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USDA/PASA Team Report

Institutional Strengthening for Control of Erosion and Improvement of Agriculture in Haiti

Prepared for the
Division of Natural Resources of the Haitian Department of Agriculture
and the
United States Agency for International Development
(USAID/Haiti)
by the
United States Department of Agriculture

Team Members:
Walter J. Ochs, Leader, SCS
O'Gene W. Barkemeyer, SCS
Donald H. Fulton, SCS
Robert E. Gray, OICD
Gerald Latshaw, SCS

Washington, D.C.
February, 1979

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Acknowledgements

The USDA/PASA team at the request of the United States Agency for International Development and the Haitian Department of Agriculture visited Haiti during the period of January 17 — February 14, 1979. The team spent the month obtaining viewpoints from Haitian Officials and other interested parties as well as officials of USAID. We visited numerous field sites where soil conservation and irrigation work was in progress. All of the four areas in the Integrated Agricultural Development Project were visited as well as the Limbé Area. Soil erosion problems were observed during these trips.

The observations and recommendations of this report represent our best effort and are presented with the genuine interest in improving the soil conservation and irrigation in Haiti. We feel confident that major improvements in the social well being and agricultural economy can be achieved if the efforts proposed are carried out.

The team wishes to express its sincere appreciation to the Government of Haiti officials for the assistance and courtesies extended. A special thank you for the help provided is extended to the Director General of the Department of Agriculture — Mr. Marcel Depestre, Mr. Joseph Wainwright — Director of the Division of Natural Resources and numerous other employees of the Division such as Y. Guéry, F. Nivose, L. Brisson. Mr. R. Cassagnol — Coordinator for USAID Projects are given our sincere appreciation.

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I. Summary

A. Issues

Soil erosion in its many manifestations is perhaps the most basic and, in the long-run, the most serious constraint to increased agricultural production in Haiti (24). It has been cited as a major reason for the very slow growth of agricultural production over the past 15-20 years. The problem manifests itself in several ways:

1. simple reduction in volume of soil resources;
2. reduction in soil fertility;
3. development of "pseudo-droughts"; and
4. wash-outs and clogging of irrigation and human water supply systems.

The true scope of the soil erosion problem is difficult to estimate, although previous studies have identified the problem as severe and widespread. Ewell (A) calls Haiti's massive soil erosion problem the worst case of widespread land abuse in the Western Hemisphere. A USAID/HAITI and Ministry of Agriculture study in 1962 (15) estimated that eighty percent of the cultivated land was suffering from soil erosion; most was described as severely eroded.

The country-wide population density of more than 160 people to the square kilometer (or over 400 per square mile) is already pushing human carrying capacity to the limit considering present levels of technology and development of infrastructure. This is especially true as the quantities of land with less than 25 per cent slope, adequate soil depth and fertility, and adequate rainfall or irrigation possibilities are very limited.

Soil erosion is certainly not a new problem in Haiti. It has been studied and warnings have been issued for decades. Yet, no nationwide educational or control programs have been implemented. The Haitian Department of Agriculture, Natural Resources and Rural Development (DARNDR) up to this point has simply not had the trained personnel, financing, nor the mandate to mount a major conservation and rehabilitation program.

The following report, based upon a short-term but intensive review of literature and wide-spread travel within Haiti by Soil Conservation Service (SCS) representatives, outlines what we believe to be a logical and systematic approach by which to begin to alleviate Haiti's severe and growing soil and water conservation and utilization problems.

In designing the proposed program, the SCS team has been fully cognizant of the view shared by virtually all authors on Haitian soil and water conservation problems. That is, that Haiti's social, political and economic framework may be the ultimate cause of the serious degradation of its natural resource base.

It should be noted that the Team did not evaluate possible income distribution or other equity effects of the proposed program. Such items as land ownership and land tenure may possibly become important issues if the program is successful. The make-up of this team and the time available in Haiti precluded major analyses of these issues.

However, the team considers that the erosion situation in Haiti is so critical that the proposed program should be implemented as quickly as possible. Other studies or programs related to equity issues could be undertaken simultaneously with the implementation of this proposed program.

B. Recommendations

1. Short Range Institutional Recommendations

a. National Level

(1) A proposed new organizational structure is recommended for the Haitian Department of Agriculture. The proposals are noted on Figures 1. 2. & 3. of Section II, Part B.

(2) A combined institutional and grass roots participation development project should be designed to allow expertise from the Soil Conservation Service (SCS) of the U.S. Department of Agriculture to assist in the process of alleviating Haiti's severe soil erosion and water utilization and management problems.

(3) A sound agreement and working arrangement should be developed among AID, the Soil Conservation Service, and the Haitian Department of Agriculture (DARNDR) as to the program to be carried out, the responsibilities of each entity, and day-to-day working relationships prior to requesting USDA participation.

(4) A seven person team from the Soil Conservation Service, proposed to be located in Port-au-Prince, would provide the Haitian Department of Agriculture with institutional management, and technical assistance expertise. The U.S. team would be composed of a senior conservationist as leader for the entire SCS effort, a conservation-irrigation engineer, a tropical agronomist, a vegetative-livestock specialist, forester, soil scientist, and a soil conservationist. This team would provide assistance for the Thomazeau project. A conservation technician should also be located in Port-au-Prince to work full time on Thomazeau. If a concentrated effort is made and maintained by the Government of Haiti, it is believed that adequate Haitian personnel can be developed within six years to carry on the soil and water conservation work without the presence of the long-term technical assistance teams.

(5) The availability of Haitian co-workers to work with and to receive on-the-job and other general and specialized training from the U.S. personnel is absolutely essential to the success of the effort to stem soil erosion and water utilization problems in Haiti. The project should not move forward without the strongest kind of commitment by the Haitian Government on this point.

b. Local Level

(1) A field USDA team of four people is proposed to assist GOH personnel in implementing action programs as partially defined in the USAID/H approved **Integrated Agricultural Development Project.** The USDA team which would consist of a soil conservationist, soil scientist, engineer, and conservation technician, would be stationed at Les Cayes and would work day-to-day with Haitian technicians, providing technical and organizational training, and would assist in gaining and utilizing small farmer and group participation in the conservation efforts.

(2) We recommend that staffing of the Les Cayes team follow the placement of the central team. Timing should be determined by AID and the GOH. Funding should be available and payment procedures should be developed to provide sufficient and timely transport of personnel, prompt repair of vehicles and equipment, purchase of needed supplies and equipment, payment to farmers or temporary laborers for jobs performed, etc.

c. Education

(1) The GOH must commit employees to the soil conservation effort who are interested and capable of absorbing training and who will have sufficient initiative to follow through after the technical assistance teams are gone.

(2) The long-term technical assistance teams with the help of their Haitian co-workers will be expected to organize and present formal training sessions from time to time for Department of Agriculture employees located at or near their offices.

(3) Joint office space should be provided for the long-term technical assistance teams and their Haitian co-workers.

(4) Short-term details to appropriate places for formal or informal training are proposed for selected DARNDR employees to accelerate the on-the-job training effort. These details should be designed to last from three to nine months and may involve as many as forty employees.

(5) The Soil Conservation Service Project Leader would be expected to evaluate the need and recommend requests for short-term out-of-country assistance as such assistance becomes necessary. The assistance may come from Hawaii, Puerto Rico, the mainland U.S. or other areas. Specialists in economics, soils, engineering, plant materials, livestock, geology and agronomy may be needed.

d. Coordination and Communication

(1) USAID/Haiti and GOH would be expected to provide adequate office space, housing, transportation, equipment, supplies, etc. for the long-term resident technicians.

(2) The USDA/PASA team recommends that a radio communication system be developed between Port-au-Prince and those field locations where reliable telephone communication is not now available.

2. Long-range Institutional Recommendations

It goes without saying that the long-range institutional recommendations are often composed of series of short-term recommendations. For the sake of brevity, the series of short-term recommendations will not be repeated here. There are, however, several long-term institutional recommendations which are not the apparent outgrowth of short-term recommendations. These are:

a. The ideas and techniques which proved successful during implementation of the Integrated Agricultural Development sub-projects should be extended to other areas of Haiti as soon as possible.

b. The USDA/PASA team recommends initiation of a long term improvement program of the Faculty of Agronomy and Veterinary Medicine to include additional and improved course work, and greater field participation, in the areas of soil conservation, soils irrigation, and related fields. The Central USDA Team with possible assistance from U.S. University personnel should assist Haitian education with this task.

3. Short-range Physical Recommendations

a. Resource Data

(1) A detailed soil survey at a scale of 1:25,000 should be done in the PIAI (Integrated Agricultural Development Project) areas.

(2) The aerial photography for soil survey and planning work should be ordered at least one year prior to the repatriating dates of the USDA soil and water Conservation Teams.

(3) The soil survey information should be used in preparing land use potential maps.

(4) Data on crops, conservation practices, and other technology should be collected by soil type to facilitate the transfer of technology to areas outside of the initial watershed.

(5) The USDA teams and the GOH should collect information and monitor the water resources within the project areas for use in planning for water conservation and utilization.

b. Watershed Protection

(1) Aerial photographs and geodetic survey maps must be available in each watershed office before planning begins. Map coverage should also include the irrigation project areas, as well.

(2) The Division of Natural Resources should request from the meteorological service a tabulation of existing climatic and stream data for each watershed. The Department should also seek additional instrumentation for each watershed.

(3) All data collection, planning, and application should be done on a sub-watershed basis. Priorities should be established by sub-watershed for the treatment of erosion problems.

(4) At least one pilot project per watershed should be established. Each pilot project must be continuously evaluated to learn from technical and organizational successes and failures.

c. Vegetation and Wildlife

(1) The tree nursery presently located at Damien should be continued at full production. The nurseries in each pilot demonstration area should be expanded and new ones established where needed.

(2) The areas and locations of state owned land in the Haitian pine forests should be determined and marked on a map at the scale of 1:25,000.

(3) Efforts should be made to educate the small farmer within the watershed areas of the values of crop rotations, strip cropping grass, seeding and shrub cultivations to complement forest production. These activities should also be implemented as quickly as possible.

(4) As there would be a need for large quantities of grass, legumes (nitrogen fixing plants) and shrub seed for use in erosion control, a plant materials center near Port-au-Prince should be established to satisfy this need. In the meantime field trials using native grass, forb, and shrub seed, should be established to determine which species would be best adapted to the various Departments when the erosion control activities would take place.

d. Irrigation, Drainage and Water Quality

(1) The Dubreuil and Jean Rabel Irrigation Project plans developed by the White Corporation consultations should be implemented.

(2) Plans should be developed for the rehabilitation and maintenance of irrigation systems in the Marigot and Thomazeau watersheds.

(3) Technical assistance should be given to small irrigation groups to improve their river diversion and water delivery systems.

(4) Photographs and maps — same recommendations as for Watershed Protection.

(5) Climatic and Stream data — same recommendation as for Watershed Protection.

4. Long-range Physical Recommendations

a. Resource Data

(1) A concerted effort should be made to recruit, organize, and train a staff of Haitian soil scientists so that the soil survey program can be conducted and completed by DARNDR.

b. Watershed Protection

(1) Based upon progress and performance of sub-watershed projects, erosion control work should expand to other sub-watersheds and then to other watersheds.

(2) The GOH through DARNDR should assume primary responsiblity for developing written technical guidance for the planning, designing, construction, and maintaining of conservation practices. USDA technical assistance teams should assist in this effort.

c. Vegetation and Wildlife

(1) An all-out effort should be mounted to develop all of the potentially irrigable land as soon as possible. This will help to counter-act the seasonal rainfall pattern which almost brings food production to a standstill in some areas during the dry seasons each year.

(2) Two National Forest Reserves — one in the Massif de la Selle and one in the Massif de la Hotte region — should be established and developed as the first step toward developing good management plans. The improvement of forests and wildlife will ultimately lead to better soil conservation.

(3) A desert brome study should be established in the area between Gonaives and Anse Rouge as a basis for developing improved management practices for the remainder of the desert area. Other practices such as water spreading should be tried in this study area.

(4) A National Wildlife Reserve should

be established in the region of Morne Chien in the North West District. Game animals should be introduced into the area and investigated as an additional potential source of revenue.

d. Irrigation, Drainage, and Water Quality

(1) The USDA teams should assist DARNDR in developing written technical guidance to assist individuals and groups of irrigators to practice irrigation water management.

(2) Springs, seeps and water harvesting systems should be developed to improve the quality and quantity of water for domestic, livestock, and irrigation uses.

C. Participation

1. Communities and Farmers

There seems to be a willingness by local community groups and farmers to participate in soil conservation and irrigation improvement work. This work has been hampered thus far as many farmers have not received the guidance they desire to perform soil conservation work. Others are not altogether aware of the need to do this work. Most irrigation farmers want help with irrigation system improvement, but few realize the potential benefits that they could receive from irrigation water management and on-farm irrigation system improvements. In general, it seems as if the farmers and local communities are ready to receive accelerated technical assistance or can be convinced of the need where applicable.

2. Government of Haiti

a. Department of Agriculture

The Haitian Department of Agriculture through the Division of Natural Resources has demonstrated its interest in embarking upon a program to alleviate the country's severe soil conservation and conservation irrigation problems. Personnel, equipment, and organizational coordination seem to be the limiting factors in performing the necessary work at this time.

b. Local Project Areas

Local community groups and project offices seem very anxious to start moving ahead to do the needed work. Personnel and equipment seem to be the primary constraints on providing the assistance needed by farmers. Local community groups are usually cooperative in helping to organize the farmers into work groups and in organizing educational meetings.

3. United States of America

a. An Integrated Agricultural Development Project

An Integrated Agricultural Development Project that encompasses the four areas proposed for long-term technical assistance has been developed by USAID and DARNDR. This project should provide a strong base for the technical assistance teams by providing some financing and other items needed for a successful soil and water conservation program in Haiti.

b. Potential Help From the U.S. Department of Agriculture (USDA)

The obvious organization to provide most of the long-term technical assistance is the Soil Conservation Service (SCS) of USDA. Personnel probably will be needed from other USDA organizations such as the Forest Service and the Economics, Statistics, and Cooperative Service — at least on a TDY basis.

c. Potential Help From Other Sources

Some TDY or long-term positions may require that people from organizations other than USDA be considered. For example, a tropical agronomist may be difficult to obtain from the USDA for a long-term assignment. Other sources such as university extension employees or private consultants may be able to provide some of the proposed long-term technical assistance but the Soil Conservation Service of USDA seems to provide a very similar type of assistance in the USA and should accept primary responsibilities for staffing the project.

