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INTRALAB/AGRICULTURAL
PRODUCTION POTENTIALS STUDY

34p

PROPOSED PROJECT PLAN

February 15, 1977

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I. INTRODUCTION

This document describes a proposed project plan to formally link the Information Transfer Laboratory (Intralab) of the NASA/Goddard Space Flight Center with the Agricultural Production Potentials Study (APPS) managed by the Economic Research Service (ERS/USDA). An ERS study team, operating under contract to the Technical Assistance Bureau of the Agency for International Development (AID), has requested NASA to provide technical guidance and assistance to ERS to determine the feasibility of integrating Landsat derived information on land cover into the data base and analytic framework of the Comprehensive Resource Inventory and Evaluation System (CRIES) CRIES is a computerized data analysis system already under development by the ERS study team, and provides the technical basis for evaluating national agricultural planning options in Lesser Developing Countries.

This proposal is written with a full appreciation of the need to develop further the long range program requirements of APPS, and of the additional assistance that NASA might provide to meet those requirements. Such long range planning for FY78 and beyond must begin soon. However, specific steps can be initiated now which will contribute directly to current

needs as expressed to NASA by the ERS study team. In developing this cooperative project plan with ERS, Intralab has placed a high priority on an analysis of the costs of routinely using Landsat for land cover mapping and the quality of specific techniques and results achieved in using Landsat derived land cover information. The primary elements of the FY77 effort are as follows:

1. Intralab will derive land cover for two test sites within the Dominican Republic via computer processing of Landsat data, and maintain a comprehensive log of all steps in the process.

2. In parallel with the above, Intralab will develop a Land Cover Data Management System (LCDMS) compatible with CRIES.

3. The Landsat derived land cover information will be placed in the LCDMS for entry into CRIES

4. The land cover data base for the two test sites will be sampled to determine the impact on classification accuracies and resulting cost savings from using less than full Landsat data resolution.

5. The LCDMS will be fully documented and delivered to ERS, together with supporting documents on project activities and results.

6. Intralab personnel will work closely with the ERS study team in evaluating all results and determining longer term requirements and goals for NASA's involvement in APPS.

Thus Intralab proposes an eight month project which will provide technical guidance and assistance, specific Landsat information products, an efficient means to integrate Landsat data into CRIES, and a preliminary assessment of the costs of using various processing and analysis methods.

II. BACKGROUND AND OBJECTIVES

Intralab staff has been meeting informally with the ERS project team since the Summer of 1976, and participated in several early planning meetings held in the Washington, D.C. area. During that time, ERS began work under contract to AID[1]. At a meeting held at NASA Headquarters on 29 November, 1976, ERS project management requested NASA to consider specific institutional and program mechanisms by which NASA might participate with ERS in the Agricultural Production Potentials Study. At that time, a technical guidance and assistance role for NASA was identified, together with the desirability of a Landsat data analysis effort as a base line activity. Specifically, Intralab was directed to work closely with the ERS study team to develop a proposal for NASA's involvement with ERS in FY77.

At subsequent meetings held at Goddard (30 November), AID (13 January) and at East Lansing, Michigan (26-27 January), Intralab and ERS personnel explored more fully the program plans and needs for the study underway in the Dominican Republic.

[1] "Comprehensive Resource Inventory and Evaluation System for Agricultural Planning" (AG/TAB-236-14-76).

ERS is in the first year of a four year program to design, develop and test the performance of CRIES. This system will be tested in at least two countries during the first four year contract period, starting with the Dominican Republic and followed by Nicaragua. A third country may soon be added to APPS, but this will probably require an additional contract between AID and ERS beyond the current four year plan.

Intralab's involvement as discussed in this plan, and the objectives of the cooperative effort with ERS in FY77, will be restricted to analysis of data for the Dominican Republic. Since the ERS study team will be evaluating Landsat data for the first time, restricting the Landsat analysis and evaluation to one country is a reasonable first step.

