PD-AAQ-334
ISN: 37442

UNCLASSIFIED
CLASSIFICATION

PROJECT EVALUATION SUMMARY (PES) – PART I

Report Symbol U-447

1. PROJECT TITLE	2. PROJECT NUMBER	3. MISSION/AID/W OFFICE
Land Use Inventory and Environmental Planning (ONERN	527-0202	USAID/Peru

4. EVALUATION NUMBER (Enter the number maintained by the reporting unit e.g., Country or AID/W Administrative Code, Fiscal Year, Serial No. beginning with No. 1 each FY) FY 85-01

☐ REGULAR EVALUATION ☐ SPECIAL EVALUATION

5. KEY PROJECT IMPLEMENTATION DATES	6. ESTIMATED PROJECT FUNDING	7. PERIOD COVERED BY EVALUATION
A. First PRO-AG or Equivalent FY 80	A. Total $ 3,100,000	From (month/yr.) 9/80
B. Final Obligation Expected FY 85	B. U.S. $ 1,600,000	To (month/yr.) 7/84
C. Final Input Delivery FY 87		Date of Evaluation Review August, 1984

8. ACTION DECISIONS APPROVED BY MISSION OR AID/W OFFICE DIRECTOR

A. List decisions and/or unresolved issues; cite those items needing further study. (NOTE: Mission decisions which anticipate AID/W or regional office action should specify type of document, e.g., airgram, SPAR, PIO, which will present detailed request.)	B. NAME OF OFFICER RESPONSIBLE FOR ACTION	C. DATE ACTION TO BE COMPLETED
Summary of Accomplishments:		
Major project objectives have been achieved. The GIS computer-based technology has been installed and appropriate ONERN staff have been trained in its use, operation and maintenance. Not only have ONERN staff developed the requisite skills to conduct remote sensing, image analysis, cartography, ground verification and thematic mapping activities, but the institution has also developed the capacity to conduct in-house training in several of these important technical areas.		
Major Evaluation Recommendations:		
1. Extend project for 30 months (primarily to allow sufficient time to meet LT training needs).		9/84
2. Provide additional LT degree training to address deficiencies in areas such as ecology, geomorphology, and spacial geography.		FYs 85-87

9. INVENTORY OF DOCUMENTS TO BE REVISED PER ABOVE DECISIONS

- [X] Project Paper
- [X] Financial Plan
- [ ] Logical Framework
- [X] Project Agreement
- [X] Implementation Plan e.g., CPI Network
- [X] PIO/T
- [X] PIO/C
- [X] PIO/P
- [ ] Other (Specify) _____
- [ ] Other (Specify) _____

10. ALTERNATIVE DECISIONS ON FUTURE OF PROJECT

- A. [ ] Continue Project Without Change
- B. [ ] Change Project Design and/or [X] Change Implementation Plan
- C. [ ] Discontinue Project

11. PROJECT OFFICER AND HOST COUNTRY OR OTHER RANKING PARTICIPANTS AS APPROPRIATE (Names and Titles)

David L. Faulkner, Project Officer, USAID/Peru
Carlos Zamora, Director, ONERN

12. Mission/AID/W Office Director Approval

Signature: John Sanbrailo

Typed Name: John A. Sanbrailo

Date: 11/9/84

A.D. 1350-12 (5-78)

	Name of Officer Responsible For Action	Date Action to be Completed
3. Provide approximately 22 months of additional T.A. to assist ONERN in GIS applications such as the completion of an environment profile of representative areas of Peru's three major geo-climatic regions.		FYs 85-86
4. Create a functioning interface between the GIS and the disciplinary departments of ONERN through collaborative efforts on the environmental profile and other GIS applications.		FYs 85-86

Actions Taken to Date (10/30/84):

1. Amendment to the Project authorization, Project Paper Supplement, and third Project Agreement Amendment approved by the Mission September 11, 1984. Project Agreement Amendment signed September 28, 1984.

2. PIO/Ts for additional technical assistance are in process and will be submitted to AID/W early November, 1984.

3. The revised Implementation Plan covering the period of the extension will have been completed in draft by the end of November, 1984.

4. Participants (both long and short-term) have been scheduled to start necessary English language training in January, 1985.

XD-AAQ-334-A
ISN: 37443

ONERN

LAND USE INVENTORY AND ENVIRONMENTAL PLANNING

AN EVALUATION

USAID/PERU

Contract No. 527-0202-C-00-2014-00

Preface

The ONERN Land Use and Environmental Planning Project was evaluated by a team from TAMS. Members were Joshua Dickinson, environmental management and team leader; William Brooner, remote sensing; and John Antenucchi, Geographic Information Systems. A total of sixty working days were devoted to the evaluation between July 4 and August 8, 1984.

The team is particularly indebted to Carlos Zamora, Director of ONERN; Mauro Mendoza and Walter Danjoy of the GIS/Remote Sensing program; Creighton Dennis, the ERIM Chief of Party, and Jack Rosholt of AID for their willing collaboration in the evaluation process. A final report was produced in Peru with the assistance of the Radio Shack Computing Center in Lima.

The evaluation is dedicated to the mystique of ONERN that makes the institution something more than the sum of its people. Through this project, Azurza Zozimo, who started as an office boy, has now become a Geographic Information System technician teaching others his skills. His success is symbolic of the challenge and opportunity for all who work in ONERN for their own and Peru's development.

Acronyms

APODESA	Apoyo al Desarrollo de la Selva Alta
GIS	Geographic Information System
ONERN	Oficina Nacional de Evaluacion de Recursos Naturales
ERIM	Environmental Research Institute of Michigan
AID	Agency for International Development
CIDA	Canadian international Development Agency
SAN	Servicio Aerofotogramétrica Nacional (Peru)
CCT	Computer Compatible Tape (Digital LANDSAT data)
DEC	Digital Equipment Corporation
INPE	National Institute of Space Investigation (The Brazilian LANDSAT Receiving Station)
IAGS/DMA	InterAmerican Geodetic Survey-Defense Mapping Agency
IGN	Instituto Geográfico Nacional (Peru)
OGCR	Oficina General de Cadastro Rural
CONIDA	Comisión Nacional de Investigación y Desarrollo Aerospacial (Peru)
INADE	Instituto Nacional de Desarrollo
I.R.E.	Importaciones y Representaciones Electrónicas S.A.
INP	Instituto Nacional de Planificacion (Peru)
MSS	Multispectral Imagery

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1.0 Executive Summary

1.1 Background

The Project. The Environmental Research Institute of Michigan, ERIM, under contract to AID/PERU, assisted the National Office of Natural Resource Evaluation, ONERN, in strengthening its capabilities in the inventory and evaluation of natural resources. At the core of the Project has been the installation of an automated Geographic Information System (GIS). In support of the GIS was planned intensive technical assistance focused on the inventory of natural resources and environmental change through remote sensing and ground verification and the process of thematic mapping. Training in environmental assessment, testing of procedures and technology at field sites and preparation of a country-wide Environmental Profile were designed to measure GIS functioning and ONERN's increased capabilities.

The grant Project as amended was carried out over a 29 month period and involved 53.6 person/months of technical assistance.

Accomplishments. ONERN now has a functioning automated GIS and satellite image analysis system. A cadre of staff has been trained in system operation, image analysis, remote sensing and cartography. This cadre is capable of carrying out in-house training in a number of areas.

Objectives Yet to be Achieved. The system works. The staff of ONERN now must acquire or refine the skills needed to interface with the GIS and then apply the system as a tool in carrying out projects relevant to ONERN's mission in Peru.

The Evaluation. The three person Evaluation Team devoted 60 days to a thorough analysis of the Project with the dual goals of assessing progress to date and to recommend follow-on activities for a proposed extension of the Project. Findings and recommendations worthy of executive attention in ONERN and AID are

presented in Section 1. 2, followed by the outline of a follow-on project proposal which would integrate most of the recommendations in Section 1.3.

1.2 Findings and Recommendations

1.2.1 The Project in Retrospect

The essential objective of installing a functional GIS became, as delays and problems intervened, almost the exclusive project activity. The Contract was decidely deficient in reflecting or referencing the detailed guidance contained in the Project Paper. The coherence among the three Project phases was not maintained, resulting in a lack of preparation in the skills and logical process of a manual GIS, thematic mapping or environmental assessment. The quality of the demonstrations reflected the lack of collateral preparation.

ERIM accomplished very effectively the critical task of GIS installation, a complex activity which required both the undivided attention of the Chief of Party in Peru and coordinated multi-disciplinary backup by ERIM staff.

The Evaluation Team recommends that AID provide follow-on support to assure that the practical applications objectives envisioned in the Project Paper are achieved. Since a functioning automated GIS is now a reality, follow-on support should consist of selective technical assistance and training to:

1. Tie up loose ends in the GIS/Remote Sensing area such as making Brazilian INPE tapes compatible with the DIPIX.
2. Create a functioning interface between the GIS and the disciplinary departments of ONERN.
3. Complement ONERN as needed in organizing and conducting a regional assessment as defined in Section 1. 3 below.
4. Provide long term degree training where deficiencies are noted such as in ecology.
5. Provide short term training for GIS operations and maintenance personnel.

It is anticipated that this support can be provided through IQC, Personal Services, or other mechanisms, as determined by AID. AID contractees involved in the yyupport of APODESA and the Palcazu projects have a complementary interest in the activities described in Section 1.3.

1.2.2 Recommendations for Urgent Action

1. Preparation, under the direct supervision of the ONERN Technical Director, of a comprehensive maintenance program for all major and peripheral equipment upon which a functioning GIS depends. This includes:
   a. Establishing maintenance agreements for hardware and for software upgrading.
   b. Preparing in-house maintenance plans for peripheral equipment, purchasing testing equipment and spare parts, and training of personnel.
   c. Translation of manuals.
   d. Establishing budget line items to cover the recurring and contingency costs of the above. AID/CIDA support for maintenance assistance should be programmed to phase out as ONERN begins to generate overhead from contracts.
2. Contract for 2 months an expert in design of a hierarchical regional/national data base structure and thematic map legend compatible with the GIS and Peruvian conditions. A three week initial visit should include an inventory of existing classification systems and a seminar on legend design. A second five week period should be devoted to definitive GIS data base design.
3. Contract for 12 months, preferably continuous, a GIS applications generalist with training and experience in resource management, ecology, physical geography and/or regional planning. This consultant should serve as an advisor to the Technical Director of ONERN. A study visit by the Technical Director and GIS/Remote Sensing Directors to similar facilities in Bolivia and Chile could be useful. Responsibilities in priority order would be:

a. Promote and facilitate the use of the GIS by teams drawn from disciplinary departments on ONERN projects.

b. After several months of experience, offer practical suggestions on de facto organizational changes to facilitate GIS use and interdisciplinary cooperation.

c. Assist in identifying GIS applications in AID funded projects at the Project Identification level.

4. Contract programming expert for 3 to 4 weeks to develop software for a DIPIX conversion routine to read Brazilian INPE tapes and to write an interim program to allow processing of Thematic Mapper data on the DIPIX.

5. AID should fund the hiring by ONERN of two persons to support Vargas and Villafranca in the operation and maintenance of the GIS. This redundancy will allow for expansion of GIS service activities and assure continued GIS functioning in the event of eventual personnel turnover. The four persons should be sent to the U.S. for refresher and more advanced training by DEC. An additional two entry level persons should be recruited for training in digitizing and related activities in support of the Profile project and expanded GIS use in general. AID funding of salaries should be phased out over a three year period as ONERN generates the funds to support the additional personnel.

6. Select 3 ONERN staff for intensive language training followed by Master's level programs in ecology (University of Florida with Dr. Ewel), geomorphology (Tricart Group, Strasbourg, France), economic/location geography with minor or summer course in GIS (perhaps Clark University).

1.2.3 Institutional Structure

During more than two decades, ONERN has developed an enviable reputation for the quality of its natural resource inventories prepared for regional development projects in the Selva, Sierra and Coast. These multi-disciplinary studies are directed by the Director of Integrated Studies. The departments are so experienced in carrying out these studies that little executive attention is needed. The advent of the world environmental movement resulted in the creation of a Department of Environmental Studies. On paper, at least, there are now three

similarly named departments under a Department for the Preservation of the Natural Environment. Remote sensing is a separate department which includes the DIPIX and associated staff. This department does aerial photograph interpretation. Photogrammetry and thematic mapping are separate departments as well. The AID funded Resource Inventory and Environmental Planning Project resulted in the creation of yet another new department, Computer Services, which houses the GIS.

Such a fragmented structure is disfunctional and not conducive to successful interdisciplinary projects, particularly those involving GIS applications. The Evaluation Team recommends the consolidation of related service functions such as Computer Services, Remote Sensing and Cartography under a single director. It is also recommended that ONERN consider a "project" approach in which the professional staff no longer operates within the isolation of disciplinary departments. Instead, interdisciplinary teams would be formed and dissolved to meet specific project goals. Project managers would be the most experienced professionals. Until such time as the formal structure of ONERN can be reevaluated, it is recommended that the Technical Director assume extraordinary powers and become closely involved in the administration of interdisciplinary projects served by the GIS. The Technical Director could draw together interdisciplinary teams from any of the disciplinary departments and assure that the service departments function coherently.

1.2.4 Overhead Charges

It is understood that a recent change in the law governing ONERN operations will now permit ONERN to augment its own budget through contracts for services. Since AID has extensive experience in negotiating overhead rates, it is recommended that AID offer counseling to ONERN in establishing an overhead rate reflecting the real cost of maintaining the GIS and other equipment essential to sustained operation. Included could be the costs of training and technical assistance needed to upgrade the GIS.

1.2.5 Competitive Salaries

In the agreement between AID and Peru, ONERN agreed to pay critical GIS personnel salaries competitive with the private sector in Peru. This has not been done, although the team has been assured that mechanisms exist for doing so. The possibility of augmenting salaries and/or benefits in order to provide performance incentives or to compete with the private sector for key personnel should be explored with the ONERN Judicial Advisor.

1.2.6 Training

The volume and quality of short term and informal training has been one of the strong points of the ERIM Contract. The Chief of Party, Creighton Dennis, deserves special credit for implementing an effective program.

The areas of training critical to improving the overall capabilities of ONERN in natural resource management are in the supporting academic disciplines and in long term internships in operational programs. For example, an agronomist can attend twenty short courses, workshops and symposia on the "environment" without ever fully comprehending the basic principles of ecology applied to development planning. This can only be achieved through the discipline of an extended period of reading, lectures, writing, discussion and evaluation associated with graduate degree training. Areas of training that could benefit ONERN include: general and systems ecology, tropical agriculture and agroforestry, geomorphology (Strasbourg, France), geography (location/economic), and rural sociology/anthropology. Any of the preceeding could include a minor in remote sensing/GIS (if available).

Directors and project managers should be afforded the opportunity to participate in internship programs covering the design, administration and ongoing operation of existing activities.

A formal training program should be implemented to augment institutional capabilities and to provide an incentive for individual self-improvement. The program should include both in-house short-term training and specialized courses, internships and degree programs abroad. Such a program is a legitimate overhead cost for ONERN.

1.2.7 GIS Applications

The Evaluation Team is in full accord with the ONERN Director's desire to prove the GIS in practice prior to marketing the new capability to other government agencies or international donors. The regional demonstrations described in the following section will provide this practical experience.

1.3 A Recommended Action Plan for ONERN and AID

1.3.1 Background

There is a convergence of two needs; for ONERN to complete the Profile which lacks the regional critical areas analysis section and for the GIS, with its supporting technology and skills, to be tested at the regional scale in reresentative areas of Peru. Those areas of assistance necessary for GIS support of the regional Profile study are outlined in 1.2.2 above.

Envisioned is a study encompassing three areas representing examples of the major environments of Peru; the Coast, Sierra and Selva, with their respective types of development problems. It is recommended that contiguous portions of the Sierra and Selva be chosen, such as Tarma and the adjacent Central Selva area because of the importance of the transition zone between the two contrasting environments. The Coast component can be chosen separately. The three areas should be studied simultaneously to preserve a balance in emphasis. The reasons for a balanced approach are twofold; first, the objective is to test the GIS and assessment integration in all three environmental types, and second, there are pressing social and economic concerns in all three areas.

