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EVALUATION

LAND CLASSIFICATION AND SOIL SURVEY PROJECT

YEMEN

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ANNEX I 61

I. EXECUTIVE SUMMARY

This evaluation of the Land Classification and Soil Survey project in Yemen (079-0042) comes approximately four years after its proposed commencement in September, 1978.

An implementing contract (AID/NE-C-1665) with Cornell University was signed March 12, 1980. Under the contract, services are to end December, 1982. A soil survey contract team was not in field operating until March 9. 1981, due to problems in getting project personnel clearance. Because of different contracting sequences, there was s several-month difference in the start of the work by the Cornell Agronomy Department and the Resource Information Laboratory. Since May, 1980, a staged execution of the contract requirements was achieved.

The negative effect of the delay has been an increase in cost.

The project will achieve its overall objectives by the projected completion date. It is recommended that a second phase project be instituted with the recommendations detailed in Section IX.

Our findings with respect to AID's performance in organizing the project would support the following statements:

- Failure to assist in project logistics by USAID/ Sanaa caused unnecessary delay in technical completion of the soil survey program.
- Otherwise AID performance was regarded as positive.

The YARG was prompt in allocating office space, counterpart participation, and providing laboratory services. They did provide personnel for training. Project labor in field activities was provided.

Our findings with respect to the contractor include the following:

- The General Soil Map is on schedule and meets contract requirements.
- The land use map portion is also on schedule to be completed in the time frame and meets contract requirements.
- The time lapse land use analysis objective could not be completed due to lack of base data from the base date of 1972.
- Cornell met and exceeded the training objectives of the contract. The training was not completed because the trainees did not fulfill their agreement to remain on the job upon their return to Yemen.
- Problems in communication and cooperation exist between the Agronomy Department and the Resource Information Laboratory and appear to predate this project. The project's (interrelated) objectives could have been expedited and improved upon had the expected cooperation existed.

A number of recommendations are made in connection with the extension of this project into the second phase:

- The general soil map and the land use map must be completed before the initiation of the second phase.
- The laboratory must be fully restaffed with administrators and technicians before the initiation of the second phase.
- A detailed soil survey should be made in selected or priority areas of limited extent commensurate with socio-economic and technical considerations.
- An Office of the National Soil Survey and Land Classification should be instituted to provide a correlated and unified system of soil survey and land classification.
- A more detailed and precise land use map should be developed to provide the necessary detailed information for the planning office.
- Expatriate assistance should be provided YARG/MOA in interpretation and use of maps, to assure their full utilization.
- The YARG/MOA must provide counterparts and trainees for all technical aspects of the program, if it is to be initiated.
- Cornell should correct the internal dissension within its organization and institute greater cooperation before being considered for a second phase contract.

Otherwise they exhibit the technical expertise, soil survey and land use, necessary for execution of the second phase project. They could make a valuable contribution to the second phase project through knowledge and experience gained in the first phase.

II. INTRODUCTION

The Yemen Arab Republic (YAR) faces a near-crisis management situation with respect to the economic development of its agriculture. The YAR is a poor country whose rich cultural heritage is threatened by the socioeconomic development of the oil rich Arabian Peninsula. The "Garden of Arabia" faces a critical situation! How can the Land Classification and Soil Survey project play a role in assisting in resolving some of the country's agricultural problems, quickly, but with long-term benefits?

The essence of the project is the maintenance of Yemeni land resources (water and soils) to accommodate an expanded and more intensive commercial agriculture.

The agriculture of the YAR was built, and is continuing, upon a fragile balance of two vital factors of agricultural production; namely, the land and farm labor:

- The first of these threatened factors is the land resource, which consists of the soil, the climate (especially water), and the topography (especially terraces). Much of this land resource is either on such steep slopes that it requires an extensive system of terraces to conserve the productive soil, or it is in areas of such low rainfall that an extensive network of water catchment and distribution is required to produce reliable crops. Other soils are so shallow that the slightest loss of topsoil or the lack of a normal water supply (amount

or frequency of available water) results in serious decreases in crop yields. The land resources upon which Yemeni agriculture is based are, indeed, in a delicate ecological balance.

- The second threatened factor of production is the farm labor supply that is available for farm production and maintenance. This fragile factor concerns both the physical availability of sufficient workers to produce and harvest the crops and to conserve the land resources, and the cost of that farm labor. Most of Yemeni agricultural production is based upon labor-intensive farming (terraces and irrigation); very little is now capital-intensive.

  The farming of terraced and/or irrigated land requires such large amounts of labor that both the availability and costs are critical problems in present-day Yemeni agriculture. Many -- too many -- terraces are not being maintained in these years of labor scarcity. Too much irrigation water is being used inefficiently to produce rather low-value crops that do not gross enough income to permit the farmers to compete for the wages now being paid for non-agricultural labor.

Because of the critical and fragile balance that has been experienced in recent years, by the shortages and costs of the labor supply needed to farm the land, it is essential

that the land resources be identified, classified, and located. This should be done in a manner that will permit the planners of agricultural development to make valid decisions and recommendations about land resource priorities. It is not only the development of the land resources that is critical, but also the maintenance and conservation of the suitable soils, the water supplies, and the steep topography.

Prior to the present Land Classification and Soil Survey Project, only limited information had been made available on the kinds of soil and the present land use in the YAR. Soil surveys had been made by various countries but most were deficient in definitive data or inadequately correlated in a national or international system that would serve the country's development needs. Also, prior to this Project, no attempt had been made to prepare a land classification map of Yemen, one that showed utility or use of the nation's land resources.

The objectives of the generalized (reconnaissance) soil survey and land classification now being conducted in Yemen are:

- To prepare a General Soil Map with an accompanying legend. The legend should consist of the names of the mapping units and their principal soil subgroups, usually two or three in number.
- To prepare a descriptive legend to accompany the General Soil Map. This should contain a complete

soil profile description of the members (sub-groups) of the mapping units or associations.

- To locate, in the developed areas, soils suitable for more intensive use. The soil associations of such a generalized survey can be defined in terms of the same kinds of taxonomic units as those recognized on a more detailed soil map. A characteristic purpose is to locate, within regions now used for extensive cropping, potential areas for intensive use through effective management. It is expected that, following the location of such areas, detailed soil surveys would be made to guide the planning of the project's soil and land management.
- To locate, within partially developed areas of scattered settlements, new soils for expansion and development and as a basis for guiding agricultural advisory programs among existing farmers.
- To locate new or undeveloped areas of soils suitable for intensive agricultural development for crops.
- To prepare a land use map showing present land use developed from the analysis of Landsat imagery, coupled with "ground truthing." The map will produce a series of useful products and identify areas to which technology could be transferred; locate areas where more detailed soil information would facilitate knowledge and introduce new technologies for crop production; formulate an operational

contingency information service; and lead to development of a complete resource information system.

In brief, this soil survey and land classification should serve to determine where the most suitable lands for agricultural use and development are located in order to plan, program and develop agricultural projects that would be economically feasible and viable. Training of Yemeni nationals in all aspects of the Project should be instituted.

III. METHODOLOGY

A. Review of the Literature and Memoranda

The evaluation team reviewed, in general, all available project documents, both in the U.S. and in Yemen. These included, but were not limited to the Project Paper (074-0042) signed August 17, 1978; Project Grant Agreement; Project Implementation Letters (P.I.L.s); Project Implementation Orders (P.I.O.s); contracts, and some contract regular reports. The "Soil Survey Report of the Yemen Arab Republic, Progress Reports I and II," dated March, 1980-March, 1981, and March, 1981-September, 1981, respectively, were studied in detail.

B. Review of the Scope of the Work

Briefly, the scope of project activities that were followed in this evaluation comprise:

- The preparation of land use information and analysis from Landsat imagery. A map at a scale of 1:250,000 will form the base data for the land use system.

- The preparation of a General Soil Map of Yemen at a scale of 1:500,000.
- A time-lapse analysis of land use with 1972 used as the base period.
- Training of two indigenous soil scientists for a period of 18 months.

Specific actions required of the evaluators in order to determine if the above goals and objectives have been fulfilled are as follow:

- Examine project objectives in view of the training of Yemenis who are to provide institutionalization of the project. Review training objectives to insure adequate coverage and transfer of skills so that the Yemeni trainees will be capable of meeting skill level objectives by the completion of their training period.
- Review both at Cornell University and the Taiz Soils Laboratory the methodology and results of soil analyses in terms of accuracy, timely scheduling and adherence to scientific rigor.
- Review YARG staffing and counterpart relationships, as well as quantify, to the extent possible, all YARG financial inputs.
- Assess, to the extent possible, effectiveness and suitability of the materials and procedures used in Yemen regarding data collection, analysis and potential for utilization.

- Assess, to the extent possible, the ratio of costs versus outputs and determine if costs were/are comparable to other similar projects.
- Determine if additional work or follow-on activities are warranted/required in order to meet overall project objectives.
- Determine if a small-scale map (1:500,000) has been prepared of the major soil regions of the country (study areas) which indicates phases of associations or subgroups as recognized by U.S.D.A. Soil Taxonomy. This will be accomplished by making profile descriptions of soils identified on the General Soil Map and by laboratory reports of all soil samples used for characterization and classification.
- Determine if the most suitable agricultural land was identified for development in terms of economic feasibility and viability.
- Determine if an appropriate legend, in sufficient detail, has been developed for the Land Class Map and if all necessary photo-satellite imagery was made available on a timely basis and is of a useable quality.
- Determine if the statistical data on area measurements were summarized and formatted so that they could be used readily.

