available here is ground water which is; 1) too salty and is 2) competing with the water for the city of Djibouti. In many respects they probably should have expanded the city out in this region. It is a little cooler and drier and has better drainage for development. There are flooding problems in the city when the heavy rains come. You can see by all the ditches and the gulleys here that just the construction of this road has encouraged a severe case of erosion. Djibouti is covered with rocks. You see the black desert varnish on the surface and the calicum carbonate deposits under the ground. When they are turned over then they have a white bottom. The calcium carbonate is not thick here and it occurs usually between 10 and 30 cm deep. It usually occurs as a kind of crust on the gravel or soil. You must understand the importance of the rock or the desert lag here. One, it reduces the amount of rain erosion because it takes some of the impact of the rain. Two, the water that infiltrates the soil uses the rocks as a mulch to reduce the amount of evaporation loss. As a result there is some vegetation here that would not survive otherwise. Three, it reduces wind erosion because the wind must move above the top of the rocks. It turns out to be a kind of wind barrier. So this country must be careful not to remove the rocks until they are ready and know their land use will be permanent and, in fact, requires the loss of the rocks.

12 Km Here you notice the road engineers took all the rocks off. You also often notice a good case of wind erosion here. When it rains, there is severe water erosion. The purpose of this PK 20 project was to establish a microcosm of the Djibouti economy so everybody could see how it was supposed to work. Some small factories are to be built that will make spaghetti from the wheat raised here. There is to be a shoe factory to use the hides of the goats that were butchered in the city, and some parts assembly plant to operate in conjunction with the port. Also there is to be dairy cattle here and some major agricultural production. At one time, they were going to dam the Ambouli river. Here we are coming to the gorge in the Ambouli, they were going to dam this and supply the water for project PK 20 from that. Several sources told them that if you do any daming in this country, you will upset the infiltration rate and furthermore, because of the sediment load of the river, your dam will be filled within 10 years. Not only would they not have water shortages in Djibouti, but they would cut off the water to the farmers who are already producing down in the Ambouli. They did not build the dam. The critical thing with the livestock grazing here is having a drought plan, because the herd size expands when the vegetation is good. Sometimes you see a lot of herds out there and the size of the herds grow at that time. But when it really starts to get dry, in the dry season and also during several years of dry periods,

the oversized herds graze back too heavily on the brush. Then when the rains come, the brush can not respond quickly enough. Because they have extrordinarily aggressive animals, represented by camels, goats and sheep, they have to be very careful in their management to protect the vegetation from the livestock. This is the only kind of livestock that can convert this kind of vegetation into milk and meat.

17Km We are now approaching the rainy area of Djibouti. We see that the vegetation is starting to get denser here. The micro climates I have indentified here in Djibouti are divided at 100 meters elevation, 350 meters, 600 and 900 meters elevation. The coolness makes a difference in the preservation of nutrients in the soil. It has an impact on the amount and type of vegetation that survives. We can also see an impact on the soil characteristics at those elevation levels. We have also seen and noted with the thermometer, distinct inversion zones at those levels. There is another one at 75 meters below sea level. There is another micro climate at each of the interior basins. They are very flat and have a very hot windy daytime climate. At night they cool off and radiate the heat very quickly. The next division in climate, comes across the crest of the mountains in front of us. It starts in Somalia and follows the mountains past Randa towards Khor Angar. The prevailing moist winds are from the east and that causes the rains to precipitate from the low mountains seaward. What we are seeing here is the humid side of that lower elevation. It will rain more frequently here than in other places. The most rain we find is in the upper mountain regions. You will notice we are close to 200 to 250 meters at this point. It seems that at 350 meters, we have the humid inversion zone from the sea. It is at that level that humidity stays below and above it starts to dry up. We come up above this little crest here about 22 Km and you will find it seems a bit dry again. We move out of the humid climate into the dry one. At the end of three dry years, there was no grass, no herbs of any type. The only thing you could see was the bushes. After rains, grass comes up shortly. We see them grazing this grass, but we do not know what the nutritive value is. The nomads do have traditions of preserving areas of this grass when it dries up for drying periods. They have a kind of draught program. Certain sections are saved until things really get desperate. I think this area by the sea was one of those areas.