It is estimated that if the activities recommended for urgent action in Section 1.2.2 are initiated promptly, then this Profile project could be initiated by the beginning of 1985 and last for 12 to 18 months. Delay will result in loss of momentum and a lapse in essential maintenance and in-house training activities.

1.3.2 The Regional Environmental Profile - a Follow-On Project

Objectives.

1. To demonstrate and refine an approach to regional environmental profiles integrating the complete array of professional skills and technology available within ONERN.
2. To perform, within the regional framework established for the Profile, project specific analyses addressing one or more issues of importance to Peru.
3. In the process, refine and expand the skills of ONERN staff and the utilization of its computer based technology.

Local Involvement. One of the primary goals of the regional scale Profile is to assess the role of institutions, such as the Regional Development Corporations, in the management of the environment. Corrollary to this goal is the involvement of these institutions in the assessment process because, in the final analysis, it is they who will implement the recommendations considered to be practical. Demonstrations of the GIS at the scale of each study will create an awareness of the utility of the system in other regions and at higher levels of aggregation.

Approach. Specific geographic regions would be selected for a multilevel analysis of regional and project scale issues. A hierarchical approach to data collection, compilation, representation, presentation and analysis would be designed to address the varying levels of detail appropriate to the issues of interest. Thematic maps would be prepared using remote sensing and other

collateral data; the thematic data would be consistent with a national or regional data GIS. The manipulations would include:

1. Undertaking capability analysis (based on the physical and environmental capacity of the resource base) and suitability analysis (based on man induced constraints and opportunities, e.g., infrastructure or laws).
2. Identification, quantification and evaluation of existing conflicts.
3. Assessment of development options.
4. Formulation and documentation of recommended actions.

The following series of tasks are representative of the process that is proposed.

Task Series 1: Work Plan

Clearly determine specific issues to be addressed, based on discussions with potential users of Profile results and field reconnaissance. Develop a detailed work program and schedule; identify participants and assign responsibilities, milestones and products; and identify key collateral data, appropriate studies and reports.

This Task is critical to accomplishment of the overall Profile mission. Five person/months of technical assistance should be devoted to providing advice in the work program design phase of the project. This team would include a regional development planner, agriculturist, geomorphologist, social scientist and forester.

It is assumed that the one year GIS advisor (1.2.2 above) would be closely involved with the team and ONERN counterparts. This team would identify specific technical assistance needs for the rest of the project. AID FY84/85 budgeting would determine the number of person months available.

Three members of the initial team wold be programmed for a midpoint review and final evaluation of the Profile project.

Collateral support would come from APODESA advisors Farnworth and Drewes and from the Regional Environmental Officer, Howard Clark.

Primary Participants: Director General, Technical Director, Environmental Protection Integrated Studies, Remote Sensing, Computer Services, and Cartography

Task Series 2: Satellite Imagery and Aerial Photography

Obtain satellite imagery for the region at a scale of 1:250,000 and 1:100,000. Should base maps not be available, utilize satellite imagery for base map control.

Primary Participants: Environmental Protection, Remote Sensing, and Cartography.

Task Series 3: Thematic Maps

Define a hierarchical data structure for all thematic information appropriate for extension throughout Peru and supportive of the requisite analysis for the chosen study areas.

Design and develop thematic maps at the macro scale (1:250,000), intermediate scale (1:100,000 or 1:50,000) and large scale (1:10,000 ot 1:20,000) using satellite, aircraft and field derived data. Utilize published information as available. Insure that the thematic maps provide an adequate information base for issue analysis.

Primary Participants: Environmental Protection, Integrated Studies, Remote Sensing, Cartography.

Task Series 4: Create Automated Data Base

Consistent with the national hierarchical data structure, digitize, edit and produce a series of automated thematic maps. Develop derivative thematic maps. Develop data base structure to support capability, suitability, and conflict analysis.

Primary Participants: Environmental Protection, Computer Services, and Remote Sensing.

Task Series 5: Capability, Suitability and Conflict Analysis

Using both automated and non-automated collateral data, undertake a capability analysis of the physical and environmental resource base, and access the suitability of it for sustainable development. Compare this analysis with existing and anticipated land uses and identify and quantify conflicts. Prepare detailed findings.

Primary Participants: Environmental Protection, Integrated Studies, and Computer Services.

Task Series 6: Alternative Development Options

Based on the products of Task Series 4 and 5 and the involvement of organizations and individuals knowledgable of the region and its development issues, construct a series of alternative development scenarios. Subject each scenario to an assessment of conflicts and opportunities. Identify the extent to which each is responsive to existing issues and the potential for mitigating future problems. Propose a prefered plan.

Primary participants: Director General, Technical Director, Environmental Protection, Computer Services.

Task Series 7: Recommended Actions

Document the recommended plan and identify needs and participants requisite to plan implementation.

Primary Participants: Environmental Protection, Computer Services, and Cartography.

Criteria for Demonstration Site Selection. It is recommended that three distinctly different physiographic regions be used to demonstrate the applicability of the proposed approach: Selva, Sierra and Coast. Three areas are discussed in the following section.

SELVA: An area covering 110km by 160km including the Pozuzu, Palcazu and Pichis Valleys amd the neighboring market centers of Satipo, La Merced and San Ramon.

Macro Scale (1:250,000)

Issues:

1. Transportation Networks, existing and potential.
   a. Distance, both horizontal and vertical, affecting economic advantage.
   b. Climatic (e.g., heavy rainfall) and topographic considerations in road location and maintenance.
2. Land Use, actual and potential.
   a. Delimitation of existing settlements and settlement/deforestation frontiers.
   b. Land use potential as determined by Life Zone, topography, and potential access to transportation.
   c. Land use conflict inferred from a and b and other collateral data (e.g., location of bare/eroded soil).
   d. Location and access to National Parks and Forest Reserves.

Intermediate Scale (1:100,000 or 1:50,000)

Issues

1. Transportation Network.
   a. Location of main and feeder road corridors.
   b. Location of maintenance hazard zones due to climate and geomorphology.
2. Land Use.
   a. Land capability for major use categories.
   b. Land capability for major use categories reflecting infrastructure, etc.
   c. Identification of existing and potential conflicts with land use capability and suitability.
   d. National Park and Forest Reserve delimitation and management planning.

Large Scale (1:10,000) Focused on sustained yield forest management area, approximately 10,000 ha.

Issues

1. Detailed delimitation.
   a. Forest management areas
   b. Estimation of forest yield.
   c. Exploitation corridors and road access.
2. Location of supporting land uses, settlements.
3. Stereo pairs as samples for macroscale interpretation keys.
4. Monitoring of selected environmental variables using CIR video (See Appendix 3).

SIERRA: Focus on existing growth poles such as Tarma, Puno, Cuzco, Arequipa, Cajamarca. Tarma provides a continuum between a representative Sierra area and the Central Selva.

Macro Scale (1:250,000)

Issues:

1. Transportation, relative accessibility and topographic constraints.
2. Land Use, actual and potential.
   a. Delimitation of settlements and major use classes.
   b. Major land use conflicts as indicated by bare and eroded areas.

Intermediate Scale (1:100,000 or 1:50,000 with 1:10,000 samples)

Issues:

1. Land Use.
   a. Refinement of Life Zone delimitation by CIR photography.
   b. Test video CIR technology for applicability to Life Zone and land capability assessments, watershed management (see Appendix 3).
   c. Rehabilitation of pre-Colombian terraces and irrigation works.
2. Studies for soil conservation, water management and use, and degraded area reclamation and recuperation.
3. Assessment and mapping of human well-being as a composite of income, health, housing, tenure, population, and density versus carrying capacity of the supporting resource base from various sources including census tapes.

COAST: A watershed and coastal fringe area extending inland to 1550-2000 meters elevation. Focus on an agricultural valley with an urban growth pole, e.g., Chiclayo, San Pedro de Lloc, Chimbote, or Huacho.

Macro Scale (1:250,000 to 1:100,000)

Issues:

1. Land Use, competition for land between urban and irrigated agriculture uses.
2. Generalized identification of agriculture use and potential use.
3. Identification of hazard areas due to flooding, landslides and seismic activity.

Intermediate and Large Scale (1:100,000 or 1:50,000 with 10,000 samples)

Issues:

1. Potential for expanding agricultural production and improving human well-being through:
   a. Changing crop mix and tenure pattern to increase participation in production, subsistence security and cash crop income.

b. Increased production through more efficient water use and decreased salinization due to poor management.

c. Identification and rehabilitation of pre-Colombian irrigation systems and terraces.

d. Through geomorphologic evaluation, identify potential for tapping groundwater resource.

2.0 Introduction to the Project Evaluation

2.1 The Project

Remote sensing projects funded by AID, worldwide, have been designed to assist host countries in developing and using advanced technologies for acquiring and analyzing natural resource information and applying this information to development planning, management and monitoring. Remotely sensed data, including aerial photography, resource satellite imagery and meteorological satellite imagery, provide a wide spectrum of resource information applicable to a variety of specific development problems. Typically, remotely sensed data provide information which is usually difficult and very expensive to obtain by other means such as field methods. Remote sensing on a regular basis allows comparisons to be made over time of changes in the environment. Such information is widely applicable to resource management and monitoring activities.

When effectively applied, remote sensing can be a dynamic source of data for a GIS. GIS provide capabilities for combining spatial data from multiple sources and performing a wide range of analytical operations. As a result, remote sensing and GIS technologies are now frequently integrated to better facilitate the timely analysis and provision of information on the quantity and character of natural resources which can assist the decision-making and planning process.

In the AID-ONERN Land Use Inventory and Environmental Planning project, both remote sensing (Sub Program 1) and GIS (Sub Program 2) components were included, and the Project was designed to facilitate their effective application for environmental assessment, monitoring and planning (Sub Program 3). While this project evaluation report discusses each Sub Program separately, an assessment of the degree of their integration in the overall project was given a high priority in the evaluation analysis.

The Project Agreement included the provision of technical assistance for 34 person months, distributed among the three Sub Programs: A Natural Resources Inventory System (10 person months); Geographic Information System (10 person months); and Environmental Planning, Assessment and Demonstrations (14 person months). In March, 1982, AID contracted with ERIM for the provision of technical assistance services,

totalling 46.0 person months over a twenty-four month period. This contract has subsequently been modified to include 53.6 person months over a 30 month period. The distribution of ERIM technical assistance by Sub Program and task is summarized on Table 1.

The objective of the ERIM contract "is to strengthen the basic capabilities of the Government of Peru's National Office of Evaluation of Natural Resources (ONERN) to meet its responsibilities and environmental assessment and protection. The contract will improve ONERN's capability to carry out nation-wide resource inventories using advanced remote sensing technology and to store and manipulate for environmental purposes, resource data in a thematic/geographic information system."

The Project's execution and implementation has deviated from the design and spirit of the Project Paper. The Project activities to date have focused on the installation and demonstration of the GIS (Sub Program 2), with limited attention to the inputs (Resource Inventory, Sub Program 1) and outputs (environmental planning applications, Sub Program 3) aspects described in both the Project Paper and the Contract. These issues and findings are further described in Sections 3 and 5, respectively.

2.2 Evaluation Objectives

The Project Evaluation has two principal objectives: to analyze progress made to date in each of the Project's three Sub Programs, and to recommend follow-on activities for a proposed extension of the Project. Specific points within these two principal objectives include:

1. Ascertain the level of performance attained within each of the Project's Sub Programs and tasks in relation to targets set by the Project Paper, Project Agreement and the ERIM Contract.
2. Evaluate the need to provide additional technical assistance and training to ONERN to ensure effective use of the GIS equipment acquired under the Project.
3. Recommend activities that build on the skills acquired by ONERN under the Project and that could be performed under an extension of the Project. Recommendations should state detailed descriptions of the activities, time required to perform them, necessary ONERN personnel and resources,

TABLE 1 Technical Assistance Summary by Project Tables

Sub Prog.	Task	Project Agreement	Original ERIM Contract	ERIM Contr. As Modified		
				Long Term	Short Term	Total
1	CIR Photography	1.0	1.0	1.5	1.5	3.0
	Digital Processing	4.0	4.0	2.0	2.6	4.6
	Photo Input & Field	5.0	5.0	3.4	1.7	5.1
	Cartography	0.0	2.0	2.0	0.1	2.1
Subtotal		10.0	12.0	6.9	5.9	14.8
2	System Design	4.0	3.0	0.5	5.2	5.7
	Equip Install & Ops. Training	6.0	9.0	4.5	5.3	9.8
Subtotal		10.0	12.0	5.0	10.5	15.5
3	Env. Profile Assess.	5.0	8.0	3.5	2.9	6.4
	Env. Demon.& Training	9.0	14.0	7.7	4.3	12.0
Subtotal		14.0	22.0	11.2	7.2	8.4
X	Other (Admin, Leave, etc.)	0.0	0.0	4.9	0.0	4.9
Total		34.0	46.0	30.0	23.6	53.6

Note: Long Term total includes 1 person/month in Ann Arbor. Short Term total includes 11.6 person/months in Ann Arbor.

technical assistance needs, and estimated costs, equipment and time to perform the activities.

2.3 Overview of ONERN

ONERN was established in 1962. Under the present direction of Ing. Carlos Zamora J., Director General, ONERN's technical departments perform a wide range of resource inventory and evaluation, environmental analysis and cartographic services.

The technical objectives of ONERN include:

1. Preparation of integrated natural resource inventory studies oriented to the economic and social development of Peru.
2. Cooperation with the National Planning Institute in the formulation of policies for uses and conservation of natural resources.
3. Study, on a national level, the interactions between man and his natural environment with the intent of proposing measures to preserve balanced ecological development.

ONERN's facilities are located in San Isidro, in suburban Lima. Its staff, approximately 180 people, are organized among 26 departments. (In Section 1.2.3 is presented the Evaluation Team's comments and recommendations on organizational structure.)

ONERN's staff and facilities have benefited over the years through a variety of AID and other international donor agency programs, providing training, technical assistance, equipment and facilities. The present Project has built upon, and complemented, past programs. For example:

1. The Remote Sensing Department has a DIPIX Image Processing System acquired in 1981 through a Canadian (CIDA) funded program, PERCEP 1. The present Project was designed to provide training and technical assistance in digital image processing, using the DIPIX hardware, and to merge DIPIX generated products with the GIS.
2. An ongoing World Bank funded program is preparing a National Landsat Photomap series of Peru, including 80 map sheets at 1:250,000 scale conforming to the standard IGM format and projection. This project includes digital processing and mosaicing of more than 76 LANDSAT scenes covering

all of Peru. As part of. this Project, ONERN has acquired digitally enhanced LANDSAT images, at 1:500,000 and 1:250:000 scales, of superior quality, and which have been used for a variety of thematic mapping analyses under the present Project and others.

ONERN's sixty plus natural resource inventory and evaluation studies and some 1800 cartographic products published over the past two decades, are of high quality and well regarded in the international community. ONERN provides technical studies and services to regional, national and international agencies and it is dependent on these projects for much of its support, particularly materials, equipment and technology assistance, which enhance its capabilities and services that are clearly of benefit to Peru's economic and social development.

3.0 Sub Program 1: Natural Resource Inventory System

3.1 Background

Sub Program 1 was designed to introduce Natural Resource Inventory System technologies and to strengthen basic capabilities of ONERN to meet its responsibilities related to the inventory and evaluation of natural resources using advanced remote sensing technology. Sub Program 1 included the provision of technical assistance services, training, materials and supplies.

Sub Program 1 introduced the concepts of LANDSAT digital image processing, uses and applications of color infrared (CIR) aerial photography, thematic mapping and field verification, and manual geo-coded data bases. As stated in the Project Paper, "Digital processing of LANDSAT data, combined with other ancillary data or themes, a thematic mapping system may be developed. The Project will develop tthe procedures and capabilities to produce such a system."

3.2 Evaluation Objectives

The general project evaluation objectives for Sub Program 1 were to analyze progress made to date and to recommend appropriate follow-on activities. The evaluation has sought to ascertain the level of performance in each of the Sub Program's tasks in relation to the goals set by the Project Paper, Project Agreement and the ERIM Contract.

Sub Program 1 introduced the concepts of LANDSAT digital image processing, uses and applications of color infrared (CIR) aerial photography, thematic mapping and field verification, and manual geo-coded data bases. As stated in the Project paper, "Digital processing of LANDSAT data, combined with other ancillary data or themes, a thematic mapping system may be developed. The Project will develop the procedures and capabilities to produce such a system."