- Determine if all U.S. financial inputs were utilized in the most effective manner and, if not, what changes or modifications would be in order.
- Identify and evaluate specific contractor problems or conditions which may have impeded progress toward project objectives, including: (a) overall staffing; (b) training; (c) budgeting; (d) technology transfer; and, (e) utilization of technology.
- In addition to the above, the evaluation should advise, to the extent possible, whether or not a second phase or follow-on project is necessary or called for.

C. Field Trip Findings and Meetings

Just prior to their departure from Washington, D.C., the evaluation team met with AID/Washington officials at NE/TECH/Agriculture to discuss the objectives of the evaluation.

Immediately following the team's arrival in Yemen, they met with Dr. Jack King, Soil Survey Party Leader. Thereafter they held brief meetings, separately, with members of the USAID staff and with the Director of USAID. Staff members present at the first meeting included Dr. Patrick H. Peterson, Agricultural Development Officer; Mr. Duane Hammer, Project Manager for Soil and Land Classification; and Dr. Mohammed Sharif Al Din (MOA), Co-Manager of all USAID Projects. All aspects of the Soil Survey and Land Classification Project were discussed in detail.

Shortly thereafter the evaluation team departed for Sadah, in the northern part of Yemen. In addition to the evaluation team who traveled with Dr. King, there were others who joined our field review; namely, Mr. Archie Hogan (AID/W), Dr. Mohammed Sharif Al Din; Mr. Duane Hammer; Dr. Salah Elgawhary, soil scientist and Director of the Soils Laboratory at Taizz; Dr. Ishmael Gewaifel, Soil Survey and Land Classification Expert, F.A.O.; and Dr. Helmud Eger, Project Coordinator, Cooperation Project, Germany.

The team was first shown several soil pit profiles that were representative of the soil association on the Sadah Plain. In this area of limited rainfall (300 mm) and deep wells, water conservation has become a matter of extreme importance. The need for additional groundwater studies in this area was immediately apparent. The unique method of growing quality grapes in four-foot deep pits to conserve moisture by reducing evaporation is a commendable practice, perhaps inductively acquired over the centuries. One pit on an old lake playa displayed relic wetness characteristics that indicate an ancient climatic period much wetter than is the case now. This is corroborated by relic grassland soils nearby with dark surface horizons that now lie beneath varying thicknesses of aeolian and alluvial sediments.

The field review took the team southward along the Central Highlands past Huth and into an area of "perched terraces." This is the area where water is harvested from the barren and rocky slopes of the mountain sides and

directed along natural drainageways into the cultivated lower hillsides and valleys below. The harvested water is carefully directed along a complex of irrigation canals and distributed equitably to the mosaic of small fields that spread over the lower hillsides and the nearly level valleys.

The scheduled route took the evaluators still farther south to the Amaron Valley where approximately 20 percent of the land is irrigated. This would seem to indicate that the area has a high potential for further agricultural development, but more information is needed on the stability of the groundwater level. Still farther south, we came upon the Sanaa Plain where an appreciable amount of land is irrigated but where the groundwater level is known to be falling. The consensus of those present on the review was that a more conservative use of the water now available could accommodate a significant increase in the land cultivated. This would apply to most all the farmed areas thus far seen.

Continuing along the Central Highlands south of Sanaa, the evaluation team came upon the rich silty soils of the Yarim and Mabar Plains. With a rainfall of approximately 400 to 500 mm these soils apparently have a high potential for agricultural development. Unfortunately, however, the many areas of fallow land lend credence to the statement by Dr. King that the indigenous population has gone to the more lucrative jobs of the cities or elsewhere.

Leaving the nearly level to undulating Plains of Mabar and Yarim, the team entered the humid (800-1,000 mm rainfall),

steeply-terraced mountain region of Ibb. Here, on rich, volcanic soils, farmers, since ancient times, have ingeniously constructed and maintained terraces on seemingly inaccessible slopes, not unlike the ancient Inca terraces of Peru. This is an important agricultural area where cash crops are encouraged by fertile soils and ample rainfall.

In nearby Taizz, generally south of Ibb, rainfall is moderate and agriculture is fair to good on extensive terraces.

While in Taizz, the team visited the soil laboratory, the facilities of which are under the direction of Dr. Salah Elgawhary, an expatriate U.S. citizen. He is assisted in the analysis of soil samples by his chief laboratory technician, Mr. Rathah Sharma, a U.N. volunteer from Nepal. The laboratory is a part of the Center Agricultural Research Station, the Director of which is Dr. Jamal Faud. Unfortunately, both Dr. Salah Elgawhary and his chief technician, Mr. Rathan Sharma, will be leaving in September, 1982, with no replacements yet identified. The laboratory staff, some of whom are only part-time employees, may prove difficult to retain unless the laboratory can continue as a viable institution. This subject is discussed in greater detail in the section on the Soil Laboratory.

While the evaluation team and others in the MOA were present at the laboratory, Dr. King presented an overview of his activities under the soil survey aspect of the project.

On the following afternoon, the same review team that had started out from Sanaa continued its travels on to the Tihamah Plain. Attention was given to the prevalence of "spate" or basin irrigation where water collected from rains on the relatively tight soil crusts was directed over the surfaces and along drainageways until it was impounded in the basins. Here, the water is permitted to seep slowly into the soil where it remains stored until used by crops of sorghum or other plantings. The team was able to evaluate generally the cropping potential not only of these areas but also of the extensive areas under irrigation from the perenially-flowing wadis that empty into the Red Sea. The general consensus was that the water from these wadis could, through more efficient use, be used in the subjugation of land not presently in use or that land now in use could be used more intensively. Time did not permit the team to travel extensively over the Tihamah Plain, but that part which they did see convinced them of the Plain's great agricultural potential. Wise use of its groundwater, its perenially-flowing wadis and its rainfall, considered collectively, could make of the Tihama a vast, enterprising area of thriving agriculture.

From Zabid, on the Tihamah, the team traveled back to Taizz and from there flew to Sanaa. During the following two days they met with three groups of AID and MOA personnel.

The team's first meeting was with the Acting Director of USAID in Yemen. They discussed, in general, their findings and recommendations, but tempered their recommendations with the need to learn more from other project personnel (at Cornell) whom they had not yet met.

On the following day, the team met, separately, with both Dr. Ali Noman, Director General of Agricultural Services, MOA, and Taher Ali Saif of the Central Planning Office. Again they discussed, in general, their evaluation of the Project but held in abeyance all conclusions until after they had had the opportunity to talk with the Cornell participants in land classification. Of considerable interest to both, Dr. Ali Noman and Mr. Taher Al Saif, was the suggestion that the entire project, both present and future, could best be served by the institution of an Office of the National Soil Survey and Land Classification. Such an organization had been instituted earlier in Lesotho by one of the evaluators. Its use then had served to remove many of the problems now being observed by the evaluators in Yemen. Following a rather lengthy discussion of the subject with both Dr. Ali Noman and Mr. Taher Ali Saif, the request was made by both that a copy of the organizational format in use in Lesotho but conforming to Yemen's needs be prepared and submitted as a part of the evaluators' overall report. The AID personnel in Yemen reiterated this request.

Following the team's rather brief overview of the Project, they flew back to the U.S., stopping first in Ithaca where they met and talked at length with several groups associated with the Project.

Their first meeting was with Dr. A. Van Wambeke, Co-principal investigator on the Project, and his assistant, Dr. Terrence Forbes, the latter of whom served as Project Coordinator. Also present at this first meeting was Dr. Ronald S. Senykoff, a Senior Extension Associate concerned with Land Classification on the Project. The team used this opportunity to question certain procedures used and conclusions reached in the soil survey portion of the project. Dr. Van Wambeke was receptive to certain suggested modifications and changes in the preparation of the descriptive legend of soils and the General Soil Map. Though the manuscript for the soil survey report was not yet completed nor the General Soil Map yet prepared, Dr. Van Wambeke was confident that their completion would fall well within the time frame of the contract.

On the same day, the team met with Dr. Joseph Metz, Head of the International Agricultural Programs at Cornell, and his assistant, Dr. Lawrence Zuidema. They requested and received a brief report of the team's visit to the project and an account of the problems observed. Dr. Metz was especially concerned about the training aspects of the project. He solicited from the team suggestions that they might have in resolving the current problem of recruitment

of trainees and the placement of qualified men in key positions of any future project.

On the following day, the team met with Dr. Ernest Hardy, Co-Principal Investigator on the Project; Dr. Senykoff; Mr. Douglas Norton, Technical Analysis Supervisor, Land Use Classification; and Mr. John Walko, Research Technician, Land Use Classification, the latter two of whom assisted Dr. Senykoff in his work of land classification. The team explored the procedures used by this office in resolving the problems of land classification and in the preparation of their land use maps. Questions were raised concerning the incomplete status of the time-lapse studies of land use and the stage of completion of the 1:250,000 Land Use Map. (See Section V.)

IV. EVALUATION OF THE SOIL SURVEY OF YEMEN

A. Procedure

The purpose of this soil survey evaluation was to appraise the entire survey so as to insure that the work is of acceptable quality and/or to provide guidance for carrying out necessary modifications before field operations are discontinued.

Field and other observations by the evaluation team were begun on August 7, the morning following the team's arrival in Sanaa, and were continued until their departure on the morning of August 13.