23 Km The little cliff where it gets cooler and dryer is here at 23 Km. You can feel it and you can see it is getting clearer. We are getting rid of some of the moisture haze.

24 Km Look at the cut of the Jaban Eas soil which is very similar to the Guister soil. There was a characteristic about this soil I wanted to note. At the end of 3 years of essentially no rain in the area, we did not have any growth in the vegetation. When the rain came the vegetation did not respond quickly. It quite surprised me because I know it rained here -- I saw it raining. I thought it must be a problem of infiltration, not

getting enough water in the root zone to cause the plant to grow. It turned out, this year when the rains came, everything greened up very well. My conclusion was that after 3 years of accumulating the salts, the plants could not respond to the first rains. We are only talking about a matter of a few inches of rain, but last years' rain leached the upper horizon 10 to 15 cm. so this year they were not fighting so much salt. When the present year's rain came the vegetation flourished. It tends to lend support that the salt accumulation is from the atmosphere. It is true that at the end of the wet season when it finally dries out, the salt should raise in the soil, the dry subsoil will dry out the moisture too, thus precipitating salts deeper also. The subsoil is as dry as the top soil so when the section is wet we have a drying going below so we can pull salts out of the system. That is a fact that has to be remembered when storing salt below the irrigated areas. You do not ever want to wet the subsoils below the soil zone that you are trying to deposit the salt. So eventually you must dry out your whole soil column. It's like trying to make soil forming processes work for us.

26 Km On the left we have the canyon of the Ambouli river. There is a flood gauge in Oueha. The Germans have measured a flood that left Oueha and arrived at Ambouli. During that period of time, 2 million cubic meters of water was infiltrated into the wadi bed. To give an indication of the amount of good fresh water that we can get, this river floods at Ambouli five time a year.

27 Km Here we are at 600 meters. You see the vegetation is getting taller and denser. Almost every year they will get some rain. We have exactly the same kind of vegetative zone on the north side of the Gulf of Tadjoura at the same elevation although the soils are a little better weathered over there. Then we have the Arta soil regime at 900 meters, just up the hill on the right. You see the upper part of that hill there is another climatic zone and there we have a vegetation change. We have a couple of different kinds of bush species that grow up there. Here we have a slightly different combination of species. Up there we have some new species and they occur above 900 meters all around the country. Also, above 600 meters is where we start encountering Mollisols providing that it is level. If it starts sloping then there is too much run-off and soils do not quite get dark enough for a Mollic espipedon. On the plateaus above 600 meters there are Mollisols and better Mollisols above 900 meters elevation. The Ambouli watershed is one of the largest in the country and of course produces water for the city of Djibouti.

29 Km As you drive along you see that the tops of the undisturbed rocks are black when they are moved the bottom is white. That is because the top has desert varnish that is ferro-magnesium deposit that happens on the top side of the rock. The bottom side has an accumulation of white calcum carbonate. The carbonate rich waters, the last water in the soil at the end of the dry season precipitates low under the bottom of the hot

rock so when you turn them over you have a white side and a black side. The depth of the white coatings tells us how far the soil is wet in most years, it leaches most of the carbonate out and precipitates it lower. This is why no water reaches the ground water table through the soil because one can see that the carbonates have been precipitating out at about 20 cm and only in very rare years have they ever wet the soil much further than that. Of course, the ground water at 300 meters just could not be reached by so little water. Therefore the water has to run off the slopes and congregate into the channel of the wadi where it can recharge the ground water. We are crossing a bridge over a channel going down into the Ambouli river on the left. The water has to run off these roads into that channel. The channels are usually along fracture zones in the rock, so the rock has been ground up due to the movement during seismic activity in the area. Then the water can flow down into the water table there. The run-off rates are between 5 and 65 mm annually. Average rain fall is between 60 and 240 mm per year. Most of the run-off infiltrates into the wadi bed. Very little of the water actually reaches the sea. After a rain, there will be very little surface water in the river because there is not much evaporation. Probably 90% or more of the water that enters the wadi is infact entering the allunuim and the subsurface water. There is a family of baboons that live in this area. There is another family that lives at Arta. We are now into the wayward side, the rainy side of the mountain. You have to take note of the height and density of the vegetation. We estimated that the bush is represented here between 5 and 15% cover depending upon where they were in the terrain. Now here you see Calcic horizon in the soil. I do not think we have enough calcium carbonate to make it a calcic. But you see a white calcium carbonate deposit at about 20 cm depths. These soils on the right of these steep slopes are the Oueah soils. On the left side, along the canyon banks, we have the Holl-Holl soils. They are very similar soils, but the Holl-Holl soil is a very steep canyon soil with a lot of outcrop. Here is a cliff in the lava flow as opposed to these mountains which are layers of lava, but overall a land use distinction needs to be made. Between these soils, descriptions show quite different soils but they are a little hard to separate in the field. There was a lava flow that followed this vally out to Djibouti City. Apparently it did that 2 or 3 times.