The Evaluation Team's recommendations have sought to build upon the capabilities acquired by ONERN under the Project and to identify additional technical assistance

needs.

3.3 Preparation of Thematic Maps

"In light of activities carried out under Sub Program 1 of this project, determine ONERN capacity to perform interpretation of LANDSAT tapes, aerial photography, and field verification to prepare computerized thematic maps."

3.3.1 Background

In the ERIM Contract, the tasks are stated as follows:

> "Cartography: Assistance will...be provided to monitor the initial preparation of the thematic map products and for the development of criteria for thematic boundary adjustments."
>
> "Photographic Interpretation and Field Verification: Correlation of airphoto classes with LANDSAT will be established and statistical accuracy of digital classification will be determined. In the area of field verification, ONERN personnel will receive guidance on the selection of sample sites and ground truthing procedures."

ONERN has produced a large number of good quality natural resource maps of Peru. Map themes include soils, geology, hydrology, climate, Ecological Life Zones, political units and infrastructure, vegetation, actual land use/land cover, and land capability/potential land use. Some of the cartographic products are nationwide, at small scale (e.g., 1:500,000 to 1:2,000,000). For specific project studies, maps have been prepared at larger scales, commonly ranging from 1:25,000 to 1:250,000, depending on project area, available base maps, objectives and data sources.

As conceived in the Project Paper, the Thematic Mapping task was to include procedures for facilitating utilization of multiple inventory maps, which might be of varying scale or format, for resource analysis. "Natural resource analysis often requires the comparison or integration of various map themes to provide a more comprehensive description of the environmental conditions of the study area." It was proposed in the Project Paper "to prepare a standardized geographic data base by compiling ONERN's

existing and new data at topographic map scales of 1:100,000. Preparation of thematic maps on transparent (acetate) overlays will provide an improved means of extracting resource information to be used for preparing policy and development plans."

The current ONERN project to prepare a National LANDSAT photomap series at 1:250,000 scale will provide the first comprehensive coverage of Peru, and will provide a standardized map base for future regional resource mapping and compilation of thematic data. Some 80 map sheets will be required for this national coverage.

The National LANDSAT Photomap Series will also provide a standardized format, or architecture, for creating a national data base in the ONERN GIS implemented in this Project, further discussed in Section 4.4.

3.3.2 Findings on Project Activities

The Project included a variety of thematic mapping activities directly relating to both GIS demonstration projects and environmental assessments. In the aggregate, the thematic mapping activities have included processing of LANDSAT digital imagery, interpretation of LANDSAT imagery and color infrared aerial photography, compilation and synthesis of existing and collateral data, and field verification.

Four mapping activities have been identified as illustrative of the thematic mapping activities of this Project, and demonstrate ONERN's enhanced capabilities.

1. As part of the Digital Image Processing course conducted by Mr. F. Thomson in October,1982, several field trips were conducted in the Tarma LANDSAT scene area, and analyses included interpretation of corrollary data as well as LANDSAT image processing to generate information on land cover types. Three study sites were selected (San Ramon, Tarma and Huancayo) on the basis of diversity of landscape and land cover features, representativeness of a variety of problems, accessibility for field work, and availability of existing maps, existing black and white aerial photos and high quality LANDSAT imagery (GEOPIC or equivalent). Color infrared photos were not acquired for this area.

   The activities conducted are described in detail in a memorandum report from Mr.

Thomson to Mr. Alarcon (AID), October 30, 1982. Based on subsequent observation by the Evaluation Team, this activity was successful because of the continuing activities by ONERN personnel discipline specialists. In subsequent projects at ONERN, the DIPIX Image Analysis System is being used for LANDSAT analyses, LANDSAT GEOPIC imagery (provided by World Bank) are being analyzed, aerial photos and ancillary maps are being integrated and used to support various thematic mapping activities and demonstration projects.

2. The first GIS Demonstration study area in the Upper Huallaga was completed in April, 1984. This activity involved thematic mapping for land use/land cover and land use (coca cultivation) change. The primary data sources were aerial photography, including both black and white and color infrared film types as well as topographic and cadastral maps. A variety of land use/land cover features were mapped, including agricultural lands, forest cover, drainage and roads. These data were integrated with topographic and cadastral maps in the GIS as well as with earlier land use maps prepared by the OGCR, Ministry of Agriculture. Using the GIS capabilities, ONERN specialists demonstrated a variety of thematic mapping capabilities of interest to AID programs, including selected land use types (coca) by slope categories, temporal changes of selected land uses (coca), and selected land uses by ownership.

3. The second GIS Demonstration study area, Puno, was designed to demonstrate ONERN capabilities to apply the GIS for thematic mapping of environmental parameters and grazing suitability modeling. The Puno GIS demonstration involved three sub-activities.

a. Preparation of a series of suitability maps of grazing areas in a 384 km2 portion of Puno Department. Field work was conducted by two ERIM and one ONERN person. Final parameters included Vegetative Associations (pasture types), Elevations, Slope and Temperature (mean annual temperture). Thematic maps were generated in the GIS, to show grazing suitability for cattle, sheep, llamas, alpacas and vicuñas.

b. Preparation of statistical cloropleth maps of Puno Department. A data base was compiled of about ten different types of statistical information on the provincial level. Information was acquired from Ministry of Agriculture and AID sources. Cloroplethic maps were generated to address regional problems, including food supply, pasture carrying capacity and livestock population density.

c. Up-grading of the Holdridge Life Zone map of Peru using LANDSAT imagery. The effort involved refining Life Zone boundaries using high quality LANDSAT imagery for a 1 x 1.5 degree area corresponding to the Juli quadrangle south of Lake Titicaca at a 1:250,000 scale. When digitized, the original and revised boundaries could be analyzed for concurrence and/or deviation, and further revisions could be made using LANDSAT data.

4. The third GIS Demonstration project, prepared in July, 1984, was conducted in the Palcazu area. Several land use capability maps have been prepared for the Palcazu area of the High Jungle region since 1981. These include maps, at 1:100,000 scale, independently prepared by ONERN, OGCR, and Dr. J. Tosi. Each map, while portraying interpretations of land use capability, is based on differing assumptions. To date, a common portion, of approximately 100 km2, of the ONERN and TOSI maps have been digitized and compared in the GIS. For each land use capability class, areas of concurrence and areas of differences between the two maps may be graphically displayed, and the associated statistical (areal) data may be generated. Presently, the OGCR map is being digitized to facilitate similar comparative analyses in the GIS.

The Palcazu GIS demonstration has been positively reviewed by an AID Contractor team. It provided an effective demonstration of the GIS ability to graphically and quantitatively compare two land use capability maps and highlighted the need for policy evaluation and analysis of the Palcazu land use capability mapping system.

This demonstration study area should have been expanded in order to fully meet the intent of the Project Paper in terms of criteria and parameters for the Environmental Assessment Demonstrations (such as the "planning and decision making for development projects as well as national policy formulation").

3.3.3 Recommendations

1. The various mapping programs by ONERN need to be reviewed in light of the need to develop or modify existing map legends for GIS Data Base compatibility. Legend design and structure must be assessed as well as map content and quality. Before a map may be entered into the Data Base, it must be ordered in a manner

to facilitate aggregation and/or disaggregation of data elements, commonly implying a hierarchical legend design. A review of existing thematic maps will also create a better understanding of the requisite considerations for future thematic mapping.

2. Further experience is needed by ONERN personnel in the creation of thematic maps using multiple source material. This includes practical integration of ground, aircraft and satellite acquired source data and the use of multi-stage sampling strategies for resource mapping and compilation of collateral data. The recommended Work Plan in Section 1.3 will contribute to meeting this need.

3. Further methodology development and experience is needed by ONERN personnel for creation of Thematic Maps from combinations of extant cartographic products. This requires understanding the concepts and procedures for interpreting and factoring discrete map elements, and is in essence a manual GIS process similar to the tasks described in the Project Paper. For example, a derivative Thematic Map of "hazards" may be developed through paarametric analysis and overlapping of soils, geology, geomorphology, and other maps. By having the analysts "walk through" the process, they will be better able to understand, and apply, basic GIS functions for specific project applications.

4. Further development of the Thematic Mapping capabilities of ONERN, which will satisfy deficiencies in the present project and fulfill the objectives of the Project Paper, can be accomplished through implementation of the recommended Work Program. As presented, it will provide opportunities for multiple data sources, multiple map scales, varying project areas and project objectives, and varying resource themes of interest, all of which must be developed in a context which is appropriate to the GIS Data Base requirements.

3.4 DIPIX Image Processing Capabilities

"Analyze capabilities of the DIPIX unit installed at ONERN under the PERCEP 1 project and the scope of future PERCEP 2 activities to determine additional needs for technical assistance or training."

3.4.1 Background

In the Project, this task is stated as follows: "The specialist (ERIM) will train ONERN personnel on the application of the digital classification system. ONERN has at present an LCT 11 mini-computer and a DIPIX Image Analysis System. ONERN's technicians have already received basic training on the use of this equipment and will initially develop procedures to guide the Project. The technical assistance will involve improvement of these procedures and training of peronnel to process and interpret the LANDSAT tapes. It is estimated that four person/months will be required."

The DIPIX, supported by the LCT 11 mini-computer, provides basic capabilities in digital image processing, including LANDSAT CCT's. ONERN's system was one of the first units manufactured by DIPIX Corporation and was provided under a CIDA PERCEP 1. The system was delivered to ONERN in February, 1981. Training, of an undetermined extent, was also provided under the CIDA grant.

3.4.2 Findings on Project Activities

When ONERN received the DIPIX system, it was installed in a basement room which did not contain environmental controls (air conditioning and dehumidifiers) and the electrical wiring was inappropriate to the system's design (the electrical wiring was not grounded and the supply line lacked a stablizer to protect the equipment from line voltage fluctuations). As a result, the system never operated properly, commonly did not operate at all, and was not utilized by ONERN personnel prior to initiation of the Project.

The DIPIX system's utilization and integration with the GIS was identified as a central objective. The Project Paper included the following statement as a measure of end-of-project achievement: "Development of the capability to carry out digital processing of LANDSAT data to produce land cover maps and for general resource research."

The Project Paper and all subsequent documents through to the AID-ERIM Contract stated that the system was operational and assumed a trained ONERN staff. The system was neither operational nor maintained, although several staff had been trained under

PERCEP 1 in its basic operation.

During the first several months of the Project, ERIM devoted considerable efforts (unanticipated) to analyzing and identifying technical problems and arranging for the repair and the repair and maintenance of the equipment. As ERIM reported (First Semi-Annual Report), "The system was down, there were no tools to perform simple diagnostic tests and/or maintenance, there was no existing maintenance contract, and there was general confusion on what had been attempted in the past to rectify these problems. Since the availability of the DIPIX system in good running order was necessary for ERIM to conduct the digital processing course, was also needed to make LANDSAT products for the study area, and crucial to later processing and analysis activities to deliver information files to the GIS system in year two of the program..." ERIM and ONERN worked closely with CIDA and DIPIX Corporation to get the DIPIX system operating and to assure future maintenance.

In July, 1982, ERIM reported that the DIPIX system was operational (but only temporarily, as several periods of failure subsequently developed). However, it was also learned that the system, as originally programmed, could not read INPE format LANDSAT CCT's. This is significant since most LANDSAT data required by ONERN under the AID grant and the World Bank Photomap Project were procured from the INPE (Brazilian) receiving station.

In order to conduct training courses on digital image processing and DIPIX system use and application, ERIM provided reformatting of a single LANDSAT CCT (Tarma study region). This service was provided at a cost of $200., outside of ERIM's scope of work. In addition, DIPIX Corporation also offered to reformat LANDSAT CCT's at a cost of $1,000. each, and to provide the requisite software for CCT reformatting at a cost of $10,000. DIPIX Corporation's costs appear to be excessive. ONERN technical staff have reviewed both INPE and EROS format specifications and are confident that they can develop the necessary software in-house.

A maintenance agreement has subsequently been provided by CIDA, for the period of May 1, 1984 to October 31, 1984. It is understood that it will be renewed by CIDA under PERCEP 2, but ONERN should be particularly attentive to assure no lapse in

maintenance agreement coverage.

At the present time, the DIPIX system is installed in ONERN's computer facility and is operating satisfactorily. It is receiving extensive use by ONERN personnel trained by ERIM. These staff, in turn, are training additional personnel. This use and application, however, is restricted to a single LANDSAT scene since none of the other LANDSAT CCT's at ONERN, acquired from INPE, have been reformatted for system compatibility. With the exception of a single sub-image demonstration provided by ERIM, DIPIX system processed data have not been entered into the GIS. ERIM has, however, provided ONERN with software to transfer the DIPIX generated data into the GIS. In addiion, the DIPIX has no hard copy image output capability or devices. Hence, LANDSAT products of the study areas for use in resource mapping, basemaps, GIS information files, etc., have not yet been generated in the DIPIX system for use in subsequent activities of the Project.

The DIPIX and GIS have not been physically integrated and ONERN is hesitant to provide such integration due to the separate maintenance contracts covering the DIPIX system and DEC PDP-11/44 computer. Neither CIDA nor AID, however, have expressed reservations about such integration if technically desirable in the future, if permissible by maintenance agreement terms.

3.4.3 Recommendations

1. A high priority by ONERN should be the development of algorithms and software to enable LANDSAT CCT reformatting from the INPE format to the DIPIX system. Until this software is implemented, ONERN cannot utilize their extensive collection of LANDSAT digital data in the DIPIX.

2. ONERN should move expeditiously to implement the software previously provided to ERIM to transfer DIPIX generated data into the GIS. This will effectively integrate the two systems without physical connections (which are thus not essential) that might negate a maintenance agreement and will enhance the capability and utility of both the DIPIX system and the GIS.

3. ERIM recommended procurement of a color display camera system (Fourth Semi-Annual Report) which could "provide ONERN with a relatively inexpensive mechanism for producing color transparencies, slides, prints (including instant photography) of data displayed on the color monitor." The principal limitation, however, is lack of requisite color processing chemistry and materials (ONERN has a well equipped color photo lab, but an inadequate supply or budget for chemicals and materials), or alternatively, the recurrent cost of polaroid-type film in an 8 inch x 10 inch format. An alternative which the Evaluation Team recommends in the near term is to continue ONERN's present practice of photographing the color monitor display using tripod mounted 35mm or 120mm (Hasselblad) camera systems to obtain slides or prints as desired. The present practice, using a Hasselblad camera, could be improved, however.

a. A light meter is not available and should be procurred for film exposure control.

b. The present facility has poor control of ambient and extraneous light, inhibiting proper exposure (see Recommendation No. 4).

4. The DIPIX Image Analysis System is located in a crowded room, shared with three digitizing tables and the Lear Siegler terminal. Work space is inadequate and the digitizers are often used as work tables for laying out large maps, etc. Moving the DIPIX system to a dedicated room would achieve multiple objectives:

a. Room lighting control would be facilitated, thereby enhancing analysis of color monitor displays and photographing the color monitor. Lacking a dedicate curtain enclosure to control extraneous room lighting.

b. Removal of the DIPIX would relieve crowded conditions in the digitizing room and provide additional and needed work space.

5. Preliminary considerations have been given by CIDA for upgrading the present DIPIX system to the current AIRES II Series. We believe this may be establish a future date, but is not necessary in the short term. The present system is being effectively used, is an excellent training system, but has only been fully operational and utilized for a relatively short time. Rather than upgrade the present system, a higher priority should be to enhance its capabilities through the above

recommendations.

3.5 Effectiveness of Training

"Evaluate effectiveness of training given to ONERN personnel at the IAGS/DMA school in Panama and relate this training to ONERN's present and future activities."

3.5.1 Findings on Project Activities

The training provided to ONERN personnel at the IAGS/DMA school in Panama was provided, under the ONERN Land Use Inventory and Environmental Planning Project, outside of the scope of work of ERIM and prior to ERIM's program. In addition, however, ERIM also provided both formal and on-the-job training to ONERN personnel. The Evaluation Team has attempted to review all of the major training elements provided under the referenced Project. (Note: Computer and GIS training are discussed in Section 4.5.)