During the course of this evaluation, the Survey Party Leader was interviewed in depth concerning his soil survey.

A study was made of his field work and other activities, including mapping and the writing of a descriptive legend. This included profile descriptions, soil associations and others. To accomplish these studies, exploratory pits, previously dug by the survey party, were observed. They provided confirmation of representative kinds of soils in the survey area. Observations of these soils in their natural landscape settings, coupled with data on reference samples, provided the evaluators with such information as accuracy of mapping, correctness of classification, suitability for interpretation and fundamental knowledge of soil composition and genesis. Assistance was given to the Cornell party leader on problems concerning mapping, classification, nomenclature and broad cropping interpretations in the area.

In evaluating the quality and progress of the field work, samples of soil mapping were carefully examined as to accuracy and legibility of boundaries, ranges and inclusions within the delineations on the General Soil Map and as to the agreement between the mapping and the descriptive legend.

A check was made on the assembly of material for the descriptive legend. The adequacy of the descriptive legend, including related soil sub-groups as identified from Soil Taxonomy and found within the soil associations, together with field notes, were evaluated. Changes, if any were

necessary, were outlined to the Soil Survey Party Leader. In preparing a descriptive legend, three minimum requirements were adhered to:

- Names of the mapping units and the presence of symbols by which they could be identified;
- Description of each mapping unit; and
- Preparation of a table and report manuscript showing the morphological and genetic relationships of each of the associated soil subgroups.

Not only were the mapping units observed for major soils, but they also were assessed as to the nature and proportions of inclusions. By inclusions are meant the small bodies of soils differing in profile or otherwise from the one or ones represented by the mapping unit name. Identification of the inclusions, either by describing them or relating them to the mapping units in the legend, together with an estimate of the rough proportions they comprise, was considered to be a part of the full definition of the mapping unit.

Necessary revisions of the survey, either to comply more fully with the immediate goals of the project or for a sound scientific classification of the soils, were indicated to the Party Leader.

Probable suitability of the field sheets for cartographic compilation of a General Soil Map for publication was assessed.

The status of the report prepared for interim use, prior to a manuscript for publication, was reviewed and plans for its completion assessed.

A careful check was made of data from soil samples that had been collected and of plans for collection of additional samples to insure adequacy of soil characterization data.

The soil laboratory at the Taizz Research Center was visited and the adequacy of the equipment and other facilities as well as the levels of expertise of the technicians was noted.

B. Descriptions of the Soils

1. Findings

On the whole, profile descriptions of soil subgroups prepared by Dr. King are near excellent. They are brief as possible without omitting essential information. They serve well as reliable guides to their identification as unique entities and to their assigned taxonomic placements in the U.S.D.A. Soil Taxonomy. Almost every soil description has taken into account all essential physical and chemical differentiae that serve to properly classify it.

One minor discrepancy noted is the occasional misplacement of a subgroup in Soil Taxonomy. This had resulted largely from the misreading of a soil characteristic, climatic factor or other feature.

Another and more important deficiency noted in the subgroup descriptions is the lack of recorded ranges in characteristics, more refined than indicated in the subgroup placement, either in the descriptive legend or in the field notes. This deficiency makes it difficult to later subdivide even wider-ranging subgroups into soil series. The latter are important basic units for interpreting agricultural use and management, important to the follow-up or second phase of this project.

2. Recommendations

Each major member (subgroup) of the recognized mapping units (soil associations) will need a brief statement on ranges in characteristics, as recorded in field notes or as known to the Party Leader. Where several field descriptions are made, one should be reflected as representative or typifying; whereas, the others are recognized as varying in characteristics from that one. The Party Leader has informed the team that these ranges for individual soil subgroups can be compiled from data at hand or from his knowledge of the soils, and that this will be done as a part of the technical appendix in the final report. For this reason it is essential that the present Party Leader continue with the writing of this report until completion of the contract.

Each profile description will require at least a cursory inspection to insure that it has been placed properly in U.S.D.A. Soil Taxonomy.

C. The General Soil Map

1. Findings

Ideally, map units on the General Soil Map of Yemen should be described at a level of generalization above that of soil series, preferably at the level of soil families or associations of soil series, but, unfortunately, neither has been established at the present level of the soil survey in Yemen. Hence, for the present, map units in the survey comprise those associations of soil subgroups that best represent the soils at the cartographic generalization appropriate for maps at the scale of 1:500,000.

These mapping units in Yemen have been recognized and described on the basis of "climate, geology, relief, vegetation and soil morphology, and by analyzing imagery obtained by satellite and aerial photography." These factors provide a valid basis for describing the mapping units; however, it would be more appropriate to give "soil morphology" a somewhat more prominent place in the sequential arrangement of the factors considered. Soil characteristics and qualities are extremely important pivotal features among members of soil mapping units or associations.

The most common and most serious deficiency in the small scale soil map presently being considered for the final report is an improper organization and description of the legend. If such maps are to be used, the legend of the General Soil Map must be organized and named in such a way that the maps can be used with reasonable ease, not only by the soil scientist but by other users as well. For example, in the 1981 Soil Survey of Yemen, under the heading "Taxonomic Soil Classification, Correlation and the Mapping Legend," the statement is made that "mapping units . . . are named by land form and soil climate." This concept is reflected throughout the report and in the legend of the General Soil Map. The associations of soils (mapping units) are given names that are scarcely discernible from the names of the landform regions described on another map in the report. Apparently, the mapping unit names in this report are made to reflect these physiographic relationships.

2. Recommendations

In the U.S. National Soil Survey, it has long been the accepted practice to have mapping units on easily distinguishable soil characteristics and, occasionally, on soil qualities. Grouping on the basis of physiography, a common practice in the early history of soil survey, should be avoided in this report and elsewhere.

There is, of course, no objection to boundaries of mapping units coinciding with physiographic boundaries, but the justification for the boundaries should be differences in soils and not differences in physiography.

The renaming of the mapping units in this report, to point up the differences in soil characteristics rather than physiography, can be achieved without appreciable disturbance of their present component make-up. For example, the mapping unit "Semi-Aridic Loessal Plains Soils" as named in the report, could be renamed:

> "Typic Torriorthent Soil Association: Deep, well-drained, brownish, silty soil of the semi-aridic loessal plains."

In view of the fact that the dominant soil, Typic Torriorthents, makes up 85% of the mapping unit, the unit name should reflect that dominance. The remaining soils, Aquollic Salorthids (5%) and Rock Outcrop (10%) can be handled as inclusions. They should be described and their positions in the landscape noted, but the dominant soil or soils, listed in order of their dominance, should make up the mapping unit name. Usually two or three dominant soils are adequate in the mapping unit name. The dominant soils also should be described as to their location or position in the mapping unit. Other changes in mapping unit names may not prove to

be so clear-cut, but all the associations (mapping units) written in the report or shown on the General Soil Map can be handled in a manner similar to the above. When these changes are made, the mapping units will be designed to have maximum significance for agricultural planning, and the General Soil Map will truly reflect soils and not physiography.

The General Soil Map has many uses, but generally it is made for one main purpose -- to identify the soil as a basis for applying the results of research and experience to individual land units. Results from an experiment or on a practice applied to a given soil can be applied with confidence to other areas of the same kind of soil. This is what the mapping unit should try to achieve.

No second phase of the Soil Survey and Land Use Classification Project should be started until all aspects of the present reconnaissance soil survey and the above-suggested revisions in the General Soil Map and Descriptive Legend are completed.

D. Soils Survey Laboratory

1. Findings

The Yemen Government maintains a central soil laboratory at Taizz. The services of this laboratory have been made available to the Soil Survey Party Leader in his work of soil characterization and classificiation analysis of representative soils. This has

applied at all levels in his work, with the exception of mineralogical investigations. The Party Leader informed the evaluation team that the laboratory has handled his soil samples efficiently, expeditiously and professionally. Approximately one hundred samples, replicas of those analyzed at Taizz, were sent to Cornell to compare results. No appreciable differences were noted.

The time lapse between receipt of soil samples at the laboratory and completion of characterization analyses poses no problems to date. All analyses were conducted and completed on schedule and returned in ample time to permit characterization of the selected profiles and their proper subgroup placement in the U.S.D.A. Soil Taxonomy. The laboratory has now completed analyses on approximately 500 samples.

The laboratory staffing does, however, pose what could become a serious problem. Both Dr. Salah Elgawhary, Laboratory Head, F.A.O., and his Chief Laboratory Technician, Ratnah Sharma, will be leaving in September. The latter, a U.N. volunteer, has served in the laboratory for the past seven years. These departures will drain the laboratory of the men who are the only ones present and sufficiently skilled to continue the administration of the work. Though Dr. Ali Noman, Director General of MOA's Agricultural Services, has assured the evaluation team that both men will be replaced, the

question of "when?" remains unanswered. The nature of the employment of the laboratory staff, many of whom are part-time workers, may lead to their seeking employment elsewhere.

The evaluation team was informed that the present staff can conduct complete characterization and classification analyses on approximately twelve samples each day. This could represent horizons of two soil profiles, more than are needed in the long-range conduct of a detailed soil survey. However, the Soil Survey is not the only user of soil analyses. It is used by all Government agencies having need of soils data.

A brief and superficial check of the laboratory equipment showed what appeared to be a shortage of glassware and other expendable items. Broken and patched hydrometer jars, displaying leakage, were being used. Otherwise, the laboratory appeared adequately supplied with the equipment necessary for general soil characterization analyses.