II. The Report

A. General—The Project Setting

The primary goal of USDA provided technical assistance would be to help design and put into practice a workable soil conservation and water utilization system based upon the participation of thousands of Haitians having small farms. The USDA/PASA Team recognizes that social and economic objectives are of equal importance to the success of the project as are the technical objectives and probably more difficult to achieve. Project planning and project implementation would move forward within the overall frame-work of establishing conservation and resource utilization solutions which are (a) technically sound, (b) socially and economically acceptable to the farmer participants, and (c) organizationally manageable on a wide scale.

The dichotomy between what are traditionally called "institutional development" and "grass roots participation" is often pointed up as a choice which must be made in selecting a development strategy (9). The authors of this paper endorse neither approach exclusively in choosing a strategy to deal with Haitian soil and water problems and potentials. We propose an amalgamation of institutional development and grass roots participation techniques to serve as the conceptual, and actual, development framework. This, we would do through concentration upon both institutional development at the headquarters and project levels as well as upon developing strong farmer participation within the field. The amalgamated approach would be done by providing USDA technical, managerial, and educational expertise at two levels within the country. One level would be through the National Office of the Department of Agriculture, Division of Natural Resources. The second and equally important level would be through resident or TDY assignments at the sites of four primary conservation projects identified and funded through the Integrated Agricultural Development Project (No. 521-T-008). The four watershed/irrigation sites are Les Cayes, Marigot, Thomazeau, and Jean-Rabel. (See map—Appendix I).

The make-up and function of the Port-au-Prince based USDA team — because of the fact that it would be the first USDA team to be established in Haiti and its anticipated leadership and educational roles — is of vital importance to project success. The team would be led by a senior soil conservationist who is skilled and experienced in bringing about organizational efficiency development and management of personnel and budgets, project planning, evaluation, and public relations. A state conservationist — either active or recently retired — would carry the ideal qualifications for this job. The team leader would be assisted by senior specialists in forestry, tropical agronomy, soil science, vegetation-livestocks, soil conservation, and engineering. These specialists would be selected not only for their technical expertise but also for their ability to convey improved levels of management and efficiency to Haitian central office and field staff as well. They would work not only with staff within the Division of Natural Resources but would provide field assistance for the Thomazeau Project and technical support for a team initially located in Les Cayes. A conservation technician would also be located in Port-au-Prince to provide day-to-day assistance at Thomazeau.

The proposed USDA field team, likewise, would provide both institutional support for DARNDR and development of the grass roots participation element of small farmers as they would be simultaneously in daily contact with DARNDR technicians, community leaders, and small farmers. A substantial portion of the day-to-day education and training of these groups would be the responsibility of the USDA field team members.

1. Implementation

The work recommended will help the GOH and AID in providing needed guidance to farmers for soil conservation and conservation irrigation. The primary effort of the long-term teams would be to help train DARNDR employees on how to gather necessary resource data, plan integrated soil conservation measures in watersheds, plan conservation irrigation systems, and provide effective technical assistance to farmers. This assistance can be implemented by providing long-term technical assistance teams familiar with working directly with farmers to motivate and instruct them on the installation of a correct combination of soil and water conservation practices for their tract of land. To do this, the GOH will have to commit employees to the effort that are capable of absorbing the training and have enough initiative to follow through after the technical assistance teams have gone.

The GOH employees should work as co-workers with the long-term technical assistance team members to receive on-the-job training. Short-term details to the USA should be arranged for some DARNDR employees to accelerate the on-the-job training. Training sessions should be organized from time to time by the long-term assistance teams to provide formal training in soil and water conservation. Long-range objectives should include improvement of the curricula at the Faculty of Agronomy and Veterinary Medicine to include more courses and expanded courses in soil conservation, soils, conservation irrigation and other related areas as well as field experiences.

To implement a sound soil and water conservation program in Haiti, it is also recommended that some adjustments be made in the organization of DARNDR. The changes should help provide efficient operation of this organization and also provide the technical support needed by field staffs. Some changes at the local level will also help in the implementation of a soil and water conservation program. Generally, these changes are designed to improve the coordination and communication between the National and field offices.

2. Long-term Technical Assistance

Long-term technical assistance to the Haitian Department of Agriculture (Division of Natural Resources) for soil conservation, resource data collection, irrigation, and resource conservation planning would be beneficial. The Soil Conservation Service of the United States Department of Agriculture is the logical organization to provide teams through USAID for this assistance.

a. Make-up and location of long-term technical assistance teams

The central team should be located in Port-au-Prince so members can work directly with the National Office of the Haitian Department of Agriculture and USAID. The central team should also provide field assistance for the Thomazeau Project area and technical support for the field team located at Les Cayes and TDY personnel located in any other area but particularly in the other two PDAI areas. This team should have a Leader and specialists in forestry, tropical agronomy, soil conservation, range conservation, soil science, and engineering. A conservation technician should be attached to this team to provide the day-by-day field assistance at Thomazeau.

The field technical assistance team should be made up of a soil conservationist, soil scientist, engineer and conservation technician. One of these team members should be designated as the field team leader. The Haitian Department of Agriculture would be expected to provide co-workers to work with each individual specialist or technician provided through USAID. These co-workers should have a background that is adequate to absorb the on-the-job training to be provided by the technical assistance team members.

b. Working Arrangements and Length of Assistance

A sound working arrangement between AID specialists, technical assistance teams, and their co-workers should be agreed upon prior to the requesting of the assistance

teams. The length of this technical assistance effort is difficult to estimate. The duration of assistance would depend principally upon the commitment of the Government of Haiti to provide the resources and personnel to solve the very serious erosion and water management problems. It is felt that with a strong effort by the GOH, adequate personnel would be trained to carry on the work within six years.

3. Housing for the Technical Assistance Teams

Housing for the technical assistance team members and their families would be provided by USAID. This would include the necessary furniture and facilities for reasonable comfort. The central team members would be located in residences in the Port-au-Prince area. Facilities for housing and office space probably should be constructed in or near the Les Cayes project area. Housing adequate for TDY assignments in Jean Rabel and Marigot projects should also be constructed.

4. Office Space for the Teams

Joint office space for the technical assistance teams and their co-workers should be secured or constructed by USAID or the GOH prior to the arrival of USDA team members. The office space should be furnished with desks, files, work tables, drafting tables, chairs, typewriters, electricity, air conditioners, duplicating machines, maps, calculators and office supplies for normal operations.

5. Transportation Requirements

Transportation would be provided for each USDA specialist and technician by USAID. This should consist of 4-wheel drive vehicles and should be available prior to the arrival of team members. In addition to the 4-wheel drive vehicles, one or two trail type motor bikes should be provided for each project area.

6. Priority for Staffing Project Areas

The central team should arrive first. It should be followed by a team for the Les Cayes area. The time for locating this second team should be set by the GOH and AID in consultation with the USDA team leader.

7. Long-term Conservation Program

The successful ideas and techniques acquired during the work on these integrated agricultural development projects should be used in other areas of Haiti as quickly as possible. The ultimate goal is to protect all of the significant sediment sources and conserve the soil. This must be integrated with conservation of soil and water on irrigated lands. To accomplish this, a priority system should be established for treating individual watersheds. The resource data collection would be an integral part of the establishing these priorities. This effort thus should also receive a substantial early emphasis.

Another important phase of the long-term conservation program should be to improve the internal training function within DARNDR and the formal education opportunities within the Faculty of Agronomy and Veterinary Medicine. This should help to provide the momentum to continue with a sound soil and water conservation program that would help to improve the economy and social well being of the people of Haiti.

B. Institutional and Educational

1. Existing Organizational Structure

The existing organization of the Department of Agriculture — Division of Natural Resources makes it very difficult to implement soil conservation and conservation irrigation work in an effective and efficient manner. The PASA team recommends a significant change in the organizational structure to improve efficiency and allow for better program management. The line and staff type organization that is proposed should also improve the coordination of inputs from other Divisions within the Department of Agriculture.

2. Short-range Institutional Changes

The organizational charts included with this report obviously cannot be used immediately. Positions should not be filled with people that have not had the education and experience to work effectively in each position. Individuals who take initiative and accept responsibility should be looked for and trained to work in the positions. Competent people are already available for many of the higher level positions and some of these may have to work in multiple positions until adequate personnel can be trained. Management training should be included in their training programs.

a. Soil Conservation, Forestry and Wildlife Service

Recent improvements have been made in this Service's organizational framework. Our proposal for a line and staff organization differs slightly from the present framework. The revision as noted in Figure 2 should provide an improved technology flow to field specialists and technicians. It should also allow for an improvement in the flow of ideas from field locations to the central office when new methods or materials are found to be effective. These ideas can then be screened for prompt use in other areas with similar conservation problems and erosion conditions.

b. Irrigation and Stream Control Service

We propose a change in the name of this Service. The new name suggested is the "Rural Engineering Service" which reflects the need for broader engineering inputs. Specifically, we recommend additional engineering input into the planning, design, and construction of some soil conservation practices. Practices such as terraces, small dams, larger grade stabilization structures, spring developments, etc. require engineering inputs to be certain that the practices will have a long and effective life. Organizational changes are similar to those previously proposed by the Service, but the suggested changes are designed to implement the line and staff organizational structure within the Division of Natural Resources. See Figure 3.

c. Soil Classification, Mapping and Interpretation Service

This organization is proposed to assume the responsibility for developing a soil survey for Haiti. Initially, the soil survey portion of the Service could consist of a one person staff at the National level. After the soil survey becomes operational with trained field parties, the staff should be expanded to at least three people. These would include a Leader plus a soil classification specialist and a soil interpretations specialist. The number of field parties and the number of soil scientists in each party will depend upon priorities and the availability of trained soil scientists. The soils laboratory and personnel at Damien would have to be expanded to be compatible with the soil survey expansion and the need for laboratory data by the other Services.

PROPOSED ORGANIZATION
for Implementing
SOIL CONSERVATION & IRRIGATION WORK
through the
HAITIAN DEPARTMENT OF AGRICULTURE

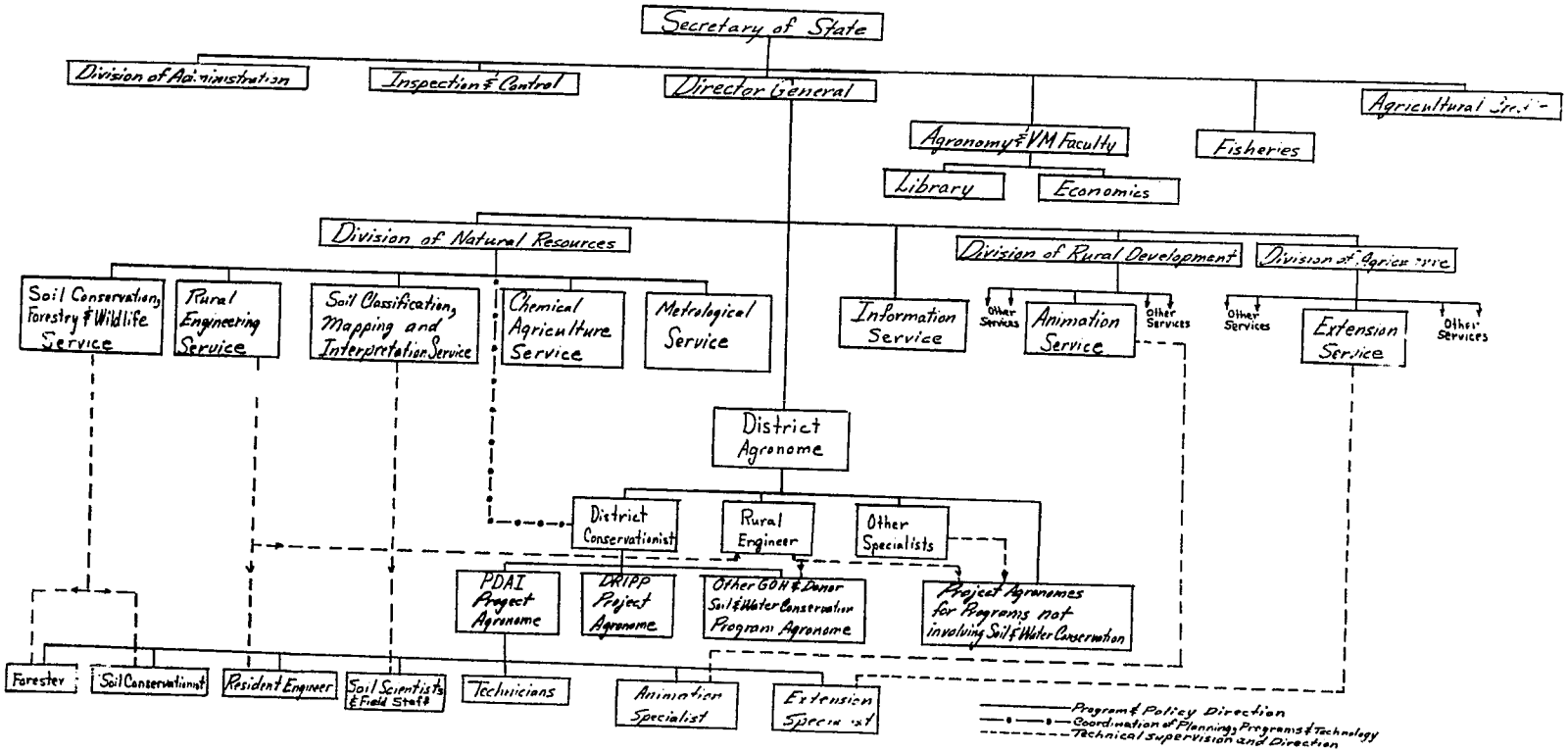


Figure 2.