3.5.2 IAGS/DMA School, Panama

Between July, 1981 and September, 1982, twenty ONERN personnel participated in a variety of formal technical training courses conducted at the IAGS/DMA Cartographic School at Fort Clayton, Panama. In recent years the school has developed a comprehensive curriculum of specialized short courses, ranging from several weeks to several months and from introductory to advanced (post-graduate) levels. The school's program is well respected by the professional community, both in Latin America and elsewhere.

Fourteen of the participating ONERN personnel were from the Cartographic Department. Their courses included Thematic Cartographic Techniques, Techniques of Color Separation, Workshop on LANDSAT Mosaics, Photogrammetry, Basic Sciences for the Photographic Laboratory, and Supervision of Cartographic Production. The courses attended were appropriate to the job functions of the participating personnel and it appears that opportunities were vertically distributed within the Cartographic

Department. The courses were appropriate and the skills and techniques acquired are relevant to ONERN's present and future activities.

The remaining six ONERN participants included technical applications staff and management personnel who enrolled in several remote sensing courses, including Introduction to Remote Sensing, Theory and Application of Remote Sensing, Remote Sensing Applied to Soils and Forestry, and Remote Sensing: Generation and Digital Analysis of LANDSAT images.

3.5.3 Digital Image Processing Training

In October, 1982, as part of the ERIM services, Mr. F. Thomson presented a course on Digitizing LANDSAT Images to nine participating ONERN staff. An additional eight or so ONERN staff participated as observers. The training focused on the theory and concepts of LANDSAT digital processing, the use and application of the DIPIX system, and field verification and sampling techniques.

This training, along with ERIM's interventions to get the DIPIX system repaired and operational, have enabled the digital image processing objectives of the program to be fulfilled. More importantly, a clear capability now exists at ONERN to apply the DIPIX advantageously and to train additional personnel in its operation and application. Unfortunately this is presently constrained by the inability to process INPE format scenes in the DIPIX. Although the transfer of DIPIX generated outputs into the GIS has been demonstrated on a single sub-scene, the ERIM provided software has not yet been implemented. The Evaluation Team believes, however, that the basic ONERN personnel capabilities to prepare and implement the recommended software are extant.

3.5.4 IAGS/DMA Video Courses

The IAGS/DMA Cartographic School in Panama, in addition to resident courses, has prepared video-cassette courses which are available at no cost upon request through IAGS/DMA. The courses generally consist of twenty segments of one hour each and include lectures, exercises and syllabus. They provide a useful and valuable supplement to the formal curriculum and are particularly well-suited to institutional programs

in-house.

Through the efforts of ERIM's Chief of Party, four video courses were conducted at ONERN:

1. Introduction to Remote Sensing (attended by all of ONERN's applications staff between 60 and 70 persons - for two hours of viewing and discussion per day for twenty days.
2. Introduction to Fortran.
3. Introduction to Engineering Statistics, Primary and Advanced (two courses) (attended by about 25 ONERN staff).

The Evaluation Team believes these courses were an excellent complement to the other training provided by IAGS/DMA and ERIM, and we recommend to ONERN to make frequent and effective use of this resource through a regular program of IAGS/DMA video courses. Procurement of video recorder by AID as originally planned in the Project Paper should be expedited.

3.5.5 Other Training

Discussion and recommendations for the environmental training are contained in Sub Program 3, Section 5.3.1.

ONERN provided for a local instructor to teach a course on Fortran 77 to eighteen staff for two hours per day over a one-month period. This, and similar type training in the future, is important for developing and expanding staff capabilities to apply the recently acquired GIS and computer facilities at ONERN.

Throughout the project, ERIM's Chief of Party has provided a diverse range of on-the-job training and technology transfer. This included color infrared photographic interpretation and correlation of photo interpretations with LANDSAT imagery, color infrared film acquisition and development (for SAN technicians), field work for verification and accuracy assessment, equipment procurement, use and maintenance, etc. From casual analysis and informal observation, it appears that the Chief-of-Party devoted a substantial effort to on-the-job training and that he was effective in

successfully transfering skills, techniques and technology.

3.6 Cartographic Equipment Procurements

"Determine adequacy of cartographic and other equipmen and supplies procured under the Project and how appropriately it is being used."

3.6.1 Background and Findings on Project Activities

The Project Agreement between AID and the Government of Peru, ONERN, provides for the procurement of a variety of equipment and supplies in support of the Project.

All equipment, materials and supplies were procured directly by AID. The responsibility of ERIM included assistance in identifying and recommending procurement items and informally included, on occasion, preparation of purchase orders for AID review and approval. ERIM's responsibilities also included "advice on the use of the 'whirler'."

3.6.2 Cartographic Equipment

The "whirler" was procured in 1982, at a cost of approximately $6.000 plus shipping. The purpose of the "whirler" is to enable in-house production of cartographic materials used as an alternative to scribe coat, a material used to prepare color separation plates. The manufacturer was unable to provide detailed instruction manuals, as they were "out-of-print." We believe that ONERN has not benefited from procurement of the "whirler."

All other cartographic equipment, materials and supplies procured, however, are being fully and appropriately used. These include a LEROY Lettering Machine, a Zoom Transfer Scope and various drafting instruments and equipment. A basic need for additional general purpose cartographic supplies, drafting equipment and scribing materials was identified early in the project, and their provision is included in the Project Agreement. In June, 1982, ERIM's Chief of Party prepared

and submitted to AID detailed listings of requested equipment and materials, totaling $30,000 plus shipping. Most of these items were not approved or procured; the evaluation team has not been able to establish reasons for AID's decisions.

3.6.3 Vehicles and Spare Parts

As provided under the Project Agreement, ONERN received two vehicles and a variety of shop tools and equipment for fleet maintenance, for use in the referenced project. There is no evidence that the provision of spare parts and tools resulted in increased operability of the existing disabled fleet.

3.6.4 Video Recorder Equipment

The Project Agreement provided for procurement of a video recorder system for ONERN at a cost of $5,000. plus shipping. When initially requested, in June, 1982, and following subsequent requests, AID denied the procurement.

On several occasions during the Project, arrangements were made for use of video recording equipment at the American Embassy (e.g. for the IAGS/DMA video training courses). Advantageous use of this equipment for field surveys was not realized. Future use of the IAGS/DMA video curriculum, which we recommend, is inhibited by the lack of this system.

3.6.5 Remote Sensing Data

Color infrared film (5 rolls, 125 feet each) have been procured for Project use. To date, two rolls have been exposed and processed and one roll is awaiting processing approval by AID. The remaining two rolls are under contract for exposure, and no arrangements have been made for their subsequent processing.

A variety of existing aerial photos, SLAR imagery, maps, etc. have been procured or made available for project use as required.

LANDSAT CCT's (six scenes) were acquired in 1981 using project funds. These data have generally not been used due to format compatibility problems associated with the DIPIX.

The project has made use of GEOPIC digitally processed LANDSAT images provided by the World Bank, including the Puno demonstration test site. The CCT's for these images (totaling more than 50 scenes) are currently not available to ONERN because they are being used in Germany to prepare the national LANDSAT photomap series provided under World Bank project funds. Upon completion of this project, however, it is assumed that ONERN will have a comprehensive, nationwide collection of LANDSAT CCT's. The requirement to develop reformat software remains, and should be a current priority by ONERN staff in order to process these data in the DIPIX system. The use and application of existing digitally processed LANDSAT imagery will surely continue.

3.7 Color Infrared Aerial Photography

"Analyze whether color infrared aerial photography can be used advantageously in Peru for resource identification and mapping."

3.7.1 Background

In the Project, this task was described as follows: "One specialist (ERIM) will advise the National Aerial Photography Agency (SAN) on the optical use of color infrared photography. This will include camera and film calibration and selection of appropriate filters and exposure procedures. The period of services in the country would be one month; however, it is anticipated that prior to his trip to Peru, the specialist will assist in the procurement of the color infrared film and processing materials."

Over the past decade, color infrared film has become a standard data source for a wide range of vegetation, land cover and land use, and environmental-related mapping and photo interpretation applications. Its use and applications are worldwide, despite the fact that it is manufactured only in the U.S. and the vast

majority of processing is provided by several U.S. sources. In Peru, however, this film had not been used or advantageously applied, and hence its introduction was identified as an important component of the AID/ONERN Land Use Inventory and Environmental Planning project.

3.7.1 Findings of Project Activities

Earlier attempts to introduce the use and application of color infrared photography in Peru included the provision of several rolls of film by AID, in coordination with IAGS/DMA, in the late 1970's. This film was properly stored in freezers, but was never used prior to its expiration date and was subsequently disposed of.

Under the Project, ERIM met the above task requirements as described below. An ERIM consultant (Mr. J. Cooper) provided two weeks of technical assistance to SAN technicians in July, 1982, including training on proper handling and storage, exposure procedures and processing. Prior to travel to Peru, the consultant acquired five rolls (125 feet each) of Kodak Color Infrared aerial film (Type 2443) for use in the referenced project. The consultant evaluated SAN's processing capabilities and recommended processing by a commercial lab in the U.S. (an appropriate recommendation). Subsequently, ERIM assisted AID/PERU in procuring processing services from Precision Photo Laboratories, Inc. in the U.S.

The acquisition/exposure of the CIR film required a contract between SAN and ONERN which was not signed until December, 1982. The contract called for CIR photoacquisition of approximately 260,000 hectares in the Upper Huallaga test site, at 1:17,000 scale, and at an acquisition/exposure cost of approximately $51,000.

It is noted that SAN has an effective monopoly on all metric aerial photography acquisition in Peru. It has excellent equipment (aircraft, cameras, etc.) and well trained technicians. It has a reputation, however, of too rapid turnover of personnel, particularly pilots, and the Commanding General, who often rotates through one year of SAN before moving on to other units of the Peruvian Air

Force. Recent reports indicate that SAN is attempting to correct this problem. A second problem, historically, has been delays in acquiring photography, particularly over the eastern Andean slopes (including the Upper Huallaga Valley). This is usually attributed to weather factors. A third issue is cost; SAN's charges have been reported by others to be abnormally high when compared to comparable organizations and commercial firms worldwide.

In September, 1983, SAN successfully exposed two rolls of CIR film over the Huallaga Valley. Processing in the U.S. was provided under an AID purchase order, and three sets of color prints were provided to ONERN (SAN retains the original color transparencies). A third roll was exposed on July 3, 1984; it has not been processed and is currently in proper freezer storage in Peru awaiting requested action by AID to procure processing services. The remaining two rolls are at SAN, awaiting exposure in order to complete the ONERN contract. Over 19 months have elapsed since this contract was executed.

Subsequent to receiving the processed CIR prints, ERIM's Chief of Party provided instruction and assistance on its proper interpretation and application for agricultural land uses in the Huallaga Valley. A forest vegetation interpretation was also conducted, but its results are incomplete and not representative of the film's uses and applications for forest mapping in the selected test area. Due to security considerations in the test area, no field work has been conducted by ONERN personnel to complete the mapping or verify interpretation results.

The evaluation team has reviewed examples of the CIR film acquired to date. Although exposures are not optimal, they are satisfactory and provide a useful demonstration and training product. The analyses would have been enhanced by using transparencies rather than prints, and substantially more information can be interpreted from these data than has been done to date. ERIM's efforts have well met their basic requirements; SAN technicians have demonstrated proper handling and satisfactory exposure practices, and ONERN analysts have demonstrated general interpretation techniques and understanding which may be further developed and advantageously employed.

A number of factors cloud the issue of future applicability of color infrared film for advantageous use in resource identification and mapping programs in Peru. These include:

1. SAN has excellent black and white film acquisition and processing capabilities and facilities, but no adequate color processing capability. They would be ill-advised to acquire color processing capabilities at this time, until a considerable processing volume can be expected on a regular and routine basis. (The Evaluation Team has been advised that a Versamat processor, for color aerial film, may be provided to SAN under PERCEP 2.) Until such time, commercial processing services in the U.S. are the best technical and cost effective alternative. SAN should establish direct contact with appropriate U.S. processing laboratories.
2. Color infrared film requires unique and critical shipping and handling procedures which are understood by SAN's technicians. These include frozen shipping and storage, careful thawing prior to exposure and refreezing for shipping to processor. Mistakes are costly and the effort requires careful planning and logistics.
3. The fact that frozen, sealed film must be imported into Peru for exposure, exported for processing and re-imported when processed, creates numerous opportunities for delays and related problems with Peruvian customs authorities. Again, mistakes are costly and the effort requires careful planning and logistics.

The Project Agreement for the Project called for color infrared photo acquisition for "at least 80 percent of up to six test sites. At least one transparency of all photography will be provided." In point of fact, ONERN contracted with SAN for only one test site which had a single application focus (agricultural/coca land use) and which was not accessible to ONERN personnel for field work. We believe this limted use and application of color infrared photography does not meet the spirit of the Project Paper or the objectives of the AID-ONERN Land Use Inventory and Environmental Planning project. As a result, the Project has failed to provide a demonstrated capability and experience among ONERN personnel in a reasonably wide range of CIR photo uses and applications in Peru. At a minimum, a test site

accessible to the ONERN analysists, perhaps convenient to Lima, should have been included in the Project.

3.7.3 Recommendations

Technically, color infrared photography can advantageously provide for multiple uses and applications in Peru for resource identification and mapping. In practice, however, ONERN and other Peruvian agencies including SAN, may be well advised to continue traditional use of black and white films unless considerable continuing technical assistance is provided for procurement, logistics and analysis. In addition, it is important to first demonstrate that current concerns for handling, processing and customs logistics and schedule performance by SAN can be reasonably achieved. The basic costs of film and processing are considerably higher for color infrared film than for black and white film. Mistakes are costly and the technical advantages may not outweigh the risks to success at the present time. When these factors can be appropriately dealt with, and when the additional costs for CIR film and processing can be justified in terms of additional information to meet specific project needs, then color infrared film can be used advantageously in Peru.

3.8 Land Cover Classification Schemes

> "Review and comment on whether the land cover classification scheme developed under the project is appropriate."

3.8.1 Background

In the Project, this task is described as follows:

> "The assistance (ERIM) consists of the development of land cover classification schemes..."under the general task heading of 'Photographic Interpretation and Field Verification'.

3.8.2 Findings of Project Activities

Early in the project, ERIM reviewed various land classification schemes which might aid in developing a Peruvian legend. This included systems with which ONERN was generally familiar from past project experiences (e.g., IGU system) as well as systems uniquely designed for use with remotely sensed data (e.g., USGS-"Anderson"). This review, however, does not appear to have included a comprehension of the Ecologic Life Zone concept as a basis for classification and environmental planning currently used in Peru, nor the application of the of potential vegetation and capability, not actual cover. Land Use/Land Cover maps provide an inventory of actual conditions at a specific time. They do not imply land capability or land use potential, although they may be useful inputs to such analysis.

As reported to AID in February, 1983, ERIM developed a conceptual design which incorporated elements of both the Life Zone concept (a la Holdridge) and land cover (a la Anderson). The conceptual scheme contains several elements: physiographic provinces; Life Zone; the legal Peruvian land classification system, above; and land use/cover. In reality, only the last parameter refers to land cover, and this parameter was not developed during the project, principally because of the lack of local interest, a perceived lack of communication between ERIM and ONERN, and conceptual failures as mentioned above.

The result of the Evaluation Team's analysis, per their referenced task, is that a land cover classification scheme was not developed under the project and thus cannot be reviewed.

3.8.3 Recommendations

The above findings provide the basis for several comments and recommendations.

First, it is important to understand, both conceptually and in practice, the fundamental differences between the Peruvian land capability system and actual land cover classification schemes, as exemplified by the IGU scheme. As applied in past project experiences, the Peruvian system can be an inventory of actual land use, but at the same time it may often include interpretative integration of

capability related parameters, or suitability related parameters such as exclusion of "protection" areas within a land use context. There is a distinction between the terms "use" implying economic activity, and "cover" implying actual landscape features or conditions. Sometimes the terms are synonymous in practice, but the conceptual differences must be understood.

An "actual land cover" map is both supplementary and complementary to other resource information. It is a discrete element of a resource data base, and may be defined as a discrete file in a GIS data base. It is distinct, and not in conflict (conceptually or implied) with multi-parametric analyses for developing land capability, life zone, or similar cartographic products. It is fundamental to programs for monitoring or analyzing land use/land cover changes over time.