2. Recommendations

The second phase of the Soil Survey and Land Classification Project should be held in abeyance until the soil laboratory at Taizz is again functioning properly, with a new Director, a new Chief Technician, and a full complement of soil analyses personnel.

Though the laboratory facilities will undoubtedly satisfy the demands of the second phase soil survey,

extravagant use of its facilities should not be permitted to infringe on the needs of other agency users.

In order to expedite their own work, the second phase soil survey should make modest contributions to the maintenance of glassware and other expendable items in the laboratory.

The survey Party Leader should maintain close liaison with the laboratory so that he can offer instructions and technical guidance in the analysis of his soil samples and the instructions and techniques employed in strictly soil survey interpretations.

E. Need for a National Soil Survey Office

1. Findings

One of the important outcomes of this project has been the establishment of a need for an office of the National Soil Survey and Land Classification. There are, at present, seven or more areas in Yemen that have been soil surveyed by separate countries, all varying more or less in their survey methods and techniques and in the classification systems they employ. The Wadi Zabid has been surveyed by the Hungarians; the Wadi Rasyan by the Dutch; the Wadi Surdud by a combination of the Russians and the English; the Dhmar Plain and Mareb Region by the English; the Wadi Siham by the French; the Amaran Valley and Wadi Jawf by the Germans; and the Sadah Plains by the Americans. Also smaller

Wadis, such as the Rima and others, have been surveyed by teams from other nations.

Each of these surveys apparently was made without sufficient regard for the need to extrapolate findings to other areas or for a systematic correlation of the varied taxonomics employed. The problem is complicated further by a current lack of trained mappers who have the technical skills to correlate these older soil surveys with the new Soil Taxonomy. This, of course, has made it difficult for the survey Party Leader of this first phase of the Soil Survey and Land Classification Project to take full advantage of all prior survey work in the country. Consequently, some of these earlier reports have become lost or simply languish on dusty archive shelves. With the continued arrival in the country of other national groups with dissimilar mapping methods and strongly-contrasting taxonomies, the correlation and subsequent interpretation problems will be intensified.

2. Recommendations

The above-stated problem points to the need for a central clearing office or, more specifically, an Office of the National Soil Survey and Land Classification, where all surveys can be mapped, correlated and otherwise conducted under a strong, unified authority. This, in turn, could lead to more clearly

defined, multi-purpose interpretations for cropping or other uses.

This Office of the National Soil Survey and Land Classification would be responsible for seeing that all aspects of the soil survey work are carried forward vigorously. These would include both training and actual work in mapping, correlation, interpretation, field and laboratory characterization, map compilation, and investigations in genesis, morphology, and classification. The administering authority, probably the soil survey Party Leader, also would have the responsibility of providing full technical and scientific guidance to insure that all soil survey work meets adequate standards. With regard to the many soil surveys already completed, he would determine those suitable for use in the National Soil Survey Program and would supplement them with revised soil profile descriptions, correlations, classifications, map revisions and interpretations as appropriate to bring them reasonably up to date and in conformance with U.S.D.A. Soil Taxonomy.

An organizational format for a National Soil Survey already has been prepared by a member of this evaluation team and presently is being used successfully in the National Soil Survey Office of the Kingdom of Lesotho. Dr. Ali Noman, Director General of the Agricultural Services in the Ministry of Agriculture, and

Mr. Taher Ali Saif, of the Central Planning Office, Yemen, have expressed considerable interest and enthusiasm in having Yemen's future soil survey program, especially as it applies to the second phase of the Soil Survey and Land Classification Project, conform to a similar plan. They have requested that the Lesotho format be adapted to the needs of Yemen and submitted as an appendix or addendum to this report.

F. Selection of Land Suitable for Future Agricultural Development

1. Findings

Areas of land with the soils most suitable for agricultural uses are indicated on the General Soils Map (1:500,000) and are described in the legend and text. However, no listing of priorities for development nor for conservation needs are given because the order of urgency for action depends upon more than the physical characteristics of the land.

The legend and description of the areas of present (1980) land use shown on the land use maps (1:250,000) indicate usage based on various intensities and the kinds of agricultural uses, as well as some non-agricultural uses. There are also indications about the physical resources (soil, topography and terraces, climate or water relations), as well as some of the economic and social conditions existing in the various areas. Nevertheless, the land use map does not, by

itself and without further interpretation, indicate which areas are most suitable for additional development and/or conservation measures.

Before those areas most suitable for various kinds of agricultural development and/or conservation (soil and water) can be shown and described, additional interpretation and analyses of the materials (maps, legends and descriptions) provided under the first phase of Project 042, as now being completed, must be made. Ideally, these interpretations and analyses would be made by Yemeni technicians working with qualified advisors.

Priorities for additional work and investments, whether public or private, should be established by the Yemenis, on the basis of the materials provided by this project, but supplemented by the analyses of additional economic, social and political information.

Quite obviously the reconnaissance soil survey and land classification efforts in the first phase of this project did not provide the degree of detail needed to permit a firm selection of land areas for future agricultural development, but they did bring certain land areas to the forefront of consideration. (Many of these areas are mentioned in the section "Field Trip Findings and Meetings.") To put these land areas in any order of priority for development at this time

would be to ignore the socio-politico-economic considerations prevalent at the time of development. Suffice it to say that there are a number of areas that, based on soil characteristics and qualities alone, would qualify for immediate consideration as suitable for development.

It would be the purpose of soil survey interpretation in the second phase of the project, following a detailed soil inventory, to organize and to present evidence about soil properties, qualities and behavior. This could be done in such a manner that users of the soil maps could make intelligent choices among alternative uses. The best use from among the alternatives for the many kinds of soil in Yemen would depend upon such considerations as location and size of farm units, the amount of land suitable for different uses, climatic conditions, availability and location of water, labor sources, and the skills, resources and desires of the operators. Thus to make soil survey results effective in land development planning, one would need to continually reinterpret the soil surveys with the development of new techniques in the agricultural arts and with changes in the socio-politico-economic climate.

2. Recommendations

In areas of suitable soils but with very limited rainfall, it is prudent for development planners to remember the extent that groundwater is available to be pumped from underground aquifers in a reliable and economic amount. The land classification (based upon a detailed soil survey) should be used to decide which lands should receive the rights (authority) to pump specified amounts of water and be developed into an intensive agriculture.

This intensive use of the agricultural resources should be based upon the efficient irrigation of intensive crops on the best lands, for a reliable and dependable market, perhaps consisting of selected fruits or vegetables or other horticultural crops. Intensive and costly agriculture cannot continue to be based largely upon the grains and forages that now seem to dominate the crop production from the use of limited groundwater -- they simply don't produce enough gross income per hectare.

The reconnaissance soil survey of Yemen, which will be completed with the ending of the first phase of the current project, is suitable only for broad-area interpretations and planning. To organize and present sufficient information necessary for definitive planning would require the detailed knowledge inherent in

detailed soil survey and present land-use maps. For this reason, it is recommended that this project be carried forward into the second phase where detailed information on soils and land use will be made available.

V. EVALUATION OF LAND USE MAPS AND CLASSIFICATION

A. Introduction

The evaluation team spent one day in the Resource Information Laboratory (RIL), Cornell University, Ithaca, with Dr. Ernest E. Hardy, Co-investigator for the Land Use part of the project, Dr. R. S. Senykoff, and with their project team. The team reviewed their methodology, which consisted of an aerial photo and landsat imaging study and interpretation. These remote sensing interpretations were tested by ground-truth observations, made in the field in Yemen. In addition to discussing their methodology and viewing their completed map and legend, the evaluation team reviewed all files, progress reports, periodic status evaluations and correspondence regarding the project, both notes on telephone correspondence and copies of written correspondence.

B. Land Use Map-Findings

The land use map project under the RIL was reviewed and evaluated at Ithaca. The land use map, scale 1:250,000, is complete and meets contract requirements. A legend recognizing 4 geographic regions and 18 land use classes has

been developed. Each region and each land use class is clearly defined and quantified as to extent. The regions and land use classes are delineated on the map.

The map was constructed using tried and recognized procedures of photo and landsat imagery interpretations by RIL, which has a long history of expertise in this field. The image interpretations were tested by ground truth observations made in Yemen.

RIL states that the Land Use Map project is on schedule. The map is complete, as is the legend. A text report to accompany the map is being prepared. Also demonstration materials to accompany the map, to help in its use, are being prepared. RIL states that all of these materials will be complete by or before project completion deadline.

C. Time-Lapse Analysis of Land Use

This objective was not accomplished. This was due to lack of back-up data during the 1972-73 period, the date of the aerial photo coverage that was to be used in comparison with imagery used in the remaining parts of the project. A reliable analysis of land use could not be made from the 1972-73 aerial photographs. During that period Yemen was suffering a severe drought; further, baseline data was lacking that would have permitted an estimate of the severity of the drought and its affect on cropping. Under these conditions, areas planted to crops, areas that were fallow, and areas that had been idle and abandoned for crop production could not be identified and separated by

photo interpretation. No other images nor aerial photo coverage were available to use in making time-lapse analysis of land use changes.

The files of the RIL on this subject were reviewed. Problems and concerns in meeting this objection were relayed to USAID by telephone on December 23, 1982, by letter on January 21, 1982, by telephone on February 9, 1982, and by Memorandum Status Report on February 13, 1982. There was no record in these files of response by USAID to these problems and concerns

To provide for technology transfer and training under this objective, RIL prepared a land use change feasibility study on a demonstration sample basis. This was used in the training of the two Yemeni nationals, to provide them some expertise and to provide technology transfer from RIL to Yemen under this objective.