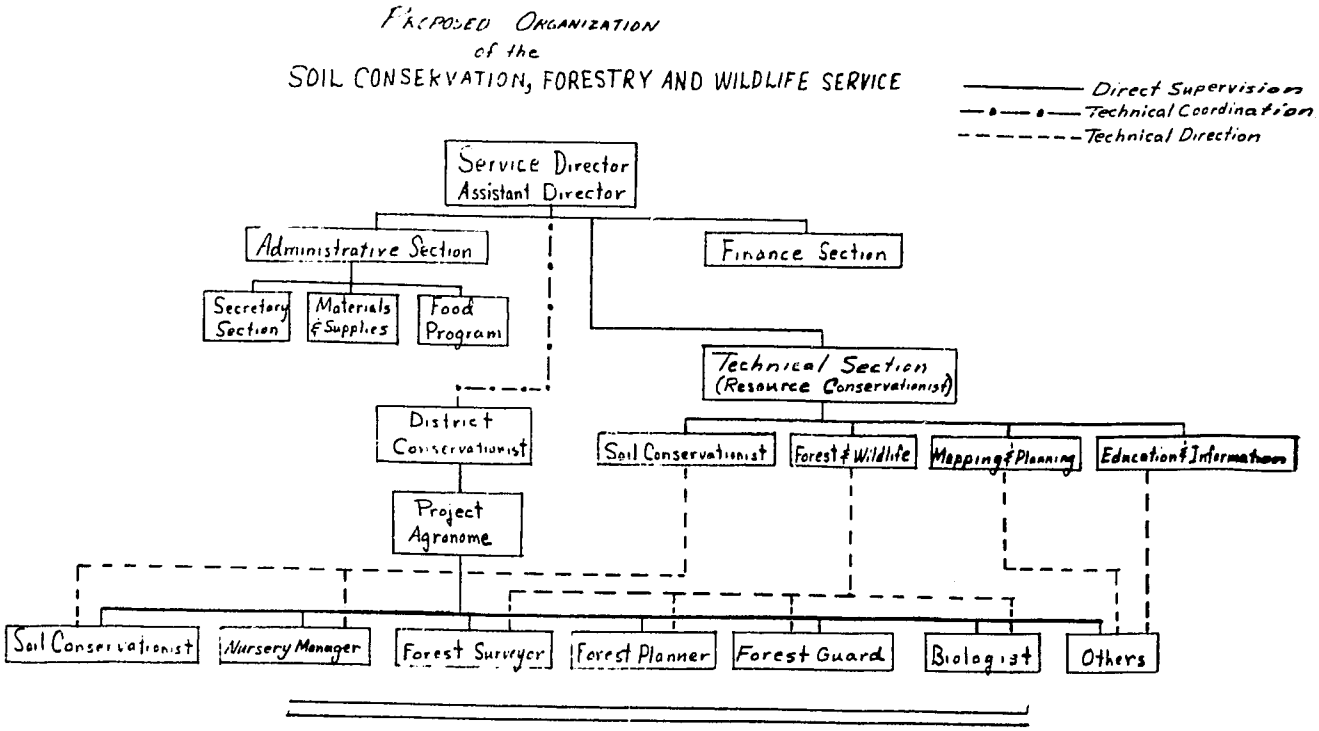
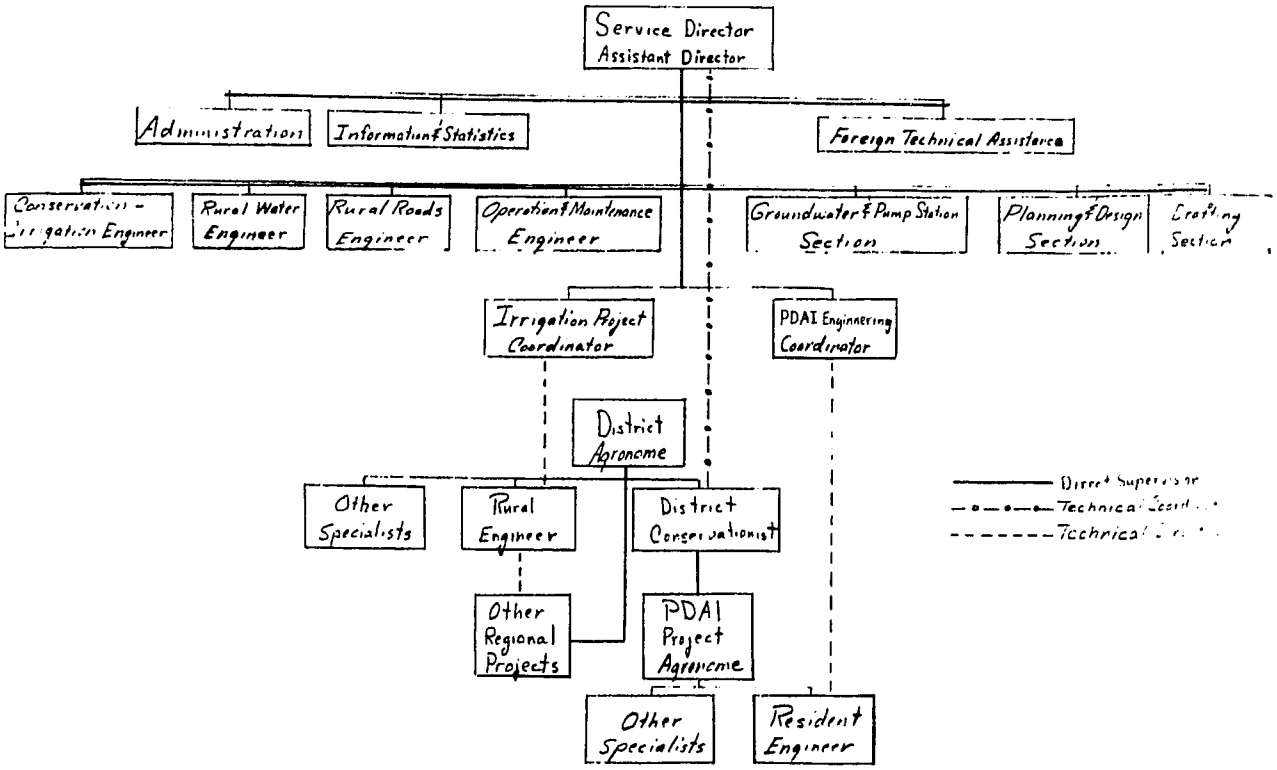


Figure 3.



3. Long-range Institutional Changes

The long-range organizational structure proposed for the Department of Agriculture is shown in Figure 1. This line and staff structure should facilitate coordination and implementation of efforts to solve the soil and water conservation problems of Haiti. Long-range organization charts are also provided for the Soil Conservation, Forestry and Wildlife Service in Figure 2 and the Rural Engineering Service in Figure 3. Most of the responsibilities for positions designated on these charts are rather obvious from the titles.

4. Education and Training

a. Co-workers and On-the-job Training

All work of the long-term technical assistance teams will be done by working with Haitian co-workers. This will provide an on-the-job training opportunity that is needed to develop competence and confidence in the employees of DARNDR. These co-workers will be expected to assist the long-term technical assistance teams in providing on-the-job training and some formal training sessions for other DARNDR employees that need the training.

b. Short-term Details

Some of the co-workers and other DARNDR employees should be selected for short-term details to appropriate places. They should receive on-the-job training during these details at field offices where accelerated experience can be gained on soil conservation and conservation irrigation. We recommend that these details be designed to last between three and nine months and that as many as forty employees could receive accelerated training in this manner.

c. Short-range Formal Training Sessions

The long-term technical assistance teams, with the help of their co-workers will be expected to organize and present formal training sessions from time-to-time for DARNDR employees located at or near their office. These training sessions should cover aspects of technical assistance that are more difficult to provide during the day-to-day on the job training. They should also be designed to reinforce the on-the-job training experience.

d. Long-range Formal Education Improvement

A program for improving the curricula at the Faculty of Agronomy and Veterinary Medicine to include more and improved courses in Soil Conservation, Conservation Irrigation, Soils and related fields should be developed. Opportunities should also be provided for students to gain field experience as part of their educational training. This is needed so that students receiving university degrees will be better equipped to deal with the major erosion and irrigation problems of Haiti. It is recommended that the central technical assistance team with possible TDY assistance from U.S. university personnel assist the Haitian educators in developing this program. This is a long-range proposal that should receive attention soon after the on-the-job training efforts have been initiated.

C. Resource Data

1. Soils

a. General Soil Map

(1) Background

A published general soil map is available in the report by OAS (13) at a scale of 1;250,000 but is not considered adequate for planning purposes. An additional general soil map of Haiti would be prepared within two years after the Soil Conservation team is assigned in the country in order to have an updated map.

(2) Specifications

Soil Taxonomy (18) would be used in preparing the legend for the map. Phases of sub-groups or soil series would be used so that adequate detail is provided for making broad area soil interpretations for Haiti. The scale of 1:250,000 would provide adequate detail although the final base map and scale would be selected by the Soil Conservation team and DARNDR. The map would be updated periodically as detailed soil surveys were completed.

(3) Objectives

The map units for the general soil map would be designed to provide maximum interpretative value in making a soil interpretation map for land-use potentials.

b. Detailed Soil Survey

(1) Background

Detailed soil surveys are not available in Haiti for operational planning. There are soil survey data published on selected areas such as the soil survey of the Artibonite Plain (7), but the information is not adequate for operational planning. The rural people depend mainly on subsistence-type agriculture. The dense population (greater than 400 people per sq. mile) and the small size of farm units (71 per cent are less than 1.3 hectares (24)) have resulted in the intensive use of the land. Haiti's topography is dominantly steep with some less sloping plains and nearly level areas adjacent to major streams. The cultivation of the steeply sloping lands has resulted in severe erosion and the degradation of the watersheds. The soils being irrigated are nearly level to gently sloping, and most are formed in stream alluvium. These soils are quite variable in texture, available water holding capacity, permeability, and other properties affecting irrigation management and crop selection. The upland soils are dominantly formed in residuum or colluvium from limestone. The soil texture, depth to bedrock, content of rock fragments, and other chemical and physical properties are quite variable. These differences have significant effects on crop adaptation, erosion hazard, conservation practices, and crop yields.

(2) Specifications

The soils would be classified using Soil Taxonomy (18). Soil series would also be defined and classified in order to implement the transfer of technology gained on erosion control practices, reforestation, crop adaptation, irrigation, salinity control, etc. Color infrared aerial photography is available for Haiti at a scale of 1:40,000. The following table shows the minimum size soil delineations on selected map scales.

Table 1. Minimum Size Delineations for Given Map Scales

Scale	Minimum Size Delineation* acres	hectares
1:250,000	623.0	250.0
1:40,000	16.9	6.8
1:25,000	6.2	2.5
1:15,840	2.5	1.0
1:7920	0.6	0.3

The mapping scale of 1:25,000 is suggested for the soil survey since it would allow enough detail for most operational planning and application. Topographic maps of Haiti are available at this scale which would help in standardizing the map scales used in the projects. There are selected areas, such as irrigated areas, which may need soil surveys with more detail. These areas could be soil surveyed, as needed, in the operation of the watershed projects. It is not considered practical to map the entire country at the large scale needed in the irrigated areas. The 1:40,000 scale would not provide enough detail in planning erosion control practices and management in the non-irrigated areas.

* Minimum size is considered an area of about a ¼ inch square.

The aerial photographs to be used for soil mapping would be obtained for the entire administrative area within the Haitian Department prior to assigning the conservation team to the project area. The photographs should be ordered at least one year prior to the reporting date of the team to avoid long delays in mapping progress. The following photographic material is needed:

One set of color infrared photographs at a scale of 1:40,000. Stereoscopic coverage would be obtained since these photos would be used for aerial photo interpretation. These photos would be used for vegetative surveys, land-use, etc., although the primary use would be for the soil survey. The hard slick surface of the paper used for these photos is not satisfactory for use as soil survey field sheets; therefore, black and white prints would be obtained for use as field sheets. It is suggested that full coverage of Haiti be obtained when ordering.

Three sets of black and white half-tone prints at a scale of 1:25,000. One set would be for soil mapping; the other two sets would be for conservation planning and other uses within the watershed area. See Appendix II for suggested methods to utilize the color infrared film to obtain these prints.

Two sets of black and white half-tone prints at a scale of 1:7920 of the areas designated for irrigation in the project areas. One set would be for irrigation planning and the other set would be used for special soil surveys (Order 1) when needed. A descriptive legend including the identification legend, soil series descriptions and mapping unit descriptions would be prepared for each project area. The guidelines in the USDA-SCS National Soils Handbook (17) would be used in developing the descriptive legend. The mapping units in the intensely used areas would be primarily phases of mono-taxa units or complexes (Order 2) and the steep to very steep lands would generally be mapped with phases of associations, undifferentiated units, complexes and in some cases mono-taxa units (Order 3).

(3) Objectives

(a) Short range — The soils in the watersheds would be identified, described, and classified. The mapping would be started as soon as adequate soil descriptions had been prepared from the watershed. The soil scientist and other team members would work closely in determining the design of mapping units. It might be necessary to phase mapping units for selected factors such as elevation. For example, a local technician indicated that mango trees do not bear fruit when growing at

700 meters above sea level or more. Soil erosion is the major soil conservation problem in most watersheds; therefore, eroded phases would be mapped where meaningful differentiations could be made.

The mapping priorities would be established within the project area by the team and in consultation with the DARNDR agronome. Generally, the mapping priority would be in the watershed and the areas designated for irrigation. Areas outside of the watershed would be mapped on a priority basis.

The major uses of the soil survey are for general planning of the watershed, application of conservation practices, crop selection, irrigation design, and irrigation water management. It would be the responsibility of the soil scientist to provide adequate training to the Haitian soil scientist co-worker so that he would be able to describe, classify and map soils after two years of on-the-job experience. A training plan would be prepared including all of the major training needs. Short, formal training sessions would be scheduled as needed in Port-au-Prince or in some cases in locations outside of the country. The Haitian co-worker would begin mapping as soon as he had received adequate training and experience.

(b) Long Range — The long range objective would be to train a core of Haitian soil scientists in soil classification, soil mapping, and soil interpretations so that DARNDR could continue and complete the soil survey of the country. The completion date of the soil survey would depend upon the priorities placed on soil conservation and the soil survey in the country.

