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AGENCY FOR INTERNATIONAL DEVELOPMENT

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A. FUNDING SOURCE	FIRST FY B. FX	FIRST FY C. L/C	FIRST FY D. TOTAL	LIFE OF PROJECT E. FX	LIFE OF PROJECT F. L/C	LIFE OF PROJECT G. TOTAL
AID APPROPRIATED TOTAL						
(GRANT)	1,400		1,400	1,400		1,400
(LOAN)						
OTHER U.S. 1.						
OTHER U.S. 2.						
HOST COUNTRY		270	270		270	270
OTHER DONOR(S)						
TOTALS	1,400	270	1,670	1,400	270	1,670

11. PROPOSED BUDGET APPROPRIATED FUNDS ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C. GRANT	PRIMARY TECH. CODE D. LOAN	E. 1ST FY 79 F. GRANT	E. 1ST FY 79 G. LOAN	H. 2ND FY ___ I. GRANT	H. 2ND FY ___ J. LOAN	K. 3RD FY ___ L. GRANT	K. 3RD FY ___ M. LOAN
(1) FN				1,400					
(2)									
(3)									
(4)									
TOTALS									

A. APPROPRIATION	N. 4TH FY ___ O. GRANT	N. 4TH FY ___ P. LOAN	Q. 5TH FY ___ R. GRANT	Q. 5TH FY ___ S. LOAN	LIFE OF PROJECT T. GRANT	LIFE OF PROJECT U. LOAN
(1) FN					1,400	
(2)						
(3)						
(4)						
TOTALS						

12. IN-DEPTH EVALUATION SCHEDULED: MM 12 YY 79

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SIGNATURE: William M. Reddy

TITLE: Acting Director, Office of Science and Technology

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PROJECT PAPER

Remote Sensing for Agriculture

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I. Project Summary and Recommendations

A. Summary

The Remote Sensing for Agriculture project intends to carry on a crop production estimation program started under Remote Sensing for Resource Assessment project, 931-1166. The crop estimation program consists of four phases, which are described in this project paper under II.B. Project Strategy. The first phase, area frame sampling, is presently under way in ten countries under the Remote Sensing for Resource Assessment project by means of a PASA with the U.S. Department of Agriculture (USDA) for $796,500. Most of the ten countries will have completed this phase under the PASA. This Remote Sensing for Agriculture project is to carry out phases 2 through 4 and, if necessary, to complete phase 1 in those countries just beginning to initiate crop statistical procedures. It is also stressed that only complete mastery of the techniques of phase 1 and the construction of an area frame in the major crop producing areas are necessary before proceeding to phases 2-4. In other words, for countries already technically equipped, phases 2-4 can be carried out in parallel to finishing up phase 1.

Nine countries (Costa Rica, Dominican Republic, Jamaica, Bolivia, Ecuador, Morocco, Thailand, Philippines and Indonesia) have been selected to participate in a four phase Remote Sensing for Agriculture project. The capability for each country to carry out the four phases of the project is assessed and based on this data the capability of LDCs in general to carry out the four phases of the project is given.

All nine countries have high interest and motivation and acceptable-to-good capability of carrying out Phases 1 (Area Frame Construction)

and 2 (Field Enumeration and National Agricultural Statistics Totals) of the project. With adequate AID support the nine countries should be able to either upgrade or initiate and complete an area frame and gather at least one and possibly two years' national agricultural statistics totals during the life of the Remote Sensing for Agriculture (RSA) project.

For Phases 3 and 4 (computer classification phase and agricultural meteorological modeling phase) no one of the countries is presently in a position to introduce the computer classification phase without substantial technical assistance, continuous cooperative counterpart training and management and probably substantial hardware acquisitions. If AID wishes to accelerate the adoption of the computer classification approach in conjunction with quality ground enumeration based on a good statistical design, it will need to make a substantial research and development investment in several of the countries. AID may thereby develop a quasi-transportable approach that may, with modifications, be introduced to other countries. Even though each country will in essence be a case in itself, several well planned and carefully developed programs will be necessary to start the process.

For most of the countries agricultural-meteorological modeling appears out of the question at this time. However, for four countries --Morocco, Jamaica, Thailand, and the Dominican Republic--there is high interest in this phase along with some capability in the country.

Before a commitment to Phases 3 or 4 in any of the countries can be made, feasibility analyses are required both in the country and in the U.S. to define the exact form the computer classification phase should take, and the details of agricultural-meteorological modeling.

It is clear that in the introduction of these technologies to the developing world, a long-term view must be taken. Effective introduction of Phases 3 and 4 demands that Phases 1 and 2 be introduced, including an objective yield survey technique. In most instances at least several years experience with area frame technology and enumeration procedures should be available before moving into later phases. The wisest investment of AID funds without over-promising, and without over-commitment to a substantial research and development program, requires the major emphasis and investment go into introducing Phases 1 and 2 in as may of the countries as is reasonable and feasible. Nevertheless, there are merits in deliberately fostering several research and development programs for Phase 3 and Phase 4 in a carefully selected sample of these countries. The purposes of this R&D program would be to assess for the countries concerned the relative advantages of investment in computer classification and agricultural-meteorological modeling in comparison with alternative investments in improving acreage estimates in the field enumeration phase and through providing a larger sample for objective yield measurements.

Finally, in order to transfer what appears to be an important application of remote sensing for crop monitoring to the greatest number of LDC countries, including those proposed directly for this project as well as all the remainder, this project will include four additional components:

1. Support for international symposia which have, as a basic theme, the use of remote sensing technology for the monitoring and assessment of crop status for the purpose of crop production estimation. These symposia would include the 16th International Symposium on Remote Sensing of Environment if held in an LDC.

2. Training of LDC remote sensing technicians in the U.S. for countries not included in the ten countries described in this Project Paper. This training would be provided on a case by case basis, with selection being made on the interests of the candidates for training in agricultural applications where the host government can show that his (her) training and knowledge can influence his (her) country's methodology of acquiring crop statistics.

3. Construction and sending of exhibits to international conventions, symposia, and workshops. DS/ST and USDA have already been requested by the FAO and the U.N. to present area frame sampling methodology with display booths to agricultural planners in Africa and Asia. There will be a continuing need during the life of this project to present crop measurement techniques by means of display boards to high level officials.

4. In order to transfer the methodology of this project to all LDCs, DS/ST will attempt in each of the nine countries identified in this paper to conduct a workshop near the end of Phase 4, with invitations to neighboring countries so that they can learn about the methodology and to FAO representatives to convince them the methodology is an assistance tool appropriate for LDCs. Attempts will be made to fit the project within the data collection requirements of USAID missions in their ongoing agricultural development projects (this fit has already been identified by the missions in Jamaica, Dominican Republic, Costa Rica, and, to a more limited extent, Morocco).

B. Recommendations

The principal recommendation for this project is for the further expansion of Remote Sensing for Agriculture support to new countries by:

-- Commitment of initiation or upgrading, and completion, of Phases 1 and 2 (area frame construction and field enumeration) including objective yield surveys for:

Costa Rica
Dominican Republic
Jamaica
Bolivia
Ecuador
Morocco
Thailand
Indonesia
Philippines

Implementation recommended for each country.

Each commitment should begin promptly after PP approval.

Detailed pre-feasibility studies on introduction of Phase 3 for:

Costa Rica or Dominican Republic	Select one only for feasibility study
Ecuador or Bolivia	Select one only for feasibility study
Morocco	Feasibility study
Thailand	Feasibility study

Pre-feasibility analysis to be completed before Dec. 1, 1979.

Commitment to appropriate Phase 3 before March 1980.

Work on Phase 3 (training, research software development, provision of hardware, if needed) to proceed in parallel with Phases 1 & 2.

-- Detailed pre-feasibility study for introduction of Phase 4 with anticipation that a limited Phase 4 experiment and development project would be introduced for each of the following countries:

Morocco	(confined to small grains)
Dominican Republic and/or Jamaica	(confined to sugar cane)
Thailand	(selected crops)

Pre-feasibility analysis to be completed before Dec. 1, 1979.

Commitment to appropriate Phase 4 before March 1980.

Work on Phase 4 (training, research software development, provision of hardware, if needed) to proceed <u>in parallel</u> with Phases 1 & 2.

If feasibility studies reveal that it is not appropriate to conduct Phases (3) and (4) in a country, then the additional funding freed by not conducting these phases should be used to initiate the area frame sample development (Phase 1) and field enumeration (Phase 2) in one of several countries which have requested this project, but the request for which AID/W DS/ST cannot honor due to funding limitations. Those countries requesting this project, and not included in this PP, are: Tanzania, Tunisia, Bangladesh, Nepal, India, Kenya and Sudan.

The reader is referred to Annex 1 for the Individual Country Profiles.

II. Project Background and Strategy

A. Project Background

Civil remote sensing applications were born from the requirements of measuring, monitoring, and assessing crops. Of all the applications of remote sensing technology, none challenge its sensors more, none offer the greatest potential to stave imminent starvation, and none demand the degree of continuous surveillance, as agriculture. Crops are dynamic, their growth and states change weekly, far too frequently to measure by a single-stage approach such as aircraft or field teams. Food availability and prices fluctuate as crop status changes, during the growing season, prior to harvest. The knowledge of crop status is the product of this project.

Crop information is the backbone of U.S. food policy. Information, not only of U.S. crops, but even more importantly, of Canada, Europe, the Soviet Union, India, China, Australia, Brazil, and Argentina, determine the price we pay for all food items--from a loaf of bread to a head of lettuce. Although not well known, it affects our entire PL 480 program to LDCs.

In addition to the impact which U.S. and other industrialized nations' crops have on LDCs, however, the crop status of the LDCs themselves affect their decisions regarding the food resources for their people. Although it

will remain beyond the means of many LDCs to produce sufficient food for themselves in the foreseeable future, it is very likely that improved information regarding their crops, prior to harvest, will not only lead to timely decisions regarding import of food commodities, but also result in more of their own land being put into crop production.

Almost every nation, LDC and industrialized, makes some attempt to survey existing crop status for the purpose of predicting production prior to harvest. In order to predict crop production with accuracies from 80-100 percent, which are necessary to hold commodity/price fluctuations down, collected agricultural data must be objective, reliable, timely, adequate in terms of coverage, efficiently acquired, and effective in terms of impact on decision-making. According to Kibler, Annex 4 - The LACIE Symposium, fewer than ten countries of the world (including LDCs and industrialized) have sophisticated agricultural collection systems which contain data possessing one or more of these characteristics. And even more shocking, half of the countries of the world have either very simple systems, or none at all, and wait ten years or more for a full agricultural census conducted on the ground. Even the U.S. Bureau of the Census, which is conducting full censuses in cooperation with small Latin American nations, requires three years to acquire the data and three additional years to compile and publish the information. Six years obviously do not represent a time

scale conducive to sound agricultural planning. According to Kibler, the four reasons for the failure of acquiring agricultural data possessing the characteristics described above are: (1) lack of funds for collecting and tabulating data, (2) inadequate technical capability to formulate sound sampling and data collection procedures, (3) absence of a suitable sampling frame, and (4) difficulty in quantifying the benefits of improved information.

Reason (3) is presently being addressed in twelve countries by an AID/U.S. Department of Agriculture PASA (see Annex 6) funded under the project Remote Sensing for Resource Assessment. Reasons (1) and (2) will be addressed when this project gets under way, and this Project Paper treats reason (4).

The U.S. Department of Agriculture has been refining its techniques in collecting crop statistics for the last one hundred years. It realizes that a full agricultural census was simply too slow in getting timely crop information into the public decision-making arena. Thus they resorted to sampling, hoping that fields selected on the basis of existing maps and "windshield" surveys (from cars and trucks) would be fairly typical of all fields in the country, state, and eventually the entire country. During the early part of this century, land uses began to change rapidly, as cities grew and new dry land farming opened up in the Midwest (setting the stage for the Great Dustbowl, incidentally). Maps

rapidly became obsolete, and ground survey teams couldn't see enough of the overall distribution of fields to select truly representative samples. The alternative was to choose a larger number of poorer, unrepresentative samples, in order to maintain the same accuracy when aggregated to country totals. As the sample size increased, however, there was insufficient time and funds to survey the fields on the ground.

Thus, in the 1930's, the aircraft became a USDA tool for crop sampling procedures. Aerial photography not only permitted rapid acquisition of information of two agricultural parameters; i.e., field size and yield, but also resulted in up to date maps for use in selecting the appropriate sample fields. Aerial photos became the primary data source in all 48 conterminous states, and are now used for the U.S. June Enumerative Survey (JES), when the agricultural data are collected.

Yet, even with USDA capital resources, aerial photo mapping became too expensive to permit flying the U.S., even on a selected basis. As a result, maps derived from airphotos became older and more useless as the years went by. Thus, when Landsat-1 was launched in 1972, the USDA naturally turned to this source of current image data to derive their maps. Experimentally, Landsat Multi-Spectral Scanner (MSS) imagery, with older aerial photography, was used to select sample fields for the JES in Illinois and California. Accuracies were so high (over 95 percent when compared to

later production reports), and the job done so much more rapidly than the older conventional method, that the USDA is now using Landsat in developing frames in all 48 states.

In 1974, NASA, USDA, and the National Oceanic and Atmospheric Agency (NOAA) teamed up to initiate the Large Area Crop Inventory Experiment (LACIE), a Landsat-based operation to survey wheat among the world's largest producers. High on technology, and attempting to minimize both the image analyst and the ground enumerator (obviously, since two of the major wheat producing countries, Russia and China, were relatively inaccesible to the U.S., LACIE was never considered by AID to even represent a model for crop data acquisition in the developing world. The LACIE program is well known by the project manager, who, with the Thailand Director of Agriculture Economics, Kluen Chaisong, attended the final LACIE Symposium at the NASA Johnson Space Center in October 1978. Although the conclusion that LACIE was not an appropriate technology for LDCs was verified by both visitors, a valuable idea for combining certain technical components of LACIE to the labor intensive area frame sampling was born. In addition, Jimmie Murphy, Director of the USDA Application Test System (ATS), colocated at the Johnson Space Center, offered his special processing systems for AID's use whenever we had an emergency situation which might affect crops in LDCs with U.S. bilateral assistance programs. ATS has a unique communications link into the NASA Goddard Space

Flight Center, with which they can tap Landsat sub-scenes immediately upon reception from the satellite.

In order to better review the status of agricultural data acquisition in the U.S., ranging from intermediate technologies such as area frame sampling to advanced technologies characterized by LACIE, DS/ST in 1977 contracted with the IQC American Technical Assistance Corporation (ATAC), to survey existing crop reporting systems and describe their applicabilities to developing countries. The final report, Preliminary Design Requirements for a Research Project in Tropical Agricultural Inventory and Appraisal, confirmed ongoing discussions between AID and USDA that the area frame sampling technique was the most appropriate technology for transfer to LDCs. Although we disagreed with several of the report's conclusions and recommendations, it seemed logical that the report's major recommendation; i.e., that the bulk of the technical assistance be furnished by the USDA Economic Statistics and Cooperative Service (ESCS), should be followed.

B. Project Strategy

While USDA and AID were digesting the conclusions and recommendations of the ATAC report and developing a project strategy during the early part of 1978, Secretary Bergland

of Agriculture and Administrator Frosch of NASA were meeting monthly over lunch to discuss future possible remote sensing agricultural activities. Since LACIE was winding down and other USG agencies were applying remote sensing technology to agriculture and forestry, OMB was becoming concerned that agency programs might be duplicative. Secretary Bergland took the initiative by establishing an interagency task committee to develop an integrated and comprehensive agricultural monitoring program. Because the AID planning activities under way at this time were so widely known in the USDA, Governor Gilligan was invited to the first meeting on February 3, 1978, in Secretary Bergland's office. The AA/DS, Mr. Sander Levin, and Dr. Paul attended. A working committee was established and a plan prepared, which Governor Gilligan reviewed during an August 8 meeting in Secretary Bergland's office. With the Administrator's concurrence, this AID proposed project "Remote Sensing for Agriculture" was folded into the integrated program and presented to OMB by Dr. Paul on October 11, 1978. The Administrator's concurrence was given in a letter signed by Secretary Bergland, Administrator Frosch, Secretary Kreps (Commerce), Secretary Andrus (Interior), and Governor Gilligan to OMB Director McIntyre dated Sept. 27, 1978. The Interagency Agreement was then signed by all parties (after AID/GC review) on Sept. 29, 1978 (see Annex 2). The Executive Summary establishing the joint remote sensing for agriculture program is seen as Annex 3. The project

described in this PP is AID's contribution to this effort; it has had one favorable OMB review, independent of the rest of AID's budget, and it has legal and administrative concurrences by top Agency officials (see Annexes 2 and 3).

This strategy of folding the proposed "Remote Sensing for Agriculture" project into an interagency program has paid off handsomely. For in addition to obtaining high level AID acceptance of it, the USDA and NASA administrators, who have been vigorously pushing the technology and are thus pleased to demonstrate an international beneficiary, have bent over backwards to accommodate AID's requests for foreign imagery and special processing of it. NASA and USDA support for this project is now guaranteed in writing, and AID's requirements and efforts can no longer be viewed as ad hoc and outside of the main stream of aerospace events in the U.S.

The AID project itself has a four-phased strategy; (1) to complete the area frame sampling activity, demonstrations for which are now being carried out under the "Remote Sensing for Resource Assessment" project, (2) national estimates, (3) automatic, computerized classification of selected crop fields, and (4) crop yield modeling.

Because of the urgency to get area frames built in twelve developing countries, DS/ST decided to start this contribution by means of the "Remote Sensing for Resource Assessment" project, 931-1166. A $796,500 PASA (see Annex 6) was written with the USDA ESCS on August 15, 1978,

which initiated demonstration frames in these countries and which is presently being carried out. In addition, with DS/PO concurrence, an advisory team of U.S. professors expert in the application of remote sensing to agriculture has been formed. This team assisted in the technical design of this project by visiting all countries collecting information and evaluating country capacity, commitment, and motivation to cooperate in carrying out the four phases described below.