A useful example for Peru may be the program developed by CIASER/GEOBOL (formerly Programa de ERTS) in Bolivia. Through an initial one-month Technical Assistance program in 1975, which included seminars with extensive dialog among a full range of natural resource disciplines, the fundamental concepts and utilization of "Cobertura Actual de la Tierra" were developed. The result of the seminar program included a detailed, hierarchal legend applicable country-wide, for either detailed or generalized levels of application, and procedures and methodologies incorporating the range of available remotely sensed data (LANDSAT, air photos, etc.) and corrollary data as available. It was both generic and specific, fully adaptable to GIS data base implementation. In subsequent application to specific inventory and mapping projects, appropriate modifications and refinements were developed, documented (1978), and implemented. In recent years, it has served as a fundamental parameter (non-inclusive) in national and regional integrated resource inventory studies, included in a subsequently developed GIS data base, and extensively used, with other data as appropriate, for resource planning, development and management studies and projects.

The evaluation team believes a similar seminar-type program would provide an appropriate forum for bringing together a range of ONERN personnel to solidify conceptual understanding and application of land cover classifications, establish criteria for developing a Peruvian land cover classification scheme which may

include modifying legends currently used, identify methodologies and procedures for incorporating remotely sensed data for land cover mapping, and to fully develop a land cover classification scheme applicable throughout Peru. A seminar format will fully involve Peruvian professionals, an important measure for insuring its future utility in resource planning and implementation in ONERN's resource inventory and evaluation programs - a capability which is well established.

In order to properly guide the process, technical assistance is recommended. The technical expert should play the role of seminar leader of moderator, shared with a cognizant ONERN counterpart. The expert should be fully experienced in the design and implementation of land use/land cover mapping programs, including experience in similar landscapes; the design of land use/land cover data bases and their implementation in GIS; experienced in remotely sensed data applications to land cover mapping, ranging from LANDSAT to large scale aerial photography; and the use and application of land use/land cover data, integrated with other data base parameters, for regional and national planning and resource development. The estimated level of effort is four to six weeks.

3.9 Test Site Selection: Background

An underlying theme present throughout the ONERN Land Use Inventory and Environmental Planning Project is the development of techniques, skills and technologies which may, in the future, be implemented nationwide. Through a series of demonstration projects and implementation of a computerized GIS, Peruvian resource specialists and environmental managers would be capable of applying Project results to nationwide implementation as well as demonstrate techniques to other appropriate Peruvian resource and environmental agencies.

The Project Paper identified a number of conditions which should exist upon Project completion to indicate achievement of Project purpose:

a. Utilization by ONERN of color infrared photography, satellite imagery and

other improved technologies for detailed identification and mapping of natural resources.

2. Implementation of a thematic mapping system for resource and environmental assessment.

3. Development of the capability to carry out digital processing of LANDSAT data to produce land cover maps and for general resource research.

4. Enhancement of the already well-established capabilities of ONERN's cartographic section.

5. Development of the capability and the awareness of the utility of a nationwide computer-assisted GIS.

6. Utilization of the data and systems by potential sectoral users, who will be trained in their applications for environmental and natural resource development.

7. Existence of the capability within ONERN to utilize the methodologies of environmental impact assessment.

8. The existence of an institutional and technical capability to greatly enhance the accessibility of this much-needed data to potential users.

3.9.1 Background

The Project Paper identified the rationale for selection of candidate test sites and recommended a final choice of "up to six test sites" chosen among a candidate list of twelve. Of particular importance were characteristics of each test site: "Over each test site, all of the procedures of the inventory system will be tested. The format of the information system theme maps will follow the standard 1:100,000 quadrangles established by IGM. Each test site has been chosen to cover six complete and continuous quad sheets."

"Multiple test sites are required for several reasons. Although the new techniques could indeed be demonstrated on only a single site, it is necessary to develop operational procedures which will be applicable to a future high volume program covering the entire country. Thus, several such sites, in total covering an appreciable area, must be used. In addition, multiple sites are required in order to

provide a representative example of the terrain types and environmental conditions of a country as large as Peru."

3.9.2 Findings

There has been substantial deviation from the above intent during the Project's implementation. The Project Agreement and the ERIM-AID Contract call for "up to seven test sites" (legally, only one would meet this requirement) and each document is ambiguous on site selection criteria; criteria in the Project Paper were not referenced in subsequent documents.

Selection of the final test sites, three in total, were based on criteria peripheral to the objectives in the Project Paper, with the result that the Project as implemented has not maximized opportunities provided in its original design, specifically:

1. The Upper Huallaga test site selected by AID had a single, narrow focus: mapping of coca cultivation and temporal changes. This is an important project objective and related to other AID and US Government programs. In the context of the ONERN Land Use and Environmental Planning Project, it fell short of implementing the Project's Natural Resource Inventory Objectives. The test site area totals only 460 km2 and is incomplete, awaiting (since December, 1982) acquisition of aerial photos by SAN. All CIR film procured for the Project has been allocated to this study area. No digital processing of LANDSAT data using the DIPIX or interpretation of high quality LANDSAT imagery was included. Ground field studies for photo-interpretation verification have not been included because the selected study area is inaccessible to ONERN personnel (political reasons). As a result the maps are incomplete and their accuracy cannot be assessed. The land use legends were simplistic due to the objectives, and do not contribute towards development of a national land cover, or other thematic, data base.
2. The Puno test site was oriented towards demonstrating GIS modeling capabilities in a drought impact area selected by AID. A major data source was vegetation associations from existing data; this could have been an excellent use of demonstrating CIR film for pasture resource mapping had CIR photos

been acquired as part of Sub Program 1 activities. Neither available high quality LANDSAT imagery nor aerial photography were used in the grazing suitability analyses, although LANDSAT imagery was used in upgrading the Life Zone map. The test site area was not large enough to demonstrate procedures applicable to larger areas, including multiple map sheets and broader diversity of terrain types and environmental conditions extent in the region. With the exception of the Computer Services Department manager, ONERN's disciplinary technicians did not participate in field studies conducted in the Puno area.

3. The Palcazu test site, based on Demonstrations to date, involved digitizing and comparing two land capability maps, one prepared by Tosi and one prepared by ONERN under a previous project. This comparison was performed in the GIS, and has successfully demonstrated a GIS capability, albeit for a limited area. As a Sub Program 1 test site, however, the demonstration lacked any functional criteria. No remotely sensed data were acquired or analyzed, no thematic maps were produced, no field verification or accuracy assessments were conducted, no ancillary data were compiled or analyzed.

4. It is noted that the Tarma area studies, included in the Digital Image Processing training course, generally met the design objectives and criteria for test site demonstration projects. LANDSAT imagery (both digital processing and interpretation), existing aerial photography, maps, field observations and ancillary data were integrated. Overlays for various resource themes were prepared. None of these products, however, were subsequently digitized to GIS data entry, and these studies have not been considered as a demonstration test site. The Evaluation Team concludes that the Digital Image training Course was well developed and of broad scope and has left a continuing imprint for future work at ONERN.

Based on the test site analyses and demonstrations conducted under this Project, it is difficult to evaluate affirmatively that Sub Program 1 goals and objectives have been attained. The test sites were too limited in size, were of narrow focus and generally did not involve thematic resource mapping using remotely sensed data. A national land cover classification legend was conceptually designed, but not developed, tested or implemented in the Project or in any of the test sites. Land cover legends differed in each test site. Field work was conducted only in

the Digital Image training course and was not included as a central component of the demonstration test sites to provide verification and accuracy assessments.

Color infrared film was acquired over a limited area of a single test site. Thus its application to a range of resource mapping themes, terrain types and environmental conditions extant in the region was not demonstrated.

LANDSAT imagery was generally not included in the demonstration test site analyses and the interaction of LANDSAT digital image processing and GIS applications has only been accomplished in a training course context and not in the context of a test site demonstration project.

The resource data compiled and entered into the GIS in the demonstration test site activities have no conformity to a national geographic coordinate data base on a standard national map projection; rather, each project area is a unique file. The purpose of thematic mapping and computer GIS is to improve ONERN's access to resource data and provide a more efficient means for analyzing the data. Non-standardized legends and formats and dispersed map sources do not lend themselves well to comparison of locational and spatial features from one map or region to another. The demonstration test site activities appear to have been designed only to demonstrate selected capabilities of the GIS. This has been done well, although the GIS's capabilities and applications far exceed the demonstrations conducted to date. None of the demonstration test site activities has met the intent of the original design objectives of Sub Program 1.

4.0 Sub Program 2: Geographic Information System Evaluation

"Determine the suitability of the GIS that has been installed at ONERN, particularly with reference to existing software and any additional software that may be needed. Describe follow-on activities."

4.1 System Objectives

The acquisition and implementation of an automated GIS within ONERN was promoted by AID and ONERN as a means of addressing multiple objectives. The Project Identification Document of August 16, 1979, set forth two purposes.

1. To assist in the identification of natural resources and determination of land capabilities in high jungle and sierra areas.
2. To upgrade ONERN's capability for environmental assessments, environmental protection plans and general natural resource and conservation policies.

By inference, the GIS is to support both the Natural Resource Inventory and the Environmental Assessment components of the Project. The capabilities inherent to GIS technology were to augment ONERN's remote sensing (both satellite and aircraft acquired imagery) capacities for systematic regional reconnaissance, baseline studies, detailed resource studies for development projects, performing environmental impact assessments and environmental protection and resource conservation programs.

The Project Agreement called for the "establishment of a computer assisted Geographic Information System. Into this GIS will be placed all of the mapped data of Phase 1 (a natural resource inventory) plus extensive resource and cartographic data available from ONERN and other agencies. The GIS will be designed to not only store and retrieve data, but to efficiently manipulate the various themes contained therein and produce customized map products at any scale."

4.2 Institutional Setting

The GIS has been incorporated into a new ONERN unit, the Office of Computer Services. By doing so, ONERN has recognized the general utility of the newly acquired computer resources to the agency and the GIS to the natural resource, environmental planning and cartographic departments. It has been set up as a service bureau. Furthermore, as depicted in Appendix 2, the ONERN staff has been provided orientation and training on the use of the computer and the GIS. This is an essential step in institutionalizing the system.

4.3 System Configuration

The GIS facility is truly a "system" in the broadest sense of the term. It requires integration of physical facilities, hardware, software, data bases and staff resources. "Physical facilities" include the structure, space allocation and environmental controls (e.g., temperature) in which the associated computer equipment and personnel are located. "Hardware" is defined to include all of the electronic components required to enter, process and retrieve information. The term "software" as used in this evaluation refers to the entire set of computer programs required to operate the central computer processor (the operating system) and to perform analytical processes (the applications software). "Data bases" include the array of information, in digital format, that are organized and automated in a manner that permits the hardware and software to perform specific analytical functions. Integral to the systems are the staff who manage, operate and maintain the facility, hardware, software and data bases.

4.3.1 Facility

The GIS has been installed on the second floor of a newly constructed building within the ONERN complex. The central processor, system console, color image processor and electrostatic plotter are separated from the data entry and basic work stations, both rooms being adjacent to the offices of the core staff. The DIPIX LANDSAT Image Analysis System is located together with the geoprocessing system.

Space for the processing and output devices is ample and capable of housing additional equipment. The area currently housing the work stations and data entry devices is fully utilized. Expansion will require additional space.

ONERN has provided adequate levels of air conditioning and humidity control for both of the work areas. Furthermore, it has installed voltage regulators to protect the computer equipment from current fluctuations.

4.3.2 Hardware

The physical components of a GIS hardware configuration may be categorized as input, processing and output devices. In some cases a device such as a CRT terminal may be used for multiple purposes. Table 2 summarizes the principal devices purchased under the AID project. The Table also identifies the category and function of each device.

The evaluation of hardware components of a GIS configuration must be accomplished in the context of the application software, the storage requirements for the data base, the form and level of production anticipated, and the personnel and financial resources available to operate and maintain the system.

AID sought a turnkey GIS for installation at ONERN. This decision was, in effect, accomplished during the evaluation of proposals in response to AID's RFP for "Land Use Inventory and Environmental Planning" assistance to ONERN. ERIM proposed a computer system from the Digital Equipment Corporation (DEC) because of its compatibility with ERIM's application software, the availability of support organizations in Peru, and its compatibility with the DIPIX Image Analysis System. The justifications were reasonable and the procurement generally followed the concept included in the proposal.The purchase was made through the AID mission in Lima. ERIM provided unbudgeted technical assistance in developing the purchase orders for AID/PERU.

System delivery and installation were to be accomplished within six months of the initiation of the procurement. Installation of the GIS was not completed until

TABLE 2 GIS HARDWARE

Device (number of)	Category	Function
DEC PDP 11/44 (512 KB core, disc and tape drive subsystems	processor	input, output, data storage, retrieval and manipulation
Summagraphics digitizing tables (3)	input	entry of polygonal line and point data
Textronix 4006 display terminals (3)	input/output	entry/editing of polygonal line and point data
ADM 36 Video display terminals (2)	input/processing/ output	non-graphic data entry and output; processing instructions
RAMTEK 9150 system controller and color video monitor	processing output	color graphic data display and manipulation
Versatek V-80 printer plotter	output	grey tone electrostatic maps and text
LA120 DecWriter III	output	matrix text printer, high speed

October, 1983, some eight months behind the original schedule. A review of the correspondence, status reports and interviews identified several causes, including procurement delays in AID; the unplanned, albeit justifiable, assemblage and testing of the hardware components in Michigan; delays at Peruvian customs; the need to complete portions of the new ONERN building and the installation of environmental and electric current controls; and the scheduling of training around the availability of ERIM staff.

The delays seriously affected accomplishment of Sub Program 3 objectives, environmental planning, assessment and demonstrations, within the twenty-four month contract and six month extension. An examination of status reports and correspondence supports a conclusion that significant levels of labor effort were diverted from planned tasks to address delays that were beyond the control of ERIM. Furthermore, it should be noted that in the experience of the Evaluation Team, the three year implementation period proposed in the Project Paper was more realistic. As noted previously, the hardware procurement generally coincided with the conceptual configuration included in the Project Paper. The following is a brief review of the major components of the system and associated findings.

1. Processing system - the DEC PDP 11/44 with 512 KB of MOS memory, floating point processor, and disc and tape subsystems is a reasonable match for the ERIM applications software and current levels of system use. Additional core storage will be required when large data bases are constructed for use in a multi-user environment.
2. Storage Devices - Three fixed disc drives, 121 MB, and two removable disc drives, 10MB, were purchased. The current amount of on-line storage is adequate for developing large data bases using tape backup for permanent storage. As the system is more fully integrated into ONERN's projects and work habits, additional on-line storage will be required.
3. Input Devices - The GIS as presently configured utilizes CRT work stations and digitizing tables. The CRT's are used to key enter data and to control the operating and application software. The digitizing tables are used to enter graphic information in a polygonal, line or point format. Three digitizing tables were purchased. Under the existing operating and training conditions, the terminal entry devices are fully utilized and two of the three digitizing tables

are used continuously. The third table is frequently used as a work surface because of the lack of standard office furniture. Continued use of the equipment in this manner may induce problems at a later time. In a production environment, the third table will be more fully utilized. Access to CRT terminals will become more difficult and may constrain use of the system. Additional terminals and an appropriate multiplexer will be required to handle the demand, particularly if terminals are distributed within ONERN.

4. Output Devices - GISs are currently limited to screen displays on the RAMTEK (color), the electrostatic plotter (small bed xerography) and a high speed matrix printer associated with the system console. Hardcopy products can be obtained from the RAMTEK screen displays through photopgraphy, though these are distorted in the horizontal direction and do not provide a cartographically correct image. The distortion does not affect the analytical functions of the device, but will continue to be awkward for the casual user and for visual comparisons of RAMTEK displays and other maps. The electrostatic plotter (Versatec) is capable of producing grey toned maps. The small size of the product (apporoximately 10 inches) can be overcome by manually taping the map strips together. A wide bed Versatec (to be provided by a CIDA grant) will provide both the image processing system and the GIS with greater flexibility and product quality.

4.3.3 Software

In its proposal to AID, ERIM proposed to provide its user oriented interactive software system developed for use at the Earth Resource Data Center and as an extension of its LANDSAT processing software. Subsequent to the Project initiation, ERIM provided supplemental information as part of a sole source justification for AID's purchase of the GIS application software. The justification set forth six reasons for the procurement of the ERIM GIS.

1. It would be a cost and time effective action, allowing for scheduled parallel activities with a knowledge of the characteristics of the GIS facilitating other project activities.
2. It was compatible with the DIPIX.