(4) Organization

The soil scientist assigned to Port-au-Prince would have the technical responsibility for coordinating the soil survey in all of the project areas and would be a member of the project team at Thomazeau. This soil scientist would be the soil survey leader for the soil scientists in the other project areas. All of the soil scientists working in project areas would have Haitian co-workers who had been selected for the specialized training in soil survey. The soil scientist in Port-au-Prince would also be responsible for coordination of activities with the soils laboratory at Damien and with his counterparts in the Haitian Department of Agriculture. The soil scientists in the other project areas would be members of the soil conservation team and would be under the administrative supervision of the team leader.

(5) Equipment

Each soil scientist would be provided with all of the equipment needed to conduct the soil survey. The list of equipment needed is itemized in Appendix IV.

(6) Training

TDY assignments from the U.S. would be made to provide additional technical assistance to the soil scientist in Haiti as needed. These assignments would normally be for periods of less than one month. Technical assistance needed would include:

(a) Two months after the soil scientist was assigned at Port-au-Prince, a soil scientist from Puerto Rico would provide about two weeks of training in tropical soils. At a minimum, the major soils in all the designated project areas would be reviewed.

(b) About one year after the soil scientist was assigned at Port-au-Prince, a soil scientist from the Office of the Director of Soil Classification and Mapping Branch (USDA-SCS) would provide approximately two weeks assistance in soil classification.

(c) About 6-8 months after the soil scientist was assigned at Port-au-Prince, a soil scientist at the National Soils Laboratory (USDA-SCS), or a selected University, would be assigned to provide consulting services to the soil laboratory at Damien to acquaint the technicians in the soils laboratory with procedures in obtaining characterization data in support of the soil survey program. This assignment would be for two to three weeks.

(d) Other assignments would be scheduled as needs arose.

c. Soil Interpretations

(1) Soil interpretation records would be prepared for each soil series at the same time that the soil descriptions were being devel-

oped. The SCS-SOILS-5 form, as shown in the USDA-SCS NSH (17), would be used as a guide. Due to the differences in land-use and soil interpretation needs, the interpretation record would require modification for adaptation to Haiti. The final format would be determined by the teams when the needs of the technical guide were determined.

(2) Land-Use Potentials

(a) Small Scale Maps — After the general soil map was prepared for Haiti, land-use potential maps would be prepared showing the relative potentials of the land for selected uses such as for irrigated cropland, woodland, pasture, range, etc. These maps would be prepared as needed and by established priorities.

(b) Large Scale Maps — Soil potential maps would be made using the detailed soil surveys. The maps would be prepared for the watershed areas as the needs and priorities dictate.

(3) Soil Interpretation Maps

(a) Soil Erosion — A soil erosion map would be prepared for the watershed after the soil map was complete. The map would indicate the classes of soil erosion within the watershed.

(b) Cropland — A map showing the location of the important farm land, or prime farm land, would be helpful for general planning. Separate maps could be prepared for irrigated and non-irrigated cropland. These would be prepared as needed.

(c) Woodland — In watersheds where woodland is important a map showing the prime woodland sites would be prepared.

(d) Salinity —In irrigated areas and in other locations where the soils have significant accumulations of soluble salts, a map showing the salinity classes of the soils would be helpful for general planning.

(e) Other — As needed, other soil interpretative maps would be prepared.

(4) Benchmark soils

Benchmark soils are extensive and important soils or soils which have unique properties thus making them important for selected uses. Benchmark soils would be selected for gathering detailed information on the physical and chemical soil properties, crop adaptation, yields, best conservation practices and response to various types of management. An effort to select sites having a benchmark soil would be made when establishing experimental plots or special trials, demonstration projects or sampling for laboratory data. The accumulation of data on the benchmark soils would improve the soil interpretations and encourage the transfer of technology with other sites having the same kinds or similar soils. It is suggested that 2 to 3 benchmark soils be selected for each project area.

2. Water

Water supply is critical in most areas of Haiti for domestic and irrigation uses. Dry periods are typical for the climate, and droughts are common in many areas. Many Haitians in the rural areas have a difficult time obtaining sufficient amounts of water for domestic needs, and in many cases the water quality is poor because of pollution.

a. Surface Water

Surface water is the major source of water for rural Haitians. The water from streams is used for domestic purposes and in some areas for irrigation. Apparently, the quality and quantity of stream flow have been deteriorating over the past years because of deforestation and acceleration of soil erosion within the watersheds.

Some information is available on surface water (13) (22). Other information on water supply is available from selected watershed studies. It would be important for the team to appraise and monitor the surface water quantities and qualities within the watershed project.

b. Groundwater

The groundwater has not been used extensively by the rural Haitian because of the lack of power to pump the water to the surface. The teams assigned to the project areas would need to collect available data on groundwater and consider the feasibility of utilizing this resource.

c. Water Development Potentials

The potential for various sources of water in the project areas would be evaluated by the project teams. Due to the lack of power, the development of springs appears to be the best way to increase the water supply at the present time. Springs within the project area would be inventoried and reviewed for potential development.

Potential reservoir sites would be located and evaluated for potential construction. In most cases, however, it would not be feasible to construct a dam for water storage until the watershed has had the soil conservation practices applied so the sediment yields were reduced to acceptable levels.

3. Vegetation

The inventory and monitoring of the vegetative communities within the watershed is important in evaluating the progress being made in the soil conservation program. The vegetative communities would be inventoried by a plant specialist at the same time as the soil survey was being conducted. The color infrared photographs (scale: 1:40,000) could be used as a map base. The vegetative communities could be recorded on mylar overlap or some other kind of transparency. As the soil conservation program in the watershed progressed, periodic monitoring of the vegetation would be made. Some information on the vegetation in Haiti is already available (3, 14, 21).

4. Climate

Climatic data are needed for conducting the soil conservation program in the Integrated Agricultural Development (PDAI) Areas. The rainfall, rainfall distribution, temperature, wind velocities, etc., are important in planning irrigation systems, crop selection, soil classification, and stream discharges. Some climatic information is available from the USDA-SCS office of Soil Classification and Mapping at Glen Dale, Maryland. The Haitian Department of Agriculture has detailed weather data for selected stations. Rainfall data are available from references (1 & 2).

5. Geology

Bedrock and surficial geology are important basic data for soil surveys since the kind of soil parent material has a significant influence upon the nature and properties of the soil. Geology information is also needed in watershed planning as it affects run-off, groundwater supplies, dam construction and other important factors. Some general information is available on geology in references (13 & 22).

There are some deposits of lignite in Haiti. Consideration needs to be given to the feasibility of mining lignite as an alternate fuel source to substitute for charcoal. Utilization of lignite could reduce the amount of deforestation caused by charcoal production.

The teams might require the assistance of a geologist on TDY to provide more detailed geological information and training of the project team members.

6. Other Data

a. Transportation Systems

Haiti has a road and highway network of 3,724 kilometers of which only fifteen per cent are paved. Most of the unpaved roads are in poor condition and not passable on a year-round basis. References to road conditions within the proposed project areas are made in the descriptions of the watershed areas. Generally, the roads are poor and a constraint to economic growth. Hand labor is being used in all four of the proposed project sites to build or improve access roads which link these areas to the rest of Haiti.

b. Population Characteristics and Social System

Haiti has conducted two population censuses, one in 1950 and one in 1971. The 1971 population was calculated at 4,314,628 considerably less than the 4,968,000 which had been projected. The implied population growth rate was thus only 1.6 per cent which was well below the Latin America average of 2.8 per cent. The modest rate of population growth rate is attributable both to a relatively

low reported birth rate and a high rate of external emigration. The 1950 census showed that 87.8 per cent of the population lived in rural areas. The 1971 figure was 79.6 per cent but could actually be higher depending upon method of interpretation. The 1971 data also show that 40.4 per cent of the population was less than fifteen years of age at the time of census.

The 1950 census shows that the vast majority of farmers — at least two-thirds and perhaps as high as eighty percent were landowners and that the percentage of owners was roughly the same in all five Departments. Unfortunately, the census document does not show how the data on land tenure, or other agricultural sector statistics, were obtained.

The average sized farm in Haiti in 1971 was just 1.1 carreau (1 carreau = 1.29 hectares) and the average sized property farmed was a mere .6 carreau.

Although the social and cultural characteristics of Haiti's rural population show some regional variations, there are enough common features to allow observations of a general nature. Rather than try to synthesize these important aspects of Haitian life, the authors refer to the references cited in Agricultural Development in Haiti by Clarance Zuvekas, Jr. pages 160-163. (24)

c. Marketing

Corn is the most important crop grown in Haiti in terms of acreage with 238,000 hectares planted in 1973. Millet, an additional food crop, was second in acreage planted; bananas were third, and coffee fourth. In terms of value, corn was again the number one crop with coffee and rice in second and third places.

Like production technologies, marketing activities appear to be very much the same for all Haitian farm families. Marketing channels differ by crop, but there appear to be few other differences according to geographical region or size — except for the few large plantations.

Despite the small land-holding and generally low levels of technology, nearly all farm families are market-oriented to a significant degree. It is estimated, for example, that at least half of all farms produce coffee — Haiti's principal export. There is also considerable small-farmer production of other export crops including sugar and sisal. In addition, there is a high degree of commercialization of food grains, fruits and vegetables, and other crops and livestock for domestic use.

D. Watershed Protection (Erosion Control and Sedimentation)

1. Descriptions of the Watersheds

As stated earlier, the four principal watersheds as identified in the Integrated Agricultural Development Project will be areas of concentration for the soil conservation/water utilisation project. The four watersheds are:

a. Marigot Watershed

This project is located in the l'Ouest-Department in the southeastern part of Haiti, about 23 kilometers east of the city of Jacmel. Its latitude is about 18° 15' N. Longitude is approximately 72° 20' W.

The drainage area is 160 square kilometers and is served by four rivers — Grande, Des Plantils, Raving Parridel, and Ravine Loguette. The Des Plantils drains two-thirds of the watershed, but the Grande carries all runoff to the south from the confluence of the other three rivers to the Caribbean Sea.

Elevations range from sea level at the outlet to 1,900 meters in the northeast near Seguin. The topography consists primarily of steep (30 to 90 percent) mountain slopes. Near Seguin karst limestone outcrops dominate the landscape. Valleys are narrow, and streams are generally high gradient. Approximately 26,000 people live within the watershed, mostly residing in the countryside or in such villages as Peredo and Macary. Marigot, Ti Feuille, and Seguin are the major populated towns adjoining the watershed.

All lands within the watershed are used to produce either cultivated crops or a combination of food trees, field crops, and/or vegetables. Some pine trees are growing at the higher elevations. About 900 hectares of irrigated land are located near Peredo, which will be described elsewhere in this report.

Micro-climates reportedly characterize the weather patterns in southern Haiti. The nearest available weather data are from Jacmel. Temperatures at Jacmel normally range from 10° to 38°C.

Rainfall varies from 600 to 1,400 mm annually. Understandably, climatic conditions within the watershed will vary between the sea coast and the 2,300 meter elevations near Seguin.

The bedrock geology is hard limestone with some soft chalky members. Karst topography is common in the upper reaches of the watershed.

The nearly level to gently sloping soils adjacent to the major streams are formed in alluvium. The soils are well drained and loamy or loamy-skeletal. The stream gradients are high which has resulted in many gravel cobble, and stone size coarse fragments in the soils. Carbonates are evident in the subsoils but salinity problems were not observed. The dominant soil class is Ustropepts.

The soils in the steep to very steep uplands are dominantly shallow stony soils with some deeper soils on the lower slopes. There are some deep soils on the nearly level to sloping areas which have loamy to clayey textures. The dominant soil classes observed include Haplustalfs, Haplustolls, and Ustropepts.

b. Les Cayes Watershed

This project is located in the du Sud Department in the southwestern part of Haiti, about 55 kilometers northwest of the city of Les Cayes. The outlet end of the watershed is located at approximately latitude 18° 15' N. and, longitude 73° 55' W. This point coincides with the river diversion dam for the Dubreuil Irrigation Project to be discussed elsewhere in this report. The drainage area is 400 square kilometers and extends northwest about thirty kilometers and extends northwest about thirty kilometers from the diversion dam. There are two rivers — the Ravine Casse

Cou and the L'Acul, which is the principal one.

Elevations range from about 100 meters to approximately 2,000 meters. Although only a small portion of the watershed was seen during the field visit, the topography appears to consist of steep (30 to 90 percent) mountain slopes. Alluvial valleys are virtually nonexistant. Except for scattered oases, the irrigated lands are outside of the watershed.

According to geodetic maps the people in the watershed live primarily in the countryside and in small villages in the lower two-thirds of the watershed. Travel by motor vehicle within the watershed area is virtually impossible. A few jeep trails have recently been made near Dessou-reas.

Rainfall, according to various sources, ranges from 1,400 mm to 2,000 mm (6). Temperature normally is between 15° and 36°C. (6) As at Marigot, micro-climates reportedly characterize the weather patterns. According to one source (19) up to 3,600 mm of rainfall per year can be expected in the mountains of this watershed.

Only a small portion of the Les Cayes watershed was visited by the team. However, from visual observation and according to DARNDR personnel, coffee is grown on the higher mountain slopes. Elsewhere the steep slopes and isolated oases produce field crops, fruits, vegetables, and grazing land either singularly or in combination with each other.

c. Jean Rabel Watershed

This project is located in the du Nord-Ouest Department in the northwestern part of Haiti, approximately 250 kilometers northwest of Port-au-Prince. At Jean Rabel the latitude is 19° 50' N. and the longitude 74° 10' W.

The drainage area of the designated project site is 2,000 hectares, which includes that portion of the Jean Rabel River watershed upstream from the city of Jean Rabel. However, the local project office also works in the adjoining watershed which enters the Jean Rabel River just north of the city. Plans are to begin soil conservation work in this watershed before completing that in the designated project area. The Atlantic Ocean is the outlet for the Jean Rabel River.

Elevations range from approximately sixty meters at Jean Rabel to about 885 meters on the south rim of the watershed. The topography of this watershed is moderately sloping, with the majority of the cultivated hillside slopes being between twenty and forty percent with some foothills being between ten and fifteen percent. Except for the absence of surface cobbles and boulders the topography typifies Haitian mountain terrain.