(1) Area frame sampling is a labor-intensive technique to statistically select the smallest sample of fields (the area frame) possible to obtain representative crop information for national export-import planning. The collection of data takes place on the ground at the sample fields. The sample fields are chosen by Landsat and air photos analysis, using skilled photo-interpreters. Landsat cannot see the individual small fields less than 10 acres so typical in developing countries. But it does see agricultural intensity patterns of an entire country in just a few days. By breaking out, or "stratifying," four of five of these intensities (land use themes) for an entire country, it is possible to select a sample number of fields (several hundred) which, if surveyed on the ground, can provide an accurate representation of national averages of yield, crop acreage, livestock, etc. The USDA regularly does this in the U.S., where accuracies

in state totals for crop harvest estimates range from 90-95 percent. Aircraft photography is expensive and, in some developing countries, impossible to obtain due to military restrictions. Landsat is available every 9 days (clouds permitting), hence the area frame can be updated when desired. At the present time the FAO is building frames using Landsat in Bangladesh and Tanzania. Besides the U.S., the USDA is building frames in Jamaica, Dominican Republic, and other developing countries under USAID funding in the Remote Sensing for Resource Assessment Project. Under this proposed Agriculture project, the frames will be completed and verified to assure a strong base for the following phases.

(2) National Estimates: The power of Landsat becomes more apparent in this second phase. Aerial photography, even if one had it for an entire country, would have to have been taken over many days, with different atmospheric conditions, different sun and shadow angles, and other diurnal variations which result in inconsistent contrast, patterns, and tonal variations on the air photos. Not so with Landsat. It images everywhere on earth at the same time of day, 9:30 a.m. With a technique called ratioing, it is possible to get rid of the subtle atmospheric effects from the imagery if necessary. Thus image manifestations in a country correspond to similar features elsewhere. It is this feature consistency which permits one to multiply the sample statistics gathered on the ground by a ratio to obtain national estimates.

The ratio is the intensity theme in the entire country to the intensity theme present in the samples. The intensity themes are quantified as hectares. This expansion to areas larger than the original samples is surprisingly quite accurate. The accuracy of the totals depends directly on the accuracy of the sample statistics and not on the magnitude of the ratio. The independence of the accuracy of the totals to the size of the expansion is due to the consistency of themes as depicted on Landsat imagery and as analyzed by trained interpreters.

(3) Computerized classification would be the next logical step. From the area frame developed under (1), the Project would have, among other things: (a) reliable average yield values for several important crops (bushels per acre), and (b) known crops growing in sample fields which, if some are large enough, can be identified on the Landsat imagery. With this data, the Project can now use the known crops to literally "train" a computer to automatically classify all sufficiently large fields outside the sample area. Then by multiplying the total hectares of each crop by the yield, total production estimates of each crop are obtained. The frame is time-consuming to construct (one to two man-years), but the automatic classification of crop hectares permits one to update the predicted totals several times during the crop growing season to take account of climatic and catastrophi events.

It will be necessary to look at field size distributions in each LDC to determine if this step makes sense. If only ten percent of the fields are larger than ten acres, but this ten percent is growing eighty percent of the crops in question, then computer techniques are obviously appropriate. If this ten percent is growing only ten percent of the crops, but the other ninety percent are all small one-quarter of an acre plots and yet consists of mile after mile of contiguous plots of the same crop (rice, for example), then again computer classification may be applicable. This classification could be done by appropriate modification or an addition to some of the computer algorithms existing in the U.S. and a limited number of developing countries.

(4) The agricultural-meteorological (agromet) models represent the final link in a viable crop prediction program. They are also the most sophisticated and expensive to use. They are computer-based, and essentially simulate the growing of a crop by inputting crop moisture, sunlight radiation, and other parameters affecting the vigor of the crop. Data collected from the field as well as remote sensing data from Landsat, weather, and other satellites are required. The important crop yield of the formula is thus determined, driving total crop production estimates up above 95 percent accuracy.

The PID (Annex 5) for this project was approved by the AA/DS signature on the Project Document Action Form on August 16, 1978.

III. Project Analysis

A. Technical Feasibility

1. Introduction: This section discusses the capability of nine countries (Costa Rica, Dominican Republic, and Jamaica in Central America; Bolivia and Ecuador in South America; Morocco in North Africa; and Thailand, Philippines, and Indonesia in Southeast Asia). The capability for each country to carry out the four phases of the project is assessed and based on this data the capabilities of LDCs in general to carry out the four phases of the project are given. The assessment is based on a four-day visit to each country.

2. Overall Summary: All nine countries had high interest and motivation and acceptable to good capability of carrying out Phases 1 and 2 of the project. With adequate AID support the nine remaining countries should be able to complete an area frame and gather at least one and possibly two years' national agricultural statistics totals during the life of the project. In the individual country accounts, each situation is spelled out in more detail.

For Phases 3 and 4 (computer classification phase and agricultural meteorological modeling phase) no one of the countries is presently in a position to introduce the computer classification phase without substantial technical assistance, training and continuous cooperative counterpart training and management. If AID wishes to accelerate the adoption of the computer classification approach in conjunction with quality ground enumeration based on

a good statistical design, it will need to make a substantial research and development investment in several of the countries. AID may thereby develop a quasi-transportable approach that may, with modifications, be introduced to other countries. Even though each country will in essence be a case in itself, several well planned and carefully developed programs will be necessary to start the process.

For most of the countries agricultural-meteorological modeling appears out of the question at this time. However, for four countries--Morocco, Jamaica, Thailand, and the Dominican Republic--there is high interest in this phase along with some capability in the country. Before a commitment to phases 3 or 4 in any of the countries can be made, pre-feasibility analyses are required both in the country and in the U.S. to define the exact form the computer classification phase should take, and the details of agricultural-meteorological modeling.

It is clear that in the introduction of these technologies to the developing world, a long-term view must be taken. Effective introduction of phases 3 and 4 demands that phases 1 and 2 be introduced, including an objective yield survey technique. In most instances at least several years experience with area frame technology and enumeration procedures should be available before moving into later phases. The wisest investment of AID funds without over-promising, and without over-commitment to a substantial research and development program, requires the major emphasis and

investment go into introducing phases 1 and 2 in as many of the countries as is reasonable and feasible. Nevertheless, there are merits in deliberately fostering several research and development programs for phase 3 and phase 4 in a carefully selected sample of these countries. The purposes of this R&D program would be to assess for the countries concerned the relative advantages of investment in computer classification and agricultural-meteorological modeling in comparison with alternative investments in improving acreage estimates in the field enumeration phase and through providing a larger sample for objective yield measurements.

If feasibility studies show that Phases (3) and (4) should not be implemented in a country, then one of several LDC's requesting this project (which could not be accommodated due to funding limitations) should be brought into the project. These countries are Nepal, India, Bangladesh, Tanzania, Tunisia, Kenya and Sudan. We need as large a number of countries as possible to work with the FAO in eventually establishing a crop information system benefiting all LDC's. Only Phase 1 would be implemented under this expansion to additional countries.

B. Economic Feasibility

This project paper requests $1.4 million to assist selected LDC's to develop a crop reporting capability. Since image classification and yield modeling by computer techniques are two objectives of this project, care must be taken to avoid procurement of expensive equipment, but instead to make use of existing institutions in each region where the project is carried out. This project is not intended to equip one or more country institutions to analyze satellite multi-spectral imagery and model crop yield. Rather it purports to provide assistance, in the form of training, limited demonstration, and software, using remote sensing analysis equipment and computers existing either in the country or in a nearby regional institution.

Based on the results of the ongoing area frame sampling under Remote Sensing for Resource Assessment, nine countries will be assisted in this project to use the sample statistics which they have acquired to project national crop estimates. For the final two phases, namely automatic field classification and yield modeling, roughly three to four countries will be selected from the eleven. The criteria for their selection will be: (1) technical progress in building frame, (2) expected length of time required for country, with USDA assistance, to complete field enumeration for entire country, (3) government and AID mission priority assigned to crop information, (4) ministry of agriculture apparent interest

and motivation to proceed to the more advanced phases of this project, (5) AID's perception of how open host country is likely to be in disseminating the information or, alternatively, if the information is classified, how the host country intends to use this information, (6) existing remote sensing analysis equipment and computers, as well as trained personnel, to carry out the more advanced phases of image interpretation and yield modeling.

Assuming that four countries are selected for the final advanced phases, nine countries for field surveys of selected areas, and in order to test out computer analysis for crop acreage and agriculture-meteorological (agro-met) modeling for yield, the question is whether the requested $1.4 million is sufficient to provide a capability to update estimates for selected main crops three to four times during the crop growing season. $380,000 is designated for phase 2, field surveys (see Section D.). Since the countries will be selected according to the six criteria of the previous paragraph, we can assume that all four countries have similar capabilities, potential, and technical requirements. Thus, we can allot roughly $1,000,000 for phases 3 and 4, or $250,000 to each. Equipment costs are minimal, since the project intends to take advantage of existing computers. It is envisioned that a desk calculator ($5,000-$10,000) and/or an interactive computer terminal ($15,000-$20,000) may be necessary to purchase. It may be necessary to purchase one additional special image analysis machine if the country is underequipped. This at most would be in the order of $20,000 to $30,000. Thus $40,000 would represent an average estimate of equipment needs for each country, leaving $200,000 for USDA/contractor technical assistance, computer

software programs, training, and image data. This is two to three times the investment for the area sample frame funded under the Resource Assessment Project. Although these more sophisticated stages require longer TDY times by USDA remote sensing professionals who would generally have higher salaries than the area frame enumerators, it is felt that this level of funding is adequate to transfer an automatic crop estimating system to a developing country. Section D, Financial Analysis, provides a detailed budget of the components of this project.

It should also be stressed that almost all countries of the world, including the poorest LDCs, are struggling to develop a crop reporting system. Thus, as we have found in the ten countries which we are assisting in the area frame sampling, LDCs generally have a large cadre of statisticians, photo interpreters, field enumerators, and a fairly adequate budget to provide their share of this cooperative effort. As agricultural ministries are funded relatively generously in LDCs, it appears that this project is assured adequate participatory funding levels from the host governments. The $270,000 LDC contribution represents an estimate of $30,000 in each LDC of participatory support. This funding includes salaries of agricultural statisticians, the use of their mapping facilities, computer time, office space, four-wheel drive vehicles for field surveys, and others. For a specific, illustrative example, Annex 7, page 9, describes the in-kind services provided by Thailand, and the last page shows the budget breakdown of these services. With the USG contributions discussed above, the project is considered to be economically feasible to carry out.

For each country in which we decide not to proceed with advanced Phases 3 and 4 (decision to be made at end of CY 1979), $50,000 is made available to introduce Phase (1) area frame sampling to one of a waiting list of seven countries not participating in this project. Our priority choices on this list are Tunisia, Tanzania and Bangladesh, since there is already under way in these three countries an area frame sampling activity, funded either by the country itself (Tunisia) or the FAO (Tanzania and Bangladesh). These existing funding sources are sufficiently limited that Tunisia (Mission and Government) and the FAO have requested our help. Our $50,000 contribution, about half of that we put into Phase (1) in our nine existing countries, should be sufficient to build an area frame for that country.

C. Administrative Feasibility

An earlier phase to the RSA project involves day-to-day management of Phases 1 and 2 by USDA with general interaction/supervision by C.K. Paul of USAID DS/ST. It is anticipated that this very satisfactory arrangement would be continued for the further RSA project, with the USDA providing TDY personnel and other appropriate persons, selected by USDA under appropriate competitive means, if necessary, for support to Phases 1 and 2, upgrading and completing through objective yield forecasting for:

Philippines, Indonesia	One full management unit
Costa Rica Dominican Republic Jamaica	One full management unit
Bolivia, Ecuador	One full management unit
Thailand	One full management unit
Morocco	One full management unit

One full management unit represents an arbitrary degree of project management (in terms of time) required by AID and USDA. Existing Landsat data only are needed for Phases 1 and 2 above, therefore only modest and feasible interaction with NASA or EROS Data Center (DOI) are needed for Phases 1 and 2 to speed up delivery of Landsat images for Costa Rica, Dominican Republic, and Jamaica. For Phase 3, special requests from AID to NASA, as done in the past, may be necessary to acquire imagery in areas not covered by foreign ground stations.

For Phases 3 and 4 a slightly different management/administrative structure seems appropriate.

General Supervisor	-	C.K. Paul, AID DS/ST
Month to month management	-	USDA/ESCS, W. Wigton
Day-to-day support	-	Individual USDA employees or TDY or industry/university sub-contractors

LDC Management and Key Agencies

In each LDC the key agencies will be as follows for each phase of the project:

Costa Rica	- Ministry of Agriculture, Office of Agricultural Sector Planning (Phases 1 & 2; outside possibility of Phase 3)
Dominican Republic	- Department of Agricultural Economics, Secretariat of Agriculture (SEA) (upgrading of Phases 1 & 2; outside possibility of Phase 3)
Jamaica	- Data Bank and Evaluation Division, Ministry of Agriculture (Phases 1 & 2 only)
Bolivia	- Division of Statistics, Ministry of Agriculture (Phases 1 & 2 only; GEOBOL if Phase 3 warranted)
Ecuador	- Undetermined, but the likely prime is Program for National Regionalization of Ministry of Agriculture, and second is Center for the Integrated Study of Natural Resources by Remote Sensing for Phases 1 & 2. Relative roles might reverse for Phase 3 if introduced.
Morocco	- Division of Statistics and Economics Ministry of Agriculture, for Phase 1 & 2 Undetermined for Phase 3; undetermined for Phase 4.
Thailand	- Division of Agricultural Economics, Ministry of Agriculture (Phases 1 and 2) National Research Council (Phases 3 and 4)
Philippines	- Bureau of Soils (Phases 1 and 2 only)
Indonesia	- Central Bureau of Statistics (Phases 1 and 2 only)

D. Financial Analysis

Total money required for this project is $1,400,000. The following is a breakdown of how the money is to be spent during the period August 1979 through September 1981.

1.	USDA Overhead		
	ESCS 18%	252,000	
	OICD 7%	98,000	$ 350,000
2.	Phase 2 for 9 countries: 1/ 2/		
	Morocco	50,000	
	Thailand	50,000	
	Costa Rica	30,000	
	Ecuador	50,000	
	Bolivia	50,000	
	Jamaica	25,000	
	Dominican Republic	15,000	
	Philippines	50,000	
	Indonesia	60,000	$ 380,000
3.	Phase 3 for 4 countries: 1/ 4/		
	Morocco	33,000	
	Thailand	33,000	
	Costa Rica or Dominican Republic	17,000	
	Ecuador or Bolivia	34,000	$ 117,000
4.	Phase 4 for 3 countries: 1/ 4/		
	Morocco	20,000	
	Thailand	20,000	
	Dominican Republic or Jamaica	20,000	$ 60,000
5.	Equipmental supplies: 3/	158,000	$ 158,000
6.	Support technicians & staff in U.S.	145,000	$ 145,000
7.	Evaluation and Feasibility Study	90,000	$ 90,000
8.	Symposium	100,000	$ 100,000
		TOTAL	$1,400,000

1/ Includes technical services, travel costs and training of nationals in U.S.

2/ Includes completion of ASF plus 1980 and 1981 National survey

3/ About half of the required equipment and supply items have been purchased by Phase 1 project and is not included here.

4/ For each country in which Phases (3) and (4) are not implemented, freed funds will be used to start Phase (1) in new LDC. See Section III B Economic Feasibility.

(D. Financial Analysis - Continued)

Supplemental Budget Sheet (by Phases)

PHASE 2

1.	USDA Overhead		
	ESCS	200,000	
	OICD	80,000	$ 280,000
2.	Phase 2 in 9 countries		380,000
3.	Equipmental supplies		158,000
4.	Support technicians & staff		116,000
5.	Evaluation & Feasibility Study		90,000
6.	Symposium		100,000
		Total Phase 2:	$1,124,000

PHASES 3 & 4

1.	USDA Overhead		
	ESCS	50,000	
	OICD	20,000	$ 70,000
2.	Phase 3 for 4 countries		117,000
3.	Phase 4 for 3 countries		60,000
4.	Support Technicians and Staff		29,000
		Total Phases 3 & 4:	$ 276,000
		Grand Total :	$1,400,000

E. Social Soundness Analysis

1. Beneficiaries: Generally speaking, the beneficiaries of AID remote sensing projects have been resource managers, agricultural planners, foresters, geologists, land use planners, environmental analysts, hydrologists, engineers, and other developmental professionals who have been aided in their jobs by remote sensing technology. Remote sensing has offered them a better, faster, and more cost effective means of performing their job. In some cases, such as the lithium survey done over the Salar de Uyuni in Bolivia, satellite imagery was the only conceivable way in which the lithium concentrations could be mapped. Thus, as far as AID's target group, the rural poor, has been concerned, remote sensing has offered tremendous indirect benefits in that more efficient resource planning by government officials has resulted in better location of development projects, improved utilization of land, and discovery of new water and mineral resources. These benefits are linked to the poor in an indirect way because: (a) usually governments must significantly alter their traditional policy of dealing with information before the information can affect the resources available to the poor, and (b) even when LDC governments do alter their policy to benefit the poor, it normally requires many years before the information leads to action which again may take years to affect resource distribution. Thus the two obstacles which

impede the benefit flow from remote sensing information to the rural poor are government inaction and long time response.

When remote sensing is used to survey crop status, and this status is then used to predict future harvests, the benefits to the rural poor become direct. There are three ways that these direct links can be shown:

(a) Total crop estimation, one to two months prior to harvest, permit roughly one-half a year for governments to take action before existing food stocks are depleted, should a crop shortfall be apparent from the collected statistics. This is sufficient time for governments to purchase or borrow more grain on international markets.

(b) USDA, in informal discussions, have pointed out that in some LDC's, where future crop production appears to be sufficient or excessive in terms of the country's needs, P.L. 480 Food for Peace commodities are doing a disservice by flooding the market and thereby driving down prices the poor farmer gets for his crops. In this case, the U. S. can use the crop statistics of these LDC's to set our own limits on the food we provide the poorer LDC's, thus, permitting the farmer a fair value for his crop.

(c) In many LDC's, small farmers use their crop as collateral for obtaining bank loans. Many times the farmer has no way of convincing a loan officer that his crops are in good shape. As a result, the farmer does not get the loan, or his loan is less than that which his crop status warrants. Crop data collected by remote

sensing over small areas could thus benefit the farmer applying for a loan. Of course, remote sensing-derived information is objective, and a poor crop status would hurt the farmer's chances of acquiring the loan. It is felt that more farmers are hurt today by bank ignorance than would be adversely affected by improved information.