D. Follow-on or Second Phase Activities in Land Use Classification and Mapping

North Yemen is a nation with very limited water supplies increasing population, and a decreasing labor supply in the sector that is available and economical for farm utilization. It has critical problems in maintaining the present system of terrace agriculture with the absence of a large pool of inexpensive labor. The terrace system is labor-intensive,

both in maintenance and in farm operations. Degradation of the terrace system of agriculture was quite evident. Problems of terrace maintenance were noted on a number of locations where large gullies had replaced terraces.

The work completed on Phase I of this project has been an important first step to assisting the YARG in addressing the need for rational decision making in agriculture. In of itself, however, it does not provide the detailed data required by YAR officialdom.

A Phase II or follow-on effort should focus on:

- The development of an interpretive land use map showing potential areas of economic production, to permit rational decisions on the groundwater to be used on the best lands (This assumes that there is not enough water to irrigate all of the suitable soils in the low-rainfall areas of Yemen.) Neither the map of potential agricultural land use, nor adequate surveys of the groundwater supplies are now available.

The kind of water rights (legal control of the use of ground and surface water) to use irrigation water for agricultural purposes is not the focus of this project, but rather to assure that the basic soils maps and land classification maps of Project 042 are presented in an interpretive manner. Also, that adequate surveys of the groundwater, in the areas of suitable soils but with limited rainfall, are

available before irreversible decisions and investments are made to develop (intensify) the agriculture of the most suitable lands. Water for irrigation is the vital limitation upon the development of intensive agriculture in Yemen.

- The kind of land classification that would be of most immediate use in Yemen, after the General Soils Maps and the land use maps are available, would be a classification of the land according to the potential intensity (level of yields) of agricultural production that its physical resources will permit under a specified level of management (more intensive than the present subsistence farming that is still common in Yemen). The level of management will include such factors as irrigation, level of production technology and mechanization, marketing channels and facilities, etc. Sub-classes of major land classes could be based upon rainfall/climate or water availability, and topography or degree of terracing.

Complementing the above is the need for training and assistance for YARG agricultural planners and decision-makers in the interpretation and analysis of collected data. Maps or other graphic displays are of little value to individuals untrained in their use.

The YARG will need to make decisions with regard to the best and most efficient use of water supplies, the best

uses of land, and the best soils to develop to maximize agricultural production to meet national needs. Some areas presently in marginal agricultural production may need to be abandoned to enable the concentration of water and other resources toward areas potentially more productive.

Whatever planning mechanism is utilized, it will need basic data to be able to make the necessary decisions. Adequate soils data, land use data, water data (both ground and precipitation), sociological data, etc., are needed.

E. Recommendations

Based on these premises, the following recommendations are made for follow-on work in land use and classification.

1. The land use map and classification project should be continued. A map at larger scale -- 1:100,000 -- should be completed based on aerial photo and satellite image interpretation, with ground-truth observations made in relation to the detail of the map. This would provide more precise data needed for planning.

2. Expatriate technicians should have host country counterparts and trainees, dedicated to the project, to assure that technology transfer would be developed in-country, so that the project could be taken over in its entirety by the host country within a reasonable time span.

3. To further assist in planning of agricultural resources, studies on water resources, sociological factors, etc., should be initiated.

VI. TRAINING

A. Introduction

The YARG faces problems in staffing their positions in agriculture and in providing counterparts for development projects. They have very few qualified technicians available to perform even the minimal duties. Nevertheless, in spite of the numerous Yemeni technicians who were in training, including studies toward degrees, the YARG was able to assign counterparts and trainees for the Project. The delays and administrative problems incurred in selecting and assigning these technicians appear to be normal; a bit frustrating at the time, but not serious in the overall functioning of the Project.

The staffs of the various offices that were directly and indirectly involved with the operations of the Project showed the limited technical training and experience so common in developing countries. The problems caused by this fact were less troublesome than the deficiencies in communications within YARG and between YARG and USAID and its contractors, including this Project. However, the good will that quickly developed among the involved personnel, Yemeni and American (and also with various technicians from several European missions) was unusually satisfactory and productive.

B. Findings

The training componentof this Project specifies that two Yemeni soil scientists from the YARG Ministry of Agriculture will receive (a) English language study, (b) six semesters of course work at a level appropriate to the background and ability of the selected candidates, and (c) approximately five months of work experience in soil mapping and interpretation of satellite imagery. Additionally, the Project will "provide institutional support both during and after the project." The "contingent funds," as called for in the Operational Plan, were provided for this training.

The two Yemeni soil scientists selected for the training both received training at Cornell University. Some problems and disappointments were experienced.

The recruitment and selection of the trainees was delayed in Yemen so that the two trainees were a little late in starting their structured program in the Resource Information Laboratory (land use) and in the Agronomy Department (soil survey). However, with the cooperative diligence of the trainees and their various teachers, they were able to complete the training at Cornell University almost on time, in spite of the late start. The training at Cornell covered all requirements (lectures, lab and field work and field trips) included in the scheduled program, and was able to stay within the final budget. Good working conditions, enthusiasm, and close cooperation were evident as the two trainees proceeded through their training, in

spite of the difficulties in handling the program with the one trainee who encountered considerable difficulty with the English language.

Additional field training, in soil survey and land use, was scheduled for both trainees, in Yemen, for a month beginning in late August, 1982. Both trainees have made plans to continue their graduate studies to begin early in September toward a Ph.D. degree; one in Egypt and the other in the U.S. Both have been working in the YAR, one at the Central Agricultural Experiment Station/Soils Lab, Taizz, since May, 1982, and the second on an irrigation project with YARG/MOA near Hodeidah, Yemen.

C. Recommendations

The YAR suffers from the same problems as most developing countries with regard to the training of indigenous personnel. Shortages of qualified candidates and deficiencies in administration of recruitment, selection and implementation of trainees are typical shortcomings. Perhaps the most significant problem, however, is retaining individuals once their training is completed.

Long-term training needs remain necessary. One answer to identifying and recruiting candidates is to plan ahead with sufficient lead time to identify promising students, perhaps even two to three years in advance. Intern programs, employment during school vacations at government facilities and otherwise cultivating student interest in the field

(holding out the possibility of external training) are suggested approaches.

The problem of retention is more difficult. One possible solution may be to tie education and training with a specified minimum time requirement for assignment by the government after the completion of training. Students will know beforehand that they have a commitment to serve in government service, and therefore would be less inclined to look elsewhere, at least initially.

The ultimate answer, though, may be for the government to develop and demonstrate to returning students the benefits of working in government service. Obviously this includes a package including everything from job benefits to career growth. It should be understood, however, that even the most attractive package may not prove sufficient.

VII. CONTRACTOR PROBLEMS AND CONDITIONS

Several areas under this heading were explored by the evaluation team. These were mainly in regard to cooperation between the contractor and AID/Washington, USAID/Sanaa, and YARG/MOA, and internal cooperation within the contractor organization.

- Cooperation: AID/Washington-Contractor. No complaints were expressed. Statements were that the two groups worked together in a satisfactory manner.
- Cooperation: YARG/MOA-Contractor. No complaints were expressed on day-to-day cooperation. With

regard to the training program, problems were expressed by both groups. Dr. Ali Noman, MOA, expressed strong displeasure that academic training was arranged for the Soil Scientist counterpart without his concurrence. The Cornell training supervisors were concerned that the two trainees under their program might not be assigned to duties where they could use the training provided, that they might not be retained in those training-related jobs long enough to make the training worthwhile, and that they might not be able to supplement the skills attained in the formal training with on-the-job related experiences. They also expressed fear that the two trainees would not be able to complete assigned field exercises in Yemen, a requirement for receiving a certificate of completion of the training.

- Cooperation: USAID/Sanaa-Contractor. The contractor was required to handle all logistics concerning the performance of the contract. We were told that this is USAID policy. However, lack of some logistic support causes waste of valuable and expensive technical expertise and time. The soil scientist had to spend time he could have devoted to the technical aspects of the project on such mundane things as clearing equipment and supplies through customs, locating and hiring drivers and laborers for

transport and obtaining licenses and clearances in-country, etc. This is very difficult and time consuming for a person new to a country and culture, and without a common language to the people, he must go through in doing these things. In most countries, it requires the new man many times the number of hours to do these things than it would take a person who has language abilities and knowledge of the local requirements and lines of authority. Also, few technicians have training in these lines of logistics. This leads to even greater waste of time.

We do not recommend that USAID assume full logistic support of contractor projects, but do make the following recommendation:

The USAID Mission should consider providing advice and support in clearance of project supplies and equipment, and in obtaining licenses and clearances necessary to perform the work in the host country.

- Cooperation within Contractor Organization: Unquestionably there was a lack of cooperation between the land use sub-project, the soils sub-project, and the training sub-project. The evaluateam questioned each subgroup on all aspects of cooperation -- that is with USAID/Washington, USAID/Sanaa, YARG, and within the project. We did not attempt to analyze the degree of friction

within the project contractor group. The contractor should have recognized these conflicts, resolved them, and provided a unified approach, as the subprograms are complementary - not separate. There is no question that the project could have been more successful had this cooperation existed.