Approximately 5,000 people live within the watershed area, including 2,000 in the town of Jean Rabel. No other towns exist within the watershed. Port-de-Paix, approximately forty kilometers to the northeast, is the nearest population center.

The entire watershed is intensively farmed to maize, corn, potatoes and beans. Small drainageways and oases are used for bananas, sugarcane, oranges, and coffee. Only about 255 hectares are irrigated which will be discussed elsewhere in this report.

Rainfall averages from 400 to 1,000 millimeters per year (20). However, most of this falls during April and May, with November, December and January being the driest months. According to local reports at the time of visit (January, 1979) no rainfall had occurred since September 1978. Of the four watersheds visited, this one experiences the least precipitation. Temperatures range from 10° to 36°C. (20)

The area in the Jean Rabel watershed has undergone extensive folding and uplift. The bedrock is soft marls which are sandy or silty in places, hard coralliferous limestone, massive limestone, conglomerate and some volcanic rocks in the upper watershed.

The soils in the valleys are formed in alluvial deposits from the limestone and marl. The soils are deep, sandy to clayey, well to poorly drained and nearly level to gently sloping. Sloping gravelly soils formed on alluvial fans are common in the valleys. The brief observations indicated the dominant soil classes as Haplustolls, Haplaquolls and Ustropepts. There are some saline soils in the irrigated area.

The soils in the uplands are dominantly steep to very steep. Shallow soils are common

on the ridge tops and on some side slopes. Deep, loamy to clayey soils occur on many of the side slopes and foot slopes. The observations indicated that the soils are Haplustolls and Ustropepts. Free carbonates are evident in most of the soils examined.

d. Thomazeau Watershed

This project is located in the de l'Ouest Department approximately forty kilometers northeast of the capitol city, Port-au-Prince. Its latitude is approximately 18° 40' N. and its longitude is approximately 72° 05' W.

The drainage area is 78 square kilometers. There are no major rivers; however, one-half of the watershed concentrates near Lalman before spreading over the flatlands between Durand and Nan Tete Source and into Lake Etang Saumatre.

Elevations range from twenty to 1,300 meters. The upper two-thirds of the watershed consists of steep mountain slopes, while the lower one-third is a slightly sloping fertile irrigable plain. The principal access is by a road presently being improved from west to east to Thomazeau.

The population of the watershed is unknown; however, a census is currently being conducted. Most of the people live in Thomazeau and along the southern access road. Others live along the northern watershed boundary. Within the mid and upper watershed, nomadic farmers live on the land only during the crop growing season. This area is otherwise unoccupied due to shortages of drinking water and to limited access.

All but 2,000 ha. of the watershed is used for some type of dryland farming or grazing. Crops grown are corn, maize, beans, and some sugarcane. On the irrigated land, which will be discussed elsewhere in this report, sugarcane, coconuts, bananas, and an assortment of vegetables are grown. Most of the trees and other vegetation have been either burned or grazed off. There were no signs of erosion control on the land.

Climate in the watershed is similar to that at Port-au-Prince. Rainfall varies from 600 to 1400 mm per year, while the temperature ranges from 10° to 38°C.

The irrigated area is located in a downfaulted valley. Alluvial deposits from the very steep hills have covered much of the valley. The bedrock in the watershed area is dominantly hard limestone although there are some soft chalky members.

The soils in the valley are dominantly deep although there are some areas where the soils are shallow to limestone. Salinity and excess sodium are evident in some of the soils. The soils are dominantly very steep and shallow in the upper watershed with significant areas of rockland. Brief examination indicates the soil orders in the watershed include Aridisols, Inceptisols and Mollicols.

2. Problems Within the Watersheds

Erosion, both geologic and that caused by improper land-use, is the most serious agricultural problem within these watersheds. Neither the rate of erosion, nor the predicted life of the remaining soil has been recorded. The general scope and severity of erosion has been reported by Murray (10), Zuevakas (24), and others.

Improper land-use and intensified farming practices are the primary causes of soil erosion. These factors, in turn, cause increased runoff and subsequent downstream flooding of roads, villages, and productive lands. Increased runoff and reduced infiltration reduces rainfall effectiveness as well as the base flows of streams, springs, and seeps.

Conservation treatment is practically nonexistant in the watersheds. Time spent by the farmers in traveling from one small plot to another minimizes the time available for work on the land except for planting and harvesting their crops. At best, access to the area is poor and travel slow due to generally rocky and steep slopes. Travel is by foot and beasts of burden.

Another erosion related problem is that of land tenure. Land holdings are small and will offer problems to broad-scale conservation treatment. Tenant farmers and renters in Haiti are principally concerned with sustaining life.

3. Recommendations

a. General

Solutions to the severe erosion problems will be difficult, even under the most ideal set of conditions. The most sincere desire of the Government of Haiti, conscientious efforts of professional agriculturalists, and strong cooperation of the farmers will not ensure a successful conservation program.

However, solutions to the soil erosion problems of the four watersheds must begin with technically sound plans which will result in action, rather than in elaborate documents which will only take up file space.

Briefly described herein are recommendations for short-range plans and long-range plans.

b. Short-Range Plans

Planning should include, but should not be limited to, the following steps:

(1) Obtain maps
(2) Data collection by sub-watershed
(3) Establish priorities by sub-watersheds
(4) Select sub-watershed for pilot project
(5) Plan conservation treatment alternatives
(6) Apply conservation measures
(7) Monitor and evaluate results.

It is recommended that all erosion and sediment control work be planned and applied on a sub-watershed, or other manageable land unit within the watershed. Some reports recommend "hillside units" (9) as bases for land treatment. The most workable method can be determined after an evaluation of a pilot project. For purposes of this report, recommendations will be on a sub-watershed basis.

It is recommended that three kinds of maps of each of the four watersheds be furnished to the PDAI Project Agronome. These are aerial photographs, black and white of scale 1:7920 and 1:25000 respectively, and geodetic survey maps, preferably of scale 1:25,000, of the respective watersheds. Before planning begins, it is imperative that all of these maps be in each project office.

Data collection should include such items as soil survey, plant identification, land-use, water supplies, access roads, rainfall, temperature, and identification of specific problems, i.e. critical erosion areas, sediment areas, and flooded areas.

Since it will be neither practical nor feasible to treat the entire watershed at once, the sub-watersheds should be ranked according to greatest need for treatment. From this ranking, the sub-watershed(s) which would become the pilot project(s) for the watershed should be selected.

The basis for selection should definitely include the readiness of the farmers to carry out the plans. No watershed should be limited to one pilot project where local interests, available funds, and technical assistance exist to do additional areas.

Planning of all conservation treatment measures for each pilot project should be done with the individual farmers, and treatment alternatives should be based upon the conservation needs of each project. In most instances conservation treatment would include both vegetative and mechanical conservation practices. Every plan must include maintenance provisions.

Application of all conservation practices would be by hand labor. To use equipment other than wheel barrows and hand tools such as cyclone seeders, hoes, shovels, rakes and machetes, would be impossible due to the restraints of topography and small land units.

Conservation treatment alternatives may include such conservation practices as reforestation, contour farming, strip cropping, crop rotation, residue management, proper grazing, terraces, waterways, and grade stabilization structures. Treatment may include innovative techniques not yet developed to slow the present erosion rate.

As new access roads, trails, and paths are built and as existing ones are improved, it is recommended that accompanying erosion control measures be planned. These may include such measures as vegetation of slopes, culverts, diversions, ditch shape and grade limitations, and other special treatments.

Based upon the USDA/PASA team's visit

to each watershed and observations during extensive travel within Haiti, recommendations and general guidance for several potential treatment measures are illustrated in Appendix III.

Visits to the DRIPP (Canadian) and Limbe (United Nations) Projects were particularly noteworthy. Erosion control practices being planned and constructed in these projects show excellent potential. Study of performance reports and follow-up field visits by the long-range team members are highly recommended.

Rock walls as depicted in "D" of Appendix III are not recommended for most sites. Extreme care must be taken to provide safe outlets and maintain a level or graded top surface. Rock walls such as those observed in the upstream area near Les Cayes are likely to create gullies. The sites were not suited to this practice and the construction control did not result in soil erosion protection that will be longstanding.

It is recommended that progress in each pilot project be closely monitored. All application work would be carefully evaluated so as to learn from successes and failures. This information could be used to develop practice standards for other projects.

c. Long-Range Plans

Based upon experience gained from each pilot project, it is recommended that treatment for all other sub-watersheds be planned.

(1) Tabulate existing rainfall and temperature data for selected weather stations.

(2) Install at least one rainfall, temperature, wind, and evaporation instrument in each watershed project, where they do not presently exist.

(3) Install stream guages upstream from each irrigation diversion dam.

(4) Establish a stream sediment sampling program in each watershed to determine effectiveness of erosion control work.

(5) Job sheets should be developed which would provide step-by-step explanation and/or illustration of why and how to design or build a terrace, why and how to plant, manage and harvest trees, etc.

(6) Standards and specifications for individual conservation practices should be developed.

(7) After erosion has been adequately controlled, the feasibility of multi-purpose reservoirs should be considered.

E. Forestry, Agronomy, and other Plant Materials and Wildlife

1. General

Many studies have been made, and much has been written about Haitian agriculture, forestry and the degradation of the soils (5, 8, 11 & 25). It is obvious even to the untrained eye that a tremendous soil erosion problem exists over most of the country. Many hours of literature review would be required to learn all that has been written about the problem. The question must now be asked, "What use will be made of the volumes of information?" The answer should be obvious. Field work should be accelerated to reduce the annual soil loss. Enough has been said about the problem. Technical assistance to the land user must be strengthened. More detailed resource inventories must be made in order to develop sound resource management plans in specific selected areas.

With this objective in mind, accelerated field work on the four pilot demonstration areas should begin as soon as possible in order to reduce soil erosion and, at the same time, improve the standard of living for those using the land.

a. Forestry

(1) General

The need for improved forestry practices in Haiti is great and methods for re-establishment of native and exotic tree species have been suggested by many forestry specialists. The major forest habitat types and needed management techniques have previously been recognized. Adapted species for reforestation plantings have been selected and tested. DARNDR is producing a variety of seedlings for reforestation work and has been planting them on selected watersheds during the past several months. Even the so-called miracle plant "Leucaena" (12) is being produced in the nursery at Damien near Port-au-Prince.

This report re-emphasizes the dire need for soil protection and stability by vegetative cover. Grass, forb and shrub cover must also be considered as companions with tree cover. A good example of total soil protection is the Haitian pine (Pinus occidentalis) as found in the forest above Seguin. Even though good forest management practices are lacking, the basic soil resource is being protected by a dense growth of fern, native grasses, agave, and several species of shrubs. The Haitian pine forests have a high potential for sustained yields of lumber. It was not determined what inventories and management plans had been developed for the Haitian pine, but the long-range objectives for these forests should be close management for maximum timber production. Detailed soils and vegetative inventories should be the first step in developing a resource management plan. These pine producing areas should be sectioned into management areas and long-range plans developed to achieve maximum timber production and soil protection. These management plans should be developed and put into effect before improved roads are constructed into these areas. It may be the reason that the pine stands remain at all is the difficulty to transport lumber or logs from the area.

(2) Reforestation

It is recognized that food producing trees should be given first priority in re-forestation to achieve soil protection. However, it is felt that there is also a need to plant understory grass, forb and shrub species for better erosion control. There are many areas on which soil is rapidly eroding to the parent material, and more emphasis should be given to the soil protecting plants. A more detailed discussion of these plants is given in the plant materials portion of this report.

Leucaena has been proposed as a plant which, by increased nitrogen fixation, can control erosion, provide livestock and wildlife forage, lumber, fuel and soil improvement. It

is presently being propagated, and seedlings established in a few locations. Time will prove its value in Haiti.

Species used for reforestation are well known to the local foresters and will not be listed here.

(3) Recommendations

(a) Continue present nurseries at full production and improve the established ones at each pilot demonstration area or establish them if they do not already exist. (See plant materials section for companion understory species).

(b) Determine the areas and locations of the State owned lands within the Haitian pine forest and show the location(s) on a map at the scale of 1:25,000.

(c) Establish National Forest Boundaries and vividly mark the boundaries.

(See the section on wildlife for other reserve recommendations)

b. Agronomy

(1) General

There are three general types of agriculture in Haiti. These are:

(a) lowland crops without irrigation,
(b) lowland crops with irrigation, and
(c) mountainside farming.

Most of the major tropical crops are grown in Haiti. The principal grain crops are corn, sorghum and rice. Sugarcane is a common crop. Some other crops are coffee, sweet potatoes, bananas, sisal, tobacco, cotton, beans, cocoa, and many others including a variety of garden vegetables. (24) Poor soil conserving practices on mountainside farms probably cause ninety percent of the severe erosion in Haiti.

(2) Recommendations

(a) Direct an educational program to the farmer as to the benefits of crop rotation. Food crops should be rotated with soil-building crops such as leucaena, vetiver, citronella, or grass-legume mixtures which can be properly grazed.

(b) Develop all potential irrigated areas. In many areas the full utilization of the irrigation potential could more than triple present production. Many crops cease to produce during the two dry seasons each year.

(c) Continue to search out and distribute improved varieties that will provide greater yields (16).

(d) Implement strip-cropping, particularly in connection with terraces. The strips, sown to a soil protecting crop, will stabilize the soil and catch sediment from soil depletion crops which may be planted above.

c. Plant Materials

(1) General

As referenced in the forestry section, other soil conserving plants must be developed and planted in connection with tree planting. Grass species should be given primary emphasis in the planting of solid strips on steep slopes. When trees are planted along terraces, grass seed should be sown at the same time. After the grass is established it should be hand rogued around the tree seedlings to reduce competition. Shrubs should also be considered for stabilizing steep slopes where mass slippage is occurring. Shrubs have a deeper root system than grass which increases the resistance to the mass soil movement. Forbs should also be considered in some areas to provide a variety of food and habitat for birds and useful insects such as bees.

All of these plant species can be utilized if a management plan is followed. Grazing by cattle, goats, sheep, donkeys, swine and horses can be beneficial to the plants if proper grazing is applied. Grazing must not be permitted until the plants are well established and a strong root system has developed. The principles of good plant management must be taught to the livestock owners. Once the plants have been established, they should never be grazed close to the ground. The majority of the livestock in Haiti are staked each day with a rope. Where this is practiced, the animal should be moved twice daily to prevent overgrazing. The grazed areas should not be re-grazed until the plants have made considerable re-growth.