2. Population Growth: Remote sensing is an informational science. As such, it does not, in itself, set actions or events in motion. But it can very directly affect events and motivate actions which contribute to the improvement of human lives and natural resource and environmental conditions. With respect to population growth, this project and its orientation to agriculture affect population growth only very indirectly. By permitting improved distribution of food resources, the project outputs can help feed growing populations in the LDC's. The geographical distribution of crop fields, available as an output of the project in the form of Landsat-derived maps, can be combined by host governments with their population data to perhaps determine more optimal planning of new agricultural areas close to consumer demand. It should be noted, however, that this integration of agricultural and population maps is beyond the scope of this project. Several AID missions, notably Jamaica, Dominican Republic, Costa Rica, and Indonesia, are exploring with econometric models the integration of these forms of data. One reason why those missions have elected to participate in this project is that these models are hungry for crop statistics, the output of this proposed project.

3. **Role of Women:** More and more LDC women professionals are finding employment in remote sensing projects conducted with country budgets and projects funded jointly and partially by foreign assistance agencies. The Thailand National ERTS project, funded by USAID since 1972, has trained 110 Thai resource planners, many of whom are women, in remote sensing. The Vice Director of Thailand's Natural Resources Council is a woman. The Philippines' second delegate to the U.S. Economic and Social Commission for Asia and the Pacific (ESCAP) Meeting on Remote Sensing last November was a woman. The USDA teams working in the nine LDCs under this project will be instructed to make every effort to identify qualified women, both for training and involvement in carrying out the project. One USDA statistician, Josephine Wallace, will be particularly sensitive to LDC women participating in this project in the Latin American region.

LDC women with basic skills in photo analysis, statistics, and computer programming will be sought for both training and participation in the aggregation of crop statistics, extrapolation to total production estimates, and the classification and modeling of crop types and yield. By striving to select at least ten to fifteen percent more women in these nine LDCs than that offered by LDC counterpart institutions, AID and the USDA have a unique opportunity to involve a large number of women in a highly specialized and important area of science and technology in a significantly large sample of the third world.

F. Environmental Analysis

No environmental analysis required. Initial Environmental Examination indicated no adverse environmental effects. AA/DS signed approval for Environmental Threshold Decision that proposed action will not have significant effect on the human environment.

G. Evaluation Plan

A Remote Sensing for Agriculture Advisory Team has been established to guide and direct this project during the course of its life. This team consists of Professor David Simonett, University of California Santa Barbara, Professor Lyle Calvin, Oregon State University, Professor Ta Liang, Cornell University, and Dr. Richard Suttor, AID Office of Agriculture. This team served in a project design capacity providing technical substance to this Project Paper. In assisting in the design of this paper, Simonett, accompanied by the USDA team leader William Wigton, visited Morocco; Liang visited Indonesia and Thailand; Suttor visited Dominican Republic and Jamaica; and Calvin visited Ecuador and, accompanied by Manuel Cardenas, New Mexico State University, and under contract to USDA, Bolivia and Paraguay.

It is intended to evaluate this project at specified intervals by a team external to the project and recommend changes in direction of the project if warranted. Specifically, in-country evaluation will be performed by team members when area frames have been constructed, prior to start up of the first activity under this project, estimating national totals from the frame statistics. This evaluation consists of the feasibility analysis in Section I.B. "Recommendations," and III.B.,

"Economic Feasiblity," and will hopefully filter the nine countries down to four or five. The selection will be based on the criteria listed under Section III.B., "Economic Feasibility." It is expected that this initial screening would take place in late calendar year 1979, several months before the USDA PASA for area frame sampling expires.

It is then planned to conduct team evaluations in Washington and in all four to five LDCs after each phase of the project. During the fall of 1980, country crop reports for the previous growing season will be checked to see if estimates for the country are being made, and to see if the countries are attempting to verify the estimates by farmer crop reports (if available). (See ANNEX 9, LOGFRAME.) USDA technicians will assist evaluation team in spot checking sample fields. Outputs such as Landsat images scaled to host country maps and sample field notes will be verified by visual inspection at ministries of agriculture.

Roughly a year later, during the summer of 1981, land use maps, Landsat images, and crop tabulations will be inspected in the recipient countries by the evaluation team to assess the computer classification of agricultural acreage. This assessment will be done by comparing the Landsat-derived land use and crop identification maps with recent aerial photography or, if not available, by random field checks. Maps for all demonstration areas in Phase 3 will be provided by USDA technicians to the team.

By the summer of 1982, the computerized yield models, yield estimates, and national crop production estimates should be completed. The external evaluation team, as well as the advisory team, will be invited to a final project evaluation during the winter of 1982, involving AID, USDA, FAO, and host country officials interested in crop estimation in the LDCs.

Sample crop-type maps, crop yield estimates, land use theme maps used in Phase 1, field enumerator notes, and, most importantly, crop production estimates for the demonstration areas will be provided to this final review committee.

IV. Implementation

A. Technical Services

Technical services will be provided by USDA/EECS Statistics, Statistical Research Division. Technicians include Mathematical Statisticians, Survey Statisticians, Area Sample Frame Construction Experts, Data Processing and Systems Analyst, Digitizing Experts and other support staff as required. The costing of these services are included in section III.D. above for each country project and phase as listed.

The area frame sampling, Phase 1, is presently being implemented in nine LDCs under the project "Remote Sensing for Resource Assessment," 931-1166. Technical assistance is provided by the USDA under a PASA with AID (see Annex 6). In turn, the USDA works on a cooperative basis with the host governments by means of two legal documents negotiated by the USAID mission in each country. One document is a project agreement, an example of which for Thailand is seen in Annex 7. The second is the Memorandum of Understanding, which is the preferred mode in Costa Rica, and is shown in Annex 8. For the purpose of this project, "Remote Sensing for Agriculture," phases 2-4 will be negotiated by amending the existing agreements and memoranda.

B. Equipment requirements will be minimal, but include the following:

1) Programmable Calculator, estimated cost $8,000 (a 40 pound 2 unit system that can be carried into the country by a technician during one of the planned consultation trips).

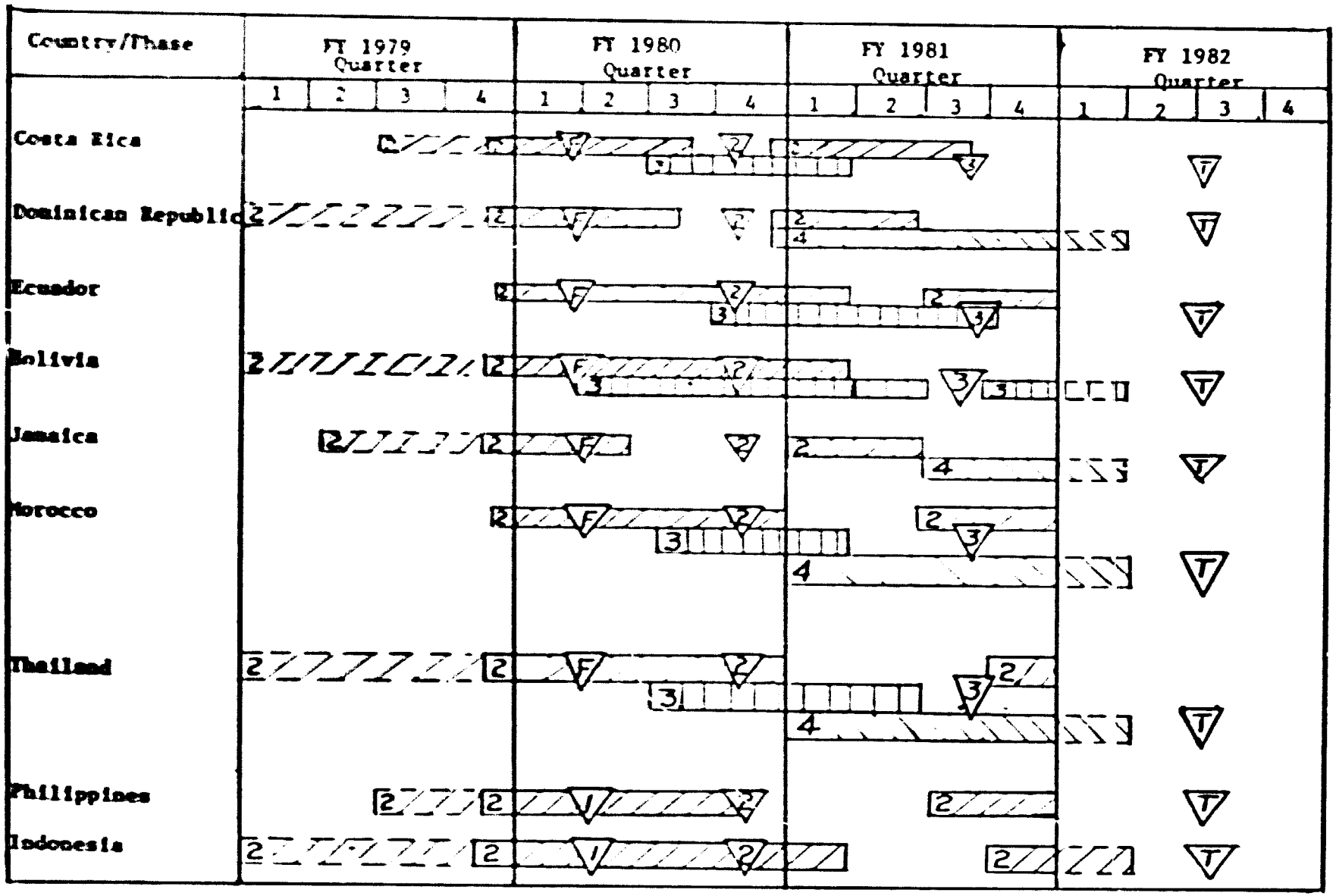
2) Landsat materials including computer compatible tapes that are available for countries listed above.

3) Color Diazo printer and developer to create color transparencies using MSS positive transparencies.

4) Maps, aerial photos, aceatate materials, etc.

5) Miscellaneous supplies and materials as needed for the project.

C. Schedule



LEGEND:

Phase 2

Phase 3

Phase 4

Phase under way by host country exclusive to this project

Evaluation Points:

Feasibility Analysis for phases 3 and 4

Termination Evaluation

Evaluation of Phase X, where X= 1,2,3,4

Individual Country Profiles

(a) Central America

(1) Costa Rica

Costa Rica has a land area a little over 5 million hectacres equal to about one-third the land area of the state of Illinois, and equivalent to one and a half full LANDSAT scenes.

Under an AID loan project, an area frame for Costa Rica is being constructed by the Ministry of Agriculture's Office of Agricultural Sector Planning (OPSA). Support is provided by a U.S. Department of Agriculture contractor. About half of the work has been completed and the rest should be finished no later than December 1979. This project also provides for a field survey of national production by crop upon completion of the frame, either in November of 1979, or in May-June, 1980.

Government of Costa Rica Interest, Motivation and Capability to Carry out the Project

Phase 1 - Area Frame Sampling

The work already carried out by OPSA on the construction of the area frame provides clear evidence of the interest and motivation of the government of Costa Rica to carry out phase 1 of the RSA project. Under joint Costa Rican-U.S. direction the construction of the area frame is progressing satisfactorily. Work is nearly complete in three regions and should be completed in all regions no later than the end of 1979. There have been some problems, some of which could be helped by the RSA project, but no insurmountable ones. The more important problems are:

1. Regional boundaries not stabilized. The government is establishing new regional boundaries. However, since these are new regions with no historical base, it may not take much pressure to change them again.

While this is a problem, it is not one which cannot be dealt with.

2. Age of aerial photographs. Some of the aerial photography used in making the present aerial frame dates back to 1944. Many changes due to urban creep, deforestation, newly colonized areas, and changes in crop production mean that stratification based upon old photos is out of date and that sampling based on such a frame will provide less precise estimates. The RSA project could assist by using LANDSAT imagery to update the imagery. New aerial photography is also needed in some areas, particularly, for sample segments. Since the country is small, judicious support from AID using medium altitude photography in the areas shown on LANDSAT to be undergoing change from the areal sampling frame should be considered.

3. Age of 1:50,000 scale topographic maps. Some of these maps used in the area frame construction date from 1944. Updated maps are needed to reflect new and old roads, river changes, and to correct errors. Cartography on this is in progress, but at a slow rate.

4. Photo interpretation. The area frame workers are obtaining on-the-job experience, but have not had sufficient training in photo interpretation. On-the-job training would be very helpful, particularly if LANDSAT imagery is to be used in updating strata. Further training will also be neeeded in interpretation of LANDSAT imagery as well as the photography.

5. Many LANDSAT scenes of Costa Rica are heavily cloud-covered. However, those during the dry season include some which would be acceptable for improving the stratification in the area frame sample design. Because the country is so small, especially enhanced 1:250,000 scale LANDSAT images which have been de-striped, fully rectified and are image sharpened (by restoring high frequency components) would greatly facilitate the

agricultural-non-agricultural land stratification, for improving the area frame sample design.

Phase 2 - Field Survey

On completion of the area frame, the GOCR is prepared to proceed with a field survey (in fact, several over the next few years), either in late 1979 or, more likely in June 1980, to estimate area and production by crop type. The present plans call for the use of the frame workers as field supervisors for the enumerators. There are expected to be about 24 supervisors and 100 new enumerators used in the survey. Training and survey methods are needed and should be provided in Costa Rica by a Spanish-speaking instructor. There would probably be 30-40 people in such a course.

There is limited capability in mathematical statistics in OPSA. However, Rafael Trigueros has worked with FAO and has had considerable field experience. However, additional TDY help would probably be needed to insure appropriate estimates and standard errors. For data processing, several options are available. Probably the most attractive is to have OPSA handle all national total statistics using a table top, programmable desk computer, with key board entry and screen display for correcting entered data. Such a device may be purchased for less than $15,000 (the Wang costs $12,000.). If it works out that Costa Rica does not move on to either phase 3 or 4, the small desk top computer approach is probably the most satisfactory. If it does move on, the Ministry of Finance presently has an IBM 370/148, though this may not be available in the future. There is a proposal pending that would give OPSA a remote job entry terminal to a central computer, possibly in the Ministry of Public Work or Finance. One programmer position is in the proposed budget, at a relatively high salary, but this may not be sufficient to attract and keep the right type of person.

The probable accuracy of the aggregation in the national totals phase is directly dependent upon the quality of the area frame constructed in the first instance, particularly with regard to how up-to-date the land use stratification units are, and the quality of the observations (non-sampling errors) during the enumeration phase. The former can be improved by use of additional new aerial photography, especially for those areas which LANDSAT indicates have been changing rapidly, and by the use of LANDSAT to sharpen the area frame. The latter (quality of observations) can only be improved as experience indicates to the Costa Rican Department of Agriculture the tightness of the supervision required for elimination of non-sampling errors.

Phase 3 - Computer Classification. The National Geographic Institute (IGN) has worked with LANDSAT II imagery and is interested in working on the project.

At the present time neither IGN nor OPSA has the technical capability to carry out the more sophisticated classification work in this phase. It is possible that with substantial training over the next one to two years, both in the United States and in Costa Rica, enough expertise could be built to carry out Phase 3 with TDY assistance.

There are two major problems in Costa Rica, however, which would make this phase of problematic value, or at least experimental rather than operational. The first is the problem of cloud cover during the growing season, frequently up to and including the harvest season. Since the value of Phase 3 computer classification directly depends on the percent of cloud cover on LANDSAT imagery, closely coincident with the time of ground enumeration, the persistent scattered cloud cover in the highlands and on the eastern lowlands would significantly

reduce the increment of information available from introducing computer processing. Before making a decision to go ahead with this phase, a pre-feasibility analysis using SMS-GOES meteorological satellite cloud observation data roughly coincident with LANDSAT time of passage for the key enumerative months should be carried out.

The second problem involves crop distribution. Many crops are grown on small fields and crop interculture is common so that satisfactory signatures will almost certainly not be available. In the United States the shift in accuracies as one moves from large fields to small fields is from 90% identification down to 50-60%, and this coupled with persistent cloud cover raises serious questions as to the value of such a procedure over all crops. On the other hand, crops that are most likely to be in large enough fields and are planted continuously so as to make the project appear feasible are bananas, sugar cane, pastures, and possibly African palm.

If the cloud cover and crop distribution problems appear on closer scrutiny to be manageable, Costa Rica would remain a candidate for introducing Phase 3 in a research and development mode. The country is small enough. LANDSAT digital tapes will need to be obtained from NASA and NASA agreement must be forthcoming to provide regular coverage of Costa Rica.

Even though Costa Rica is more advanced than most of the countries in the sample with respect to sample frame already underway and plans for national total statistics to be available by mid-1980, the time required to effectively bring up a computer interpretation phase is such that a pre-feasibility study should begin promptly in the new fiscal year, and a decision be reached very early in 1980 as to whether

to move ahead with Phase 3. This feasibility analysis should include a thorough analysis of the equipment needs. It may be more reasonable to carry out the whole project on a DEC PDP 1145 or comparable device, rather than the Ministry of Finance IBM 370/148, or the proposed central computer in the Ministry of Public Work or Finance. There's enough uncertainty on these issues at this time that they can only be resolved by a further visit and feasibility analysis. In any case, it must be recognized that a hard and skeptical look at the introduction of this relatively costly phase for a small country characterized by many small fields and extensive cloud cover, and requiring substantial TDY assistance and hardware and software support, must be given.

Phase 4 - Agricultural-Meteorological Modeling

There is no, or limited, experience in this area in Costa Rica, and it does not appear likely that any work on thise phase can be accomplished within three years.

Project Management and Project Needs

Project Management

OPSA, with U.S. AID/Costa Rica loans, is prepared to carry out most of Phases 1 and 2. Personnel, equipment, vehicles, and in-country travel are expected to be covered satisfactorily. Although space for TDY personnel is not available in OPSA, some space could probably be provided in the rural development office of the US AID/Costa Rica. For the successful completion of the project it is important that TDY personnel actually be integrated completely on a day-to-day basis with the Costa Rican personnel and space should be negotiated if at all possible with OPSA.