The overall objective of the proposed plan is to provide the ERS study team with an opportunity to evaluate the Landsat system as a data and analysis component of CRIES. ERS is particularly sensitive to the cost of routinely using Landsat as well as the quality of resulting data and products obtainable from Landsat. If the results of this project suggest that Landsat can be a cost-effective component of CRIES, than the subsequent cooperative effort between NASA and the APPS program should be designed to transfer the capability of Landsat data utilization to the ERS study team.

Excellent results have already been achieved by various foreign investigators using Landsat 1 and 2 data. AID, the World Bank, the Inter-American Development Bank, the United Nations, and other public and private international agencies have begun and/or developed practical demonstration and applications programs using Landsat.

Yet one significant area for which there is still insufficient experience in foreign investigations and application of the Landsat system is in the use of digital data processing and the incorporation of the results into a systematic data management and analysis system. The APPS program thus provides an excellent program setting in which to evaluate Landsat digital data within the framework of a national resource assessment system (CRIES) for use by Lesser Developing Countries.

III. ADMINISTRATIVE STRUCTURE

Figure 1 outlines the administrative structure within which Intralab will perform its responsibilities on APPS.

AID

ERS

Intralab	Michigan State University	Other USDA Agencies, e.g. ARS, SCS

Figure 1: Administrative structure of proposed cooperative project between Intralab and ERS/APPS Program.

Michigan State University is under contract to ERS to provide the management and technical staff to design and develop CRIES. ERS has administrative agreements under which ARS and SCS will provide personnel and supporting resources for data gathering and analysis tasks. While Intralab does not plan to enter into a formal contract with ERS, Intralab will have specific technical and management responsibilities as a partner in the APPS Program.

Intralab will provide a project leader, with overall responsibility for the project management and liason with ERS, MSU and the other cooperating agencies of USDA. The project leader will be assisted by a Data Processing Coordinato who will be responsible for the Landsat data analysis task, and a System Development Coordinator, who will be responsible for developing the LCDMS.

IV. TECHNICAL PLAN

This section contains a description of the tasks to be performed by Intralab in FY77. The various tasks are outlined in Figure 2, the Schedule of Milestones. The discussion that follows will describe the tasks in the order listed in Figure 2.

1 - Design and Develop CRIES (MSU)

As already discussed, CRIES is under development at Michigan State University and this task will continue throughout FY77. Intralab has no responsibility for this effort; it is listed, rather to indicate specific times at which products from Intralab's work will be delivered to the ERS/MSU study team in East Lansing, Michigan.