32Km We are crossing the Ambouli river at Oueah. This is the flood guage on the right. The other guage is in Ambouli. It is from here to there that in one rain enough water enters the wadi bed to irrigate 2 square kilometers per flood. Djibouti should need somewhere in the neighborhood of 250 to 400 square kilometers to produce all the food to feed the population. The terrace soil here is a Dijon Der. These little terrace positions will be sought out for agriculture also. Here we see another kind of representative of Dijon Der.

34 Km A road that goes up this wadi over the mountains and arrives at Holl-Holl stands here. It is a very difficult trip. Upstream we see the kind of terraces one could be using the water up here before it goes past the dam point.

36.8Km Here we can turn off to Arta Plane. At the turnoff we have a waterfall which is falling off the edge of the lava flow that follows this valley. The lava flow is a backward sloping lava flow to some extent and there is alluvium piled on top of it this is what we call a knic-point. That is a point where the erosion is finally coming up the river. The water that infiltrates on the upper river side as we continue along from the turnoff is held in the alluvium and it proceeds slowly to the knic-point; to the natural dam. The rock has formed a natural dam. There is permanent water at the bottom of the waterfall. That water is there because the water has infiltrated during a flood up this side. This is a source of water for irrigation in agriculture. We have to find all these little places where the flow inside the channel has been retarded so that we can have between one week and 3 months, maybe six months, of water availability after a flood happens. Each farmer will have to calculate how much infiltrated in his section of the wadi channel during each one of the floods. Then he knows how much water he has to raise a crop and he can plant appropriately.

38 Km Here is the Didjan Der soil site. This is the terrace deposit. This is one of the better agricultural soils. It probably will be used more for cereal grains than anything else. This stony or gravelly soil with its calcic horizon is very common on the second terraces. One of the ways we can tell where the water is in the alluviam is by watching the vegetation. You see the trees are green now that we are in the dry period. You can tell by the size of the trees that they are still getting water so there must have been more water stored in this region or the water is available over a longer period of time. One would want to check this place out as a possible place to do some agriculture. They vary up and down the valley. Dr. Merekt felt there were three levels of terraces in Djibouti outside of the flood plain. We are on the second level right now. There is one more level along the sides of the hills here that he noted. There were probably three distinct episodes of the elevation change of the general terrain, or lowering of the sea level if you prefer that.

40.2 Km You will notice the vegetation has changed considerably, the bushes are shorter, the vegetation is more sparse. We see more herbs in this area, if it happens to be a year when there has been enough rain for the herbs and grasses can grow. We are past the wet side the rains occur on the front side of the mountains. We are moving into the arid portion of the land, around 300 to 400 meters high. We are in a warm arid region traveling along an old terrace and these gravelly soils would be very suitable for agriculture if we could find the water. As a rule of thumb, I would consider that you could irrigate one square meter of land for every square meter of channel that you have available. That always depends on many factors like whether the channel could hold that amount of water or not, so you see there is far more land here than there is water available to irrigate it. We are about to approach one of the government farms. This is called the GENIE Rural farm because it was developed on a well that was drilled by GENIE Rural for the road that we are driving on. This particular well is using water from the alluvium that enters the channel in association with the knic-point that we saw way down stream. The quality of the water is pretty good in this well. The management of the land isn't that good. In fact, there is a small garden here. It is an example of the mechanism of the natural dam retarding the subsurface flow in the channel and making the water available for a longer period of time to establish a garden.