IGN would participate in Phase 1 to provide LANDSAT imagery,

aerial photography, and improved cartography. Specially enhanced imagery would be provided by AID through contract with appropriate US agencies or firms. Phase 3 would be a dual responsibility of IGN and OPSA for which the details will need to be worked out after a feasibility analysis.

Project Needs - Summary:

Phase 1 - LANDSAT imagery to update strata for the areal frame.

- Aerial photography over selected areas (possible AID funding)
- Additional training and photo interpretation.
- TDY review of area frame construction.

Phase 2 - In-country short course on survey methods (in Spanish).

- Training assistance for enumerators and supervisors.
- TDY mathematical statistician and possibly further training of a Costa Rican statistician.
- Data processing and program analysis.

Phase 3 - Thorough feasibility analysis of all phases of the project before commitment. If feasibility is proven, then the following needs become important:

- NASA agreement to provide digital tapes of LANDSAT imagery during the critical times in the growing season.
- TDY coordination of OPSA and IGN activities.
- Thorough training of Costa Rican personnel in remote sensing interpretation, computer classification techniques, integration of national ground sample statistics from Phase 2 for training and predicting in Phase 3.

-TDY assistance in computer classification

Phase 4 - Not anticipated.

Costa Rica Summary

The GOCR has already progressed far enough, both in construction in the area frame and in planning for a national totals phase to believe that the revision of the Phase 1 and Phase 2 RSA project has a very high chance of successfully implementing the new technology. For the computer classification phase it would be a likely candidate, but only after a thorough pre-feasibility analysis is carried out, paying consideration to delivery of digital LANDSAT imagery in a time frame relative to project success.

(2) Dominican Republic

The Dominican Republic has a land area of some five million hectares, or one-third of the land area of the State of Illinois, equivalent to one and a half full Landsat scenes. An area frame constructed with U.S. Department of Agriculture assistance has been in use in the Dominican Republic for several years. Area and production estimates are now obtained for coffee, cacao beans, rice, plantains, yucca, and other crops. A notable exception is sugar cane. The estimates are computed and published by the Department of Agriculture Economics in the sub-secretariat for planning of the secretariat of agriculture (SEA).

Sugar is the most important export crop in the Dominican Republic. Sugar cane production and milling is controlled by the State Sugar Council (SEA), a semi-autonomous agency of the Dominican government. SEA, through its sugar cane operations, controls about 20 percent of the cultivable land in the country. If, on further study, an upgrading of the area sample frame appears appropriate for the Dominican Republic, employing band ratioing

enhanced Landsat imagery, together with additional aerial photography in the next year, the RSA may, with modest funding, be able to spur such development. Through inclusion of sugar cane as part of the sample, this RSA project could take the initiative in such improvements.

Possibilities exist for experimentation with a Phase III computer classification program, but no significant in-country capability presently exists in the area. Work is underway on agrometeorological modeling for sugar cane, but it is at an early stage and AID funding could stimulate further development in this area (Phase Four).

Government of Dominican Republic Interest, Motivation and Capability to Carry Out Project

Phase I-Area Frame Sampling

An area frame sample on national production estimating procedures has been in operation in the Dominican Republic for two years. Aerial photographs at 1:40,000 scale for the whole country, funded in 1967-68, were used for construction of this frame. Since this base is now already 10 years old, and since area frames need upgrading at about five year intervals, it is appropriate to consider upgrading the frames through the use of enhanced Landsat images, and if feasible, new aerial photography. The Cadastral and other agencies need new aerial photography for the entire country, and this has been under discussion for more than a year within the government. To finance it, the various agencies will have to pool their funds. Although no firm plans presently exist, it is probable that the country will be flown in the next year or two, and AID support could make this more likely.

Photographic maps for the entire country were published in 1966-1968 at scales of 1:50,000 and 1:250,000. Maps, photographs and LANDSAT imagery can be obtained from the Instituto Geografico Universatirio (IGU), or the Santo Domingo office of the Inter-American Geodetic Survey (IAGS). The previous maps also used for constructing the present sample frame may be available on stable base material to provide the revised sample frame, if such a project is initiated.

Phase 2 - Field Survey

Field surveys and enumeration are carried out in the existing area frame sampling procedure in the Dominican Republic. Improvements in sample allocation through upgrading the area frame as outlined in a new Phase I would propagate through the system and would, in any case, need to be included if a Phase 4 (agrometeorological modeling) addressed to sugar cane actual sugar yield per hectare is to be investigated. There will be little point in initiating a Phase 4 program addressed to sugar cane yield unless sugar is incorporated in the area frame, or unless the procedures used by CEA are accepted as a satisfactory comparison base by a TDY team composed of an expert in sample frame and national totals aggregation, and an expert in agrometerological modeling.

A continuing problem in preparing national estimates in the Dominican Republic, and probably in almost all LDCs, is that inter-cropping seriously influences production estimates. Various levels of inter-cropping may be detectable on aerial photography and a regional adjustment program to accommodate that cropping may be feasible. At least such a possibility should be tested in any further work in the Dominican Republic.

It is expected that any modifications to both the area frame and the enumerative procedures could be handled entirely within the Dominican Republic, since they are already engaged in their own enumerative procedures and training programs.

If a decision is made to use LANDSAT imagery to upgrade the area sample frame, NASA should be requested to provide new imagery as soon as possible over the Dominican Republic. Both dry season and wet season imagery would be desirable.

Phase 3 - Computer Classification

The former head of the area frame sampling group,now Deputy Director of agricultural economics, and the new head of the area frame sampling group, have expressed great interest in the use of computer classified LANDSAT data as described in the Wigton-Huddleston paper.
They argued that the relatively developed status of the area frame sampling in the Dominican Republic provides a base for experimenting with the new techniques they have. This is in general correct, except for the exclusion of sugar cane from the area frame sample, and should be so stated.

The Dominican Republic faces the same problems as in Costa Rica, which would make this phase problematical and at best, experimental, rather than operational. There is a high degree of cloud cover during the months when the enumerative samples are obtained, inter-cropping, especially of subsistence crops, irregular field boundaries, and difficulty in defining boundaries for coffee and cacao, plantains, yucca and similar tree and/or subsistence crops. This whole area is quite experimental and U.S. experience is no guide to how adequately the computer classification

will yield significant increments in quality of information (through improved precision of estimates). We do know enough to know that it will be no better than the more complex areas of the United States and may be of marginal utility. In order to really establish the limits to performance of the technique of combining computer analysis with area frame sampling and enumeration, following the procedures developed by Wigton and Huddleston, it may be necessary to deliberately sponsor a research project in an area such as the Dominican Republic in which there is not a strong forecast of success. Clearly, a brief feasibility analysis of the problems must be carried out to sharpen these qualitative judgments and to define whether the investment in a Phase 3 is warranted. The Dominican Republic though, does remain one of the areas where such an investigation must be pursued. Since the study team member was unable to evaluate the effectiveness of the existing area frame sampling system, it is possible that assistance would be more useful in more traditional, less experimental areas than computer classification and agrometeorological modeling. The TDY team should keep an open mind and not necessarily rule out other types of assistance.

Details of computer hardware available in the Dominican Republic are not available at this time and a pre-feasibility study should include an analysis of this possibility plus possible purchase of mini-computer for the Phase 3 Project.

NASA will need to provide digital tapes in a timely manner to be used with the national total estimates. As since the national totals

will generally be available within a month or so of harvest, rapid turn around from NASA will be essential. If not forthcoming, the project could not be introduced. It is this writer's judgement that it will be a tour de force to obtain the data expeditiously, and process it and use it effectively in the short time between the national estimation and the actual harvest.

Phase 4 - Agrometeorological modeling

CEA has been working on models relating sugar cane yield to meteorological variables. Thus far, they have no empirical results due to the lack of appropriate computer software. CEA, however, operates a sugar experiment station with a meteorological section. The experiment station has available data and is capable of collecting additional data for agromodeling. Rainfall is continuously recorded at some 30 stations in the Dominican Republic.

No information is available at this time on details as to the meteorological variables obtained, and whether their meteorological satellite data is obtained, and would be usable in agro-meterological modeling. A pre-feasibility study would be necessary by someone experienced in agrometerological modeling, preferably with sugar cane. This should include examination of the results of an OFDA (Office of Foreign Disaster Assistance/AID)-funded project to prepare weekly weather assessment reports from countries in the Caribbean basin, employing ground observations and satellite imagery interpretation at the center for climatic and environmental assesment of NOAA, Columbia, Missouri. The contact person is Mr. Paul F. Krumpe, OFDA, AID, Washington, D.C.

Project Management and Project Needs

GODR Support

The greatest interest in the Dominican Republic appears to be in a Phase 3 computer classification of LANDSAT data. Both the Department of Agriculture and the IGU have interests in this area. But neither have the equipment and cannot afford it at present. Manual classification techniques are being used by Dominicans and foreign advisors are financed by the DS/AGR Comprehensive Resource Inventory and Evaluation System (CRIES) Project. SIEDRA (which is the Dominican acronym for CRIES) is developing plans for greater national remote sensing capability. However, the roles for IGU, SIEDRA, the Cadastral , Department of Agriculture and other user agencies have not been worked out yet. No information is available at this time whether space would be available for TDY personnel in the Department of Agriculture, or whereever else the computer facilities may be located.

At this time, no information is available on whether GODR would be interested in participating in an upgrading of their sample frame and enumerative procedures to include sugar cane. A Phase 4 is possible, but a pre-feasibility study would need to be carried out for both this and Phase 3.

Project Needs

The most immediate need is to send a TDY Team consisting of an expert in computer classification and an agrometeorological modeling expert to Santo Domingo to develop a plan of work and perform a thorough pre-feasibility analysis, which will, in addition to technical issues,

explore the commitment of the USAID mission, the government of the Dominican Republic, and financial issues related to introducing any one of Phase 1 or 2, a new phase 3 or a possible phase 4.

(3) Jamaica

Jamaica has a land area of a little over one million hectares,equal to about eight percent of the land area of the state of Illinois, or half the state of Maryland, and equivalent to one-third of a full LANDSAT scene. An area frame construction is already underway in Jamaica, through a PASA with USDA, sponsored by the USAID mission. This PASA expires at the end of January 1979. The mission would like the assistance to Jamaica continued. Roy Russel, Director of Data Bank and Evaluation Divison of the Minitry of Agriculture, who manages the area frame system, is interested in support for all phases of the project. A good working relationship has been established with USDA.

Government of Jamaica, Interests, Motivation and Capability to Carry Out Project:

Phase I - Area Frame Sampling

An area frame has been completed for at least ten of the thirteen parishes, and it is anticipated that a frame for the entire country will be completed for the next quarterly survey in March, 1979. The entire island of Jamaica was photographed at 1:50,000 scale in 1971 by the Geological Survey Unit in the Ministry of Mines and Natural Resources, with assistance of NASA and AID funds. This photography is being used

to construct the area frame. The island has also been photographed at 1:50,000 or larger scales in 1941, 1953, 1962 and 1968. Photographic maps at 1:12,500 were developed in the 1960s for the entire island.

Phase 2 - Field Survey

Although some field work has been done with the frame in parts of the country, no estimates have been published. Apparently major errors are common due to the inexperience and lack of training of enumerators and deficiencies in field supervision. Data processing problems are also serious, but perhaps more easily solved.

Enumerators now use a questionnaire method and thus rely upon the farmers for estimates of yield. An objective yield method, whereby small plots are measured and crops harvested and weighed, is being actively considered by the director of the Data Bank and Evaluation Division of the Ministry of Agriculture, which manages the area frame system. A centrally funded RSA project should provide training for enumerators and field supervisors, in addition to that already provided. This would be short course training in Jamaica. Most of the potential students have not yet been hired; 26 of 65 enumerators, 4 of 13 parish supervisors and none of four regional supervisors are yet on board.

Phase 3 - Computer Classification

Roy Russell is very interested in computer classification of LANDSAT data, in conjunction with area frame ground data, using the methods described in the Wigton-Huddleston paper. His hope is that he can obtain quicker estimates of production by means of this methodology and would like to produce monthly estimates for sub-national areas. This is very ambitious,

especially since a lot of time and energy is still needed to get the basic area frame system functioning properly. We should continue to talk to him about computer classification, but we should be careful not to divert attention from the need to develop the more traditional techniques. The Geological Survey has a remote sensing laboratory, which is expected to serve all of the government agencies. The Jamaican Defense Force has an RC-10 camera system that can be used by civilian agencies.

The Geological Survey is preparing a project proposal for research on the applicability of LANDSAT to forestry, land management, coastal pollution, flooding and other non-agricultural uses. It is not clear whether they want to get into computer classification, an area in which they, and apparently, no other Jamaican agencies, has any experience. No information is currently available on whether a suitable computer and associated peripherals is available for use in the computer classification.

The small size of Jamaica, the frequent cloud cover, the wide range of crops grown (52), the substantial number of enumerators to be employed in the ground enumeration phase, and the small size of many fields except for sugar cane, raises serious questions on the value of proceeding with this phase.

Phase 4 - Agricultural-Meteorological Modeling

The Director of the Data Bank and Evaluation Division of the Ministry of Agriculture, would like to explore agricultural-meteorological modeling, particularly for sugar cane and bananas.

The Sugar Industry Research Institute (SIRI) has carried out some work on the effect of climate on sugar cane yields. They have an extensive data set on yields, rainfall, solar radiation, temperature and evaporative transpiration. It appears that additional work could be done with already available and new data now being collected. The RSA project could provide an expert to consult with SRI on the development of additional analytical models, particularly define whether forecasting seems reasonable.

The Banana Board has some data that could be used for agricultural-meteorological modeling. However, the banana data are apparently not as extensive as that for sugar, nor does there appear to be as much interest or need for agricultural-meteorological modeling. Possibilities can be explored with the Director of Research for the Banana Board (Dr. Ittyieippe).

Because of the small size of the island, full-scale agro-meteorological modeling, involving the use of meteorological satellites, does not appear warranted. It may well be more effective to increase the number of rainfall stations. It would of course be even more effective to introduce a ground enumeration/objective yield forecast methodology under Phase 2

Project Management and Project Needs

Project Management

A good cooperative arrangement is already underway between USDA and the government of Jamaica, and should be continued with incorporation of training for an objective yield survey so that a really efficient Phase I and Phase 2 operation in Jamaica is brought to completion. Continued discussion of allocation of scarce resources to the more traditional versus

the more experimental techniques is required. Occasional use of RC-10 medium altitude photography may, because of the small size of the island, be more effective than converting to a full digital approach in Phase 3. Until Landsat D arrives, it is questionable whether digital procedures should be pursued. The large number of enumerators to be employed may prove the traditional techniques able to provide the needed information, with a careful evaluation of the design.

Project Needs - Summary:

Phase I - no additional support needed

Phase 2 - training assistance with supervisors and enumerators-in-country short course on survey methods

-further training in data processing procedures

-introduction of the objective yield method

Phase 3 - prepare a feasibility analysis of all phases of the project, before commitment, especially a review on enhancing the traditional procedures in comparison to commitment to Phase 3.

Phase 4 - no work with satellite meteorology is anticipated

-possible TDY assistance from agricultural-meteorological modeling experts to refine existing models, employing ground meteorological observations.

(b) South America

(1) Bolivia

Bolivia has a land area of 110 million hectares, equal to 7.5 times the size of the state of Illinois or twice the state of California,

equivalent to about 30 full Landsat scenes. While the eastern (Oriente) portion of the country might be eliminated for Landsat digital classification at this time, the size of the contry would nevertheless involve processing very large amounts of data.

An agricultural census is planned in 1979, to be conducted by the National Institute of Statistics (INA). The last census was conducted in 1956. It is presently having some budget problems, although it is anticipated that the GOB will eventually provide around half of the required 2.3 million dollar total. A request for financing to AID has been turned down, although AID will provide $25,000 to study the possibility of using FOSDICK from the U.S. Census Bureau in a computer analysis of this data. Additional funding is expected from international agencies, probably the European Common Market and FAO. A frame for the agricultural census will be based on farm units as obtained from the 1976 population census, within community units in what might be called a semi-area frame. It is intended to be a full census for primary data, with secondary data obtained from a sample.

GOB is interested in continued support in construction of the area frame and in switching to an areally-based ground enumeration phase. Feasibility of and the commitment of the GOB to a Phase 3 requires further investigation. Phase 4 does not appear feasible during the time frame of the project.

Government of Bolivia, Interest, Motivation and Capability to Carry out the Project:

Phase I - Area Frame Sampling

Since 1974, AID has had a PASA with USDA for an area frame construction in Bolivia. This is being carried out under Hector Nogalez, in the Division of Statistics, Ministry of Agriculture (MACA). It has been progressing rather slowly. A USDA contractor (Josephine Wallace) visits about three or four times per year to review progress and make suggestions for continued work. Only one department has been completed so far, although two or three more may be completed within the next six months. While it is expected that the area frame will be continued independent of the RSA project, additional and continuous on-the-spot support seems to be needed to move the project forward more expeditiously. The project presently suffers from lack of an adequate supervisor. The USDA has apparently given tentative commitment for providing half the cost of the person being stationed in Bolivia to assist in the area frame construction, and in the development of the survey if the remaining funding can be obtained from the AID mission. They would prefer to proceed in this manner if a person to fill the position can be found.

There has been some problem in obtaining aerial photographs as needed, but most of the problems seem to be internal and should be solved eventually. It will probably take an additional one to one and a half years to complete the construction of the area frame for the entire country, even with additional RSA support. Thus, it could be ready no earlier than December, 1980, given the previous slow rate of progress, even with RSA support.

Phase 2 - Field Survey

The field survey based upon the area frame is expected to be carried out in 1980, or more likely 1981. Present plans call for two surveys a year, in November and May. About half of the budget will be provided

by the government of Bolivia; plans are to request additional funds from AID through the mission.

Computing facilities are now available at Cenaco, a central computing facility. Tentative plans call for a computer in the neighborhood of $100,000 to be obtained for MACA , although this may actually be placed in the agricultural bank with a terminal to MACA. Present specifications call for a 64K machine with options to 256K bytes. They expect bids to go out in March. Programming and computing capabilities at the present time resides with Cenaco, and will probably continue for some time. A desk top computer provided by RSA may be a more satisfactory approach than relying on a central computer facility yet to be purchased. Options should be looked at thoroughly.