3. It could be concluded within budgetary limits.
4. It met all known and anticipated user requirements.
5. It was a tested and mature technology.
6. It was, by definition, a system procurement and not the purchase of individual components. In addition, ERIM has performed evaluations and reviews of various choices that maximized overall system performance.

The software was made available at the time of equipment installation. Four individuals from ONERN were previously instructed at ERIM on the operation of the GIS. Following installation, approximately twenty individuals received an additional two weeks of training at ONERN.

In making its review, the Evaluation Team considered:

1. The state of the art of GIS technology.
2. The responsiveness of the procurement to system characteristics identified in the proposal, the contract, and the sole source justification.
3. The system's overall utility to ONERN for land use inventory and environmental planning.

Geographic information systems are best characterized as cellular or polygonal. The cellular systems store, retrieve and manipulate data by specified unit areas (called cells), optimizing on the computer's efficiency in handling matrix mathematics and linear processing. Characteristics of the geographic units (e.g., soils, geology, socio-economic data) are associated with each cell. Some degree of generalization occurs as a function of cell size and spatial pattern of the data. Polygonal data systems store, retrieve and manipulate data by retaining, through a series of coordinate points, the irregular spatial patterns of the geographic features and can therefore more accurately represent the feature. Polygonal data structures are more complex and generally require more processing time and core storage. Most polygonal systems have the dual capability of converting polygonal data to cellular data (of user specified size) and to process complex analytical models in that mode.

In its Response to Technical Questions (December, 1980), ERIM described its GIS as a "hybrid polygonal-cellular system." ERIM elaborated on the form and strengths of its system in Enclosure B of the Technical Response document. The "hybrid" nomenclature refers to the capability of the ERIM system to capture data in a polygonal format and subsequently convert the data into a user specified cellular format for processing. Though the polygonal data is retained in the ERIM system, it cannot be manipulated in this format. The ERIM proposal clearly specifies this form and structure.

No documentation suggests that a rigorous evaluation of alternative systems was undertaken or required. As a result, ERIM provided to AID a respectable though somewhat limited cell based system that falls short of state-of-the-art, measured against both polygonal and cellular systems readily available on the commercial market. The system does fulfill the justification presented as the basis of the sole source procurement though other systems may have fulfilled or exceeded these requisites.

The ERIM GIS can satisfy the analytical needs of ONERN given the anticipated applications. Some additional software development should be anticipated and a more comprehensive integration of the DEC-Datatrieve data base management system within the GIS application software would substantially increase the flexibility/utility of the system.

ONERN management has expressed an interest in developing application capability for automated cartography. This application requires a system and application software distinctly different from the capabilities of the installed GIS. Computer Aided Mapping (CAM) systems are being developed and marketed for turnkey installation. The selection, implementation, operation and maintenance of CAM systems requires substantial analysis and effort. Facility, personnel and financial resources required to support such a sstem can equal or exceed that expended in the implementation of the GIS.

4.3.4 Data Base

Geographic information systems are, by their very nature, dependent on a large volume of data. The AID procurement required neither the construction nor the structure of a data base, though by reference to thematic mapping in other portions of the contract, there may have been an inference to either or both.

Limited data bases were developed for three demonstration areas: Puno, Upper and Central Huallaga, and the Pichis-Palcazu, discussed in the previous section. As a precedent, an index of data types was prepared with a modicum of structure. Using a range of 500 values, approximately 160 data types were indexed, creating discrete "cubby holes" for various data. The resultant organization lacks hierarchical structure and cohesive integration or relation between and among parameters.

The cataloging builds upon and emphasizes a "project" orientation for the data bases and fails to move toward a comprehensive and national data structure, hierarchical in order, inclusive of graphic and non-graphic attributes (i.e., characteristics of specified parameters which can serve as a basis for sophisticated modelling of capability and suitability).

The long term implication of the current approach is the construction of loosely organized data bases with varying cell sizes, data structures, and parameters that do not aggregate to regional or national data bases. The argument that the data will be retained in a polygonal structure, therefore remaining convertible to other cell sizes, avoids the issue of developing a framework within a comprehensive and compatible data structure. A second, and costly, implication is the extensive amount of mass storage required to handle a data base that can be more compactly organized.

Currently the Office of Computer Services at ONERN has four full time staff members; including a unit chief, a data base manager, a hardware manager, and one full time data entry person. Staff throughout the resource and environmental departments have been provided various levels of orientation and training on the

system's use and capability. ERIM has instructed approximately twenty-five individuals on the use of the GIS.

Under most GIS organizational structures in agencies similar to ONERN, staff resources are utilized in three ways:

1. System operation and maintenance.
2. Data base development and maintenance.
3. System application.

Generally, where a GIS is operated in a service bureau environment, the center is responsible for Item 1 and participates in Items 2 and 3. Its participatory role can range from undertaking a total project to providing technical assistance and guidance to more knowledgable users.

The training and level of staff development within ONERN is consistent and supportive of the service center approach. As discussed in the prior section on Institutional Setting, ONERN will need to work aggressively from the highest levels of management to improve integration of GIS capabilities into the various activities of the institution. As this occurs, the computer unit staffing will need to grow accordingly, competitive wages provided, and training for GIS use made more pervasive within the Government of Peru.

4.3.5 System Applications

The AID-ERIM Contract required up to seven separate but interrelated environmental demonstrations. By inference, the GIS was to be used in accomplishing these. Three demonstrations have been undertaken using the GIS since the training sessions ended. Over the four month period, the Upper Huallaga was studied for agricultural activities and, in particular, the intrusion of coca cultivation; an area near Puno was analyzed for the effects of the drought on the availability of pasture for cattle, sheep, llama and alpaca; and the Pichis-Palcazu area was studied to support a comparison of agricultural and forestry suitability proposals. Additional detail is presented in an earlier discussion.

The significance of the demonstrations for environmental analysis will be discussed in a later section.

Each of the demonstrations of the GIS represented a simple illustration of the system's capabilities. The selection of the demonstration areas was biased by considerations which comprised the full achievement of GIS testing goals. For example, choice of the Upper Huallaga coca area resulted in a narrowly focused effort with no possibilty of field work. Also, demonstration areas overlapping two UTM zones were avoided, yet the system is capable of handling this problem. ONERN staff were not exposed to the development of more sophisticated analytical models and problems. With greater forethought and time, both the AID agendas and a more comprehensive demonstration of the GIS's capabilities could have been simultaneously achieved.

4.3.6 Relationship to DIPIX

The role of LANDSAT and other space platform sensors has been correctly perceived as a valuable source of spatial and temporal information in Peru. The selection of the DEC PDP 11/44 as the GIS's central processor was, in part, based on a desire to retain compatibility with the CIDA provided DIPIX. The utilization of DIPIX processed data can occur through a tape transfer. Software to accomodate this transfer was developed by ERIM and installed on the DEC. Testing of the algorithm was limited to reading a single tape. As discussed previously, additional tapes were not available for processing on the DIPIX. The available LANDSAT data that was compatible with the DIPIX did not coincide with the demonstration areas and as a result an operational test of the data transfers has not been attempted.

4.4 GIS Recommendations

4.4.1 Institutional Setting

To insure the full utilization of this technology, ONERN management will need to make the same efforts required at other GIS installations. These include:

1. Develop and maintain competent and experienced staff within the Office of Computer Services, with particular attention given to personnel responsible for hardware, software, data base development, application design and implementation, and maintenance.
2. With senior and middle management, develop a high level of familiarity and awareness of the system's capability.
3. Insist on a high level of inter-agency coordination and participation in use of the GIS.
4. Provide and encourage training of staff throughout the agency for exploiting all the capabilities of the newly acquired computer and, in particular, the GIS.
5. Address the fragmentation of related services, e.g., remote sensing and cartography, to insure a closely integrated process for geographic analysis and mapping.

4.4.2 System Configuration

1. Facility. ERIM has suggested the relocation of the computer equipment to the basement level of the structure in which the computer is currently housed to provide additional security. If this occurs, similar precautions should be taken to control environmental factors (e.g., temperature, humidity and dust). Furthermore, the work stations, and in particular the digitizing tables, may benefit from improved environmental controls, though they should be located in proximity to the application personnel.

2. Hardware. ONERN emphasizes the production of quality graphics to supplement its varied inventories and plans. High quality graphics from the GIS are essential if the system is to augment the traditional function of ONERN. Additionally, graphic quality output will directly influence the reception of analytical products developed using the GIS and the "marketing" of the system within ONERN and other Peruvian agencies. ONERN and AID should

carefully evaluate the alternatives for adding additional output capabilities to the system.

As noted previously in discussions related to the institutional setting of the GIS, there is an opportunity to extend the use and accessibility of the GIS throughout ONERN. In part, the access must be accomplished through institutional arrangements and coordination among the departments of ONERN. The second part of the solution is a function of hardware and electronic linkages.

Under the current ONERN organizational structure, it is recommended that four additional work stations be established. Each work station would be located in a central location, servicing multiple departments within ONERN. The work stations would consist of one or more ADM 36 video displays. The CRT's would support GIS applications and possibly, word processing, scientific applications, and a broad range of other applications including, project management, inventory control and accounting.

Should non-GIS applications increase substantially, ONERN should purchase additional CRT's, printers, and core memory for the DEC to support the respective share of the system usage.

3. Software. In conjunction with application projects and demonstrations, ONERN should develop software modifications that permit a greater reliance on DEC's Datatrieve for data manipulation (modelling) and handling a hierarchical data structure.

4. Data Bases. ONERN should, as a priority, seek assistance in evaluating data sources (both traditional and contemporary) and hierarchical formats for organizing the complete range of physical, environmental and socio-economic parameters. Within the capabilities of the GIS, as augmented by the DEC Datatrieve data base management software, a uniform, comprehensive, and hierarchical data structure should be established. Within

this structure, attribute data for specific parameters (e.g., specific soil suitability for soil classes and subclasses) should be nested as an alternative to independent data types as is the current practice. The hierarchy should reflect varying levels of detail that are available from different source material (e.g., field photos, aerial photography, satellite data), the use to which the data will be put (e.g., regional analysis vs. project design), and the inherent characteristic of the data. The structure should be developed for utility throughout the country, though data may be developed in greater or lesser detail for any single place.

A few uniform cell sizes should be selected as a basis for regional and national data bases. These should be preselected to reflect the scales and precision most commonly needed or commonly available from existing data and base maps. The sizes should also permit aggregation and disaggregation of frequently used cell sizes (e.g., 50m, 100m, 1000m).

ONERN should develop a national and regional data base map series upon which a standardized cell configuration would be established. It is suggested that the 1:250,000 national LANDSAT photomap series being prepared by IGF-Germany serve as the base. Projects involving only a portion of the 1:250,000 sheet can be "windowed" from merged sheets as appropriate. This approach supports the construction, over time of an integrated national data base.

4.4.3 Staff Resources

ONERN should move quickly to develop a redundancy among key staff associated with the GIS. Currently the hardware and data base managers are additionally responsible for training, demonstrations and programming. Both a software specialist (DEC and Fortran programming) and a GIS application specialist (interdisciplinary) should be recruited or trained. Digitizing, key entry, and clerical support should match demands for data base development and applications.

ONERN should obtain the assistance of a consultant in GIS applications to aid in the design of applications for ONERN, the Peruvian agencies, AID, and other multilateral agencies. In conjunction with the recommended ONERN application specialist, the GIS expert would (as recommended in the ERIM semiannual report, March, 1984):

1. Assist on project conceptualization, design, implementation, monitoring and evaluation.
2. Assist in the development and debugging of user specified software.
3. Provide logistics and liason between ONERN and AID and ONERN and hardware and software vendors.
4. Assist in training and education of ONERN staff and other users.

4.4.3 System Applications

In concert with a specific multidisciplinary project (e.g., environmental profiles and assessments), ONERN should demonstrate the general utility and sophisticated analytic capabilities associated with the GIS. In doing so, ONERN senior management should provide guidance to assure that eacch department and unit participate in the design and implementation of the project.

4.4.4 Relationship to DIPIX

ONERN should develop a demonstration project or undertake an analysis effort in an area where LANDSAT data can be incorporated into the GIS data base. An excellent opportunity exists for incorporating LANDSAT derived data into the development of regional environmental profiles being discussed within the Department of Environmental Protection.

4.5 GIS Training Evaluation

"Evaluate the training received in the U.S. by ONERN technicians thus far and recommend such training as may be desired. Describe follow-on activities."

4.5.1 Operating Systems

Two ONERN technicians (Vargas and Villafranca) received two weeks of training in July, 1983, by Digital Equipment Corporation (DEC) in the U.S. These courses were:

1. RSX-11 Operating System: Utilities and Commands (both).
2. RSX-11 Systems Management (Vargas).
3. Datatrieve-11 User (Villafranca).

These personnel are presently responsible for the operation of the computer and related software programming, applying the skills acquired through the DEC courses. In addition, they are presently training additional ONERN staff. This training was appropriate and is effectively employed in their respective activities at ONERN.

The courses offered by DEC are intensive. Additional and, perhaps, a repetition of DEC System courses would expand the depth of the staff's knoweldge on system operating capabilities.

4.5.2 Application Software

In February, 1983, four ONERN employees, including the department manager and technical staff, attended a four week GIS training program in the U.S. The course included visits to several facilities to observe GIS operations and applications prior to the installation of the ONERN facility. The selected participants were appropriate and all have contributed to transferring the experiences gained to other ONERN staff.

In October, 1983, after installation and run-up of the ONERN GIS, ERIM provided an eight week technical training program for ONERN personnel. This training course provided ONERN staff the basic technical skills to operate and use the ERIM GIS. Nine individuals, mostly at the technical level, participated in the training program. In addition, approximately ten other technical personnel observed portions of the curricula and were provided a general orientation.

Presently, there appears to be an adequately trained staff who are training additional ONERN personnel. For most of the staff, the training opportunity has been limited to the "mechanical" operation of the system. For the GIS to be effectively "used," staff must be given the opportunity to apply a range of disciplinary skills in a coordinated fashion to an actual project.

4.5.3 Maintenance

A discussion of this topic is included in the following section.

4.6 Recommendations

4.6.1 Operating System

The system and data base managers (Vargas and Villafranca) should be provided additional training opportunities through DEC to consolidate and expand theur existing capabilities. Furthermore, ONERN should quickly move to build redundancy of these critical skills by increasing the number of core staff and providing similar training opportunities.

4.6.2 Application Training

The cost of recurrent training implies a major new financial commitment by ONERN. ONERN's budget may be strained in achieving the level of continuity required.

ONERN should continue to provide orientation and detailed training to the staff of its various departments. Continued in-house training opportunities will enhance the possibility of integrating the GIS technology throughout ONERN.

4.7 GIS Maintenance Contract and Training Evaluation

"Ascertain the adequacy of ONERN's maintenance contract and the maintenance training received in the U.S. for ONERN GIS specialists. Describe follow on activities."

Though the GIS was purchased as a turnkey system, it is comprised of equipment from six manufacturers, an operating system from Digital Equipment Corporation (DEC), and an application software package written by ERIM. In summary, these components include:

Vendor	Component
DEC	PDP 11/44 Computer, disc and tape drive systems, console, and operating system software.
RAMTEK	Color video display
Versatec	Exectrostatic printer plotter
Lear-Siegler	CRT's
Sumagraphics	Digitizing tables
Tektronix	Graphic display devices
ERIM	Applications software

4.7.1 Computer Maintenance

ONERN maintains a service contract for the DEC components with G y M Information. The current contract expires at the end of September, 1984, requiring an extension to be negotiated. The contract with G y M excludes maintaining the operating software. No arrangement has been made with DEC to obtain a software maintenance contract and to obtain releases of new versions of the RSX-11 operating software.

4.7.2 Peripheral Equipment Maintenance

Maintenance agreements with manufacturers of all of the remaining components of the GIS are currently not available in Peru.

4.7.3 Application Software Maintenance

ERIM provides a software maintenance and update service for distributing vorrections and enhancements to their GIS application software. ONERN is not contracting, at this time, for this service.

4.7.4 Maintenance Training

Basic maintenance training on the DEC PDP 11/44 was provided to ONERN technicians during DEC management courses as discussed in the previous section. Maintenance training for peripheral equipment was limited to informal discussions during system installation. Additionally, a complete set of equipment documentation (in English) is available and useful for a limited amount of self-instruction.