43 Km Once again, looking ahead, we can see the green trees showing that there is a natural dam here to our right and it has been holding the water back up into that valley. As a result, we are seeing the increased growth on the vegetation. The geology of the country is in many respects rather simple. It is mostly layers of basaltic rock that overlays a rhyolite. There is a sandstone below the rhyolite. There are some areas of rhyolite exposure in both the north and south parts of the country. The rhyolitic areas are very infertile and poorly developed in terms of soil characteristics. The basaltic sediment is another class of soil material. We have the playa sediments and these valley sediments. That pretty much constitutes the geology.

44.3 Km The white buildings to the right are the well site for building the road and they used this water to develop the small irrigated farm there. Just as you come up the hill from this small stream, look to your right. You will see an abandoned farm. One of Djibouti's resources are the mountains. The mountains encourage rain and cause the water to run rapidly so they form good watersheds. Furthermore, the soils are thin over relatively unfractured rock. As a result, the water also runs off the surface rather than penetrating the ground. Since the rainfall is very low you want maximum run-off, so that it will be concentrated in a usable quantity. A watershed is an important land use for this country. Most people want to go into vegetables because of the high rate of return but the problem with that is that not everyone can raise vegetables. Most agricultural land is dedicated to cereals and row crops.

47.6 Km Turn off to Lac Easal. Most people want to raise vegetables but actually vegetables represent a very small part of the agricultural picture. Most of the land has to be dedicated to oils, cereals, and forages. For vegetables and fruits you must pick your most reliable and highest quality water resources. Those occur on the north side where the mountains are higher and the rains occur more frequently and the run-off is better because the slopes are steeper. The areas along the wadis that we have seen here on this road to Dikhil, are probably more suitable for raising cereals that grow quickly. Any rain that comes through can give enough water for one to two months thus raising either cereals or forage. In fact, maybe this is better for forage because you can raise grass and preserve it for the dry years and have good distribution of grazing for your range land That way you can manage the range on a local basis. A man can live on this valley, graze off the region around him and bring his herd into eat the hay that he has spent years raising when the dry period comes. That requires more distribution of the populace throughout the countryside. In that sense, it is very good that the water resource is well distributed rather than having a good aquifer that would cause the people to congregate. The returns on irrigated grass is almost equal to that of many of the vegetable crops. It is easier to raise, it uses less water and the market is more stable. The area that should have enough run-off water to supply all the vegetables is on the Sadii river in the north. Fruits can be distributed along all the streams and watersheds from the north of there, Sadii towards Tadjoura, Randa and the area around the Gobaad. It rains more frequently there. The very gravelly soil could support bushes and trees and vine crops. Otherwise we are looking at cereals. Cereals do require from 2 to 4 months of available water. These conditions are more likely to occur along the wadis which have a larger supply of water over a longer period. The Gobaad and the Cheketti wadis, and even the Bissidrou area on the Weima wadi represent channel beds that are frequently flooded and have thick alluvium for storage of large quantities of water.

46 Km Here is the garden developed with the water from a well tapping the alluvium aquifer associated with the lava dam downstream. The country is blessed with the mountains that is needed in a watershed. Now if the land were flat, it would be really useless, but it sheds water really quickly and high run-off is an important factor, gathering that little bit of water into a single place. It is shedding water about as efficiently as if it were designed for that purpose.

48 Km Looking ahead, we see we have passed the crest of the mountain. We are into the leeward side of the mountains into the rain shadow. You will notice the size of the trees has dropped markedly on the forward hills compared to what we see on the left and the sparcity is greater. We don't see grass here as often. We are now entering the interior climate.

49.8 Km We are at the turnoff to Tadjoura and Lac Easal. As you notice, because of the run-off and the 150 mm of rain a year, there is no salt accumulation in the soil. Earlier there was a real worry about this. Djibouti was called a salty area. One of the sources causing that confusion comes from a regional map that was made by the United Nations. It declared that these soils have a high salt content. In his definition of salt he was including calcium carbonate. This has caused consternation because calcium carbonate is not the problem that sodium salt

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are. There are not many sodium salts accumulated in the soils here that cause any serious problems. Therefore, there are no alkali soils, and I think that the amount of calcium carbonate is not even that serious. We have some marl deposits that won't support any vegetation because of the high calcium carbonate. Here we have 10 or 20 cm of A horizon or upper horizon that is leached of carbonates.