Phase 3 - Computer Classification

Although the geological service of Bolivia through its ERTS program (GEOBOL) has a considerable remote sensing capability, together with some capabilities for computer classification, it presently appears doubtful that GEOBOL has an understanding of the intent of Phase 3, although the work could technically be carried out there. While MACA has much understanding of the need, it doesn't have the expertise to carry out the phase. Also it appears unlikely that the two groups will be able to cooperate very well, although one person of MACA might be assigned to work with GEOBOL on Phase 3.

Implementing a Phase 3 in Bolivia seems out of question during the time period of the project, bearing in mind that it will not be until 1981 that the first national totals are likely to be obtained.

Nobody in the country has experience as yet, and there is no knowledge of software in place capable of taking large numbers of digital tapes and processing them quickly. No information is available at this time on hardware and software availability, and on the rapidity of delivery of digital tapes from Brazil or possibly from NASA. A thorough pre-feasibility analysis would be required before commitment to this phase, with the distinct likelihood that it will not be introduced.

Phase 4 - Agricultural-Meteorological Modeling

There is no or limited experience in this area in Bolivia and it is unlikely that any work on this phase can be accomplished within the 3-year project.

Project Management and Project Needs

Project Management

MACA, with continued USAID assistance, is prepared to carry out Phase 1 and with further assistance, Phase 2 . Adequate space for TDY personnel appears to be available in MACA.

Project Needs

There are special needs that the RSA project could supply to supplement and speed up the work on the Phases 1 and 2 and to review the possible (not probable) feasibility of introducing Phase 3. Additional needs for each phase are as follows:

Phase I - a resident US/AID funded position to assist in the completion of the area frame and provide additional project supervision.

- LANDSAT imagery to provide updating on stratification
- Further training and further interpretation

Phase 2 - in-country short course on survey methods (in Spanish)

- TDY Mathematical Statistician
- TDY evaluation of data processing procedures, including Fosdick

Phase 3 - prepare a critical review and pre-feasibility analysis of whether further commitment to Phase 3 is warranted.

Phase 4 - Not anticipated within the three-year project period.

(2) Ecuador

Ecuador has a land area of 27 million hectares, about 1.9 times the land area of Illinois, and equivalent to about 8 LANDSAT scenes.

GOE Agencies and Their Relationship to Project

Two GOE agencies would be responsible for most of the activities under the RSA project. They are the Center for the Integrated Study of Natural Resources by Remote Sensing (CLIRSEN) and the Program for National Regionalization (PRONAREG) of the Ministry of Agriculture. A heavy emphasis is being placed upon the regionalization program to promote decentralization of activities to relatively small homogeneous regions of the country. Many types of land use and resource maps are being prepared at the present time so as to give a basis for the establishment of the regions. It is anticipated that data will be useful in updating these maps.

CLIRSEN was established in December, 1977, to carry out on a continuing basis a national inventory of renewable and nonrenewable resources, to plan, organize, coordinate, and carry out remote sensing activities in the country, to assist other GOE agencies in map development activities,

and to provide technical assistance in remote sensing and related activities to other GOE agencies. A year ago it had three members, but it has now expanded to twenty members with various areas of expertise. Apparently, the agency is able to pay somewhat higher salaries than other government agencies and therefore has attracted well-qualified and competent personnel. The Department of Agriculture also appears to have good personnel and an active program. Under a French-sponsored project, the Office of Scientific Research (ORSTOM) maintains a list frame of farm units. Using this list frame, a survey covering area and production of crops was carried out in 1975. A methodology report has just been released, although a full report of the survey is not yet out. The methodology in establishing the list frame appears to be quite good but still carries the inadequacies of any list fame with the necessity for continual updating. While the other members of PRONAREG express a strong interest in the area frame construction, the interest by members of ORSTOM was not so apparent. However, their activities were enough tangential to the main thrust of PRONAREG that their reluctance would not be a deterent to the Ministry of Agriculture participating fully in the construction and use of the area frame.

While both CLIRSEN and PRONAREG expressed a strong interest in all phases of the project, they were not yet at a point where they could say exactly which group would have responsibility for each of the activities. CLIRSEN is willing to take the lead in coordinating the project. This appears sufficiently good that an agreement can be obtained. It would appear now that CLIRSEN as well as PRONAREG might be well involved in

the first phase, that PRONAREG would be most involved in the second phase, but that CLIRSEN would be more heavily involved in the third phase of the project. In the absence of any work to date on an area frame, it is doubtful that Ecuador can advance to the fourth phase within a three year period.

The only other project closely related to the RSA project is the ORSTOM project which is discussed above. If the area frame is to be used as a basis for a survey of area and production, it is possible that the Ministry of Agriculture would like an evaluation and comparison of the two methods. It the matter were discussed further with them, this evaluation could take place without having to run a survey based upon both types of frames.

GOE Interest, Motivation and Capability to Carry Out the Project:

It was very clear that both CLIRSEN and PRONAREG are very interested in the project and would like to work on it. In fact, Ing. Alberto Segovia, Executive Director at CLIRSEN, has written a letter indicating their interest. Ing. Oswaldo Guevara, PRONAREG, expressed a similar interest orally at the time of the meeting. It is anticipated that these two organizations will be able to provide the personnel, the space, and the logistic support for the project. The project would be particularly useful to CLIRSEN at this stage of the development to give the needed experience in using satellite imagery and aerial photography. Because only rough estimates of area production of many crops are now available in Ecuador, the project would also prove useful for the Ministry of Agriculture in providing information needed for the orderly development of the country.

Phase 1 - Area Frame

Neither CLIRSEN nor PRONAREG has at this time anyone with experience to supervise the construction on area frame. Each of them do have individuals, however, who, with some training in this country and some TDY assistance in Ecuador, should be able to successfully head up such a program. Neither adequate scale maps nor aerial photography is available for the entire country. The U.S. Air Force took aerial photos during the 1960s and these would have to be used for part of the country. The Military Geographic Institute has two planes and has been taking aerial photos for the past two years, which has helped to update the older photography but still does not provide 100 percent coverage. Nearly 50 percent of the country has been topographically mapped at a scale of 1:25,000. Fortunately, much of the country that has been mapped is the productive agricultural land. This means that additional mapping and additional air photography would have to be carried out to successfully complete an area frame. It might be necessary to confine the area frame initially to the Sierra and coastal regions, omitting the Oriente region to the east. LANDSAT imagery would be required, plus considerable on-the-spot training. The earliest a frame could be completed would be December 1980.

Phase 2 - Field Survey

The Ministry of Agriculture has had more experience but has not carried out a fully successful survey of this type to date. With some additional training in survey methods and sufficient TDY assistance for collection and analysis of the data, they should be able to carry out Phase 2 successfully, but the earliest national totals could not be

obtained until 1981 or early 1982 which would hinder development of Phase 3.

Phase 3 - Computer Classification

A feasibility survey is needed promptly for a possible Phase III project.

At the present time CLIRSEN does not have the experience to be able to carry out Phase 3. Within two years, however, by the time Phase 3 is ready for operation, CLIRSEN could well have the capability of working in this area. They do not yet have a suitable computer or software but they do have some of the people that should be prepared by that time to work on the project. If it were possible to obtain computer support early in the project, with some AID support, they would be obtaining experience much more rapidly than if this were not obtained for two more years.

In fact, probably the primary strength of GOE, both with CLIRSEN and with PRONAREG, is the quality of the people who would be working on the project. If the project is to succeed any place, it would depend upon good people. The quality of personnel in CLIRSEN and PRONAREG is high. The collective group in CLIRSEN is as strong as in any developing country. The major question is whether they have the experience of leading a group through a project to its successful completion.

In spite of the difficulties with cloud cover over the coastal regions and with lack of experience in area frame construction or remote sensing, the project has a reasonable chance of success in

Ecuador because of the personnel that would be attached to it. Within the three year period, Ecuador could have an area frame for most of the country, conduct a field survey to obtain area and production estimates, and be able to initiate a program in computer classification for at least rice, sugar cane and pastures.

Project Management and Needs

Project Management

Project management would be as outlined earlier between CLIRSEN and PRONAREG.

Project Needs

Phase I - LANDSAT imagery to assist in stratification for area frame

- Updated aerial photography over selected areas (AID support)
- Training and interpretation of aerial photos and LANDSAT imagery
- Training in U.S. for two specialists in area frame construction
- TDY assistance in area frame construction in Ecuador

Phase 2 - In-country short course on survey methods (in Spanish)

- Training for enumerators and supervisors
- TDY mathematical statistician
- Training in data processing, programming, analysis

Phase 3 - Feasibility survey

- Timely delivery of LANDSAT tapes (NASA or Brazil).
- Suitable computer and software
- Training in computer classification techniques and use of ground truth procedures.
- TDY assistance in computer classification
- Software/Programmer support

Phase 4 - Not anticipated within three year project.

(c) North Africa

(1) Morocco

Morocco has a land area of 110,000,000 hectares, about equal to the area of California, and equivalent to some 30 full LANDSAT scenes. The principal agricultural areas are less than one-half of the total area.

Morocco's agricultural areas are characterized by a distinct dry Meditaerranean climate, much akin to that of California's southern coast and central valley. Its agriculture includes mixed irrigation and both large and small-field dry land grain crop production. It should lend itself well therefore to all phases of the RSA project.

Government of Morocco Interest, Motivation and Capability to Carry Out the Project

Phase 1 - Area Frame Sampling

The Ministry of Agriculture has both the interest and capability to carry out construction of an area frame, and personnel resources needed. Their statisticians were alert to the possibilities of an area frame, appeared to be sympathetic to the approach, and were prepared to try it on a pilot study basis. It is anticipated that the pilot study would begin by summer 1979 in the Kenitra area and would continue through the harvest in the summer of 1980.

It is anticipated that the construction of the area frame for the whole country would not be completed until December 1980, and that it would be the 1980-81 crop year that would constitute the first country-wide evaluation of Phase 2. A wide variety of high-grade materials are already available in Morocco for the construction of an area frame:

(1) Topographic Maps. High quality topographic maps at a scale of 1:50,000 are available for nearly all the settled agricultural areas. Most of these maps are less than 10 years old and a good number have been completed in the last 5 years. Essentially all the important agricultural regions are covered at a scale of 1:100,000 and the entire country, excluding Spanish Morocco, is covered at scale of 1:200,000. Spanish Morocco is covered at a scale of 1:250,000.

(2) Aerial Photographs. A surprisingly wide variety of large scale and medium and small scale aerial photographs are available, well organized and readily accessible in the Cartography Division of the Ministry of Agriculture. Large portions of the principal irrigated regions have large scale photographs at various scales; some as small as 1:3,000 to 1:10,000. Other areas have 1:10,000 to 1:15,000 and quite large sectors of the area roughly 50 miles inland from Safi beyond Casablanca, Rabat and Kenitra north to Tangiers and then east to Melilla and Oujda are at the same scale. In addition there is extensive coverage of large scale photography (1:15,000 to 1:20,000) in the irrigated regions surrounding Marrakech. This large-scale photography is of varying date but almost all is later than 1960 vintage and much is from the mid to late 1970's. Medium scale photography from scales of 1:20,000-25,000; 1:25,000-30,000 and 1:30,000-40,000 partially overlaps the large scale photography and fleshes out the balance of the agricultural areas. The earliest of this photography dates from about 1962, but most is of 1970 vintage and later. Some pieces were flown as recently as 1975 and 1976. Small scale photography at scales of 1:40,000-1:50,000 and smaller covers virtually the entire agricultural and pastoral regions of Morocco.

(3) Special Purpose Maps. A variety of special purpose large, medium and small scale thematic maps are also available which will be invaluable in setting up the sample frame. These include city and village town plan maps, irrigation project maps, national cadastral survey maps, national forest maps, etc. All are well-housed and readily available in the Division of Cartography of the Ministry of Agriculture and Agrarian Reform.

(4) A considerable variety of LANDSAT images are already available in Morocco. However, these are of poor quality (mostly EROS Data Center). Properly prepared and enhanced LANDSAT imagery in conjunction with the existing very good base of maps and aerial photography would enable a high quality area sampling frame to be established in Morocco.

Phase 2 - Field Survey

Field surveys based on the area frame would be carried out in the 1980-81 crop year, with as many as three or four repeat surveys depending on the crop mix and livestock statistics desired. It is expected that other than the advisory role by the USDA/AID team and provision of LANDSAT materials, that all resources will be provided by Morocco.

There is a substantial new IBM computer facility available in the Ministry of Agriculture. At least one of the computer software specialists has gone through a training program of 6 weeks under Bill Wigton in UN/FAO, Rome. However, the computer facility is new and they are presently slow in processing large streams of data. Alternatively, a small mini computer could be purchased by USDA/AID (for $12,000) and - with modification of the programs already developed by USDA to meet Moroccan conditions - could be operated directly in

the Division of Statistics and Economics for preparing national estimates. Clearly, however, the IBM computer might be of value if Phase 3 is introduced in Morocco.

The technical personnel participating in the pilot study carried out during Phase 1 in the Kenitra area would form the cadre for training or field interviewing groups for the country-wide survey.

Phase 3 - Computer Classification

There are no significant remote sensing facilities, personnel or software presently in Morocco. The quality of personnel potentially available is high. However, the Department of Agriculture is interested in implementing Phases 1 and 2, and with a well-planned training program and implementation of software, Phase 3 could be introduced. If started no later than March, 1980, a Phase 3 project could have an impact on improving the crop forecasting possibly in the form of a pilot study involving several provinces for the 1980-1981 crop season. It is unlikely, however, that a substantial country-wide program could be developed for the 1980-1981 season. At best then only an experimental and pilot study could be carried out within the time frame of the project. I doubt whether there was real understanding of the magnitude of the commitment by Moroccan personnel. A further visit would be necessary to investigate the feasibility of a Phase 3. In-depth discussions with the computer systems personnel and investigations of delivery schedules of computer compatible tapes and costs from Telespazzio in Italy, would be necessary. Phase 3 could not be put together in the time that is available, if it had to follow the development of the area frame.

The feasibility analysis started concentrated on personnel, computational and software matters, difficulties of software conversion and obtaining computer compatible tapes from Telespazzio. It would require a significant investment of Moroccan personnel and would probably require virtually continuous use of a very experienced computer programmer from the United States well familiar with such procedures. It should not be sold as an operational program, but rather as pilot research potentially leading to an operational project.

Phase 4 - Agro-Meteorological Modeling

The likelihood that a useful Phase 4 could be gotten underway in Morocco appears higher than that of Phase 3. The Meteorological Service is interested, and has a related project already underway. With objective yield forecasting installed in Phase 2, a Phase 4 project designed to monitor the condition of the crops after the date of the objective yield forecast, and up to the harvest, is potentially possible and could be carried out independent of whether Phase 3 is introduced or not. A feasibility study would be required to establish in detail the exact form of such an experiment.

The meteorological service in Morocco has 30 first order stations connected by teletype to the central forecasting facility gathering daily data on temperature, rainfall, evaporation, and relative humidity. Some 90 additional stations provide data every 10 days, but only on total daily rainfall. In addition they have facilities for receiving the visible band of Meteosat (European earth synchronous meteorological satellite, comparable to the SMS/GOES and NOAA satellites). They have no personnel trained in and familiar with the use of nor do they have

the capability to receive Meteosat thermal IR data. They thus have part of the capability needed to monitor daily rainfall utilizing meteorological satellite data from Meteosat and from NOAA 5 and NOAA 4 satellites in conjunction with their 30 station teletype network.

Under United Nations/FAO and WMO sponsorship there is a joint agrometeorological project directed by Dr. Cremeinis. A United States agrometeorological project is based upon the use of the 10-day accumulated rainfall statistics. The data is forwarded to a central station in Algeria which, under Cremeinis's direction, monitors general crop condition with an emphasis on wheat. This is a 3-year project which is only just begun. Mr. Saad, director in the Moroccan meteorological service, was much interested in the possibility of an agrometeorological project that would employ the meteorological satellite data and in addition monitor in a more timely manner (than every 10 days) crop progress and condition. It was clear from the discussions that Morocco would be a good potential choice for pushing a project through Phase 4. This is irrespective of whether a Phase 3 LANDSAT computer phase were introduced.

A feasibility study would need to be carried out to determine whether a pilot agrometeorological study of a portion or the whole of Morocco might be appropriate. The principal purposes of the feasibility study would be to establish: (a) the personnel and material resources needed to carry out both pilot studies and potential operations; (b) background agronomic and related research available in Morocco; (c) new agronomic and meteorological research needed in Morocco; (d) cooperating personnel in the Ministry of Agriculture, the Meteorological Service, the Departments of Agronomy of the universities, and cooperating

agricultural experiment stations; (e) estimates of cost of pilot study; (f) ground rules and procedures for performance of pilot study; and (g) cost estimates for an operational country-wide agro-meteorological monitoring system.

Project Management and Project Needs

Project Management

The Division of Statistics and Economics, Moroccan Ministry of Agriculture (DSE) will be the in-country key agency with support from USDA/USAID for Phases 1 and 2. Personnel, equipment, vehicles and in-country travel are expected to be covered satisfactorily. Questions of space for TDY personnel remain to be resolved. LANDSAT imagery, including special enhancements if appropriate, and stable base maps would be provided by USDA/AID. Aerial photographs and project consumable maps would be provided by Morocco. In-country management of Phases 3 and 4 remain to be evaluated in a feasibility analysis in the Fall, 1979.

Mangement of USAID/USDA contributions would be by DS/ST for AID and ESCS for USDA. USDA/ESCS would manage all subcontractors technical and scientific work including Phases 3 and 4 if introduced.

Project Needs - Summary

Phase 1 - LANDSAT imagery (USDA)

- Existing Aerial Photography (Morocco)
- Training in Photo Interpretation & Frame Construction
- TDY Statistician, Photo Interpretation.

Phase 2 - In-country short course on survey methods (in French)

- Training assistance for enumerators & supervisors
- TDY Mathematical Statistician, Field Interview Supervisor & Computer Programmer
- Desk-Top Computer for National Totals Aggregation

Phase 3 - Feasibility Analysis. If proven feasible then:

- Telespazzio agreement to provide digital LANDSAT tapes during critical times in growing season
- TDY Management/co-ordination/training of Moroccan personnel in remote sensing for agriculture, Wigton-Huddleston procedures, integration of ground statistics for Phase 2 etc.