2 - Landsat Data Analysis

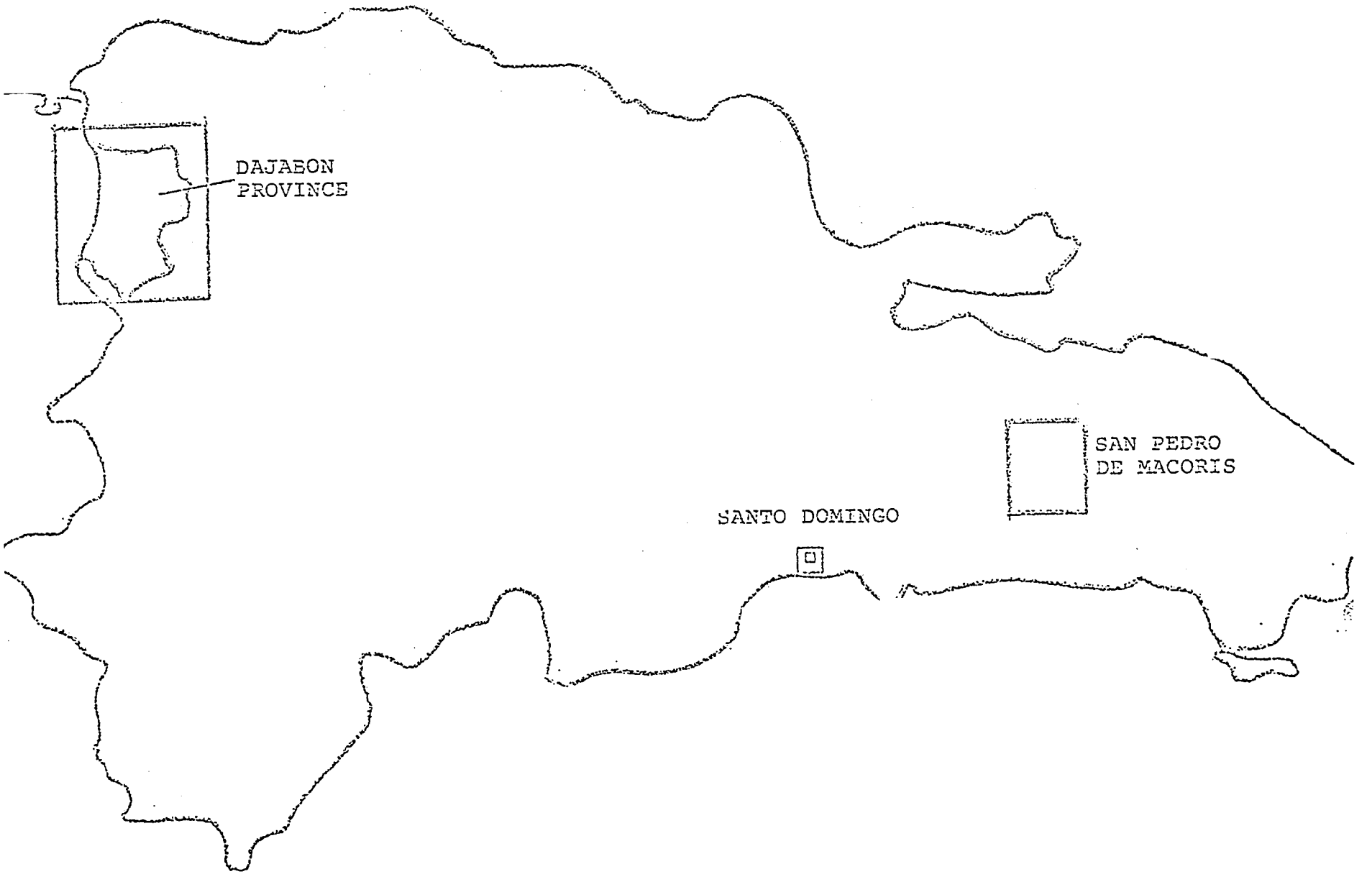
Based upon preliminary planning between Intralab and ERS. two test sites within the Dominican Republic have been selected for Landsat digital processing. Land cover products are to be prepared for Dajabon Province and the extensive sugar cane growing area (San Pedro De Macoris) north and east of the capital, Santo Domingo (refer to Map 1).

FIGURE 2: INTRALAB/APPS PROGRAM - SCHEDULE OF MILESTONES (1977)

TASK	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEP
1 Design & Develop CRIES (MSU)								
2 Landsat Data Analysis				B		C		
3 Prepare Enhanced Images		A						
4 Develop Land Cover Data Management System (LCDMS)							F	G
5 Sampling Study						D		
6 Workshop (Intralab)							E	
7 Project Review Meetings.		o		o		o	o	
8 Establish Advisory Team							o	
9 Travel MSU Dominican Republic			o o		o o		o	o

Explanation of Key Letters

A - Enhanced Images to ERS
B - Preliminary Landsat Classification
C - Final Landsat Classification
D - Sampling Study Results to LCDM
E - Workshop for Study Team, DR personnel if available
F - LCDMS tape to ERS (MSU)
G - Project Results and LCDMS Documentation to ERS



Map 1 - Location of Test Sites in Dominican Republic

The Dajabon test site will be contained within a rectangular area with UTM boundaries of:

200000 - 250000 Easting

2120000 -2180000 Northing

This results in a 50X60km test site with 3000 1-km cells. The UTM boundaries for the San Pedro De Macoris test site are:

490000 - 520000 Easting

2050000 - 2080000 Northing

This results in a 30X30km test site with 900 1-km cells.