4.8 Maintenance Recommendations

4.8.1 Computer Maintenance

The current hardware (DEC) contract should be extended and not permitted to expire during the useful life of the computer. Expiration and subsequent renewal will have the effect of tripling or quadrupling the maintenance fee.

ONERN should obtain a maintenance and upgrade service contract for the DEC operating system, as customized for an adequate level of service to the Lima facility.

4.8.2 Application Software Maintenance

ERIM's software maintenance and update service should be acquired to keep the GIS system current with ERIM technology. It should be noted that if ONERN

acquires this service, it must also acquire maintenance for the DEC operating system to insure compatibility of software.

4.8.3 Maintenance Training

Substantially increasing the in-house capability to maintain the entire range of equipment and to perform trouble shooting of system problems is essential if the GIS technology and applications are to be sustained within ONERN. For those equipment components that cannot be maintained through in-country maintenance contracts, selected ONERN staff should receive adequate training, either in Peru or the U.S. ONERN staff should also be provided appropriate diagnostic and repair equipment. Spare part kits should be purchased for those devices not supported in Peru.

5.0 Sub Program 3: Environmental Planning, Assessment and Demonstrations

In Sub Program 3, the ERIM contract calls for:

1. The preparation of an environmental profile by ONERN with technical assistance from ERIM.
2. Two courses with a total duration of six weeks to be given on environmental assessment methodologies and environmental protection.
3. Up to seven separate but interrelated environmental demonstrations to be conducted, including:
   a. Pasture and forest inventory.
   b. Land cover mapping from SLAR and photography.
   c. Critical areas survey; erosion and colonization.
   d. Land use conversion; urban expansion.
   e. Statistical accuracy of LANDSAT land cover classification.
   f. Sampling methods applied to remote sensing.
   g. Environmental data.

In the original ERIM contract, Items 1 and 2 above were to require a level of effort of 8 person/months and Item 3, a total of 14 person/months. By contract amendment, this level of effort was officially reduced to a total of 18.6 person/months.

5.1 Evaluation Background

The Project Paper is clear in its intent that Sub Program 3, Environmental Planning, Assessment and Demonstrations, be an integral part of the overall project. The demonstrations were seen primarily as field oriented training exercises in the use of the various technologies which input into a GIS in direct support of Sub Programs 1 and 2 objectives. In addition, each demonstration was to illustrate discrete applications of remote sensing, aerial photograph interpretation and thematic mapping to specific problems.

The Environmental Profile was seen as an integrated output of the entire process developed in Sub Programs 1 and 2. The Profile, with its national and macro

regional perspective, was conceived as a particularly useful output of the GIS combined with more conventional data gathering and analysis techniques.

The training courses were to provide training in environmental assessment and planning and to pre-adapt professionals in government agencies to use the GIS technology. "Training will also be open to Departmental Development Corporations to pass on appropriate technologies to enable each Department to compile pertinent environmental data for inclusion into ONERN's geographic information and evaluation program."

In the Project Paper it was anticipated that the $75,000 worth of environmental monitoring equipment was to be acquired under the Project. No mention was made of training for ONERN staff using the equipment nor were any acquisitions actually made.

The ERIM contract provisions related to the environmental aspects of the project were derived from the Project Paper, but do not convey the integrative intent. Time consuming delays in installing the GIS system coupled with an apparent failure by ERIM and AID to appreciate the intent of the Project Paper resulted in significant shortcomings in the accomplishment of the Sub Program 3 objectives. The recommendations contained in this evaluation are intended to guide AID follow-on support designed to meet the original Project objectives.

The following sections address the specific questions in the Evaluation Terms of Reference.

5.2 The Environmental Profile

> "Review the environmental profile prepared by ONERN, comment on its accuracy, and recommend how to optimize its usefulness."

5.2.1 Background and Findings

Field oriented profiles have been prepared and published for more than a dozen countries. With the exception of Ecuador, where the Profile was prepared entirely by a national team directed by the Fundacion Natura with AID funding, all Profiles have been prepared by expatriate consultant teams. The Profile, as conceived in Peru, represented an optimum structure. It was to be prepared by a competent national entity, ONERN, with expert assistance and new GIS technology through the AID/ERIM Project. The Profile in the process of preparation represents a synthesis of the wealth of information available as a result of its long experience in resource assessment. What did not materialize was the integration which would have provided the Profile team with access to technical expertise, methodologies and practical experience cponcentrated in the GIS project. Most technical assistance was provided by Mr. D. McCaffery, the AID Regional Environmental Officer. The relatively short time that Mr. McCaffery was able to devote to assisting in outline preparation and draft review was no substitute for the direct and indirect support for the Profile envisioned in the Project paper and budgeted in the Contract. Unfortunately only Chapters I and II, the chapters cataloging the overall state of the environment, have been completed and partially reviewed. This type of inventory work is the great strength of ONERN. Where the greatest need for technical assistance lies is in systematic analysis, including selectivity in the choice of data to be cllected. Configuration of data for manipulation in the GIS would have been valuable training and would have resulted in an immediately useful product. The most important chapters of the Profile leading to recommended environmental management strategies were not available for review. From a review of the completed portions of the document, it is apparent that the Profile will be a valuable contribution to knowledge about the Peruvian environment.

A publication providing guidelines for profile preparation, prepared by the Evaluation Team leader, was circulated in ONERN at the beginning of 1984 by Mr. McCaffery (See Dickinson, 1984 in Selected References). Subsequently, the most relevant portions of the preparation guidelines were translated into Spanish.

5.2.2 Recommendations

1. In the guidelines, the section on institutional analysis could be effectively adapted to the Peruvian Profile. A thorough inventory of private environmental groups was carried out by Mr. J. Lieberman and is available from the AID Mission Director. The section on promotion in the final product could also be useful.

2. The approach to structuring a regional scale study in the guidelines would effectively complement the GIS action plan suggestions outlined in the Executive Summary. The Coast, Sierra and Selva demonstrations studies proposed as part of the Profile will be an excellent exercise in the use of all of the Remote Sensing and GIS technology.

3. The use of the Köppen system of vegetation classification in an Environmental Profile of Peru is confusing and unjustified. The Life Zone system is widely used and understood, scientifically valid amd legally established as an integral element of land use planning.

4. The periodic updating of the Profile should be budgeted and closely integrated with the GIS.

5.3 Environmental Short Course

"Review and comment on the short courses given at ONERN in environmental impact assessment, recommend design and content of future courses on environmental analysis."

5.3.1 Background and Findings

In November, 1983, ERIM provided ONERN two environmental courses under Sub Program 3 of the Project:

1. Analisis del Impacto Medio Ambiental.
2. Medio Ambiente y Desarrollo (seminar).

The first course was conducted over a two week period by a team of Peruvian and U.S. consultants. It was attended by ten ONERN technical staff plus an additional fifteen observers from ONERN and other Peruvian agencies. The second course was designed for management level personnel and conducted in the evenings for a three day period by the above consultant instructors. The seminar

was attended by approximately eighty professionals from a variety of government agencies and institutions.

A particularly strong point in the courses given at ONERN was the balance between Peruvian and international speakers. In a similar vein, the courses were an ONERN affair, not a "show" put on by consultants at ONERN. Given the professional caliber of the speakers and the strong orientation to practical problems in Peru, it can be assumed that those in attendance benefitted significantly.

The total time devoted to the environmental assessment training was half of that originally contemplated. While the concept of a field trip followed by a workshop devoted to an integrated methodology was sound, the time constraint limited results. For example, after six days of lectures and discussions on a variety of topics, only seven days were left for the field work and the workshop. The four day field trip included two days riding a bus. Substantive ground truthing of remotely sensed imagery would be difficult in two days. It was not clear that the half hour devoted to the GIS was generic in scope or related directly to manual processing of data checked in the field. In any event, the cursory treatment of the GIS related activities going on under the Project did not reflect the intent of the Project Paper or the Project Agreement.

There is always a place for informative and consciousness raising lectures. However, a course in impact assessment should have a structure designed to achieve a specific set of results, such as those defined in the Project Paper for each of the demonstrations.

5.3.2 Recommendations

1. ONERN should offer environmental management courses. A management course balances concern for the mitigation of impacts with a search for optimum sustainable development strategies. Impact assessment employs the same disciplines and techniques but tends to foster a negative, adversarial

relationship with powerful development sectors. ONERN is a development institution concerned with productive and sustainable use of natural resources.

2. When appropriate, courses should promote and fully integrate use of the GIS and supporting technologies, keeping in mind such technology is a tool, a complement to the trained eye and integrative mind of the professional.

3. The demonstrations envisioned by ONERN as part of the Profile process offer an unprecedented training opportunity for both ONERN personnel and for professionals representing agencies such as Departmental Development Corporations in each of the regional target areas of the Coast, Sierra and Selva. An approach to this process is outlined in Section 1.3 of this Evaluation.

5.4 Impact Evaluation

"Evaluate ONERN's capability to conduct environmental impact evaluations across the whole spectrum of Peru's development projects; if necessary recommend how to enhance this capability."

5.4.1 Background and Findings

ONERN has an in-house capability to conduct impact assessments over a wide range of development projects. Where expertise is lacking in-house, ONERN draws upon expertise from other institutions, as in the case of a recent study of tourism impacts on the mangrove resource in Tumbes. This is far more economical and effective than trying to staff ONERN with experts from all disciplines.

In 5.3 above, it was suggested that ONERN should project a management perspective rather than an "impact" orientation. This will be difficult to achieve if international donors continue to foster the adversarial, impact oriented approach which evolved out of the application of the National Environmental Policy Act in the United States. The profiling process referred to in 5.2.1 above outlines a positive, development oriented approach.

5.5 Environmental Demonstrations

"Evaluate the environmental demonstration activities that have occurred at ONERN."

5.5.1 Background and Findings

The Demonstrations have been discussed in detail in Section 3.0 as they functioned as an input to GIS capability development. The training opportunities lost due to the incomplete execution of the demonstrations can be recouped in the regional profile studies recommended in Section 1.3.

6.0 Other Evaluation Issues

6.1 Applicability of ONERN Technology

"Assess the application of ONERN technology to other projects and development activities in AID/PERU portfolio."

AID is involved in activities that can utilize the capabilities of ONERN's GIS and Remote Sensing facilities while serving the dual function of providing ONERN with multiple opportunities to expand its experience with these resources. The GIS can be useful in policy formulation, statistical research and small scale projects as well as for regional analysis with which it is normally associated. In addition, though the GIS is usually associated with natural resource analysis it is equally suitable for the storage and manipulation of any data with a spatial/geographic component, e.g., socio-economic data, health conditions and statistics.

Discussions and demonstrations of the GIS are ongoing between ONERN and AID contractors working on projects in the Pichis-Palcazu and Upper Huallaga areas. Discussion with AID staff and contractors, and a review of AID/PERU FY 1986 Annual Budget Submission Action Plan was accomplished to establish a starting point for considering the utilization of AID funded GIS capabilities in ONERN. The listings which follow suggest applications which are representative of the breadth of AID's potential use of the GIS:

1. Project No. 527-0282 Agricultural Sector Recapitalization

Centralize and make compatible the agricultural data base; assist in the expansion of the data base including agricultural activity, land use, socio-economic statistics; support agricultural research and in particular locational analysis; aid in the capability/suitability analysis of agricultural activities; and undertake comparative and locational analysis

related to resource (land and water) conservation, management and productivity.

2. Project No. 527-0283 Policy Development Program Assistance

Assessment of coca cultivation and eradication activities; and analysis of capability for substitute crops.

3. Project No. 527-0284 Decentralized Planning and Investment

Comprehensive and regional assessments of decentralization options and development opportunities; resource analysis; transportation and electrification corridor analysis; comparative opportunity analysis for disaster reconstruction, environmental planning, and impact analysis.

4. Project No. 527-0285 Improved Health Sector Efficiency

Rural water supply and sewage disposal analysis; epidemiology studies related to residency, occupation, nutrition and health services.

5. No. 527-0240: Central Selva Resource Management: Pichis-Palcazu*

Land use planning, monitoring of environmental change, road corridor location.

Other candidate projects include:

No. 527-0244: Upper Huallga Area Development*
No. 527-0221: Rural Water Systems and Environmental Sanitization
No. 527-0156 Water and Land Use in the Sierra
No. 527-0220 Soil and Water Conservation
No. 527-0226 Small Hydro Development*
No. 527-0231 Expanded Reforestation

*Discussion on GIS application utility held with AID contractors

6.1.1 Recommendations

AID/PERU should hire an in-house "omsbudsman" who would be responsible for assessing and, as appropriate, integrating the use of ONERN's GIS into AID funded projects. Until such time as AID can recruit an individual, it should utilize a contractee to periodically review AID Requests for Proposals for the applicability of GIS technology, assist in Project Paper and contract preparation, and serve as technical advisor for the resultant contracts between AID and ONERN.

6.2 In-House Training

"Can ONERN train replacements for its middle level technical staff in-house?"

ONERN has initiated an extensive in-house training program for staff ranging from clerical to mid-level technical/disciplinary levels. An active program of instruction through on-the-job training by staff colleagues has been developed for word processing, the Datatrieve data base management system, digitizing, GIS application software and the DIPIX Image Analysis System. Should ONERN maintain the skills of the technical staff of the Office of Computer Services and the Remote Sensing Department, it should be able to sustain the current in-house program.

6.3 Dependence on External Training

"Will or should ONERN be dependent on external training for particular skills? What are the logical sources for continued training of its personnel in these skills?"

The U.S. is the origin of continual developments and enhancements to GIS, remote sensing and environmental planning technologies as well as computer technology in general. AID and ONERN have "bought into" this technology and specifically those GIS related technologies developed by selected hardware and software vendors. As discussed in previous sections, ONERN staff should be periodically exposed to additional external training to consolidate and expand

upon skills recently developed. This training should encompass DEC operating system software and special application packages, equipment maintenance, and GIS application software and disciplinary skills in environmental analysis and planning. Educational material on GIS applications is sparse and frequently academic. Contemporary discussions of GIS applications are, however, presented through a number of professional organizations and conferences, e.g., Urban and Regional Information System Association (URISA), the Pecora Symposium (USGS-EROS Data Center), and the Harvard Computer Graphics Conference. Attendance at selected conferences can provide ONERN staff with an opportunity to achieve currency with the state-of-the-art of GIS analysis as well as the technology.

Several additional project components have been inadequately or incompletely addressed in the present project. In Sub Program 1, for example, a seminar-type program is recommended to design a national land cover classification scheme, including conceptual development and program implementation to regional resource inventory and evaluation projects. Further experience in the use and application of color infrared aerial photography, involving multiple test sites representative of Peru's physical diversity is needed. Development of a national GIS data base design and structure is lacking, and should include careful evaluation and re-design of the full range of thematic legends and products traditionally prepared at ONERN. Each of these, and related issues defined in the Sub Program findings, may be effectively addressed through appropriate short-term technical assistance.

6.4 Skill Needs

> "Identify the key skills for continued performance of its thematic mapping, GIS and environmental functions."

As justified in an earlier discussion, ONERN would benefit from augmenting its current computer service staff with, at a minimum, a software specialist and a GIS application specialist. As system usage expands, additional data entry and digitizing personnel will be required.

The software specialist would be responsible for enhancing and augmenting the GIS and DIPIX application software. As such, the individual should have a thorough knowledge of function and be capable of working with DEC operating systems and the drivers for the peripheral equipment.

The application specialist would be responsible for the design and execution of GIS projects within the Office of Computer Services and providing assistance and liaison for the design and use of the GIS within other departments of ONERN, other Peruvian agencies, AID, and other international organizations. The application specialist may come from a variety of discipline backgrounds, but should have experience in inter-disciplinary natural resource sciences. Moreover, the individual should be experienced in both project level and regional environmental planning and analysis.

ONERN is developing digitizing and data entry capabilities throughout the organization. However, if it successfully attracts projects from other agencies and organizations, it will need to maintain a production staff capacity for data entry. Additional staff will be required. Skill levels will include clerical, drafting and cartography. Previous experience on a system is not a requisite.

6.5 Demand for Services

> "Assess demand for ONERN services within the Government of PERU. Who uses the services now? Do these users value the service sufficiently to budget funds to pay for them? Identify other public or private customers who could benefit from ONERN's capabilities."