Phase 4 - Feasibility Analysis. If proven feasible then:

- Concentration on Wheat and other small grains
- Determination of models employing ground and/or meteorological satellite observations
- Subcontractor support of Moroccan agro-meteorologists and meteorologists

(d) Asia

(1) Philippines

The Philippines has a land area of 116,000 square miles. It takes 43 Landsat frames to cover all the islands, 30 frames for land areas alone. The major land uses amenable to measurement from remote sensing are irrigated lowland rice, rain-fed lowland rice, upland diversified crops, sugarcane, coconut, ranches, open land, denuded forests, forests, swamps, marshes, mangroves, and built-up areas.

Government of Philippines Interest, Motivation, and Capability to Carry Out the Project

Phase 1 - Area Frame Sampling

Initial contacts with the Bureau of Agricultural Economics staff indicated that they were rather cautious in making changes. They had been used to the list sampling system and had not started on the area frame sampling system. Mr. Bruce Graham (USDA ESCS) has worked with the group before and thus has their confidence. It is expected that after a brief period of working with them again, Mr. Graham, together with Mr. Charles Caudell (USDA ESCS), would have a positive effect on them.

Within the Ministry of Agriculture, the Bureau of Soils had some staff members fairly well-trained in the interpretation of conventional airphotos, but there was very limited experience in using Landsat data. It was interesting to note that this group did not participate in, for instance, the Mindoro project (Landsat) which was recently completed under the sponsorship of USAID. It appeared that in the conduct of the proposed program, participation and coordination of talents of photo interpretation and remote sensing groups from the various agencies should be effectively directed.

Director Alcacid, of the Bureau of Soils, is very interested in the program. He advocated the establishment of a Landsat receiving station in the Philippines and indicated that the Agricultural Ministry should play a major role in remote sensing to monitor the many changing features (in

contrast to such relatively unchanging features as geology). Mr. Santos of his Bureau had gone through a brief LARS training program at Purdue University in 1972. The Soils Bureau is working on a set of land use maps covering the entire country. Maps covering the Island of Luzon had been completed and the rest might be completed in a year. These would be of great value to the proposed area frame sample.

The major remote sensing group is located at the Natural Resources Management Center, Ministry of Natural Resources. The remote sensing activities there is built around the General Electric Image 100 which is used actively for various projects, mostly oriented to geology and mining. This appeared to be an enthusiastic and effective group and had extensive training and educational plans as well. They do not perform traditional photo interpretation themselves. They believe that besides identifying crops (including rice, corn, sugarcane and coconut), the satellite images might also pick up information about the effects of irrigation. They agreed that mixed crops and small fields would present problems.

The University of Philippines Training Center group is primarily engaged in airphoto interpretation training and projects. Dr. Bruce of the university said that nearly all of the Philippines is covered by 1968 or more recent 1:15,000 scale airphotos, in addition to the complete coverage by older military airphotos. Over the years, his Center has trained many photo interpretors from various government

departments, now returned and scattered in the agencies.

One project he is working on is of major significance to the area frame. In this project, he is compiling three sets of maps for the whole country under the sponsorship of Dr. Florencio Librero, director of the National Training Center for Rural Development at the University. These three sets of maps would cover: 1) soils of the Philippines, 2) slopes of the Philippines, and 3) present land use of the Philippines. They were based on existing information from maps as well as from the 1 to 15,000 scale air photos. The first two sets of maps has been completed. The third set was 20% completed and expected to be 100% completed by September 1979. This land use set would classify the land into nine categories: 1) irrigated lowland rice, 2) rain-fed lowland rice, 3) upland diversified crops, 4) sugarcane, 5) coconut, 6) ranch, open land, and denuded forest, 7) forests, 8) swamp, marsh, and mangrove, and 9) built-up area. This last set of maps would provide valuable data for the area frame.

Phase 2 - Field Survey

The Bureau of Agricultural Economics is presently conducting field surveys using list sampling as a means to select fields for ground enumeration. The objective of phase 1 above will be to convince this Bureau to change to area frame sampling methodology. If at the conclusion of phase 1 this Bureau decides not to use the area frame for enumeration, we will terminate the project at this point in the Philippines.

Phase 3 - Computer Classification

Whether the Philippines is going to have a Landsat receiving station is a significant factor influencing phase 3 of the project. It takes about 43 frames of Landsat images to cover the entire country, about 30 frames for land areas alone. Mr. Bruce Graham brought along a computer printout from the U.S. of available Landsat images covering the Philippines. This printout indicated that there were only 164 good quality acquisitions during the years 1972 through 1978. This points to the lack of adequate data if a Landsat receiving station is not to be established in the Philippines. Many more useful sequential images would be needed in phase 3 to classify crop by real time processing of Landsat data tapes.

At the Ministry of Agriculture, Assistant Minister Zosa questioned many aspects and was skeptical about the merit of establishing a Landsat receiving station in the Philippines just for the benefit of crop yield forecasting. He thought that much additional benefits such as minimizing crop damages and monitoring natural hazards would be needed to justify the cost of the station.

As for the capacity of the computer classification work, there was a nucleus of remote sensing people in the Natural Resources Management Center working around the Image 100 equipment. This would be an excellent base for automatic classification of large fields if current Landsat data were

available. There were also likely scattered remote sensing talents in the various departments. In the area of photo interpretation, there seemed to be sufficient support, trained by Dr. Bruce and others, scattered in the various departments. Coordination to maximize efforts would be needed.

Technical problems regarding small fields, mixed and/or rotational crops as well as the prospect of improved resolution that would favor the use of the future Landsat are common to about all Southeast Asian countries, and not necessarily peculiar to the Philippines. For this reason, as well as the reluctance of the Ministry of Agriculture to adopt new technology, it is not recommended to proceed to phase 3 in the Philippines.

Phase 4 - Agro-Meteorological Modeling

There was no active R&D discovered in the Philippines using agro-met models for crop yield assessment. It is possible that any efforts were missed; however, if the agencies contacted were deeply committed to this endeavor, it must be assumed that they would have broached the subject during the discussions which the design team had there. It is recommended that phase 4 not be considered in the Philippines.

Project Management and Project Needs

Project Management

The Philippines Bureau of Soils should be the coordinating agency of this project in the Philippines. Although the manpower is available in the Ministry of Agriculture, their

reluctance to adopt new technology such as area frame sampling indicates that they will be a follower instead of a leader in this project. The Natural Resources Management Center will be involved and, although it is well equipped and staffed to perform automatic image classification of crops, this Center will not be the lead agency since the application is in agriculture. The Center's usual work is in geological and coastal mapping. USDA personnel would work in cooperation with the Bureau of Soils, with USDA providing Landsat imagery and stable base maps. The Bureau of Soils and Ministry of Agriculture would provide working space, personnel, equipment, and vehicles.

Project Needs - Summary

Phase 1 - Landsat imagery (USDA)

- Existing Aerial Photography (Philippines)
- Training in Frame Construction (USDA)
- TDY Statistician, Photo Interpretation (USDA)

Phase 2 - In-country short course on survey methods (USDA)

- training assistance for enumerators & supervisors (USDA)
- TDY Mathematical Statistician, Field Interview Supervisor, & Computer Programmer (USDA)
- Desk Top Computer for National Totals Aggregation (USDA)

(2) Thailand

Thailand has a land area of 200,000 square miles. It takes 23 Landsat frames to cover all land areas of Thailand. Thailand is a major food-exporting country and depends greatly on the foreign exchange generated by such exports. However, exports vary greatly with the success of the crop harvest and prevailing market conditions. In 1976 Thailand exported 1.9 million metric tons of rice. In 1977 Thailand's rice export set a record at 2.9 million tons, but the 1978 crop is expected to fall back to 1.8 million tons as a result of drought. Similarly corn, sugar, and cassava exports vary greatly from year to year. Thailand is concerned about the effects of variable production and exports on the availability of domestic supplies. Above all, it needs better crop information for setting export policies.

Royal Thai Government (RTG) Interest, Motivation, and Capability to Carry Out the Project

Phase 1 - Area Frame Sampling

Under a DS/ST-funded grants project, area frame sampling was introduced to Thailand in 1977. Due to severe cloud problems that crop year, no current Landsat imagery could be obtained on the satellite tape recorders and the project failed to demonstrate the applicability of Landsat imagery in building frames. Since that time, Iowa State University has been working with the RTG Division of Agricultural Economics (DAE), building frames with the help of aerial photography.

Because the aerial photos are now quite old, and because the Thais are building a Landsat receiving station which will assure them current image data, they are interested in participating in this project to update area frames in those provinces where their existing frames need updating, as well as building new frames in the remaining provinces.

At the Ministry of Agriculture, the staff of the Division of Agricultural Economics has the interest to cooperate, and capacity to carry out the program with the guidance and assistance from the staff of the U.S. Department of Agriculture. Forecasting yields of their major crops--rice, corn, sugarcane and possibly cassava--is very important. Although their staff appear to be technically weak at this time, the USDA staff would find them a good group to support and work with.

There was little remote sensing capability within the Agricultural Economics group. However, within the Ministry of Agriculture, there were people trained in photographic interpretation scattered in the Forest Department, the Land Development Department, and possibly others, who were capable of undertaking some aspects of the proposed program.

Phase 2 - Field Survey

The Division of Agricultural Economics presently has many field enumerators collecting agricultural data on the ground. These people are well trained, and the Thai know how to train more. Other than the RTG involving these

enumerators in the demonstration surveys of this project, there is no further RTG cooperation, nor USDA training or assistance, needed in this phase.

Phase 3 - Computer Classification

Regarding remote sensing, the two major sources of support would be the National Research Council (NRC) and Asian Institute of Technology (AIT). The NRC has facilities to process, print, and interpret satellite data such as Landsat products. They are highly motivated, enthusiastic and willing to proceed. AIT has excellent computing facilities and personnel. They work with an IBM 370/145 and are knowledgeable in digital analysis of satellite images. This fact, together with the impending establishment of the U.S. co-sponsored Regional Remote Sensing Training Center, to be located at AIT, would be a very strong asset to this Agriculture Project. The Center staff here, however, was not strong in traditional air photo interpretation, which would be needed in some aspects of the program. Some means to integrate the photo interpretation personnel from different departments within the government and to have them interact with the remote sensing group at NRC would be essential for a successful program.

It is proposed that a feasibility study be conducted under this project to assess in greater detail the desirability of entering phase 3 of this project. Although rice, grown in small fields thousands of which are contiguous and thus

amenable to Landsat identification, might be automatically classified by computer techniques, other crops are grown in small fields and are mixed and annually rotated, making ground truthing and computer training difficult.

Phase 4 - Agro-Meteorological Modeling

Metoerological input would come from weather satellite data from the Office of Meteorology. In addition to the construction of a Landsat receiving station, the Thai are also installing a new weather satellite receiving station (to receive the new TIROS-N and the Japanese GMS data). The Ministry of Agriculture however has the responsibility of modeling crop yield with these data. The Ministry of Agriculture in addition has plans to expand their existing computer facility to provide for this yield modeling. As this Ministry is responsible for the area frame sample, it is recommended that a feasibility study also be done to better assess the RTG readiness to proceed with this phase.

Project Management and Project Needs

Project Management

The Department of Technological and Economic Cooperation (DTEC) is the coordinating agency in the RTG for this project. They will involve the Division of Agricultural Economics as a lead agency in phases 1 and 2, the National Research Council in phase 3, and appropriate Ministry of Agricultural and Meteorological personnel in phase 4. The National Research

Council will lend their remote sensing skills where necessary throughout all phases of the project.

Project Needs - Summary

Phase 1 - Landsat imagery (USDA - until RTG station operational April 1980)

- Existing Aerial Photography (RTG)
- TDY Statistician (USDA)

Phase 2 - None

Phase 3 - TDY Image Analyst, Computer Programmer (USDA)

- Landsat receiving station (RTG)
- U.S. training on digital image analysis (USDA)

Phase 4 - Improved weather satellite receiving station (RTG)

- Yield models (RTG and USDA)

(3) Indonesia

Indonesia has a land area of 735,000 square miles made up over 13,000 small islands and spanning an area of 3,000 miles in an east-west distance. There are up to seventy Landsat images covering the main islands alone. It is the fifth most populated country in the world and world's largest importer of rice. Each year around 2 million metric tons of rice are imported to supplement the rice grown in Indonesia. The Government of Indonesia pays dearly for that grain.

The Department of Agriculture in Indonesia is extremely understaffed. Most of the Departments are functioning and the heads are extremely competent but adequate staff at the

lower level at the present time is not possible because of a lack of qualified people. AID/Indonesia has a contract with Iowa State University to train Agriculture economists, install a data processing center, and build a capability to use agricultural statistics as input data to linear programming models for economic models. The remote sensing project would tie in very nicely to the existing project because we would improve the agricultural statistics and the Indonesians could make excellent use of the data generated by this project.

Government of Indonesia Interest, Motivation and Capability to Carry Out Project

Phase 1 - Area Frame Sampling

In Indonesia two Departments are interested in the Area Sampling Frame and Phase II work. The Central Bureau of Statistics (CBS) has shown interest in the remote sensing project. USDA evaluation teams have met two times with the Director General, Abdul Madjid, who is responsible for collecting data in the field. At the present time Indonesia uses an FAO data collection system that is very inefficient for agricultural data. The field interviewers have to spend a lot of time in the field doing field listing. The CBS could use the area sampling frame to collect data on all types of land use related surveys, not only agriculture. The Ministry of Agriculture also has indicated that they would like to have the remote sensing project tie into the Iowa state project.

Work could start soon with counterparts from both Ministry of Agriculture and CBS. CBS would take the lead and provide the facilities and most of the personnel. Plans are to start in two areas--one in Central Java and another in Sumatra. Next, all of Java and Sumatra will be completed. Bakosurtanal, Agriculture School at Bogor (IPB), and CBS have expertise to construct a photo mosaic, photo interpret aerial photography and satellite imagery, and to select samples. Bakosurtanal has all available Landsat images for Indonesia. Also they are in the process of obtaining color IR photography for most of the big islands. They have excellent facilities and seem very willing to help. Their land use maps made from color IR will be very useful for this project. Good maps will be a problem since in some areas they are not available. Funding for Indonesian personnel may be a problem but the Indonesians are planning to obtain funds.

Phase 2 - Field Survey

At present CBS has field intervievers with experience. Once they have been trained, and considering their great interest, they will be excellent for this project.

No phases 3 and 4 are planned for Indonesia.

Project Management and Project Needs

Project Management

The Indonesian government needs this project to improve its agricultural data as input to planning for imports of rice and acquiring foreign exchange. Some highly skilled Indonesians

are working within the various departments, however, more are needed. Transportation and communication will not be simple but the project will be extremely useful to both AID/Indonesia to help in planning, using the Iowa State project, and to assist in determining PL480 food needs, and to the Indonesian Government, to help them with many of their data needs relating to agricultural and planning in the Ministry of Agriculture.

Indonesia represents a tough challenge to the project. There are many islands, and transportation is difficult, even on one island. This country will require intensive USDA technical assistance. Landsat imagery is scarce. The Central Bureau of Statistics will be the coordinating agency in Indonesia.

Project Needs - Summary

Phase 1 - Landsat imagery (USDA)

- Existing Aerial Photography (Indonesia)
- TDY Statisticians (2), Photo Interpreters (2), (USDA)
- Gaja Mada & Bogor university support (Indonesia)

Phase 2 - Ground enumerators (USDA-2, Indonesia-10)

- Gaja Mada & Bogor univerisity support (Indonesia)
- Desk Top Computer for National Totals Aggregation (USDA)

- In Country Short Course on survey methods (USDA)

- TDY Mathematical Statistician, Field Interview Supervisor, and Computer Programmer (USDA)

Draft 3/9/79

INTERAGENCY AGREEMENT

AMONG THE

UNITED STATES DEPARTMENT OF AGRICULTURE,

UNITED STATES DEPARTMENT OF COMMERCE,

UNITED STATES DEPARTMENT OF THE INTERIOR,

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,

AND THE

AGENCY FOR INTERNATIONAL DEVELOPMENT

FOR A

JOINT PROGRAM FOR

(AGRICULTURE AND RESOURCES INVENTORY

SURVEY THROUGH AEROSPACE REMOTE SENSING)

(AGRISTARS)

I. GENERAL INFORMATION

WHEREAS, the Department of Agriculture has responsibility within the Federal government to acquire, analyze, and interpret information for the purpose of estimating and forecasting national and international supply and demand for agricultural commodities; for measuring and assessing impact on agricultural production of changes in land use, conservation practices, and pollution, and for reporting this and appropriate related information to the people of the United States; and,

WHEREAS, the Department of Commerce, through the National Oceanic and Atmospheric Administration, has responsibility within the Federal government for the monitoring and reporting of weather conditions, the forecasting of weather, the issuance of storm and other severe weather warnings, and the collection and dissemination of global weather information and the distribution of meterological and climatological information; and,

WHEREAS, the Department of the Interior is one of the principal agencies of the Federal government responsible for the management of the nation's natural resources, including public and Indian lands, territories and outer continental shelf areas; and has responsibility within the Federal government for the public dissemination and sale of USGS remotely-sensed earth resources data and NASA acquired Landsat data; and,

WHEREAS, the National Aeronautics and Space Administration has responsibility within the Federal government for the preservation of the role of the United States as a leader in aeronautical and space science and technology and for developing techniques to apply this technology and for collaborating in the transfer of this ability in the conduct of peaceful activities; and,

WHEREAS, the Department of State, through the Agency for International Development, has responsibility within the Federal government for assisting developing nations of the world in establishing natural resources information systems and for transferring related technology.

NOW, THEREFORE, these agencies enter into this agreement to cooperate in the application of aerospace and related technology for agricultural resources management.

II. PURPOSE

The purpose of this agreement is to provide a framework for a seven year program including a six year program of research, development, and application of aerospace and related technology for agricultural resources management beginning in FY 80 and continuation of existing cooperative efforts in FY 79. This program will build on experience gained through prior research, development, and testing -- both intra and interagency.