VIII. COST EFFICIENCY OF PROJECT

Data on costs per unit area of mapping in the developing countries are scarce, and often data that are available do not provide a satisfactory description of the methodology nor the type and value of the output. Therefore, one often wonders if he is comparing oranges with apples.

A. Land Use Mapping

The methodology used on the land use mapping and the measurement and checking of mapped units went beyond the standard procedures now used in the U.S. Innovative procedures were used and carefully checked both in the lab and the field. As a result, the quality and quantity of the output (maps, descriptions, and surface measurements) appears to be of much higher accuracy and usefulness to planners than expected.

In maps of 1:250,000 scale and minimum mapping units of about 25 hectares, the total cost of $360,000 results in an average of about $0.03 per hectare. This includes the costs of the field orientation and checking in Yemen as well as

the $10,000 of special equipment needed to process the satellite imagery. These costs do not include the training of the two soils technicians.

This cost -- three (3) cents per hectare -- appears to be about 1/3 to 1/2 of the cost of alternative methods that might have been used, such as aerial photo interpretation and satellite imagery. Land use mapping in Kenya cost less (1.6 cents per hectare), but did not provide the detail and accuracy of Cornell's land use mapping in Yemen.

B. Soil Survey

The methodology used to prepare and ground-check the soils maps (1:500,000) resulted in total costs (in Yemen and Cornell) of $539,899 for the 11,564,000 hectares surveyed. That is about $0.047 per hectare. Venezuela recently surveyed large areas at 1:500,000 for about 10-15 cents per hectare. However, a compilation of costs for soil surveys at general levels of precision and detail at 1:500,000 in developing countries showed that the trend was about $0.02-0.03 per hectare (1960 dollar values), which would be roughly double those cost figures in 1982 dollars.

The consensus is that the land use mapping and soil survey output/results as being completed under the Project was cost-efficient. Considering the methodology that has evolved and the quality of the results, it might even be a bargain.

C. Yemeni Financial Inputs

The limited time of the evaluation team in Sanaa precluded a quantification of the Yemeni financial inputs to the Project. YARG provided, in a generally satisfactory manner, for the counterpart expenses to work closely with Dr. King, for the office of King in Taizz, and for the testing of soil samples in the Soils Lab at Taizz. Additionally, the nominal financial inputs of YARG involved in the several visits of Cornell technicians on the land use/land classification work were satisfactory.

D. Training Costs

The budget for the carefully-programmed training of the two soils men in the U.S. and in Yemen was $109,922. The cost is greater than most training because it was individually programmed for the two men and did not include very many regular academic courses offered by a university. It was a program developed especially for this type of specialized training, to fit the needs and academic background of the two Yemenis. The costs should not be considered as excessive under these special circumstances even though it is higher than most normal degree programs for regular graduate students.

A. General

In our view the objectives of Phase I of Project 042 have largely beer met. The foundation for follow-on work has been established, as has the recognition by the YARG of the present value and future need for more detailed soil survey and land use mapping and classification activities.

It is our recommendation that a Phase II be initiated, to develop the more detailed data necessary for inclusion into the decision-making process.

It should be stressed, however, that immediate discussions between AID and the YARG should be initiated to clarify and definitize the scope of activity and the conditions that we believe should be in place prior to the commitment of funds and the selection of a contractor.

The following detailed recommendations apply to present and in particular future activity, should that be forthcoming.

B. Soil Survey

We strongly recommend that Phase II of the project be held in abeyance until all aspects of the present reconnaisance soil survey and the following suggested revisions to the General Soil Map and Descriptive Legend are completed.

- Review all subgroup units or members of soil assosication to check for their occasional misplacements in Soil Taxonomy.
- The groupings of soils on the General Soil Map and in the Descriptive Legend should be on the basis of soil characteristics and not physiography. This discrepancy, though of major

significance, can be remedied with a minimum of effort by complying with the procedure as outlined in this report.

- Ranges in characteristics of the soil subgroups should be noted in the descriptions of the typifying or representative members of soil associations or mapping units. The locations and percentages of subgroups in the mapping units should be noted in the Descriptive Legend.
- Should Phase II be instituted, we recommend that strong consideration be given to commencing the detailed soil surveys initially in the southern region of the YAR. Not only is there significant potential for agricultural development in this area, but also the close proximity of the Soil Laboratory to this area would ease logistical and administrative arrangements.

C. Soil Laboratory

The recommendation for continued detailed soil survey work is closely associated with the continued effectiveness of the Soil Laboratory.

Continued prompt and detailed analyses by the Laboratory are needed for accurate characterization of the soils so that they might easily be placed appropriately in the international system of soil classification (Soil Taxonomy).

- So important is the Soil Laboratory to the project that we recommend no second phase activity be initiated until such time as the Lab has been adequately staffed with a new Director, a new Chief Technician, and a full complement of soil analysis personnel.
- With the commencement of the second phase of the Project, the Soil Survey Party Leader should continue to maintain close liaison with the Laboratory and be prepared to offer technical advice and directions concerning his needs in soil characterization and research.
- A modest program of assistance to the Laboratory in the form of the replacement of glassware and other expendable items should be instituted.

D. Institution of an Office of National Soil Survey and Land Classification

One of the important outcomes of this evaluation has been the recognition of a need for a National Office of the Soil Survey and Land Classification. As discussed in detail in the body of this report, a strong unified authority is needed to bring together the many soil studies made by various nations and to offer a correlated approach to soil survey and land classification. The offices of MOA and CPO, together with USAID/Yemen, have voiced a common request to have the organizational format, previously developed and

used by one of the evaluators in Lesotho, examined by appropriate Yemeni and USAID officials with a view toward modifying it to fit the needs of Yemen's soil survey.

E. The Land Use Maps and Classification

The completed land use map (1:250,000) under Phase I is an important first step in assisting the YARG in addressing the need for national decision-making in the agricultural sector. What it does not provide, however, is the detailed data required by analysts and planners. We therefore suggest the following:

- A map at larger scale, 1:100,000, should be completed. This map would be based on aerial photo and satellite image interpretations with ground-truth observations. This map would provide more precise data that is needed for agricultural development planning.

The map should show potential areas of economic development, and classification of land according to the potential intensity (level of yields) of agricultural production that its physical resources will permit under a specified level of management (more intensive than the present subsistence farming that is still common in Yemen). The level of management should include such factors as irrigation, level of production technology and mechanization, marketing channels and facilities, etc. Sub-classes of major land classes could be based upon rainfall/climate or water availability, and topography or degree of terracing.

- Complementing the preceding activity should be the initiation of several studies or if already completed, the integration of findings, in such areas as water resources, socioeconomic factors, et al., that will assist planners in the development of the agricultural sector.

F. Staffing of Phase II Activity and Training

Expertise in using and interpreting collected data and maps should be provided to make the most efficient use of these findings. Without such expertise in use and interpretations, the data is just paper and will not be used. Expatriate technicians must have host country counterparts and trainees dedicated to the project, to assure that technology transfer and technical ability are developed in-country. Within a reasonable time span, the program should be taken over in its entirety by the host country. This will require development of host country expertise and funding.

We have developed the following suggested staffing pattern for Phase II. Obviously, it should be viewed as a guide since precise project requirements, levels of effort and funding levels need to be developed.

Suggested Project Staffing - Second Phase - Expatriate Technical Advisors

Soil Survey Party Leader (Soil Scientist)

Soil Scientist - Assistant (Soil Scientist)

Land Use Party Leader (Geographer)

Land Use Technician (Image Interpreter)

Agricultural Planner - To direct use and interpretation of soils and land use data (Land Use Planning Expert/Economist)

Counterparts Needed (Yemeni) for :

Soil Scientist

Land Use Inventory

Land Use Planning

Trainees - Yemeni:

Soils - 2

Land Use Inventory - 2

Land Use Planner - 1

G. Training

With respect to training, we suggest the following:

- Increased levels of in-country training for Yemeni officials involved in agricultural planning. It is important that as many officials as possible be able to review, analyze and understand the product developed.
- To increase the pool of prospective trainees, candidates should be identified earlier and be exposed to the project and its activities through internships, part-time assignments, lectures, et al. Individuals with the greatest potential can then be considered for long-term external training.

- The issue of retaining trained technicians is not easily solved. It is a problem that the YARG shares with most of the developing world. One potential solution is to tie external training to a specified period of government service to commence after the training program has been completed. Trainees understand beforehand what obligation they have to the project (YARG) and are more likely to return.

The establishment of an Office of Soil Survey and Land Classification would also hold out the potential for career growth within the Government that presently may not exist for these technical disciplines.

H. Administration and Logistics

Project Staffing

One of the more sensitive issues for all parties in development projects is the selection, approval and placement of expatriate technical advisors. In this project it was nearly one year from the signing of the contract to the arrival of the expatriate team. While the delay did not prove insurmountable from a technical standpoint, it did add to the cost of this Project. We strongly suggest that solutions be considered to narrow this time frame. The continuity of Phase I to Phase II is extremely important. Naturally, there will be overlap in definitizing the scope of work, funding levels,

conditions precedent, et al. -- these are expected. There should be no reason, however, that additional delays should be incurred because of delays in project staffing.

We recommend that whatever contracting mechanism for Phase II is utilized, the contractor should submit the nomination of individuals committed to working in the YAR for review by AID/W, USAID/Yemen, and the YARG before any contract is signed. This option can save time and money for the project, allowing for more expeditious placement of a team, perhaps within 30-60 days after contract execution.