A good example of erosion control by a grass species is the growing of vetiver on the hillsides just east of Les Cayes. The oils in the roots of this grass are extracted for making perfumes and other substances. Vetiver is

controlling erosion on the hillsides even though the grass is dug-up frequently. The leaves and stems are incorporated back into the soil when this is done, thus increasing the organic matter, the soil fertility, and water intake rate. Vetiver is very unpalatable to livestock; therefore, it does not constitute a grazing management problem. Citronella is another oil producing grass which could be grown for erosion control and also provide a direct cash return.

(2) Suggested Species

Literature review did not reveal or suggest low-growing vegetative species which should be used for erosion control. The following list is not intended to be inclusive but is presented for consideration only.

(a) Grass Species
- Panicum maximus-Guineagrass
- Cenchrus ciliaris-buffelgrass
- Brachiaria brizantha
- Brachiaria decumbens
- Andropogon annulatus
- Digitaria decumbens-dwarf pangolagrass
- Digitaria sp. - pangolagrass
- Paspalum notatum-bahiagrass
- Hemorthria altissima-limpograss

Other grasses

- Penisetum sp.
- Cynodon dactylon - Bermudagrass
- Lolium sp.
- Oryza sp.
- Zoysia sp.
- Stenotaphrum sp.

(b) Legumes
- Glycine wightii - glycine
- Arachis glabrata - forage peanut
- Dolichos hosei - arawakbean
- Stylosanthes humilis - townsville lucern

(c) Shrubs
- Tritonia crocosmaeflora - tritonia
- Plumbago zeylanica - wild plumbago

(d) Other species
- Saccharum moentai - wild cane
- Zea mays - 'Jala' corn
- Sorghum vulgare var. technicum - broom corn

(3) Recommendations

(a) There is a need for large quantities of grass, legume and shrub seed for use in erosion control. It will be extremely difficult, as well as expensive, to purchase all seed necessary for ground cover. A plant materials center capable of producing seed and other plant materials should be established near Port-au-Prince to satisfy this need. In the meantime, several field trial areas should be established to determine which species would be best adapted to the various Departments in Haiti. Seed for field trials could be requested from USDA-SCS plant materials center in Hawaii and Florida.

(b) Collect native grass, forb and shrub seed and use in various field trials.

d. Wildlife, Natural Study Areas (Conservation Areas) and National Parks

(1) General

Presently there are no big game animals in Haiti. A detailed study of the Zagouti, (Plagiodontia aedium) and Nez longue, (Solenodon paradoxus) was made by Woods and Rosen from 1973 to 1977 (23). In connection with this study, the two scientists recommended that two forest preserves be established and perhaps designated as "National Parks." The two proposed parks, "La Hotte" and "Massif de la Selle", might include the upper portion of the Marigot and Les Cayes watershed areas, depending on where the boundaries were established. If the proposed parks were established, they would aid in increasing the natural mammal and bird life on the upper portions of the watersheds.

Woods and Rosen (23) studied only the high mountain areas. The desert region of the Northwest has a great variety of cacti and would be of scientific interest to many biologists. Animal life in that area is completely different from the rest of Haiti. Many species of small birds thrive in this desert biome, either feasting upon insects living on the plants or sucking the nectar from the many flowering cacti. Humming birds especially enjoy the nectar of the agave flowers.

There is a good possibility that desert

deer and Javalina would thrive in this habitat, if introduced.

The region of Morne Chien in the Northwest has a dense growth of low-growing trees and shrubs. This would be a good region to establish a wildlife reserve. The area would support a variety of introduced big game species.

(2) Recommendations

(a) National Forests Reserves should be established in the Massif de La Selle and the other in the Massif de La Hotte regions. This would be the first step in the process of developing good management plans for the improvement of the forests and wildlife and ultimately achieve soil conservation.

(b) Establish a desert biome study area between Gonaives and Anse Rouge. A study of the trends of natural vegetation as a result of good land management could provide information on the best methods of management for the remainder of the desert area.

(c) A National Wildlife Reserve should be established in the region of Morne Chien in the Northwest District. Introduced big game species could increase the revenue from this area.

F. Irrigation, Drainage and Water Quality

1. General

Irrigation is important to each of the four watershed projects, but relative to watershed size and the erosion problem, irrigation is small. The most significant irrigation is done on a project basis where water is furnished by a public conveyance system. Irrigation projects range from 255 ha. to 1,600 ha. in size. In some instances three to four farmers combine resources to build crude, temporary, but effective river diversions to irrigate their lands. Irrigation is also practiced around small seeps and springs. These oasis areas are generally from garden size to a few hectares.

Drainage, either for water management or salinity control, is not being practiced. Both problems are apparent in the Thomazeau watershed. There are no major problems of high water tables nor salinity in the other three watersheds. During rainy seasons there undoubtedly are some locations which could benefit from surface drainage.

Water quality for irrigation reportedly is good; however, data are limited. Water quality for livestock and domestic use is questionable.

The J. G. White Engineering Corporation of New York has developed plans for two irrigation projects — the Dubreuil and Jean Rabel. (19 & 20) Preliminary surveys are in progress in the Marigot and Thomazeau watersheds.

All irrigated areas, except at Jean Rabel, are managed by an irrigation water master one or more canal riders.

2. Identification of Problems

a. Marigot Watershed

Two irrigation systems are located near Peredo in the Grande River flood plain. One is the Belle Roche (100 hectares); the other is the Rodaille (800 hectares). Both systems were constructed during the 1940's. Both systems were severely damaged in 1966 by hurricane produced floods.

(1) Belle Roche System.

The diversion structure was partially destroyed and cannot be restored, because the river has changed its course and degraded. The existing rubble masonry canals have been renovated, and a temporary diversion dike has been installed upstream approximately 1 km from the original intake. A hand-dug earth-lined canal connects the dike and the original canal. Seepage losses are visible. There are no written plans to improve this system. On-the-farm irrigation improvement, or water management, is not evident and there are no plans for this activity.

(2) Rodaille System

This system has not been in use since 1966, when the storm damaged the concrete diversion dam, clogged a 1m x 1m x 500m long concrete siphon with river bedload, and totally unearthed and washed out another portion of the siphon. To repair or to modify this system will require considerable engineering expertise, time, and money, although an engineering survey was initiated on February 1, 1979 to mark the beginning of a renovation plan.

Since this system has not been used since 1966, most of the irrigated land has reverted to mango, coconut, and breadfruit trees. It will be difficult and expensive to remove the undesirable trees and to remove cobbles and boulders which were deposited on the irrigable lands by the flood.

b. Les Cayes Watershed

The only major irrigated area associated with this watershed lies immediately downstream from it. It is called the Dubreuil Irrigation Project, which presently serves 1,600 ha. Another 400 ha are potentially irrigable. This project lies alongside the east

bank of the L'Acul River and around the villages of Le Duc and Ducis.

Based upon visual observation, there is a tremendous need for technical assistance to individual and/or groups of farmers to become better irrigators.

Lack of upstream watershed protection, including flood prevention, is detrimental to the Dubreuil Project and results in expensive operations and maintenance costs.

The irrigated area occurs on the Cayes Plain which is the largest coastal plain in the Southern peninsula. There are a few isolated hills in the plain which are marly limestone. The bedrock in the watershed is dominantly limestone, marly limestone with some metamorphic rocks.

The soils on the plain are deep, stratified and formed in alluvium. The soils are dominantly loamy to clayey with moderate to slow permeability. Soils having gravelly and very gravelly textures and rapid permeability are common on the plain. Soil classes observed include: Ustifluvents, Ustropepts, Argiustolls and Haplustolls. The soils in the uplands are dominantly steep, loamy and clayey and are shallow or moderately deep to limestone bedrock. The soil classes observed include Ustropepts, Haplustolls and Argiustolls (The soils in the upper watershed may have udic moisture regines).

c. Jean Rabel Watershed

The Jean Rabel Irrigation Project includes approximately 400 ha; however, presently only 255 ha. are being irrigated. Once the diversion dam, presently under construction and expected to be completed by July 1, 1979, and the new canal system are completed, plans are to irrigate the entire 400 ha.

Four problems are apparent in this Project — inadequate irrigation water supply, siltation of existing and planned irrigation canals caused by erosion immediately upslope, lack of timely implementation of the White Corporation plan, and lack of on-the-farm irrigation water management.

d. Thomazeau Watershed

The irrigated area is located south of an existing canal between Nan Tete Source and Debras, just west of Thomazeau. This system, which includes a diesel powered pumping plant, was installed in the early 1950's. Its water source is three springs at Nan Tete Source.

Presently, 158 ha. are under irrigation — 48 ha. by pump and 110 ha. by several gravity flow springs. According to J. G. White Engineering Corporation preliminary plan — which reportedly has been prepared, there is a total of 585 ha. of land potentially suitable for irrigation.

The Irrigation Service is presently surveying a potential canal route generally along the 100 m contour. Their plans are to develop several springs in the Glore area and flow this water westward by gravity, which would further increase the irrigated hectarage.

Problems in this irrigated area include maintenance of the existing pump and delivery systems, inefficient secondary canals and on-farm delivery systems, absence of on-farm irrigation water management, and saline soils near Debras.

Flooding and surface drainage is a problem along the southern boundary of the watershed. Here man-made ditches drain excess water to Lake Trou Caiman and Lake Etang Saumatre. These ditches offer opportunity to develop irrigation tailwater recovery systems, particularly since one ditch flows beneath an irrigation canal. Mechanical lift would be low.

"Bitter water" in Lake Etang Saumatre reportedly makes it unfit for irrigation and domestic use. Fresh water apparently occupies Lake Trou Caiman and is a potential source for irrigation water. All soils and water need to be analyzed during system planning to ensure suitability for irrigation.

A shortage of domestic water exists in the upper watershed, where water harvesting techniques may be a substitute for walking six kilometers for domestic water.

Springs and seeps in the lower watershed need further development to ensure a larger volume of flow, longer life, and improved quality for domestic, livestock, and irrigation uses.

Of the four watersheds visited, the Thomazeau project offers the best potential for

improving irrigation efficiency and for increasing food production.

3. Recommendations

a. General

Recommended solutions to some of the problems listed will not appear to be logical to most conservationists. It would be more reasonable to first control erosion and prevent flooding before either restoring old irrigation systems or building new ones. However, due to the long-range erosion control process and the short-range food production requirements, both must proceed simultaneously.

Irrigation projects will require timely maintenance until erosion can be effectively controlled. The Jean Rabel project is a prime example.

Short-range and long-range recommendations are described below.

b. Short Range

Short range plans should include, but should not be limited to, the following actions:

(1) Implement the Dubreuil Irrigation Project Plan.
(2) Implement the Jean Rabel Irrigation Project Plan.
(3) Complete the detailed engineering surveys for rehabilitation of the Rodaille System. Develop and implement a plan for its restoration.
(4) Complete the detailed engineering surveys for a new canal in the Thomazeau watershed.
(5) Assist small irrigation groups to improve their river takeout and delivery systems.
(6) Obtain maps and collect climatic data as described in section II D. 3.b. for the Marigot and Thomazeau irrigation projects. Supplement the Dubreuil and Jean Rabel project maps and data as needed.
(7) Develop maintenance plans for each irrigation project.

c. Long Range

Plans are recommended so that the ultimate benefits of water conservation and optimum crop yields can be achieved. Recommendations are as follows:

(1) Develop job sheets and standards and specifications.
(2) Develop irrigation guides.
(3) Assist individual and groups of irrigators to plan and apply water management practices, i.e. land leveling, irrigation scheduling, and automation.
(4) Future expansion of irrigation systems where quality and quantity of water permit.
(5) Develop springs to improve quality and quantity of water. Consider redistribution of flow by means of pipe or lined ditch to facilitate domestic use. Provide separate facilities for bathing and livestock use.

G. Integrated Agricultural Development Project Areas

1. Communications

Prompt and reliable communication between the field teams and the central team is important for efficient operation. This is also true for communications between the Haitian Department of Agriculture and their field offices. We recommend the development of a radio communication system for those locations where reliable telephone communication is not apparent.

2. Technical and Administrative Support for Field Teams

a. Central Team

A central team should be located in Port-au-Prince to assist the Division of Natural Resources in the Haitian Department of Agriculture. This central team will also provide technical support to the field team at Les Cayes and future TDY teams at Marigot and Jean Rabel. The central team would be expected to provide day-to-day field technical counciling for the Thomazeau Project area.

b. Temporary Duty Assignments

Temporary duty assignments will also be necessary from time to time to provide technical support services and to provide training at Marigot and Jean Rabel. The need for TDY's will be recommended by the project leader and may include specialists from Puerto-Rico and other U.S. specialists such as economists, soil scientists, engineers, plant materials, agronomists, foresters and geologists.

3. Fund Allocation for Local Purchases, etc.

Certain day-to-day expenses are expected for the field team. A fund allocation should be made to facilitate prompt repair for vehicles, purchase of needed supplies and equipment, payment of some temporary help, etc.

4. Status of Each Project

a. Les Cayes Watershed and Surrounding Area

Some planning efforts have been completed and erosion control as well as irrigation practices are being installed. Numerous subwatersheds still require planning work and practice application. Work already installed needs to be evaluated and the results should be reflected in future planning and practice application.

b. Marigot Watershed and Surrounding Area

Minor planning efforts have been done in the watershed. Most of this work still must be done. A very good coconut, banana and bean companion crop demonstration farm has been established in the project area and will facilitate educational work with the farmers. Small rock erosion control structures have been built in two subwatersheds adjacent to the project watershed and will be available to evaluate performance.

c. Jean Rabel Watershed and Surrounding Area

An irrigation plan has been prepared for a portion of this watershed by the J. G. White Engineering Corporation (20), and the plan is in the process of implementation. Planning efforts are needed for the watershed protection and irrigation work in the remaining irrigable areas. Groups of farmers are being organized on a community basis to work together to solve their soil conservation problems. Substantial technical assistance will be required in both the upstream and the irrigated areas. Some work has been done and will be available for evaluation.