The ERS study team has requested specific seasonal periods for Landsat processing, on the San Pedro De Macoris test site, namely, September to November and April to July. The former falls during maximum sugar cane growth and the latter corresponds with harvest and maximum bare ground conditions. Unfortunately, there is very limited data for this area of the Dominican Republic, and adjustments to these desired times will have to be made because of data limitations. Figure 3 is a summary of data for the two test sites. It represents a thorough search of all useable Landsat 1 and 2 data (40% cloud cover or less) from 1972 through December of 1976.

Figure 3: Landsat Data Availability for Dominican Republic Test Sites

Dajabon Province

DATE&ID	REMARKS
28 Aug. 1972/1036 14390	Does not cover all of Dajabon. Minor cloud problem. Have tapes.
3 Nov. 1973/1468 14371	Western tip of Dajabon may be missing. Minor cloud problem. Have tapes.
6 Feb. 1975/2015 14332 and 2015 14334	Both tapes needed, yet western tip of test site may be missing. Both tapes on order.
19 May 1976/2483 14273	Have ordered photography for inspection prior to deciding on tape order.

San Pedro De Macoris area

DATE&ID	REMARKS
8 Dec. 1973/1503 14311	Have tapes for processing. Clouds obscure entire test site.
26 Dec. 1973/1521 14302	50% cloud cover, but test site area is partially clear. Have ordered tapes.
31 Jan. 1974/1557 14293	Tapes on order.

While it is unfortunate that only limited data are available, this should not jeoprodize our objective of evaluating Landsat processed data within the data file and analytic framework of CRIES.

Initial Landsat processing will be performed using an unsupervised classification technique. This technique will produce various spectral groupings of land cover but the specific cover types (e.g., brushland, bare soil) may not be known until the preliminary results are evaluated by on-site fieldwork in the Dominican Republic. Thus the field trips are required in order to compare the spectral groups with the specific land cover types found in the test sites. Following this, supervised classification can be performed such that specific ground cover and/or condition is known before the processing begins.

Preliminary land cover classification results will be made available to the LCDMS in mid-May, with final land cover results available in July.

The ORSER system will be the primary classification system used for Landsat analysis. ORSER offers a f exible,

high performance software library, featuring both interactive and batch processing. Accurate cost accounting will be kept for each processing step performed during analysis.

The Image-100 system will also be used for Landsat classification, since its operation provides a direct experience in system performance offered by private industry. Again, processing steps and times will be documented so that cost estimates for routine processing can be computed.

3 - Prepare Enhanced Images

Two Landsat images of the Dominican Republic will be computer enhanced. Enhancements will be made to correct image geometry, optimize color and to bring out edges and fine details. The resulting digital images will be transferred to film using an Optronics film recorder. This will produce 8 X 10 inch color negatives at a scale of approximately 1:1,000,000. The color negatives will be used to create high quality color prints at a scale of 1:250,000. Full Landsat scenes at this scale cover about thirty by thirty inches. Six (6) prints of each scene will be made. These prints will become an important resource for subsequent data processing efforts. They will serve as reference images to acquaint project participants with test sites, scene content and Landsat image characteristics. The final prints will be available

to the project one month after the tapes are submitted for computer processing.

4 - Develop Land Cover Data Management System (LCDMS)

The LCDMS will be prepared in parallel with the Landsat data analysis. In summary, this system provides for computer storage and retrieval of the results of Landsat classification in a form readily useable within CRIES. When entered into CRIES, it will become one of the several environmental files, along with soil types, agronomic units, etc.

The basic structure of the system provides for a 1-km square matrix, on an Universal Transverse Mercator (UTM) projection, with the three dominant cover types and their areal extent (percent) coded into each cell. Comparisons with other data files in CRIES is easily achieved.

The structure of the LCDMS, together with the modules (software) that are to be developed in this task, are discussed in more detail in Appendix A.

The LCDMS, software and the Landsat classification data base, will be turned over to the ERS study team by the end of July. This is an extremely tight schedule requiring a start on this task by the last week in February.