USAID/Yemen Assistance to Contractor

The field technician soil seientist on Project 042 had to spend a large segment of non-technical time coping with customs clearance of project supplies and equipment, arranging transportation, obtaining licenses and clearances, etc., that were necessary to perform his technical duties. The USAID Mission should provide advice, assistance and support in job-related needs, where possible, to enable the technicians to spend the maximum amount of time on the completion of the technical aspects of the project. One solution may be the funding for a short-term local-hire administrative assistant familiar with the local scene to assist the technical assistance team in these matters.

Equipment Procurement

It is strongly recommended that USAID and the Contractor consult with the Soil Survey Party Leader or the SCS/USDA concerning field equipment needs prior to the initiation of the detailed soil survey to avoid receipt of unnecessary or inappropriate field and laboratory equipment.

Contractor Selection

It is often considered wise to select the same contractor who successfully implemented Phase I of a project for follow-on Phase II work.

In this case, however, there is an important caveat. There were evident problems of communication and cooperation within the contractor organization that affected the quality of the project to some extent. These problems must be resolved and a cooperative unified approach toward completing objectives must be exhibited before the contractor should be considered for second phase work.

Annex I

Annex I

THE ADMINISTRATION AND TECHNICAL PROCEDURES OF THE OFFICE OF THE NATIONAL SOIL SURVEY, MINISTRY OF AGRICULTURE, YEMEN ARAB REPUBLIC

This annex provides a proposed policy for making soil surveys in the Yemen Arab Republic. This policy should become effective on the date of the commencement of any follow-up project concerned with detailed soil surveys. If, after a period of time, revisions are needed in this policy statement, they should be made, as required, to provide a clear and continuing program for conducting soil surveys in Yemen.

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MINISTRY OF AGRICULTURE,
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Introduction -- The National Soil Survey of Yemen may be said to have had its beginning in the Spring of 1980. It began with the reconnaissance soil survey of the entire nation of Yemen as conducted by Cornell University. This survey is expected to be completed in December, 1982.

The General Soil Map and Descriptive Legend for this modern reconnaissance soil survey adhered closely to the technical requirements of soil survey techniques, Soil Taxonomy and updated report-writing procedures of the U.S.D.A.

Although the organizational format for a National Soil Survey was not conceived at this early date, the need to bring together the multiplicity of variables inherent in the soil survey procedures and soil taxonomies of various, earlier donor nations was readily recognized.

The current reconnaissance soil survey by Cornell University covers an estimated 75,000 square miles, or approximately 48,000,000 acres (22,000,000 hectares), but now the project is faced with the possible future task of mapping detailed soil surveys on nearly 4,000,000 acres, hopefully, within the next decade.

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Whereas the reconnaissance soil surveys accommodate only larger areas which are limited to broad area planning, the detailed soil surveys will permit detailed planning of use and management on areas as small as 40 acres.

In order to achieve this rather ambitious future goal of a national detailed soil survey, as stated above, the Office of Soil Survey should encourage adherence by all project groups to a basic national system of soil survey so as to avoid duplication of efforts. It should further recommend that the Office of Soil Survey be designated as a clearinghouse for all technical matters pertaining to soils and soil surveys. The adoption of these suggestions, coupled with other recommendations requisite for an efficiently-operating Office of Soil Survey are discussed in the following pages.

Purpose of the Office of Soil Survey -- The Office of Soil Survey is directly concerned with those researches necessary (1) to determine the important characteristics of soils, (2) to classify soils into defined types and other classificational units, (3) to establish and to plot on maps the boundaries among kinds of soils, and (4) to correlate and to predict the adaptability of soils to various crops, grasses and trees, their behavior and productivity under different management systems, and the yields of adapted crops under defined sets of management practices.

The fundamental purpose of a soil survey is to make predictions. Although the results of soil surveys are being applied increasingly to engineering problems, such as the design and maintenance of highways, pipelines and building sites, applications in Yemen are chiefly in the field of agriculture.

The different kinds of soil in Yemen have dissimilar management requirements for economic, sustained production. Throughout the centuries Yemen's farm families have learned through trial and error what crops to plant and what methods work best on their various fields. With the development of modern science, however, efficiencies in agriculture began to manifest themselves. For example, soil survey throughout the world became the basis for classifying, synthesizing, and reporting results in soil research and experience. Yemen, in concert with many other countries, recognized the need to distinguish among its various soils and to use each soil according to its capability. The result has been the adoption by Yemen of soil maps to serve as the basis for differential crop recommendations.

Long-Range Objectives of the National Soil Survey -- The National Survey of Yemen, recommended at a scale of 1:10,000, could be expected to be completed in ten or more years. This overall survey would be designed to furnish soil maps and interpretations needed in research and educational programs, in technical assistance to farmers, and in other programs dealing with soils and soil use.

This long-range plan would aid in budgeting funds and in assigning people for efficient and orderly completion of soil mapping. The completed soil survey would establish accurately the nature and location of the kinds of soil in the Nation. The nature of the soils would be studied, in relation to research and experience. This would serve to predict the yield and quantity of crops, forage and trees that might be obtained under defined systems of management, and to predict the effects of such use on the soil. Such predictions would enable technicians to make practical recommendations for the use and management of specific fields or tracts with the highest efficiency made possible by modern technology. Capability or suitability groupings of the soil would be used for convenient arrangements of predictions about similar soils.

Completion of the National Soil Survey within ten or more years takes for granted that the Office of Soil Survey would remain staffed with (1) an Administrative Soil Scientist and his National Counterpart, (2) an Assistant Soil Scientist, and (3) one or two Soil Scientist (Mappers). Their work, hopefully, would be augmented from time to time by volunteer or consultant (professional) soil scientists assigned to donor projects by various Nations.

Local nationals would be trained at all levels in the program of soil survey so that they might assume full responsibility for the Office of Soil Survey as soon as they had developed optimum technical and administrative competence in the Soil Survey program.

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Organization of the Soil Survey Staff -- From the outset of any soil survey program there should be (1) a clear understanding of the nature, area and extent of the work to be done, (2) the role that would be taken by each member of the soil survey staff or by those serving on the semi-autonomous donor projects, and (3) the channels of administrative and technical responsibility assumed by each participant.

In brief, the Administrative Soil Scientist and his National Counterpart would serve jointly as head of the Office of Soil Survey and be directly under the administrative authority of the MOA. The Administrative Soil Scientist and his counterpart would be aided at high technical levels by the Assistant Soil Scientist who would be assigned major responsibility for one or more important phases of the work (i.e., interpretations). One or more Peace Corps or UN Volunteers who serve as Soil Scientists (Mappers) could assist in field mapping, sample collecting, etc.

The latter arrangement proved to be so harmonious and productive in a survey program instituted in Lesotho that other donor projects were encouraged by the Office of Soil Survey to solicit similar volunteers to conduct soil surveys and/or to provide guidance in the use of soil survey information. This program served to upgrade soil survey proficiency and to expedite completion of the National Soil Survey. It is well to point out, however, that there must remain a central office of soil correlation.

Expatriate soil scientists, both professional and volunteers, employed on or serving with such semi-autonomous projects, must remain under the technical guidance of the Office of National Soil Survey and must conform to the technical requirements as set forth for staff members by that office.

(In the foregoing and following statements, any references to "Soil Scientists" is to be construed as either expatriate personnel or Yemen Nationals.)

The general specifications, plan and assignment of professional workers, as well as volunteers, within the Ministry of Agriculture, but excepting some administrative responsibilities of those serving on donor projects, are set forth in the following paragraphs.

The Office of Soil Survey is responsible for all soil survey activities in the Nation, and the Administrative Soil Scientist and his counterpart, working under the administrative direction of the MOA, are responsible for seeing that all aspects of the National Soil Survey are carried forth efficiently and vigorously.

The Administrative Soil Scientist, his national counterpart, and the Assistant Soil Scientist will serve the purposes of the MOA in providing full scientific and technical guidance in the Soil Survey. They will insure that the soil survey work meets highest standards. They will give attention within the Ministry of Agriculture to (1) assignment or approval of Soil Scientists

to accomplish related work of high quality; (2) transfers and details of Soil Scientists (nationals) to give able men experience in different soil areas to help prepare them for more responsible positions; (3) technical supervision and review of the soil survey work; and (4) orderly scheduling of the soil survey work and related activities, including field mapping, description of soils, and the work needed for soil survey interpretations, classification, correlation and investigations.

Assignments will be made with reference to the needs for soil surveys, nature of the soils to be surveyed, training and experience of the soil scientists available, and opportunities for development of capable Nationals through varied experience. The Administrative Soil Scientist and his counterpart will also assist their immediate superiors in analyzing work loads and staff requirements.

In collaboration with his national counterpart and the Assistant Soil Scientist, the Administrative Soil Scientist will assume the responsibility for mapping, classification, correlation, interpretation, investigations into soil genesis, morphology and classification, and for insuring close-working relationships with those who use and apply the results. To the extent possible, the Administrative Soil Scientist, his counterpart and the Assistant Soil Scientist will utilize the standard nomenclature developed in the National Soil Survey and will make full use of earlier-acquired soil survey and laboratory data. They will give technical

leadership within the Nation to a comprehensive program of soil survey interpretation and publication. This will include the development of yield estimates, productivity ratings, management requirements, use capability, and technical groupings of the kinds of soil mapped in the field and shown on soil maps. Special reference will be made to the requirements of soil and water conservation, education and research programs of national groups needing and using soil survey information. They will plan and give technical leadership to investigations of soil formation, soil geography, and laboratory analyses of soils and will contribute to an understanding of the basic principles of their behavior and change.