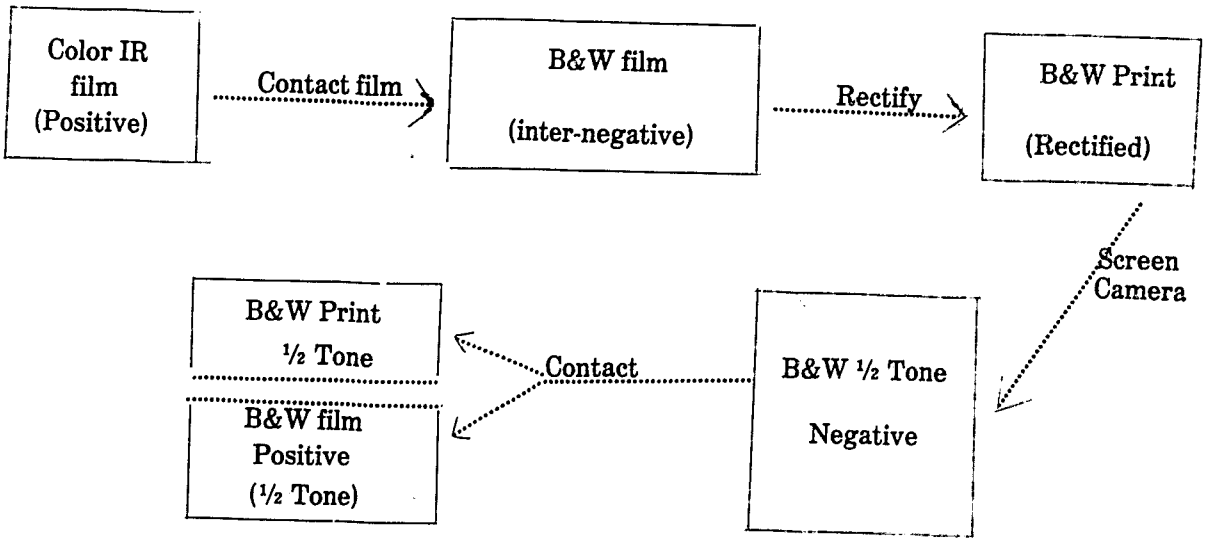
d. Thomazeau Watershed and Surrounding Areas

Planning efforts are awaiting the arrival of technically trained staff to develop proposals. They are also needed to assist the farmers with soil conservation and irrigation application work. Access to the upstream areas of the sub-watershed is very difficult and will limit soil conservation practice application until improved roads can be constructed. Work is already underway on some of the roads, and substantial distances should be completed during the next few months. Opportunities for water development and improvement in this area look promising. Springs are available and are used. Water conservation and additional spring development should be emphasized. In the upstream area, opportunities exist for water harvesting techniques to be used to supply livestock and domestic water supplies.

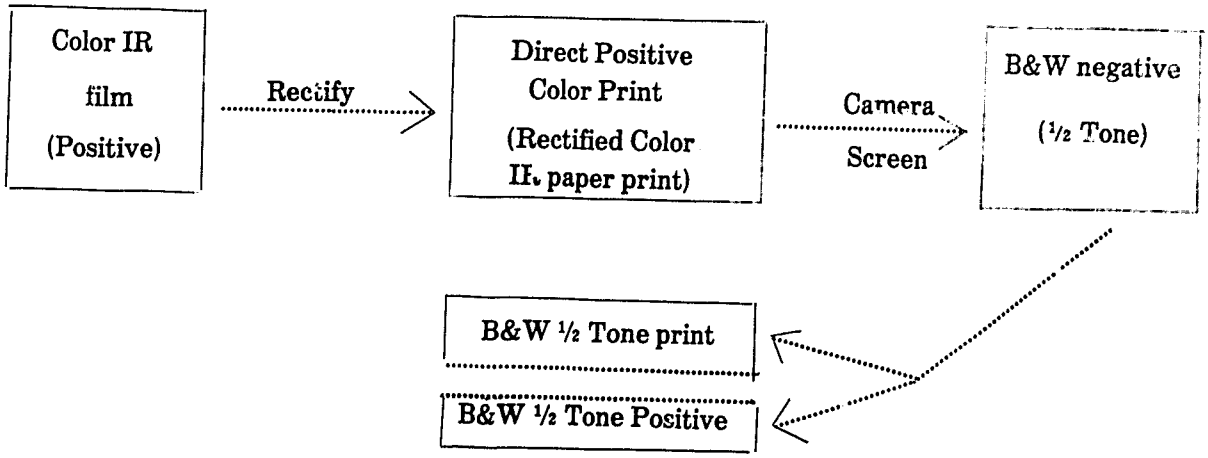
Appendix I — PDAI Project Area Location Map

Appendix II
Alternate Options for Utilizing the Color Infrared Film For Obtaining Map Base for Soil Survey

Procedure I

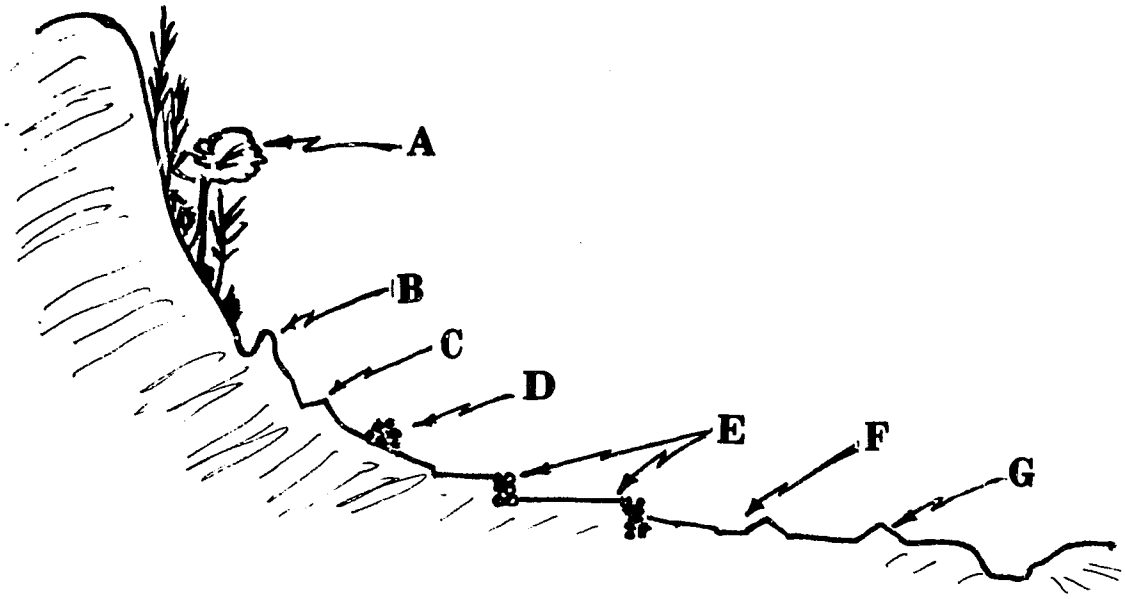


Procedure II



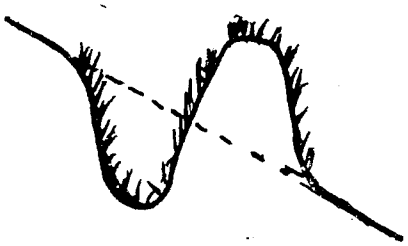
Color IR film is available for processing color IR in Black & White. If this is type film start with Procedure II step two (B&W film).

Appendix III
Potential Erosion Control Measures



Typical Mountain Slope

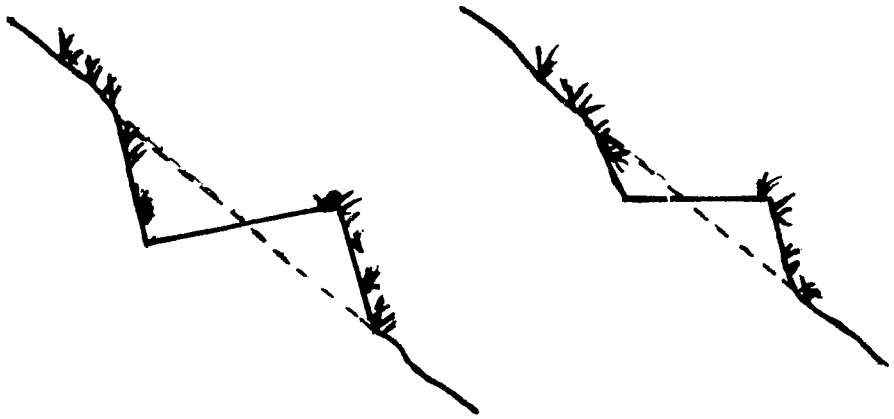
A Trees, underbrush and/or grass
B Diversion or Basin Terrace



Vegetated Cut & Fill Slopes
or

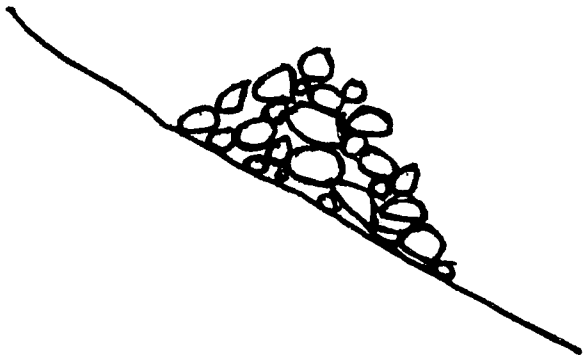
Vegetated Slopes with Trees

C Bench Terrace



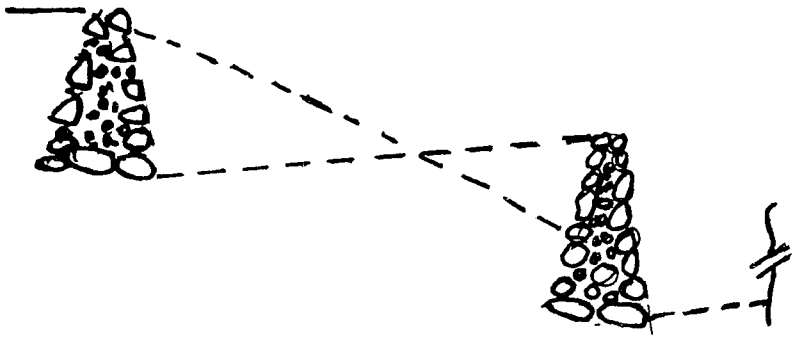
Reverse Slope or Level Vegetated Cut & Fill Slopes

D Rock Terraces

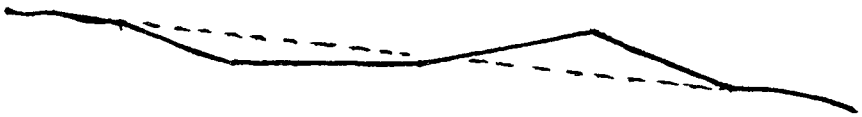


Generally Not Recommended

E Rock Wall Terrace with Level or Sloped Bench



F Channel-Type Terrace



G Ridge-Type Terrace

Factors for Size & Spacing

Slope
Soil Type & Depth
Rainfall
Type of Crop
Level of Maintenance

Construction—On contour and stable channel grade.
Provide stable outlets.

Alternatives for Waterways and Terrace Outlets

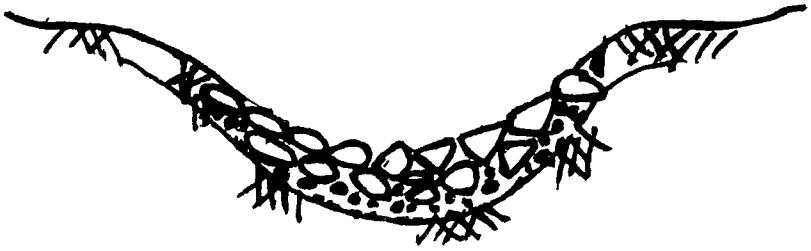
1. Sugarcane, bamboo, or other fibrous rooted crop.

2. Shaped and vegetated. Typical shapes are:

Parabolic

Trapezoidal

3. Rock Lined



4. Rock or rubble masonry drop structure or check dam.

5. Rock or rubble masonry chute.

Appendix IV
Material & Equipment Needs

The following list of equipment and materials is suggested for each team member:

1. First aid kit for placement in vehicle
2. Roll of plastic electricians tape for each vehicle
3. Pocket calculator (type to vary with position)
4. Box of mechanics tools for each vehicle
5. Jerry cans (2-1 for water & 1 for gasoline) 5 gal capacity each for all vehicles
6. Handiman jack for each vehicle
7. Hand air tire pumps for each vehicle
8. Ax & shovel (small for vehicle)
9. 2 gallon insulated water jug
10. Insulated carrying box
11. Boy Scout type knife
12. Insect repellant
13. Machete
14. 4 Wheel Drive vehicle
15. Abney level
16. Office equipment, desk, chair, table, file, map file, lamp

Additional equipment and materials for each team location:

1. Bright colored plastic flagging ribbon
2. 3-roll up type steel tape in millimeters & meters (15 meter minimum)
3. 2-35 mm cameras with telephoto & regular lenses
4. 2-Binoculars (7x50)
5. 1-Color, Polaroid type camera
6. 1-Slide projector and screen
7. Overhead projector & clean plastic for overhead slides
8. 1-Portable power unit (generator) for operating projectors
9. 1-Movie projector
10. Photo copy machine—Duplicating equipment
11. Misc. office supplies, such as, notebooks, paper, pencils, etc.
12. Typewriter (2 in central team office)
13. 3-No. 2 shovels
14. 2-Sharp - Shooter spades
15. 1 set soil sieves
16. 1 easel with blackboard and chalk

In addition to these lists the following suggested materials should be obtained for the various specialists:

Tropical Agronomist

1. National Agronomy Manual
2. Guide for Field Crops in the tropics and the sub tropics
3. Scales in Kilograms
4. Cloth sacks
5. Roll of twine or cord

Soil Conservationist

1. Sample Technical Guides from Puerto Rico, Hawaii, Florida, Louisiana, Texas and California.

Forester

1. Increment borer
2. Diameter Tape
3. Woodland information stick
4. Denisometer
5. National woodland manual
6. Tropical tree identification guide
7. Hysometer
8. Prism
9. Hand Compass
10. Angle gauge