52 Km We can now see here the opening on to the Petite Bara or Badda Yar in Somali. We are starting to see some of the projects the country tried very early around independence or before independence to look at the agricultural potential using some of the wells that had been dug for this road. But more important, in the Petite Bara we have a soil called Aada which is a sandy sediment, a coluvium deposited over the top of the previous lake mineral. This is one of our better agricultural soils but it has no water source except rain water run-off. There is a lot of sheet erosion here and there is run-off from the local mountains nearby. We would like to see some run-off agriculture developed here and have the storage here in the actual soil where the farming is going to happen. Then plant the vegetation that will respond to wetting the soil the number of times that it rains. There is some data to be collected in terms of climatic conditions before recommendations can be made. The house on the right is a well house. The well failed. It was expected that some development could happen on the left. A project was started to put some people over on the left to do the developing before the well was finished. The well broke down. The water was also of poor quality. They had to abandon this project. Here we are taking 8 parts per million boron and 2,500 parts per million total salts. The Petite Bara is a good place to talk about gazelles, especially in the winter time because we often see them here. The Thompson Gazelle is the symbol of Djibouti. The one with the little black strip on the side. They are beautiful little animals. There is also a long necked giraffe gazelle and a third kind of an intermediate size, but the Thompson gazelle is the more common one. It is kind of a loner. The Dig-dig is deer-type of gazelle and occupies the position in the ecology here that the jack rabbit does in Texas. It is about the same size as the jack rabbit, with long back legs. It is always in pairs. If one of the pair dies, the other will die of loneliness. Djibouti is also presumed to be the home of the donkey. It actually evolved in this area. Knowing donkeys, I can see it is probably true. They would survive quite well here. Djiboutian camels were very renowned here, and probably still are. They are excellent milking camels. There are in good sleek condition. They raised a lot of camels and sent them over the the Arabs for centuries. One of the items that should be encouraged is for someone to look seriously into a weather modification in Djibouti. We have a lot more humidy than we are getting rain out of. That is because the mountains are not high enough to cause the precipitation necessary. Since we are looking at a random distribution of the rain anyway, you are not going to be confined to making it rain in a

given place and the fact that there are seasons when everything is ready to rain but it doesn't quite do so. I think a good program of experimental weather modification would be appropriate here in Djibouti. I also would like to see them put in at least two Doppler radar stations. The weather people have developed a radar that will record how much water is in the air and where it is at. This would be an excellent way to keep track of where the rain fell and how much fell in an area so that you can advise the farmers as to what his water availability would be. I do not think it would be that expensive. It is a pretty reasonable operation and it would seem to me to be pretty easy to double the rainfall in this country, going from 150 mm to 300 mm.

52.4 Km The area cleared of rocks to the left is the proposed project that failed. It was learned from this one should not clear the land until one knows they have the water source. This is the best example you will see of the bara, the playa system. These are very interesting in terms of agriculture and hydrology. They usually have a narrow watershed around the edge and the water runs into them. This one happens to be open on one end and the water drains into the Ambouli river system. Many of them are closed on the lowest end. The soil we are driving on is the Aada soil. It is an excellent agricultural soil. It is a sand that has accumulated from the rivers' entering along the left side of the playa. It covers the silt and the clays of the old Pleistocene lake that was here. They are very good agricultural soils and respond well to irrigation, but the ground water here is particularly salty and unsuitable. What one would like to see is a system of bunding. That is a kind of long embankment that controls the sheet erosion. In this case, the sheet erosion concentrates the water as soon as it rains, so that perenial grasses will respond to the extra water. If a second rain does not come, and the grass begins to wither, it can be cut and used for forage. This practice can be done all the way to the mountains. Bunding is done in Somalia, India, Sudan and Tunsia. The farmers here ought to be given title to watersheds and sub-watersheds. Property boundaries ought to be based by the way the water runs off the land so a man has control over his water rights rather than any other characteristics since the land has not been subdivided yet. This does remind one of Nevada, West Texas, Arizona and parts of Southern California. In fact we have soil zones described in those areas and we correlate directly with them. By the way, on the Petite Bara and the Grand Bara keep an eye out for gazelles, goats and camels. There are many rabbits, skunk, jackels, fox and hyenas that are a serious problem when farming begins. There are also chipmunks, squirrels, cheta, or leapord type cat here and from time to time a lion. By the way the Petite Bara is on the cattle trail for bringing the livestock from the Ethiopian highlands to this part of Djibouti for sale. This is the old nomadic trail.