The primary goals of the joint effort are to determine the extent to which aerospace remote sensing data can be used to improve the objectivity, timeliness, reliability, and adequacy of information for management of agricultural resources and to provide an input for future USDA decisions regarding the routine operational use of satellite sensed data. This program addresses the following information requirements identified by the Secretary of Agriculture:

1. early warning of changes affecting production and quality of commodities and renewable resources;

2. commodity production forecasts;

3. land use classification and measurement;

4. renewable resources inventory and assessment;

5. land productivity estimates;

6. conservation practices assessment; and,

7. pollution detection and impact evaluation.

Specifically, this agreement provides a mechanism to focus research and development and operational activities of supporting agencies on the identified requirements of USDA; establishes a

management structure which will ensure maximum utility of agency resources allotted to the joint program and coordination of related research and development and operational activities of the participating agencies, identifies the roles and responsibilities of participating agencies, and provides the framework for preparation and approval of a detailed plan for the program.

III. REFERENCES AND AUTHORITIES

USDA enters into this agreement pursuant to the authority vested in it by 7 USC 2201; USDC enters into this agreement pursuant to the authority vested in it by 15 USC 313; USDI enters into this agreement pursuant to the authority vested in it by 31 USC 716 A&C; NASA enters into this agreement pursuant to the authority vested in it by 42 USC 2473 (d) and, AID enters into this agreement pursuant to the authority vested in it by 22 USC 2392.

IV. DEFINITIONS

User Agencies - USDA and AID, and USDI Supporting Agencies - USDC, NASA, USDI

V. AGENCY ROLES

A. USDA

1. As lead agency, define information requirements and

priorities for USDA programs; and,

2. cooperatively plan, with other agencies, research, development, and technology programs addressing USDA requirements; and,

3. participate in research and development of techniques for analysis and interpretation of remotely sensed data; and,

4. develop capability and plans for large-scale tests and evaluate technology and procedures which emerge from the research program; and,

5. integrate new aerospace data and techniques which meet their needs and are cost effective into operational global early warning and commodity production forecasting systems.

B. USDC

1. Collect, validate, analyze, and disseminate environmental data of NOAA which are required by the joint program; and,

2. provide general and specialized environmental forecasts as required; and,

3. develop, maintain, and disseminate climatic information as required; and,

4. operate the environmental satellite system to provide data and develop techniques for analysis and interpretation of the data as agreed to in the program plan; and,

5. work with USDA in determining the basic environmental data for current impact assessment; and,

6. cooperatively plan with other agencies, research, development, and technology programs that address their USDA requirements and specifically establish joint activities with USDA to develop quantitative crop yield/weather models.

C. USDI

1. Evaluate utility and applicability of research and development products from this program to USDI missions; and

2. disseminate preprocessed Landsat and certain aircraft data to agreed upon requirements of timeliness and format necessary to support the research, development, and application activities carried out under this joint program.

D. NASA

1. Assume lead in supporting research activities that lead to advance techniques for analysis and interpretation of aerospace remotely sensed data; and,

2. Assumes lead in research, development, and pilot test of foreign commodity production forecasting techniques.

3. cooperatively plan, with other agencies research, development, and technology programs that address user agency requirements; and,

4. collect and provide preprocessed data from NASA satellites and aircraft necessary to support research, development, and applications activities carried out under this joint program; and,

5. develop requirements for new sensors and research systems.

E. AID

1. evaluate utility and applicability of research and development products to their programs.

VI. MANAGEMENT

A. Program Review and Policy Guidance Boa

The activities under this agreement shall be under the overall policy guidance of appropriate policy-level officials from each agency at the Assistant Secretary or equivalent level. This group shall, at least semi-annually:

1. review program to assess progress; and,

2. assess need for change of emphasis or direction; and,

3. resolve issues brought forward from Interagency Coordinating Committee

B. Interagency Coordinating Committee

This Committee, chaired by USDA, will be composed of one senior representative from each agency, and operating within the overall policy guidelines, will meet at least quarterly to:

1. approve program objectives and establish priorities;

2. approve the detailed joint program plans and schedules and changes thereto;

3. assess progress, identify problems and develop corrective actions,

4. coordinate the use of resources assigned to the joint program; and

5. approve all press releases concerning this program.

C. Joint Program Management Team

The Program Management Team, led by USDA consisting of members from each participating agency, and operating within guidelines established by the Interagency Coordinating Committee, will be responsible for:

1. preparation of the detailed program plan; and,

2. management of the program to meet the objectives within the schedules and funding constraints.

VII. JOINT PROGRAM PLAN

The joint program plan will be the controlling document for the program and will contain the program objectives, the detailed responsibilities of each agency toward meeting these objectives for program elements, expected accomplishments, schedules, and

resources. This document will be controlled by Interagency Coordinating Committee and changes issued when approved.

VIII. RESOURCES

Each agency is expected to provide and manage their resources necessary to meet agreed upon commitments, subject to limitations imposed by appropriations.

IX. PUBLIC AFFAIRS/PRESS LIAISON

Press releases shall be released simultaneously by all agencies or with concurrence by the others when a release is by one agency.

X. AMENDMENTS AND REVIEW

This agreement may be amended at any time by the mutual agreement of the Program Review and Policy Guidance Board. This agreement will be reviewed periodically, by all participating agencies, but not less than annually. Each agency agrees that prior to major changes in policy, budgets, or procedural practices in the agency, they will communicate this information immediately to the other agencies.

XI. EFFECTIVE DATE, DURATION, AND TERMINATION

This agreement will remain in effect from the date of the last

signature to this agreement until its termination on September 30, 1985. An Agency can withdraw from this program upon 90 days written notice. This program is subject to mutual termination at any time.

XII. OTHER PROVISIONS

Nothing herein intended to conflict with current directives of any agency which is a party to this agreement. However, should any of the terms of this Agreement be found to be inconsistent with future Agreements or Directives, the provisions of this Agreement shall govern until such inconsistency is resolved. This Agreement shall be modified, as necessary, to be consistent with changes in Law or Executive Orders.

USDA

NAME:

TITLE: **DATE:**

NOAA

NAME:

TITLE: DATE:

USDI

NAME:

TITLE: DATE:

NASA

NAME:

TITLE: DATE:

AID

NAME:

TITLE: DATE:

ANNEX 3

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

Sept. 27, 1978

Honorable James T. McIntyre, Jr.
Director, Office of Management and Budget
Executive Office of the President
Washington, D. C. 20503

Dear Mr. McIntyre:

The need for improved world-wide information on prospective crop production that impacts trade in commodities, development and administration of domestic farm programs, management of food reserves and effective use of natural resources has been dramatized on several occasions in the 1970's. Two of the most recent examples are the reduced 1977 Soviet Union wheat crop and the short 1978 Brazilian soybean crop that were not identified until a significant portion of the U.S. crop had been sold by farmers. I feel that the use of aerospace technology provides a possible avenue, with significant potential, for better satisfying such USDA information requirements.

We have just completed several years' cooperative research with DOC and NASA on forecasting wheat production in several major producing countries using aerospace technology. Enclosed are USDA and NASA documents that (1) discuss the essence of the LACIE project, (2) provide comparison data for LACIE and official USDA forecasts, (3) identify key technical and operational problems, and (4) indicate the direction for future work to capitalize on the LACIE experience.

The Secretaries of Agriculture, Commerce, and Interior and the Administrators of the Agency for International Development and the National Aeronautics and Space Administration met recently to discuss the development of a long range multi-agency program of continuing and new research, development and application of aerospace technology for satisfying USDA and other cooperating agencies' information requirements. There was unanimous agreement that a responsive program can and should be developed. Further, the potential economic impacts of inadequate information are so great that this effort should be undertaken despite FY '80 budget constraints.

The technical staffs of each agency have devoted considerable effort to the development of a joint integrated multi-year program for broad application of this technology in agriculture, building on previous experience and results.

My associates from the cooperating agencies and I have reviewed a proposed joint program and feel the modest funding increases for the purposes outlined in the lead sentence merit inclusion in the FY '80 budget.

These efforts are truly interagency in nature, and hence should be reviewed and analyzed as a single program. The role each agency will assume in this joint program is reflected in its individual FY '80 budget submission. We will appreciate your arranging for our staffs to conduct a joint briefing for the OMB Budget Examiners for these agencies. This would enable us to cover the entire program with a single briefing and provide the examiners with a more complete understanding of the total program.

Sincerely,

BOB BERGLAND SEP 0 5 1978
Secretary of Agriculture

ROBERT A. FROSCH
Administrator, NASA

JUANITA M. KREPS
Secretary of Commerce

CECIL D. ANDRUS
Secretary of Interior

JOHN J. GILLIGAN
Administrator, AID

Enclosures

ANNEX 3

EXECUTIVE SUMMARY JOINT PROGRAM FOR APPLICATIONS OF AEROSPACE TECHNOLOGY IN AGRICULTURE

USDA-USDC-USDI-NASA-AID
SEPTEMBER 29, 1978

RECIPIENTS OF THIS REPORT ARE REMINDED
THAT FY 1980 BUDGET ESTIMATES AND RECOMMENDATIONS
CONTAINED HEREIN ARE ADMINISTRATIVELY CONFIDENTIAL UNTIL MADE
PUBLIC BY THE PRESIDENT IN ACCORDANCE WITH
OFFICE OF MANAGEMENT AND BUDGET CIRCULAR NO. A-10,
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SUMMARY

This document describes a six-year program of research, development, and applications of aerospace remote sensing for agricultural resources beginning in fiscal year 1980. The program is a cooperative effort of the USDA, USDC, USDI, NASA, and AID.

The primary goal of the program is to determine the extent to which aerospace remote sensing data can be used to improve the objectivity, reliability, timeliness, and adequacy of USDA information for support of national agriculture and trade policies. A secondary goal is to integrate the resulting technology into routine use in either existing or future USDA/USDI information systems. The overall approach is through a balanced program of remote sensing research, development, and testing which addresses domestic resource management as well as foreign commodity production information needs.

The program specifically addresses seven information requirements identified in the USDA Secretary's Initiative[1] as follows:

1. early warning of changes affecting production and quality of commodities and renewable resources;
2. commodity production forecasts;
3. land use classification and measurement;
4. renewable resources inventory and assessment;
5. land productivity estimates;
6. conservation practices assessment; and,
7. pollution detection and impact evaluation.

While all seven are of major importance to the USDA, the first two requirements, early warning and commodity production forecasting, have been given the most emphasis because of the USDA's most immediate need for better and more timely information on world crop conditions and expected production.

The USDI has identified areas of common interest with those of USDA in land and water resources management and has defined a complementary project to establish a national facility for the dissemination of Landsat and aircraft data to be considered in the normal budget process.

This plan addresses the information requirements in three major discipline areas: Crops, Renewable Resources (primarily Forest Resources), and Land Use (including productivity, conservation, and pollution). The crop discipline is subdivided into an Early Warning/Crop Condition Assessment (EW/CCA) activity, a Commodity Production Forecasting activity and

[1] Joint Program of Research and Development of Uses of Aerospace Technology for Agricultural Programs dated February 1978.

Supporting Research activities. The EW/CCA addresses 19 crop/region combinations in the U.S. and seven foreign countries (USSR, Argentina, Brazil, Canada, People's Republic of China, Mexico, and Australia) for six major commodities (wheat, barley, corn, soybeans, rice, and cotton). This function will begin limited operations in fiscal year 1980, primarily with qualitative assessments and will expand to provide operational capability and quantitative assessments by 1985.

The Commodity Production Forecasting activity addresses 12 crop/region combinations in the U.S. and six foreign countries (USSR, India, Argentina, Brazil, Canada, and Australia) for the same six commodities as EW/CCA. Specific objectives of this program element are to improve the precision of state and local acreage estimates in 10 states in the U.S. and to provide operational capability for improved production forecasts in the foreign areas. A USDA investment decision is targeted for late fiscal year 1981, to insure adequate time to acquire hardware, software, facilities, and personnel to support the cumulative operational capability by 1985.

The renewable resources inventory and assessment information requirement has been addressed in three main categories; national inventory requirements of the Resources Planning Act (RPA), stress/damage assessment techniques for both man-made and natural disturbances, and improved classification maps for local planning units. Operational use of the Landsat multi-spectral scanner is planned for 1983, and use of the higher resolution Thematic Mapper on Landsat-D by 1985.

The emphasis in land use classification, productivity estimation, conservation practice assessment, and pollution monitoring is directed toward improved predictions and management models, change monitoring capability and the establishment of common data bases for timely, periodic, and objective updating of land use categories.

The primary roles of each department/agency are shown in figure 1. In the yield model development, each department/agency has a unique responsibility for lead development activities. The USDA will focus on the physiological models, NASA on the spectral inputs, and NOAA on the regression-type models. USDI will provide for the storage, retrieval, and dissemination of Landsat data. AID will evaluate utility and applicability of research and development products for AID programs.

FIGURE 1

DEPARTMENT/AGENCY ROLES

USDA

- DEFINE INFORMATION REQUIREMENTS
- RD&T AND APPLICATIONS YIELD MODEL DEVELOPMENT
- RD&T - APPLICATIONS ANALYSIS FOR AREA, YIELD, AND PRODUCTION ESTIMATION
- AGRONOMIC/ANCILLARY DATA BASE
- LARGE SCALE APPLICATIONS TEST
- GROUND DATA COLLECTION
- RD&T AND APPLICATIONS CROP/WEATHER ASSESSMENTS
- EARLY WARNING APPLICATIONS
- RENEWABLE RESOURCES APPLICATIONS - RD&T AND ANALYSIS
- LAND USE, PRODUCTIVITY, CONSERVATION & POLLUTION APPLICATIONS - RD&T AND ANALYSIS

NASA

- RD&T AREA AND PRODUCTION ESTIMATION FOR FOREIGN COUNTRIES
- SUPPORTING FIELD RESEARCH
- LANDSAT DATA BASE
- RD&T SPECTRAL INPUTS TO YIELD MODELS
- SUPPORTING RESEARCH, DEVELOPMENT, AND TECHNOLOGY QUANTITATIVE EARLY WARNING ASSESSMENT
- RD&T INVENTORY & PRODUCTION TECHNIQUES FOR TIMBER & RANGE LANDS
- RD&T INVENTORY AND MONITORING TECHNIQUES FOR LAND USE PRODUCTIVITY, CONSERVATION, AND POLLUTION

NOAA

- METEOROLOGICAL DATA BASE
- APPLICATIONS OF ENVIRONMENTAL SATELLITE DATA
- YIELD MODEL RD&T
- RD&T WEATHER/CROP ASSESSMENTS

USDI

- LANDSAT DATA STORAGE, RETRIEVAL, AND DISSEMINATION

AID

- DEFINE INFORMATION REQUIREMENTS
- APPLICATIONS IN DEVELOPING COUNTRIES

The total program cost is estimated to be $332 million for a six-year period. Of this amount, the USDA program will cost $134 million, the NOAA cost is $21 million, and the NASA cost is $177 million. This option is the lowest of three levels studied.

Funding by fiscal year for the total program is as follows:

	80	81	82	83	84	85	Total
NASA	20.1	33.0	36.5	37.8	37.4	12.6	177.4
NOAA	3.3	3.6	3.6	3.7	3.6	3.3	21.1
USDA	14.6	17.5	19.8	24.3	25.3	32.0	133.5
Total	38.0	54.1	59.9	65.8	66.3	47.9	332.0

NOTE:

1. This program does not include cost for USDA capital investment or operational costs. A decision to utilize the technology operationally would be reflected in the FY 83 USDA budget.

2. All costs are in FY 80 $M.

I. BACKGROUND

The USDA has been actively engaged in developing and using remote sensing in support of major departmental missions since the 1940's. Until the past decade remote sensing efforts largely involved use of aerial cameras mounted in fixed-wing aircraft to obtain photographs of the country's land area. In July 1972, the first Earth Resources Technology Satellites (ERTS), now called Landsat-1, was successfully orbited, and remote sensing took a giant step forward. Since then it has been demonstrated that digital products, as well as image products, derived from the data collected by the Multispectral Scanner (MSS) on Landsat, through appropriate analysis techniques, can provide useful information to those engaged in monitoring and planning the development and conservation of the Earth's resources.

In 1974 NASA, NOAA, and USDA began the Large Area Crop Inventory Experiment (LACIE) to explore the value of Landsat remote sensing for estimating production of an important world commodity, wheat. After conducting this experiment over three crop seasons, the technology has been developed to the point where a country level production estimate was made for the USSR and regional production estimates were made for the U.S. Great Plains and Canada. Technical problems in the project as originally planned made it impossible to measure the statistical accuracy of the LACIE estimates in all countries for several years. However, results show LACIE estimates at harvest for the USSR and winter wheat in the U.S. Great Plains were within the stated accuracy goal. Estimates for the spring wheat crop in the U.S. and Canada were not within the stated accuracy goal. More important than the actual estimates produced by LACIE is the experience base developed in this experiment, and a better understanding of the complexities involved in crop production forecasting and estimation. LACIE has clearly demonstrated the need for well-designed sampling strategies, including adequate sampling frames, also the need to design experiments which will provide measures of all biases and errors, both sampling and non-sampling, associated with crop production estimation. The need for more supporting basic research was identified in LACIE.

Following several years of a small-scale research effort, in 1977, the Statistical Reporting Service (now part of the Economics, Statistics, and Cooperatives Service of USDA) completed an experiment for using Landsat digital data to improve crop acreage estimates for all major spring planted crops in Illinois. This experiment used the large-scale coverage (census) provided by Landsat in combination with a ground-based probability sample to produce estimates of crop acreage and land use at the county, multi-county, crop reporting district, and state levels. This experiment using full frame classification combined with ground data collected from a probability sample, demonstrated the usefulness of remote sensing data for estimating domestic crop acreages and for supporting land use estimation activities.