Soil Survey Field and Laboratory Activities -- All members of the Soil Survey Staff will be directly concerned with the field mapping of soils. In the conduct of their survey assignments they will observe the steepness, length and shape of slopes, the size and nature of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They will dig many holes to expose soil profiles and will study and record the characteristics and qualities observed. They they will classify and name the soils according the the Yemen-wide, uniform procedure as set forth in the U.S.D.A. Soil Taxonomy.

After classifying and naming the soils, the soil scientists will draw boundaries of the individual soils on aerial photographs.

While the survey is in progress, the soil scientists will take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kind of soil in other places also will be assembled. Data on yields of crops under defined practics will be assembled from farm records (where available) and from field or plot experiments on the same kind of soil. Yields under defined management will be estimated for all the soils.

The more experienced soil scientists will not only observe how soils behave when used as a growing place for native and cultivated plants, but also, where needed, as material for engineering structures, foundations for structures, or covering for structures. They will relate this behavior to properties of the soils.

Thus the soil scientists will use observations and knowledge of soil properties, together with available data, to predict limitations or suitability of soils for present or potential uses.

After data have been collected and tested for the benchmark or representative soils in the survey area, the soil scientist will set up trial groups of soils. They will test these groups by further study and by consultation with farmers, agronomists, engineers and others. They then will adjust the soil groups according to the results of their studies and consultations. Thus the soil groups that are finally evolved will reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

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The soil survey staff, with other members of the MOA, including the Offices of Planning, Extension and others, will help determine the form and content of the Soil Survey Report and accompanying maps, so as to make them adequate and easy to understand. The soil scientists also will be expected to furnish basic facts and predictions to guide programs in areas of special soil erosion or other land use programs.

In carrying out these functions, the field soil scientist will be expected to improve as he gains experience, and as he utilizes experiences of others by keeping in touch with the literature.

The procedure adopted for soil mapping in Yemen will need to conform to the method employed by the U.S. Department of Agriculture. The soils will be identified, mapped, classified and interpreted at the series or phase level, and each will show its subgroup and family placements in the U.S.D.A. Soil Taxonomy.

It is hoped eventually that the Office of Soil Survey will maintain and operate its own laboratory for chemical and physical analyses of soils. This laboratory would be used only for the characterization of the soil unit and would not be used to conduct fertility or other forms of analyses for other government agencies or for the public-at-large. This would avoid duplication of the responsibility that could officially be assigned to the other laboratories.

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The Descriptive Legend -- At the beginning of each major soil survey within the National Survey, there would be prepared a descriptive legend which is, in effect, the initial part of a soils handbook for that appropriate geographic area. In the initial draft of the descriptive legend there would be three minimum requirements: (1) the identification legend of mapping units and symbols by which they are identified; (2) a description of each mapping unit; and (3) a table showing the characteristics and genetic relationships of each of the units.

As soon as possible a fourth section should be added, explaining the principal geological and topographic features of the area for guidance of the soil scientist and others. As the work progresses, an interpretation of each mapping unit would be made which includes basically the alternative systems of management together with yield estimates (where available) and the effects of the alternative systems of management on long-time productivity. This information is basic for capability groupings and other groupings of the soils. In its advanced development the descriptive legend includes a complete record of the research applicable to each soil unit, and its interpretation for technicians and others using the survey prior to publication.

The legend, descriptions and tables will be available to all mappers, and users of the maps during the survey. Whenever it is necessary to add a new soil mapping unit to the legend, this new

unit must be approved by the Administrative Soil Scientist or his designated representative. All legends in use by both surveyors and users of the survey must be kept current in regard to these additions.

A uniform approach to the classification of soils in all surveys is needed so that the mapping units can be properly identified in the Nation-wide system of soil classification. For most surveys at least, this will require a definition of each mapping unit in terms of a soil type or phase. On lands capable of only extensive use, mapping units may be soil associations, defined in terms of two or more soil taxonomic units. The highest usefulness of the mapping (i.e., experimental plots, dam sites, etc.) requires that legends of detailed surveys consist chiefly of mapping units that are refined subdivisions of soil types.

In the reconnaissance surveys, mapping units have consisted mainly of combinations of soil types not necessarily alike in their properties but occurring in characteristic patterns. To relate reconnaissance mapping units to the nationwide system of soil classification, the soil types occurring within a mapping unit and their approximate proportions and locations must be known.

Descriptive legends in use on all currently active surveys should be reviewed by the Administrative Soil Scientist or his

designated representative in the light of the principles stated above. The following suggestions are intended as guides in this review.

- Area where mapping is just getting well underway should be reviewed to consider how well the legend being used meets the requirements described above. The legend should be adjusted where necessary to meet these requirements. Where the legend is revised, completed mapping should be revised to fit the new legend as soon as this revision can be fitted into the survey schedule.

- Areas where considerable mapping has been done (approximately 25-75% complete) should be examined to see how well the legend and mapping meet the requirements given for legends. Units that are too broad to permit effective application of information should be subdivided with as little change in the numbering as possible. The units in use should be defined in terms of series, types and phases wherever possible; using complexes, associations, or groups of similar soils for units broader than the currently recognized series, types and phases in the area.

- Surveys completed or nearly complete should be reviewed, and the mapping revised wherever this is necessary to promote technically sound agricultural plans or to provide a scientifically sound classification for publication Legends describing the units in terms of soil types or

suitable groups of types, as well as in connotative terms, should be prepared and made available to interested parties for use with copies of field sheets.

Records of Time and Progress -- A continuous record will need to be kept by the soil scientists in each survey area of acres of soils surveyed, type of survey and time.

Narrative and Oral Reports -- The Administrative Soil Scientist, his Counterpart and the Assistant Soil Scientist will prepare each month a schedule of proposed activities and, at the regular staff meetings, present oral or narrative statements of their own most important activities and comments about significant progress of soil survey work in the Nation.

Annual Plan of Operation -- Within the framework of a ten-year objective of the MOA, an annual plan of soil survey operations for the Nation should be provided. The Administrative Soil Scientist and his National Counterpart will assume responsibility for developing this plan. This rather informal plan will be submitted to the MOA for use in planning National aspects of the agricultural program. The annual plan should contain a statement of work to be done, including where, how, when and by whom. The annual plan should be prepared at the beginning of the calendar year and should contain information on at least the following items:

- Status of earlier soil surveys; new areas to be surveyed; total acreage of each; acreage surveyed to date (by kinds of surveys if significant); and survey goals for the period.

- Soil survey areas in which field mapping will be completed.

- Soil survey reports to be written.

- Training of National Soil Scientists.

- Interpretation of soil surveys.

- Soil descriptions, and descriptive legends or soils handbooks.

- Supervision and field reviews of surveys.

- Coordination of soils work within the survey areas.

- Work on correlation of soil surveys.

- Soil survey investigations.

- Names of soil scientists expected to be assigned, including planned transfers and details of soil scientists.

Soil Survey Work Plans -- Soil survey work in each major survey area (50,000 acres) within the Nation should be covered by a survey work plan. Each work plan for a soil survey should contain specific statements about preparation of soil survey report (if

required) and of the materials needed for compilation of the soil map for publication. This plan will be prepared by the Administrative Soil Scientist, his Counterpart and/or the Assistant Soil Scientist, and submitted to the MOA.

Field Reviews -- The ultimate usefulness of soil classification and soil mapping depends upon accurate soil correlation. This process involves: (1) comparing local classificational units with those already defined and named in the adopted USDA system of classification; (2) recognizing, establishing, and naming the new units consistent with the system; (3) grouping taxonomic units into series, families, or associations and subgroups; (4) grouping geographic units into named and defined soil associations; and (5) arranging the units into keys or groups, as needed to bring out principles and relationships, according to observed characteristics, inferred qualities, genetic factors, or combinations of these.

It is the responsibility of the Administrative Soil Scientist, his National Counterpart, and the Assistant Soil Scientist to aid other National Soil Scientists (Mappers) in defining the units in their survey areas so that their appropriate correlation and nomenclature will be facilitated. At the same time they should avoid any possible warping of the definition of local units in anticipation of particular correlations. Their first responsibility is to see to it that the classification in the survey area is internally consistent and adequate. Names of established units should not be

given the local units until they are reasonably certain that correlation will hold in the subsequent review; else workers in the survey party may get a name associated with a wrong set of soil characteristics.

Since the Administrative Soil Scientist and his National Counterpart are charged with the responsibility for classification, mapping and report writing for adequacy and accuracy, as well as with correlation, they will be required to conduct periodic field reviews or inspections of large survey areas (50,000 acres) as follow:

- Initial

  An initial field review is made at, or shortly after, the beginning of each survey and follows the preliminary investigation.

- Progress

  Progress field reviews are made periodically during the survey to guide the survey party and to insure that field work is of adequate quality. A comprehensive progress field review, which covers all segments of survey work, is required half-way through the field mapping.

- <u>Final</u>

  A final field review is conducted when the field mapping is complete but while the field party is still in the survey area so that necessary corrections can be made.

For areas less than 50,000 acres, only an initial and final review or inspection will be required.

In consequence of the above, if the National Soil Survey is thus carefully planned, properly staffed and ably executed, it will enable its many users in Yemen to make reliable predictions concerning profitable and safe use of the land.