63 Km This is the Sortir, Somali for a land divide, and separates the Petite Bara and the Grand Bara. On the left are two white buildings that are a well that was drilled. It proved to have too much salt on the water and far too much boron for agricultural development. But the little plain there has very good soils. Some local development can be done with run-off and bunding and a lot of surface water. If you look closely, you will see the littttle small channels, the gullies of erosion. Water can be stored at other places than behind dams and the soil is an important one. It can hold far more water than a dam because 10 to 20% storage capability in one meter over several square kilometers is a lot of storage. I believe that the natural erosion system has developed the natural dams where they are and this condition can be exploited. Further, it is a flow through system that can handle the overflow well and it can also absorb well into the wadi bed. No matter what you build out there, after 100 years you would have just as much water flowing through and out of the system as you do now. Temporarily you may hold up some of the water, but in fact you would reduce the infiltration rate. It is best to identify where nature already has effective dams and is storing the water in the subsurface. The water is stored in a reservior the evaporation rate here is probably between 3 to 5 meters per year. This is in terms of evaporation rates of 1 to 2 cm/day.

67.2 Km We are coming down on the playa and to the left you see a little patch of trees way off in the distance. That was another well, drilled on government land again. It is far too salty. The trees they put in as a wind break are still surviving but it is not producing. You will notice there will be mirages on this playa. It is simply the light reflecting off the heat waves. This playa floods between three and five times a year. These soils are not salty, they have a good texture and probably at one time, in the long past, were supporting vegetation when the climate was more humid. During Pliestocene time, this was a lake. The reason this is barren is it floods often enough to kill the arid vegetation and the water does not remain long enough to support vegetation that requires more moisture. There are 10 or 20 cm of water that floods this basin and when it finally infiltrates and evaporates, it leaves a crust of silt or the surface which is very hard for seeds to penetrate. As a result, we have this barren plain. These soils could be managed and brought into production. It would be wiser though, to develop the sandier soils around the edge. But, a lot of water is stored in the surface of this playa and by concentrating it with ditching, and embankments on the outside areas and encouraging the infiltration, it would be possible to accomplish a certain amount of agriculture. This watershed is 900 square kilometers in the Gran Bara watershed and the flat part of the Grand Bara is 225 square kilometers. There is only enough water here to irrigate about 90 square kilometers and that would be in cereal and forage. These playas in various sizes are well distributed about the country. The fact that they do accumulate water makes them a prime target for rain-fed irrigation. In agriculture like the grasslands, preserved forage can be well distributed around the country for the dry years. Djibouti needs range management instead of nomadism. Nomadism means you can pick up and go wherever you want to. You stay with the livestock. Range means you and your livestock have a limited area but you manage the livestock by the distribution of water and salt using these factors to provide the animals needs. On the left side of the road, you will notice there is erosion from the lake that is formed by the water coming in and the road being built here is holding the water back from getting into the barren flats. They are doing all kinds of repairs to preserve the road itself. Actually, the protective structures they have developed along here are an example of the kind of bunding we need to concentrate the water and increase the vegetation.

79 Km Now we are approaching the turnoff for Eli Sabieh. Beyond there is Mouloud and after this turnoff, to your left, you will see the embankments that were designed to divert the water from the road into channels. This is an example of the bunding that would be useful in concentraing the water so it infiltrates the soil making water available for a longer period of time for permanent vegetation. We have a little highway beautification here. They irrigate these trees at this turnoff. Turning toward Eli Sabieh, on our right, you will see another bunch of trees and buildings. This is another well that was drilled for the road and another agricultural site that was developed in the hopes they could really develop the Gran Bara into a major agricultural resource. Here, what we see is the use of the sandy soils along the edge for forage and grasses to eliminate this feast and famine cycle with the wet and dry years. Following up a small wadi on the left, we see the delta of that wadi. These deltas are all suitable to agriculture. In this case, the channel upstream could have a system of drainage fields installed and the water brought out to this delta for good agricultural production. We are driving up this way to look at a small garden developed by using the waters returned in the wadi itself. We are coming up to the Catholic Relief Services Food for Work garden. They have built this all with hand labor that was paid in terms of relief food. This was built on the recommendation of using exactly the type of thing we have been talking about. It was built to use the flood waters from the wadi system.