At present, no Peruvian governmental agencies or private companies are utilizing ONERN's GIS. In view of the fact that ONERN has only recently completed its first demonstrations of the system, this is neither unexpected nor unreasonable. The potential for applications within Peru is substantial. ONERN is moving effectively toward developing presentations and training

opportunities which will be useful in "marketing" the system to a broadly defined user community. AID can play a supportive role in encouraging the use of the GIS by other Peruvian agencies through its projects with those agencies. Furthermore, AID in conjunction with Canada CIDA can be influential among multilateral agencies and other doners by increasing their awareness of the existence and utility of the technology. ONERN should be given an oportunity to hone and consolidate its skills before aggressively marketing the system beyond AID.

In respect to natural resource inventory and evaluation, traditional ONERN activities, linkages and service provisions to other Peruvian agencies are well established through a continuous series of projects. As the GIS capabilities are further developed to the point of benefiting resource evaluation and assessment projects for other agencies, these capabilities and services should be "marketed" by all of ONERN's line departments.

6.6 Professional Contacts

> "Does ONERN have sufficient contact - formal and informal - with the leading institutions in mapping technology to keep itself current?"

Only a few ONERN staff are members of international mapping societies, such as the American Society of Photogrammetry (ASP) and the Sociedad de Especialistas Latino Americanos en Percepción Remota (SELPER). Due to institutional structure and constraints on travel budgets, there is limited opportunity for travel to international meetings, symposia or workshops.

It is recommended that ONERN acquire through institutional subscriptions and memberships the leading remote sensing and mapping journals and newsletters. This material should be circulated and deposited in the ONERN library or the recommended Information Resource Center. Contact with the IAGS/DMA Cartographic School in Panama should be maintained, and the continued use of the video course curriculum will provide effective and economical (no cost) training and technical improvement opportunities. Participation at

international meetings, symposia and workshops with Peruvian and donor funding will increase opportunity for professional improvement. Participant selection, however must benefit the professional staff as well as management personnel.

Improved diaglogue and communication for the sharing of information and experiences with other Peruvian agencies should be encouraged at all levels of the professional staff. While periodic formal meetings and conferences are important, regular informal contact is often the most effective. The local Peruvian agencies should include IGN, OGCR (Agriculture), SAN, CONIDA universities, private sector consultants and professional organizations, etc. All organizations can benefit, and Peru will benefit.

6.7 Technology Choice

> "Can ONERN be expected to evaluate new instruments and computer technology and select the most appropriate product for its level of technology use and ability to support the institutional role and function in Peru?"

ONERN has, at this time, little experience in rigorously assessing its own needs and comparing them to the technology currently available in the market place. As an example, though GISs are available from several vendors and were observed at various user institutions, no detailed discussions were held with the manufacturers, and no comprehensive comparison was undertaken by any of the parties. ONERN staff were not involved in an analysis of competing system components. A case in point is the purchase of the RAMTEK video monitor which produces a stretched image, rather than a geometrically correct one. Both RAMTEK and other vendors manufacture display devices which project undistorted images, a feature that enhances the "friendliness" of the systemn to non-analytical users.

Given that AID has little experience with the GIS technology, a continued reliance on contractor support appears certain. In those cases where contractors have a vested interest in a particular system or equipment components, both ONERN and AID should seek assistance and collaborative

recommendations in future major procurements. Over time, ONERN can be expected to develop the in-house expertise to make these judgements.

Since the present GIS at ONERN is installed and operational, the priority issue should now be its effective application to land use and natural resource inventory and environmental planning. Future assistance, in the near term, should focus primarily on applying the system to the resolution of specific natural resource management problems, and in this manner to further develop and refine staff skills in the use and application of the installed technology.

6.8 Information Resource Center

The implementation of the GIS and DIPIX can serve as a focus and catalyst for establishing an Information Resource Center (IRC) within ONERN. The Information Resource Center would serve as a central depository of physical, environmental and socio-economic data of all forms. Published and unpublished reports, reference documents, maps, photography, satellite imagery, and products of the GIS would be cataloged and physically located in a central location near the computer facilities as a workstation. The facility would function as a user facility as well as a lending library to ONERN staff.

The GIS is a tool that can effectively expand an organization's ability to undertake analyses of complex problems requiring the integration of many disciplines. It is, however, not a tool that should be used singularly. The automated data base is more powerful when augmented by other collateral data, including photography, maps and other manual and digital data sources. The IRC would serve to consolidate and organize information to facilitate its use with the GIS and DIPIX.

The IRC would serve all of the offices and departments within ONERN and be a point of contact with other organizations and individuals seeking information. In addition to the depository role, the IRC would direct requests for information and other inquiries to appropriate individuals and handle the sale

of reports, maps and computer products.

Costs for implementing the Center would be limited to:

1. Information storage and display equipment (e.g., map files. book shelves) that would probably be purchased and distributed throughout ONERN in the absence of the IRC.

2. Initial cataloging of information.

3. Maintenance of the IRC.

The costs may be offset by charges for report/map reproduction and document sales. The IRC might also serve as the contact point for Image Processing and GIS products to the private sector.

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13. ERIM, Second Semi-Annual Report: Contract No.1 527-0202-C-00-2014-00. Project No. 527-0202. March 19, 1983.

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15. ERIM Fourth Semi-Annual Report: Contract No. 527-0202-C-00-2014-00. Project No. 527-0202. March, 1984.

16. ONERN, Monitorio del Area del Huallaga Central y Bajo Mayo.

17. ONERN, Agreement between ONERN and DIPIX SYSTEMS LTD. MAY 1, 1984.

18. ONERN, Contrato de Servicios de Mantenimiento de Material CH-06/83, entre I.R.E. y ONERN.

19. ONERN, Contrato: Entre Servicios Aerofotografico Nacional (SAN) y ONERN. December, 1982.

20. ONERN, Perfil Ambiental del Peru. Junio, 1984.

21. ONERN, Organigrama D.C. No. 20588. 1983.

22. Ministerio de Agricultura, Reglamento de Clasificacion de Tierras, Decreto Supremo No. 0062/75-AG, 22 de Enero de 1975. Febrero, 1975.

23. Resources Development Associates, Land Use Inventory and Environmental Planning Project: Peru. April 1, 1980.

24. Miscellaneous correspondence, procurement and management files, ref. AID Project No. 527:0202.

Appendix 1: Persons Consulted

AID	Jack Rosholt E. Alarcón David Bathrick David Himelfarb Nicholas Metes
ERIM	Creighton Dennis Don Lowe Barry MacRae Tom Reinholt Buzz Sellman
ONERN	Carlos Zamora Carlos Calderón Cesar Calderón Walter Danjoy Jesus Echenique Carmen Manabe Mauro Mendoza Enrique Milliones Zoila Rodriguez Carlos Vargas Javier Villafranca Percy Zorogastua
CIDA	Barry O'Neil
Other AID Contractors	Wolfram Drewes Edward Farnworth Robert Tillman Joseph Tosi

Appendix 2: ONERN Staff Receiving Formal Training

PROGRAMA DE CAPACITACION EN: Fort Clayton, Panama

Nº	NOMBRE	CURSO	DURACION
1.	GIRALDO, Alfredo	Técnicas de Cartografía Temática	8 Sema. 27-07-81
2.	MEZA, Lillian	Técnico en Separación de Colores	8 Sema. 27-07-81
3.	COELLO, Juan Carlos	Técnico en Separación de Colores	8 Sema. 27-07-81
4.	CARRANZA, Carlos	Técnico en Separación de Colores	8 Sema. 27-07-81
5.	CALDERON, César	Teoría y Aplicación de la Percepción Remota	4 Sema. 17-08-81
6.	CHIRINOS, Humberto	Teoría y Aplicación de la Percepción Remota	4 Sema. 17-08-81
		Percepción Remota Aplicada a Suelos y Forestales	2 Sema. 14-09-81
7.	VARGAS, Carlos	Teoría y Aplicación de la Percepción Remota	4 Sema. 17-08-81
8.	RODRIGUEZ, Zoila	Teoría y Aplicación de la Percepción Remota	4 Sema. 17-08-81
		Percepción Remota Aplicada a Suelos y Forestales	2 Sema. 14-09-81
		Percepción Remota, Generación y Evaluación Digital de las Imágenes LANDSAT	2 Sema. 28-09-81
9.	ALAYO, Santiago	Cartografía	10 Sema. 21-09-81
10.	ORTIZ, Antonio	Supervisor de Producción Cartográfica	3 Sema. 30-11-81
11.	VARGAS, Gilmer	Supervisor de Producción Cartográfica	3 Sema. 30-11-81
12.	CARRILLO, Eduardo	Taller de Mosaicos LANDSAT	3 Sema. 30-11-81
13.	ORTIZ, Dora	Cartografía	10 Sema. 29-03-82
14.	CUELLAR, Teófilo	Cartografía	10 Sema. 29-03-82
15.	FREYRE, Alberto	Fotogrametría	10 Sema. 29-03-82
16.	MONTERO, Elio	Ciencias Básicas de Laboratorio Fotográfico	10 Sema. 29-03-82
17.	ECHENIQUE, Jesús	Introducción a la Percepción Remota	4 Sema. 03-05-82
18.	PAREDES, Angel	Introducción a la Percepción Remota	4 Sema. 03-05-82
19.	ALAMA, José	Técnico en Separación de Colores	8 Sema. 26-07-82
20.	MOZ, Eduardo	Cartografía	10 Sema. 20-09-82

PROGRAMA DE CAPACITACION EN LOS ESTADOS UNIDOS

LUGAR : DIGITAL EQUIPMENT CORPORATION (DEC)

Nº	NOMBRE	CURSO	DURACION
01	VILLAFRANCA, Javier	XXDP/DECX-11 Utilities and Commands	1 Sema. 18-07-83
		DATATRIEVE 11 User	1 Sema. 25-07-83
02	VARGAS, Carlos	RSX-11M System Management	1 Sema. 18-07-83
		RSX-11M Utilities and Commands	1 Sema. 25-07-83

LUGAR : ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN (ERIM)

Nº	NOMBRE	CURSO	DURACION
01	RODRIGUEZ, Zoila	Geographic Information System	4 Sema. 14-02-83
02	MANABE, Carmen	Geographic Information System	4 Sema. 14-02-83
03	MENDOZA, Mauro	Geographic Information System	4 Sema. 14-02-83
04	MORENO, Luis	Geographic Information System	4 Sema: 14-02-83

PROGRAMA DE CAPACITACION EN LIMA - PERU

LUGAR : OFICINA NACIONAL DE EVALUACION DE RECURSOS NATURALES (ONERN)

Nº	NOMBRE	CURSO	DURACION
01	MENDOZA, Mauro	Digitalización de Imágenes LANDSAT	4 Sema. 04-10-82
02	LEON, Humberto	Digitalización de Imágenes LANDSAT	4 Sema. 04-10-82
03	MORENO, Luis	Digitalización de IMágenes LANDSAT	4 Sema. 04-10-82
04	OSEJO, José	Digitalización de Imágenes LANDSAT	4 Sema. 04-10-82
05	VARGAS, Gilmer	Digitalización de Imágenes LANDSAT	4 Sema. 04-10-82
06	GIRALDO, Alfredo	Digitalización de Imágenes LANDSAT	4 Sema. 04-10-82
07	ZOROGASTUA, Percy	Digitalización de Imágenes LANDSAT	4 Sema. 04-10-82
08	RODRIGUEZ, Zoila	Digitalización de Imágenes LANDSAT	4 Sema. 04-10-82
09	MANABE, Carmen	Digitalización de Imágenes LANDSAT	4 Sema. 04-10-82

PROGRAMA DE CAPACITACION EN LIMA - PERU

LUGAR : OFICINA NACIONAL DE EVALUACION DE RECURSOS NATURALES (ONERN)

Nº	NOMBRE	CURSO	DURACION
01	GALARRETA, Luis	Sistema de Información Geográfico	8 Sema. 13-10-83
02	JUAREZ, Pedro	Sistema de Información Geográfico	8 Sema. 13-10-83
03	MENDOZA, Mauro	Sistema de Información Geográfico	8 Sema. 13-10-83
04	MORENO, Luis	Sistema de Información Geográfico	8 Sema. 13-10-83
05	MANABE, Carmen	Sistema de Información Geográfico	8 Sema. 13-10-83
06	RODRIGUEZ, Zoila	Sistema de Información Geográfico	8 Sema. 13-10-83
07	VARGAS, Carlos	Sistema de Información Geográfico	8 Sema. 13-10-83
08	VARGAS, Gilmer	Sistema de Inform ación Geográfico	8 Sema. 13-10-83
09	ZOZIMO, Azurza	Sistema de Información Geográfico	8 Sema. 13-10-83

PROGRAMA DE CAPACITACION EN LIMA - PERU

LUGAR : OFICINA NACIONAL DE EVALUACION DE RECURSOS NATURALES (ONERN)

Nº	NOMBRE	CURSO	DURACION
01	MONTJOY, Oscar	Análisis del Impacto Medio Ambiental	2 Sema. 02-11-83
02	LLUEN, Alberto	Análisis del Impacto Medio Ambiental	2 Sema. 02-11-83
03	ROBLES, Carlos	Análisis del Impacto Medio Ambiental	2 Sema. 02-11-83
04	CERVANTES, César	Análisis del Impacto Medio Ambiental	2 Sema. 02-11-83
05	CHAVEZ, Gerardo	Análisis del Impacto Medio Ambiental	2 Sema. 02-11-83
06	GONZELES, Daniel	Análisis del Impacto Medio Ambiental	2 Sema. 02-11-83
07	SOTELO, Justo	Análisis del Impacto Medio Ambiental	2 Sema. 02-11-83
08	JORGE, César	Análisis del Impacto Medio Ambiental	2 Sema. 02-11-83
09	BUSTAMANTE, Marita	Análisis del Impacto Medio Ambiental	2 Sema. 02-11-83
10	ZOROGASTUA, Percy	Análisis del Impacto Medio Ambiental	2 Sema. 02-11-83

LUGAR : OFICINA NACIONAL DE EVALUACION DE RECURSOS NATURALES (ONERN)

CURSO : MEDIO AMBIENTE Y DESARROLLO (Seminario)

DURACION : Del 2 al 4 de Noviembre de 1983

PARTICIPANTES : Diversas Entidades, Estatales y Privadas.

Appendix 3: Color Infra-Red Video System; Applications in the Profile Project

The use of Color Infra-Red (CIR) video technology has a wide range of applications in resource management. Among those are the following:

1. Forest Management.
   a. Detection of major variations in vegetation cover.
   b. Detailed location of exploitation strips and extraction roads.
   c. Detection and documentation of forest areas converted to agriculture or pasture.
   d. Detection of areas affected by fire, disease or blowdown.
2. Land Use Monitoring.
   a. Detection and documentation of spontaneous settlement.
   b. Verificataion of adherence to land use plans, tenure limits and concession conditions.
   c. Land use inventory - samples by area and crop.
   d. Detection and measurement of the presence and extent of drought or disease stress on crops.
3. Documentation of areas affected by flooding and location of surface water bodies.
4. Monitoring of road corridors for landslides, work progress and settlement activity.

Advantages

1. CIR video is superior to conventional color video in the detection of vegetation differences and condition and in detecting surface water bodies.
2. CIR video requires no processing as is the case with CIR photography.
3. CIR video can be viewed immediately on readily available Betamax or VHS equipment and a television set such as already exists in Iscosacin. Tapes can be saved or reused.
4. The video camera can be mounted vertically in a conventional camera port or on a removable door mount. A small television monitor aboard the aircraft is used to verify system operation and assure target areas are being covered.

5. Video data can be annotated by real time voice recording on the recorder built into the video camera. Video can also be complemented by 35mm oblique or vertical photography.

6.Pictures can be taken of specific video frames using color Polaroid film.

7.The relatively low resolution imagery gained from the use of video equipment can be used to justify more precise, but more time consuming and costly aerial photography or the acquisition of LANDSAT images.

Equipment Needed

1. CIR video camera (cost about $11,000 US).
2. Conventional video recorder and tapes.
3. Small (4-6 inch) TV monitor for use in aircraft.
4. TV Monitor.
5. Polaroid camera and film.
6. Bracket for attachment of camera to door of high wing aircraft.
7. Battery recharger, batteries, cables and carrying case.