5 - Sampling Study

The objective of this sampling study is to quantify the cost/accuracy tradeoff at different Landsat sampling densities. A set of subroutines will be implemented in LCDMS to facilitate a sampling study. Once appropriate sampling densities have been established, future Landsat classification of large areas or entire countries can be done with the minimum amount of data and thus minimum cost. The LCDMS will allow the user to specify horizontal and vertical sampling rates prior to aggregation of classified Landsat data to the 1-km cell level.

Separate data bases will be generated and maintained for each sampling option selected. The specified sampling rates will be used to fill the special data bases through aggregation of the classified data. Since the data bases are in register, it will be possible to directly compare the results of different densities with each other and with the unsampled data.

The comparison of two data bases will be done at two levels. First the overall totals for each Landsat ground cover class over a full test site or province will be computed and listed. Second, the data bases will be compared at the 1-km cell level. The comparison criteria used will be to determine if the same three ground cover classes are present

in both data bases and are in the same cardinal order. The absolute percentages will not be compared.

Dicomed film products (see Appendix B for sample Dicomed products) will be generated to show the results of cell level comparisons. Cells which meet the criteria will be assigned one color and those which do not meet the criteria will be a different color. This will give a spatial view of the effects of sampling over the province or test site. A total of six different sampling densities will be studied for one of the test sites at one study time.

6 - Workshops

The ERS study team in East Lansing has requested at least one workshop to take place at Intralab. This workshop which will run for two to four days, is scheduled for July, just prior to delivery of the LCDMS software and Landsat data bases to the study team.

The workshop will be designed as a "walk-through" of the various techniques of using the LCDMS, and a review of the other project tasks. While the workshop will be designed for the ERS study team staff and Dominican Republic personnel, special half-day summary sessions can be planned for additional participants.

7 - Project Review Meetings

Periodic review meetings have been listed on the Schedule of Milestones. It is assumed that such project reviews take place at least once a month, either in the Washington, D.C. area or at East Lansing.

8 - Establish Advisory Team

The ERS study team is vitally interested in the most cost-effective ways to employ contemporary technologies for evaluating national agricultural planning alternatives. This project will provide an initial test of the utility of Landsat system as a component part of CRIES. Yet Landsat's performance must ultimately be tested and evaluated in an operational environment, effectively used by agencies not now accustomed to using such technologies.

It is important, then, that thorough review take place to establish the long term prospects for disseminating the Landsat system in Lesser Developing Countries. To this end, it seems appropriate that an advisory group, comprised initially of members from the participating agencies of APPS, be formed to evaluate the operational systems options for routinely using Landsat in support of developing country planning programs.

When and where appropriate, membership could be expanded to include other public and private sector agencies who may have a unique role to perform in the operational era of APPS.

V. PROJECT RESOURCE REQUIREMENTS

Summarized below are the resources needed to perform the project. Intralab can provide the personnel, computer time, and contractor support as listed. Additional funding is needed to prepare the Land Cover Data Management System (Task 3) and provide for the proposed travel budget.

Civil Servants		
Code 920 (Intralab)		
Project Leader	.25 man yr	
Data Processing Coordinator	.50 man yr	
Code 930		
System Development Coordinator	.40 man yr	
Systems Support	.20 man yr	
Computer Time		NASA (Intralab
AOIPS (LCDMS Development)	160 hrs	
ORSER (Landsat Analysis)	6 hrs	
Contractor Support		
Landsat Analysis	12 K	
Land Cover Management System	30 K	30 K
Travel		
Michigan State University	1.00 K	1.00 K
Dominican Republic	2.50 K	2.50 K
2 persons/2 trips/1 week per trip		
Proposed transfer of funds from U.S. AID to NASA	→	33.50 K

APPENDIX A

DESCRIPTION OF SOFTWARE TO BE DEVELOPED FOR THE LAND COVER DATA MANAGEMENT SYSTEM

Data Base Structure

The LCDMS data base structure will conform to the CRIES data base. Data will be retained for one kilometer cells in the Universal Transverse Mercator map projection. Data bases will reside on an AOIPS 88-megabyte disk storage unit. Separate data base files will be created for each test site and study time. For each 1-kilometer cell in each data base file a separate record will be maintained. These 1-kilometer cell records can be visualized as being arranged in array order, that is, in rows and columns so that each cell can be assigned a row and column index. The row and column index together with the known UTM location of the cell in row 1, column 1 completely defines the location of each cell. Each cell record within a test site will contain the following information as a minimum:

Row index from 1 to N (N less than or equal to 100)
Column index from 1 to M (M less than or equal to 100)
Province code
Category code for primary land cover class in this cell
Percent area for primary class
Category code for secondary land cover class in this cell
Percent area for secondary class
Category code for tertiary land cover class in this cell
Percent area for tertiary class.

Data Base Structure (Modules to be developed and installed)

(1) Routine to make geometric transformations between UTM and Landsat projections.

(2) Adapt existing routines (CT5UMF, CT5UMI, CT5ZTZ) to make transformations between geodetic and UTM projections to AOIPS hardware.

(3) Modify existing routine (ERTS200) from 1-nautical mile WMO structure to 1-km UTM projection.

Input

The primary input data for LCDMS will be classified Landsat images. Two systems will be used to classify the data for the Dominican Republic test sites. The ORSER system at Penn State will be operated from Goddard to perform maximum likelihood classification. Classification results will be written onto magnetic tape at Penn State and sent to GSFC. Software will be implemented to allow LCDMS to read tapes in ORSER format and integrate this data into the data base. The second system to be used for classification is the Image/100 parallelopiped classifier at GSFC. Results derived from this system are in the form of theme planes in a video refresh memory. Each theme represents a different ground cover class. A "fast video I/O" program is used to write the theme data to magnetic tape. Software modules will be developed and added to LCDMS for reading fast video I/o theme tapes and integrating the data into the data base.

The AOIPS computer facility at GSFC includes a Hazeltine Image Analysis Console. A vidicon scanner is a part of the Hazeltine console. This hardware makes it possible to digitize images, maps or line graphic material. The field of view can be adjusted from 2 x 2 inches to 30 x 30 inches. The digital representation formed is a 512 x 512 array of eight bit pixels.

At least five levels of gray can be distinguished by the vidicon and these intensities are translated into distinct numbers in the 0 - 255 range. The digital image is transferrable to disk storage where it is accessible to AOIPS programs and can be processed like any other digital image. It would be desirable to compare this automated method of digitization with the manual approach currently being used at MSU. This will be done by digitizing the provincial boundary of Dajabon and adding a province indicator to each cell in the data base. All data base cells within the province of Dajabon will be marked with a two character code. A comparison of the manual approach (MSU) with the Hazeltine approach will be made using the CRIES system where both digital province maps will be available. To facilitate use of Hazeltine digital images with LCDMS, provisions will be made for the province designator in the data base and appropriate software generated to register the province boundary image with the UTM data base projection and enter the province code in the data base.

Input (Modules to be developed and installed)

(1) Read routine for ORSER format classification tapes.

(2) Read routine for AOIPS (Image/100) Fast Video I/O classification theme tapes.

(3) Data aggregating routines

(A) Locate classification pixels corresponding to each data base 1-km cell.

(B) Aggregate these pixels to determine the three major ground cover classes and their percent area within the 1-km cell.

(C) Store aggregated data into data base record for given cell.

(4) Hazeltine support routines

(A) Read Hazeltine digital images off AOIPS disk.

(B) Convert province line boundary to raster format i.e. 'paint' in the interior pixels.

(C) Transform Hazeltine image to data base projection.

(D) Store province code for each cell within (50% or more inside) the province.

Modifications to existing Water Resources Data Management System (WRDMS) modules

(1) Operator control options to allow selection of any of above modules and specify any parameters required by the modules (tape unit, province code, etc.)