86 Km We are here at the garden. The bunch grass you see on the mountain is what they call donkey grass. It is not very palatable. The animals do not care for it very much. They also call it the grass that came with the Frenchmen. It is used for arthritis and kidney stone problems. They make a tea out of it. We can see that the natural dam site here has held up all of this alluvial deposits. So the real source of the water at the bottom of that thing is what has infiltrated in

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this region upstream. You notice the trees are still showing green here and the vegetation is taller than we were seeing on other terrain. That is an indication of where to seek out the better water retention areas.

87 Km Now we are in the rhyolitic zone. You notice an immediate drop off in the amount of vegetation. We have a vegetation type change also. This bush we haven't seen in the lower elevations. We are at about 700 meters here. This is definitely watershed land use. There is essentially no grazing. They often get rains here they don't get elsewhere. Now the northern part of the country looks much like this in the rain shadow on the back side of the mountains. They have a lot of rhyolitic mountains up there and they will have very much the same appearance. When I'm looking at the trees, I'm looking specifically at the acacia as an indicator because they grow everywhere. This other bush is able to stay green over a longer period of time. It is just a more drought tolerant species. We see it a lot in the wadis.

90 Km We have come to the guard station in Eli Sabieh. Eli Sabieh is the site of a large refugee encampment. This town is becoming the summer vacation area.

92 Km We are at the commissioner's headquarters. On the right is the railroad going to Addis Ababa from Djibouti. This is one of the regions for water supply. Water comes from those areas up about 900 meters and higher. There is often rain here when there is no rain elsewhere. We do not have rain gauges in the mountains. The rain guage is down here so we don't really know how much rain we are getting. They get much more rain out here in these little hills or mountains than they do in town. Catholic Relief Service is going to do some reforesting up here. Agricultural Service gave Catholic Relief Service this nursery over here to start their trees with. They have done much expanding and improving on it.

96 Km Here a home was located. The owner put his well in the right place. This one survived because it is just behind the natural dam and he has the infiltration from this whole region and its run-off from way back up to the south. He managed to maintain a little garden and this garden seemed to have survived through the whole system. Places like this establish the tradition on irrigated agriculture with the reservoir, the channels, the pump, the hand dug well in the wadi, fencing the perimeter and the inundation type irrigation with the beds.

97 Km We are here at the dam site. This is the Ada Madole dam. We will be discussing some agricultural development along the wadis out of the valley the other direction from the dam. They probably have enough forms along some of these wadis now to supply the local fresh vegetable market. So Eli Sabieh ought to dedicate itself to some cereal grain production or the oil

crops, such as sesame for whatever water resources they have. We are at a peak here, the water runs off towards Layada, Holl-Holl in one direction and in the other direction it goes straight into Somalia and at the other one it goes over into Etheopia. There are three rather major wadis that have some terraces along the way that could be planted into forage or oil crops. We look to the left here and see the alluvium that has caught the water upstream and that is the knic-point or natural dam where they have their well. If they come over here and put in a drainage field, they could get water.

103 Km We have crossed the railroad and we are in front of the commissioner's place. At the next stop we are going to be at Maloud. Maloud was also a site that was picked because the well was dug for the road. They developed the agriculture there rather directly. There is going to be an accumulation of boron problem. It is not the concentration of boron in the water but the accumulation of boron with time and evaporation. This is an apportunity to see a current program that was designed to actually do some agricultural production. They have been selling crops off of the Maloud program. The people have been pretty much making their own living off their own parcel of land. It is kind of a pilot project. For a while, they were hoping to resettle more people in this manner. Without being able to do it on a drilled well basis, it sort of stopped everything until they can get into the other kind of water resource development.

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