Vegetative-livestock specialist

1. Clipping rings, various sizes, 2.4, 4.8 and 9.6 sq. ft.
2. Gram scales
3. Cloth or plastic sacks (shopping bag size)
4. Roll of string or twine

5. Heavy duty clippers—shear type
6. Clippers—brush trimming type
7. Set of engineering pins
8. National Range Handbook
9. Plant Materials Handbook
10. 50' small diameter rope (Nylon)

Engineers & Technicians

1 - Case marking keel
2 - Stream velocity meters
2 - Boxes Log-Log Paper
4 - Engineering Field Manuals
2 - Sets of National Engineering Handbooks
4 - National Handbook for Conservation Practices
Irrigation Guides form California, Texas, Hawaii, Puerto Rico, Florida, & Louisiana.
2 - Dumpy Levels
2 - Transits
4 - Survey rods (metric)
8 - Range poles
2 - Steel chains w/survey pins
2 - Spirit Hand Levels
2 - Drafting Tables w/mechanical drafting arms
2 - Engineer's Scales
2 - Architects Scales
12 - Map Scales
4 - 12" - 45° Plastic Triangles
4 - 12" - 30° - 60° - 90° Plastic Triangles
12 - 6" - 30° - 60° - 90° Plastic Triangles
2 Leroy Lettering Kits
2 - Rapidiograph Pens
8 - Pentel Retractable Pencils w/.5mm Head of H, HB & 2H Hardness
8 boxes - 2H Pencils
2 boxes - 3H Pencils
2 boxes - 4H Pencils
Supply of erasers & eraser shields
2 Rolls 10x10 cross-section paper
2 Rolls Plan-Profile Paper
2 Rolls Plan-Paper (unlined)
1 Dozen Survey Books (Engineering)
2 - Conductivity Meters
2 - Speedy Moisture Kits N/1 case of reagent
2 - Eley Volume Meters

Soil Scientist

— Soil Taxonomy book
— Bucket-type auger
— Screw auger
— Pick or digging bar
— Muncell color book
— PH indicators
— Conductivity meter
— Hach field kit for determining selected chemical properties. (CEC, exchangeable Na, and etc.)
— Soil survey field sheets (See Section II C.1.b.(2).
— 10X hand lens
— Geology hammer
— Dilute hydroclhoric acid (10% solution)
— 4x5 or 2¼ x 2¼ formated camera pencils, erasers, etc.
— Rapidograph pens. (No. 2, No. 1, No. 0, No. 00)
— Mapping board (size to be determined by the size of the 1:25,000 — scale field sheets)
— USDA—SCS—National Soils Handbook
— USDA—Ag. Hdk. No. 18, Soil Survey Manual, 1951
— Mirror - type stereoscope w/legs
— Pocket stereoscope
— Calculator (TI-SS or similar statistic calculator)

Appendix V
Profile of Positions of Long-Range Technical Assistance Teams

Technical Assistance Leader

The Technical Assistance Leader should be a senior soil conservationist that is skilled and experienced in bringing about organizational efficiency. The position should be filled with an individual that has served as or would be acceptable for a SCS State Conservationist position in the USA. The leader should be:

1. Experienced in operating and managing a soil and water conservation program.
2. Experienced in field conservation practice application in areas with steep irregular topography and in irrigated areas.
3. Familiar with project planning and implementation of plans.
4. Capable of providing competent advice and counsel on organizational development, operation, and management.
5. Experienced in the management of personnel and organizational budgets.
6. A competent public relations individual that is proficient at motivating people.
7. Familiar with training concepts and experienced in the successful training of employees to provide effective soil & water conservation technical assistance.
8. A competent administrator with experience in using a multi-discipline approach to land use planning and management.
9. Patient and have the ability to work effectively with people.

Soil Conservationist

The Soil Conservationist should have a solid background in resource conservation and land improvement. This person should have knowledge and experience in the following:

1. Must be a total resource planner.
   a. Acts as coordinator of resource plans of other specialists.
   b. Can plan on a broad scale project type or in detail at the individual farm level.
2. Is capable of directing a total soil conservation program including vegetative and structural practices.
3. Is an expert in the control of erosion on steep mountain slopes which are cultivated.
4. Can recognize and present alternatives for controlling soil erosion on irrigated and non-irrigated cropland which have high erosion rates.
5. Has a good knowledge of plants and their use in controlling soil erosion.
6. Has overall responsibility in development of technical guides and works closely with other specialists in accomplishing this task.
7. Understands soil potentials and limitations.
8. Has a good knowledge of sound tropical agronomic practices.
9. Knows tropical soil conserving plants and crops.
10. Understands the use and limitations hillside terraces.
11. Must understand the work of the other specialists and be able to crosswalk their plans and programs into a total soil and water conservation program.
12. Must be a highly qualified trainer. Can train co-workers and land users in the art of good land management.
13. Can work well with Government of Haiti officials in directing a total resource conservation program and in exchange of ideas.

14. Must have the ability to work closely with many different personalities and interests. Is friendly, understanding and businesslike.

Vegetative-Livestock Specialist

The vegetative - livestock specialist's knowledge and duties will be much the same as a range conservationist in the U.S. but he must be able to direct his expertise toward tropical forage and livestock species. This specialist must be able to:

1. Identify native grass, forbs and shrubs and know the value of each for the reduction of soil erosion and the forage value for livestock and wildlife.
2. Know how to manage all forage species to obtain maximum use while maintaining plant health and vigor.
3. Must understand plant ecology.
4. Must have a good understanding of soil-plant relationships.
5. Must be able to determine present condition of the natural ecosystem in relation to the potential.
6. Understands wildlife needs and can manage vegetation to achieve maximum wildlife habitat.
7. Knows what plant species are best adapted to the various soils and climate.
   (a) Drought tolerant
   (b) Soil binding
   (c) Forage values
8. Knows types of grazing animals, their food requirements and grazing preferences.
9. Knows nutritional value of all plant species.
10. Understands the plant materials program
    (a) Seed production by species
    (b) Viability of seeds
    (c) Storage ability
    (d) How, where and when to plant
    (e) Can plan and evaluate field trials, (experimental plots).
11. If necessary can operate special equipment for preparing seedbeds and be able to harvest seed.
12. Can direct the safe use of chemicals for the control of undesirable plants.
13. Has a working knowledge of land economics.
14. Works with a veterinarian to control livestock parasites and diseases.
15. Has a working knowledge of the manu insects which affect plants and animals and knows how to keep undesirable ones under control.
16. Is a well qualified land use planner.
17. Can make land use decisions without the direction of higher position employees.
18. Has the ability to train others that have limited education and experience.
19. Above all, this person must be able to effectively communicate with others, recognize problems where they exist and suggest alternative solutions.

Tropical Agronomist

A tropical agronomist knows tropical crops and their values. Some of these are:

(a) Food crops and their value for nutrition
(b) Soil building crops
(c) Food trees
(d) Fiber crops
(e) Oil crops

1. This specialist must know the water and fertilizer requirements of tropical crops.
2. He or she must have a good knowledge of soils and knows the crops adapted to these soils.
3. Must understand irrigation systems and how to apply the required amounts of water for maximum production of the crop.
4. Can recommend alternative irrigation systems and works closely with the irrigation engineer in designing irrigation systems.
5. Knows water holding capacity of the various soils.
6. Has a working knowledge of crop depleting insects and diseases and can recommend their control.

7. Understands the safe and correct use of chemicals.
8. Knows best planting methods for each crop.
9. Knows root depth requirements for each tropical crop and best cultural methods.
10. Knows potential production of tropical crops.
11. Has a knowledge of the highest producing variety of each species.
12. Has a working knowledge of agricultural economics.
13. Can work effectively with people who have minimum knowledge of good agricultural practices.
14. Can give effective training to less knowledgeable people in tropical agriculture.
15. Must be able to recognize people problems and present acceptable solutions to the problems.
16. Must be a good land use planner and present solutions to soil erosion problems.

Tropical Forester

The tropical forester must be able to identify all tropical tree species, know their value and growing needs. He or she must have a knowledge of the following:

1. Know the best and most economical value of each tree for:
   (a) lumber
   (b) Wood carvings
   (c) Fuel
   (d) food
   (e) Wildlife habitat
   (f) Other values such as livestock, forage, shade and soil protection.
2. Knows soils and their relationship with each tree species.
3. Know where each tree species is best adopted to the various soils and climate.
4. Is a well qualified forestry planner and is able to achieve the best management.
5. Can make resource inventories on forest lands.
   (a) Kinds, amounts and production of each tree species.
   (b) Understory value for soil protection, wildlife use and value for livestock and other uses (multiple use values).
6. Knows best harvesting techniques.
7. Can outline a usable management plan for Haitian Pine Forest improvement.
8. Must be able to work with the Government of Haiti in establishment and managing national Forests.
9. Understands the ecosystem of the 5 forest habitat types in Haiti.
10. Knows climatic and elevation requirements for the various tropical food trees.
11. Can assist the forestry educators in Haiti in classrooms and field instruction if requested.
12. Give training to Co-workers in forestry practices.
13. Understands re-forestry methods.
14. Knows all possible species, both native and introduced, that have high possibility for success.
15. Recognizes tree diseases, parasites and harmful insects and knows how to control them.
16. Understands safe use of chemicals.
17. Knows understory vegetation and its use for soil erosion control, value for wildlife, livestock and other.
18. Works closely with vegetative livestock specialist in total resource management.
19. Can work effectively with people in exchanging ideas and transferring knowledge.

Soil Scientist

The soil scientist must have a broad range of experience in soil morphology, soil genesis, soil classification, soil survey mapping and soil interpretation. The individual must have the ability to organize conduct, and complete a soil survey with very little assistance from other soil scientists. Experience in preparing soil interpretations and presenting the soils infor-

mation to individuals or groups is important. He needs to have experience working with other disciplines in preparing soil survey interpretations and the ability to take the leadership in developing the interpretations.

The following list provides some additional requirements of the job:

1. The ability to work with other disciplines in the completion of all phases of soil survey.
2. A good on-the-job trainer of co-workers and other members of the soil conservation team.
3. Must have a good working knowledge of soil taxonomy and is able to apply with minimal assistance.
4. Capable of interpreting and using soil characterization data, climatic data and other data in the classification and interpretation of soils data.
5. Has a good understanding of soil engineering properties and the effects of the soil engineering interpretations.
6. Understands the factors which effect soil erodibility and is familiar with effective practices to reduce the erosion.
7. Is familiar with and capable of assisting in the collection of data on the adapted crops, crop yields, site indexs and etc.
8. Is proficient in aerial photo interpretation and use of stereoscope.
9. Is familiar with the field test equipment and procedures for determining select chemical properties of the soils.
10. Must be physically able to walk over the steep rugged topography of Haiti. Access to some areas will be restricted to horseback, trail bike or on foot.
11. Needs a good background in geology and geomorphology to help in understanding the complex pattern of soils.
12. The individual must be patient and willing to work under difficult conditions due to the dense population, rugged terrain and lack of adequate facilities at many locations. The small farm size will make field operations more difficult than would be normally expected in less populated areas.
13. Must be experienced in designing mapping units and determining the composition of the soils in the mapping units.

Profile of Conservation/Irrigation Engineer

General

Education & Training Requirements:

1. Minimum of BS Degree in Agricultural Engineering, or
2. Minimum of BS Degree in Civil Engineering with a minimum of five years of field experience in erosion control and irrigation.
3. Attendance of Irrigation Water Management Course desirable.

Experience Requirements:

1. Minimum of 10 years of professional experience.
2. Planning, design, layout, and construction of terraces, waterways, and grade control structures on a wide range of soils and varied climatic conditions; experience on slopes greater than 12 percent desirable.
3. Knowledge and experience with rock, rubble-masonry, or concrete construction is desirable for both the grade control and irrigation structures.
4. Knowledge and experience in working with irrigation districts and irrigation groups.
5. Planning, design, layout, and construction of surface irrigation systems, using both concrete and earth lined canals and small pumping plants.
6. Working knowledge and experience with reorganizing irrigation systems and
7. Must possess expertise in soil-plant-water relationships and the evaluation of surface irrigation methods. Expertise in tropical crop culture would be desireable.
8. Spring developments.
9. Hydraulics and hydrology.

Special

Central Team Engineer should have the following special skills:

1. Plan, organize, develop, coordinate, and manage a technical program such as erosion control and irrigation water management.
2. Development of conservation practice standards and specifications.
3. Development of irrigation guides.
4. Design and construction of diversion dams.
5. Principles of water quality, especially salinity management.
6. Soil mechanics, especially principles of slope stability analysis.
7. Development of rainfall - runoff - sediment relationship procedures for mountainous terrain.
8. Familiar with Groundwater & Sedimentation Geology.
9. Must be innovative, be a good trainer, and work effectively with people.

Field Engineer should have the following special skills:

1. Creativity, patience, trainer, and willingness to work under adverse conditions.
2. Development of instruction techniques, such as visuals, job sheets, etc.
3. Be able to work under minimum technical supervision.
4. Be a team worker and work effectively with people.

Profile of Soil Conservation Technician

Education & Training Requirements:

He could be a paraprofessional with a High School diploma and possibly additional college or special formal training. Attendance of a irrigation water management course would be desirable.

Experience Requirements:

1. Soil Conservation Technician with a minimum of 10 years of qualifying experience, or a
2. Civil Engineering Technician with a minimum of 10 years of experience, 5 or more years of which must have been in erosion control and irrigation works.
3. Topographic mapping; routine surverying and notekeeping.
4. Simple design, layout and construction of terraces, waterways, and rock, rubble-masonry, or concrete grade control structures.
5. Contour forming practices on a wide range of soils and varied climatic conditions; experience on slopes greater than 12 percent is desirable.
6. Simple design, layout, and construction of on-farm irrigation practices, such as land leveling, ditches, structures, and water measurement.
7. Working knowledge of the application of both mechanical and vegetative conservation practices.
8. Experience with tropical agriculture would be desirable.
9. Must be able to work with a minimum of supervision; be creative, practical, patient, and effective in showing individuals and groups how to do something.
10. Be able to work under adverse conditions and with people of limited knowledge of good agricultural practices.

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