Output

1. CRIES Compatible Tape

The LCDMS data base will be reformatted onto magnetic tape for input to the CRIES system. A format for this tape has been established. The tape will be 9 track, 1600 characters per inch with ASCII (American Standard Code for Information Interchange) character code for all data. The tape will contain two files, one for each test site. The records within a field will be in a linear array arrangement, that is they will be ordered, (1,1),(1,2),...,(1,N),(2,1),(2,2),...,(2,N),...,(M,1),(M,2),...,(M where the first index is the row and the second is the column. The column index increases as the cell location moves to the east and the row index increases as the cell location moves to the south. The record structure is specified by the following table:

Bytes	Contents
1 - 3	Row index (from 1 to M)
4 - 6	Column index (from 1 to N)
8 - 9	Province code (blank if not Dajabon, non-blank for Dajabor
11-12	Code for primary category in this cell at study time 1
13-15	Percent area within cell for primary category.
17-18	Code for secondary category in this cell at study time 1
19-21	Percent area within cell for secondary category.
23-24	Code for tertiary category in this cell at study time 1
25-27	Percent area within cell for tertiary category.
29-30	Code for primary category in this cell at study time 2.
31-33	Percent area within cell for primary category

CRIES Compatible Tape Record Format (Continued)

Bytes	Contents
35-36	Code for secondary category in this cell at study time 2
37-39	Percent area within cell for secondary category.
41-42	Code for tertiary category in this cell at study time 2.
43-45	Percent area within cell for tertiary category.
46-80	Blanks

Unique codes will be assigned by NASA to each ground cover class and these codes will be used on the CRIES tape. A table of the codes with their definitions will be supplied by NASA. Records will be unblocked, 80 bytes per record.

2. Dicomed Output

Subroutines will be developed and implemented in LCDMS to utilize the Dicomed film recorder for photographic recording of images off the Image/100 color CRT. Supporting subroutines will be implemented which create single theme and multiple theme images from Landsat classification data contained in the LCDMS data base. Single theme images will depict the percent ground cover of a given class within each cell The user will be allowed to define a color assignment table which relates color to land cover percentage. For example, each ten percent interval from 0% to 100% can be assigned a different color. When the single theme image is formed and transferred to a

Dicomed film product, the percent ground cover for the given class (theme) will be easily recognized for each 1-km cell in the study area: Multiple theme images will depict the primary ground cover class for each cell. The user will again define a color assignment table with different colors for each ground cover class. In this mode, when the multiple theme image is formed and transferred to a Dicomed film product, the dominant ground cover class for each cell in the study area will be easily identified. Multiple theme Dicomed products will also be obtainable for secondary and tertiary ground cover classes in the same fashion. For cells with no data value to represent in the film product the user can select black and white as a default color. Since the Dicomed film recorder works at a finer resolution than that required for a typical study area, a scaling option will be implemented to enlarge the image digitally prior to recording onto film. The scale factor will be specified by the user to produce the nearest to full format image output. Results of the Landsat sampling study will be recorded on film using the Dicomed capability just described.

Output (Modules to be developed and installed)

(1) Routine to extract data base records for a 1-km cell at each study time, reformat the data and write it to a 9 track CRIES compatible tape.

(2) Routine to allow users to define color assignments for single theme Dicomed output.

(3) Routine to allow users to define color assignments for multiple theme Dicomed output.

(4) Write routine to create magnetic tape with Dicomed image from data in AOIPS main memory, data base or CRT refresh memory.

Sampling Study (Modules to be developed and installed)

(1) Routine to allow user to specify horizontal and vertical sampling rates.

(2) Modify existing routine (AGGR) to use specified sampling rates when aggregating Landsat classification data to 1-km cells.

(3) Cell by Cell comparison routine to determine effects of sampling by comparing data base derived using sampling with data base derived using all data in test site. Comparison results will form an image on CRT (or Dicomed) to show spatial arrangement of results.

(4) Tally routine to collect data at cell level and total it at the province or test site level. Can be used with sampled or unsampled data bases.

REFERENCES

(1) AOIPS Water Resources Data Management System, Earth Satellite Corp. Final Report, on contract NAS5-22894, September, 1976.

(2) Configuration Description and Load Analysis for the Atmospheric and Oceanographic Information Processing System (AOIPS), John T. Dalton, GSFC X-document number X-933-75-217, July, 1975.