These two experiments (LACIE and Illinois Crop Acreage Experiment) have provided ample evidence to support additional exploration of the possibilities for extending applications of remote sensing to other domestic uses, as well as additional crops in other countries. The USDA, along with USDI and AID, as user agencies, agreed to generate requirements in these areas. This led the Secretary of Agriculture to define seven information requirements categories in priority order as listed in the Summary. Use of data from

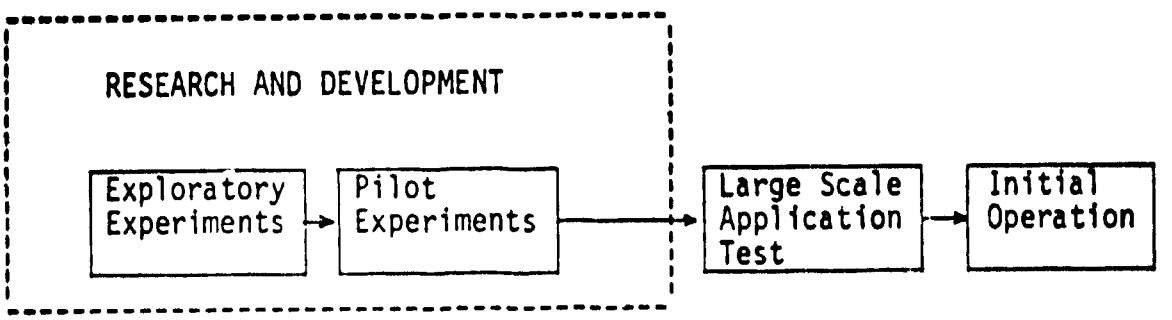
both Landsat and environmental satellites as input to Early Warning and Commodity Production Forecasting has been implicit in the planning effort.

II. TECHNICAL APPROACH

The major elements of the joint plan, in terms of product flow, are shown in figure 2.

Figure 2

Program Structure



The Research and Development element is primarily aimed at component technology capability, including such components as:

- sampling frames/sampling strategies;
- classification procedures;
- yield models/crop calendars;
- data base development; and,
- supporting field research.

This plan assumes that multi-agency teams will be involved in the research and development of components. A pilot experiment may be performed on either a major component, or a first integration of components into a particular system. The Large Scale Application Test (LSAT) is the responsibility of the user agency and will normally be performed in user facilities. Basic system changes will not be made in this element of the program, but if major deficiencies are identified, they will be returned to the Research and Development element for resolution.

The third element or step in the flow process is the Initial Operations (IO). This is defined as adaptation by the operational user of the technology developed by research and development with operational modifications from the LSAT.

The flow of technology through these program elements is not always straightforward and variations will frequently occur. Also, the current state of remote sensing technology clearly indicates that certain capabilities are ready for operations now, some are in a developmental stage for pilot experiments, and some are in a research stage.

III. SCOPE

This program plan has been developed to address in some degree all of the seven information requirements in the Secretary's Initiative document. Because of the high priority assigned to Early Warning and Commodity Production Forecasting approximately three-fourths of the planned work is in direct support of these two requirements; however, it should be noted that a significant part of the effort identified under crops will be of direct benefit in satisfying some of the other information requirements. Figures 3 and 4 are indicative of how efforts designed to satisfy one information requirement flows into or provides partial solutions for other requirements.

A. Crops

The two highest priority tasks in the USDA initiative (and they are all inter-related) are Early Warning of changes affecting commodity production and Commodity Production Forecasting. Developments in remote sensing over the past five years indicate that environmental satellites and the Landsat satellites can effectively provide valuable early warning indications and assessments. These methods are mostly qualitative, but can be quite useful for Early Warning, say for triggering a more quantitative evaluation. These capabilities, when combined with statistical sampling methods, will provide a cost-effective means of meeting USDA operational requirements for global food and fiber monitoring. These capabilities will be of benefit not only in foreign areas, where accurate information is not available, but also in the U.S. at state, county, and crop reporting district levels.

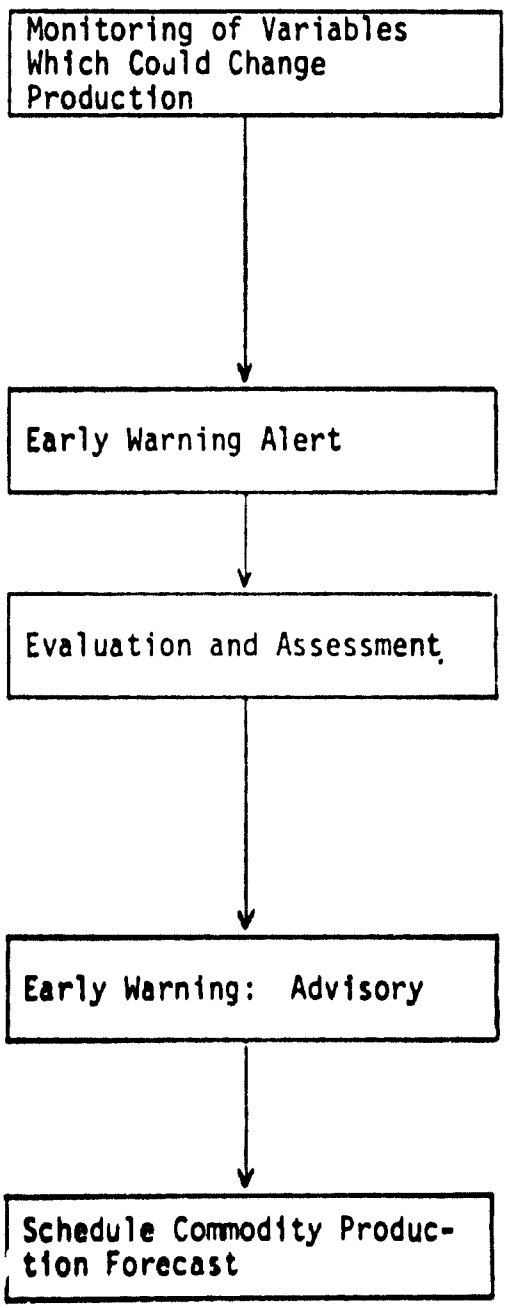
Research, development, and testing for crops will be targeted on three areas to: (1) develop methodology for monitoring crop conditions, especially adverse or superior conditions, and to measure the ultimate effect of these conditions on production; (2) determine optimum (in terms of resources required and accuracy or reliability of data) procedures for using remote sensing data to identify and measure area devoted to target crops; and (3) develop yield models using as independent variables current and improved weather data, the Landsat spectral channel values, and other data that can be measured by remote sensing (including both Landsat and environmental satellite data).

1. Early Warning

The crops monitoring part of the planned joint program concentrates on the urgent need for better and more timely information on world crop conditions and expected production. As a consequence of the natural phasing of

Figure 3

Monitoring Component of a Food Information System



- o Satellite
  - Landsat
  - Environmental
  - Other
- o Meteorological Data
- o Economic
- o Production Inputs
- o Agricultural Policy

- o Identification of event which has occurred or is expected to occur which could significantly impact production levels. May or may not be weather related.

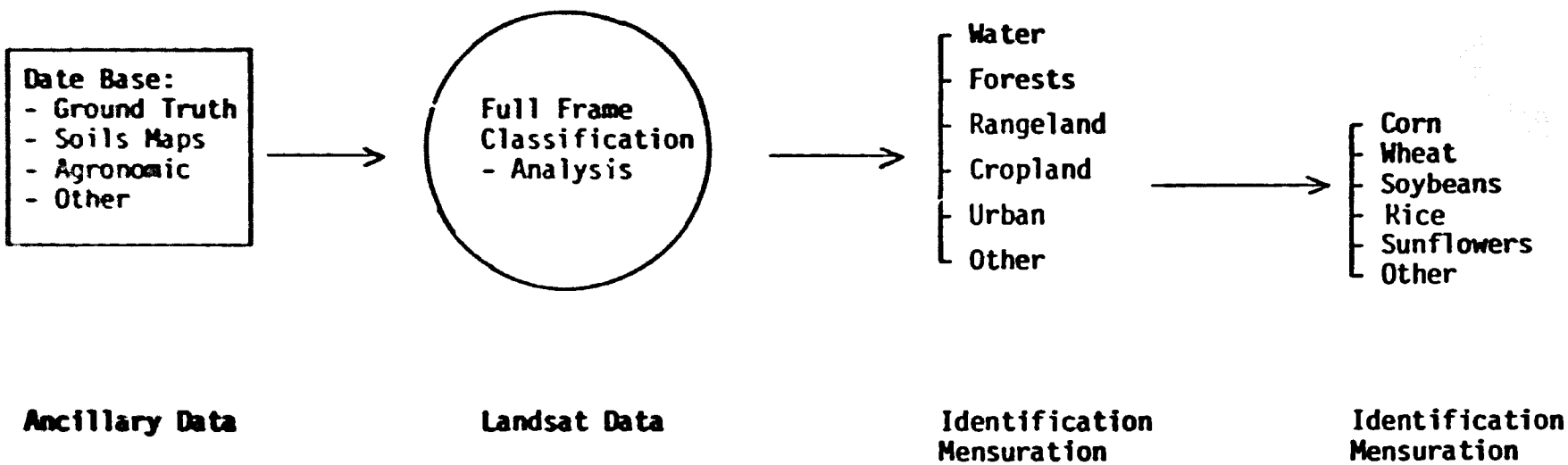
- o Detailed evaluation and assessment of actual impacts based on all factors. If overall effect is negligible, further action would cease. If significant impact determined, an early warning: advisory would be issued. Entire activity would be carried out by interdisciplinary team.

- o Indicates to production analysts that a significant event has occurred that should be taken into consideration in future forecasts.

- o Indicates areas for concerted effort by other components of food information system.

Figure 4

Domestic Land Use - Crop Acreage Estimation



the growing seasons of major crops in geographical regions of importance in the world, improved information on both potential production and factors which affect production is required throughout nearly the entire calendar year. Scope of the crops Early Warning/Crop Condition Assessment element in terms of countries/crops is shown in figure 5.

While only limited amounts of prior research have been focused on "early warning," the program plan recognizes that some capability already exists for producing useful early warning information. Examples of this capability include:

- drought monitoring - Landsat and meteorological data;
- measurement of small grain winter kill;
- monitoring soil temperatures;
- yield models (wheat);
- crop calendars; and,
- vegetation - estimation of amount (biomass) and condition (stress).

Thus, the proposed early warning activities outlined in this plan will build incrementally on existing capabilities. The early warning plan, while identifying priority crops and countries for the purposes of constructing data bases and yield models, has as its ultimate objective the development of a global early warning commodity information system.

The Early Warning and Crop Condition Assessment function is shown schematically in figure 6.

Early Warning/Crop Condition Assessment
(FY 80 $M)

	80	81	.82	83	84	85	Total
NASA	0.4	1.2	1.3	1.4	1.8	.6	6.7
NOAA	1.1	1.3	1.4	1.5	1.4	1.2	7.9
USDA	5.0	5.8	5.0	4.6	4.3	3.7	28.4
Total	6.5	8.3	7.7	7.5	7.5	5.5	43.0

2. Commodity Production Forecast

Building on the LACIE and other experience, the Commodity Production Forecasting part of the plan emphasizes a broad-based research

FIGURE 5

EARLY WARNING/CROP CONDITION ASSESSMENT

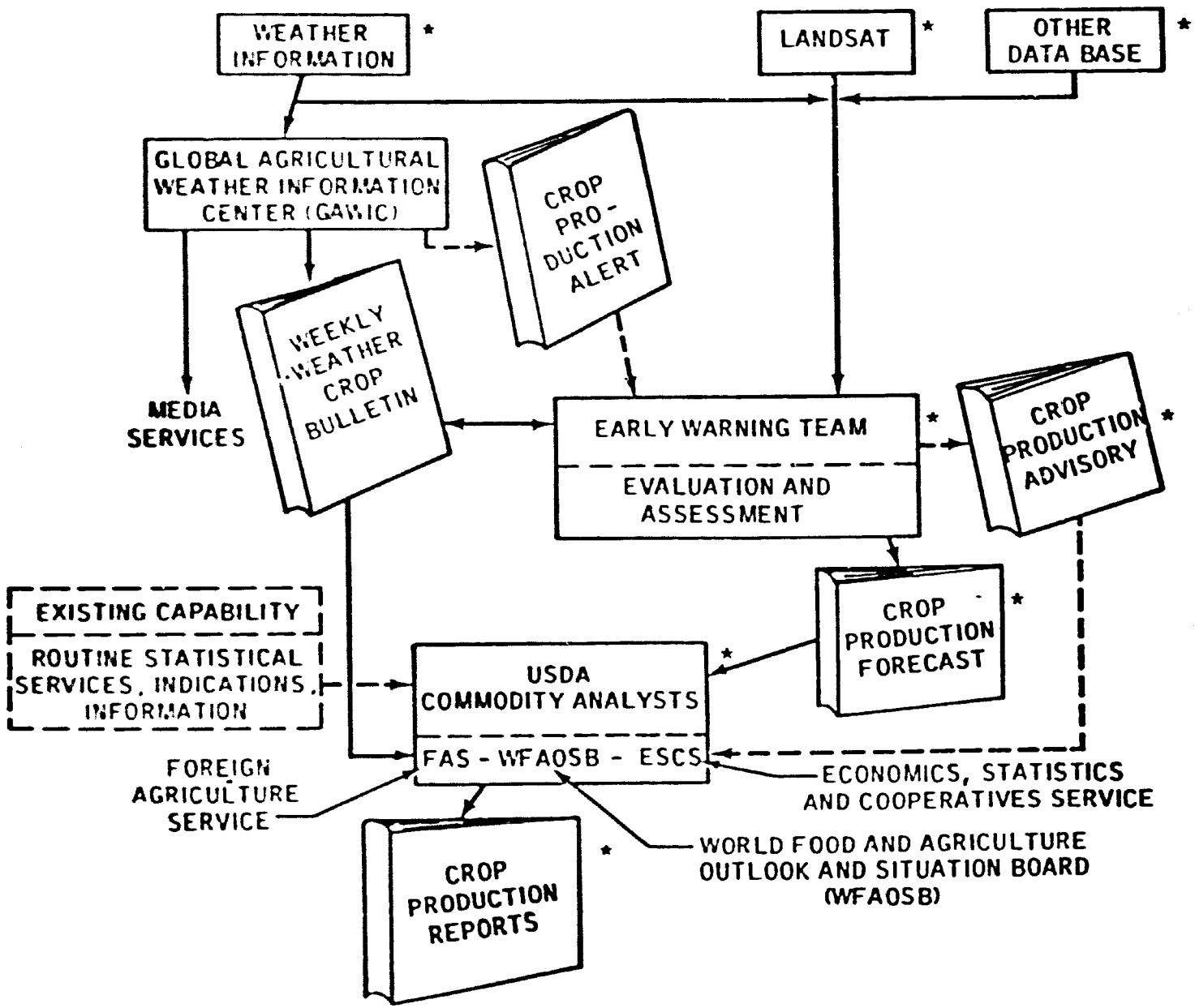
COUNTRY	COMMODITY
USSR	WHEAT, BARLEY
ARGENTINA	WHEAT, CORN, SOYBEANS
BRAZIL	CORN, SOYBEANS
U.S.	WHEAT, CORN, SOYBEANS, RICE, COTTON
CANADA	WHEAT, BARLEY
PRC	CORN, SOYBEANS
MEXICO	CORN
AUSTRALIA	WHEAT, BARLEY
CROP/COUNTRY COMBINATIONS	19

FIGURE 6

NASA-S-78-12134A

OPERATIONAL CONCEPT

EARLY WARNING AND CROP PRODUCTION FORECASTING



*DENOTES AREAS COVERED BY THIS PROGRAM

program addressing the following components:

- experiment design;
- sample frame construction/sampling strategy;
- exploratory classification experiments;
- yield model development;
- crop calendar development;
- exploratory experiments for improved production estimation;
- pilot experiments; and,
- large scale application tests.

Crops/countries to be included in this program are shown in figure 7 for the funding level shown below.

Commodity Production Forecasting
(FY 80 $M)

	80	81	82	83	84	85	Total
NASA	7.3	14.2	15.6	16.6	20.0	4.8	78.5
NOAA	1.9	1.9	2.0	2.0	2.0	1.9	11.7
USDA	6.3	7.6	10.7	15.1	16.1	24.0	79.8
Total	15.5	23.7	28.3	33.7	38.1	30.7	170.0

3. Supporting Research Activities

This element of the program contains the activities that are common to Early Warning and Commodity Production Forecasting, including the data bases, computer facilities, and supporting field research. In addition, the research efforts in information extraction procedures support renewable resources, land use classification, and the other information requirements.

The experience gained in the LACIE showed the need for a stable research effort in the university/industry community as well as the need for a strong field research effort. This base provides the mechanism for solving the technical issues that are known to result from the LACIE and other experience, and new issues that will be identified in this new program. The supporting field research will provide ground truth for accuracy assessment, improved understanding of basic radiation patterns of specific crops and their soils

FIGURE 7

COMMODITY PRODUCTION FORECASTING

R&D AND LSAT

COUNTRY	RATIONALE	COMMODITY
USSR	IMPORTER POOR DATA	BARLEY
INDIA	IMPORTER PRC ANALOG	RICE, WHEAT
ARGENTINA	EXPORTER FAIR DATA	WHEAT, CORN, SOYBEANS
BRAZIL	EXPORTER VERY POOR DATA	CORN, SOYBEANS
U.S.	BASIC R&D AREA	CORN, SOYBEANS, RICE, SORGHUM*, SUNFLOWERS*, COTTON*
U.S./CANADA	BASIC R&D AREA USSR ANALOG	WHEAT, BARLEY
AUSTRALIA		WHEAT
CROP/COUNTRY COMBINATIONS		12
DOMESTIC		10 STATES

*SUPPORTING FIELD RESEARCH ONLY

background, under normal and stressed conditions. It will assess what can be done with existing sensor systems and what could be done with future improved systems. It will contain a major effort to measure surface soil moisture by remote sensing and develop root zone models for use in improved yield estimation. The contribution of spectral information to yield estimation improvement will be assessed.

Figure 8 shows the elements of the supporting field research activity and the overall approach. Funding by fiscal year is as follows:

Supporting Research Activities
(FY 80 $M)

	80	81	82	83	84	85	Total
NASA	8.3	12.6	15.3	16.2	13.3	6.0	71.7

B. Renewable Resources

In the renewable resources area cooperative efforts are defined for collecting forest and rangeland inventory and management data. These efforts address national, regional, state, and local area needs and support major legislative requirements including the Resource Planning Act of 1974 and the Resource Conservation Act of 1977.

Work dealing with use of aerospace technology for renewable resources includes a series of research and development projects focused on three major areas:

- detection, classification, and measurement of disturbances;

- classification and mensuration of forest and rangeland resources for small planning units; and,

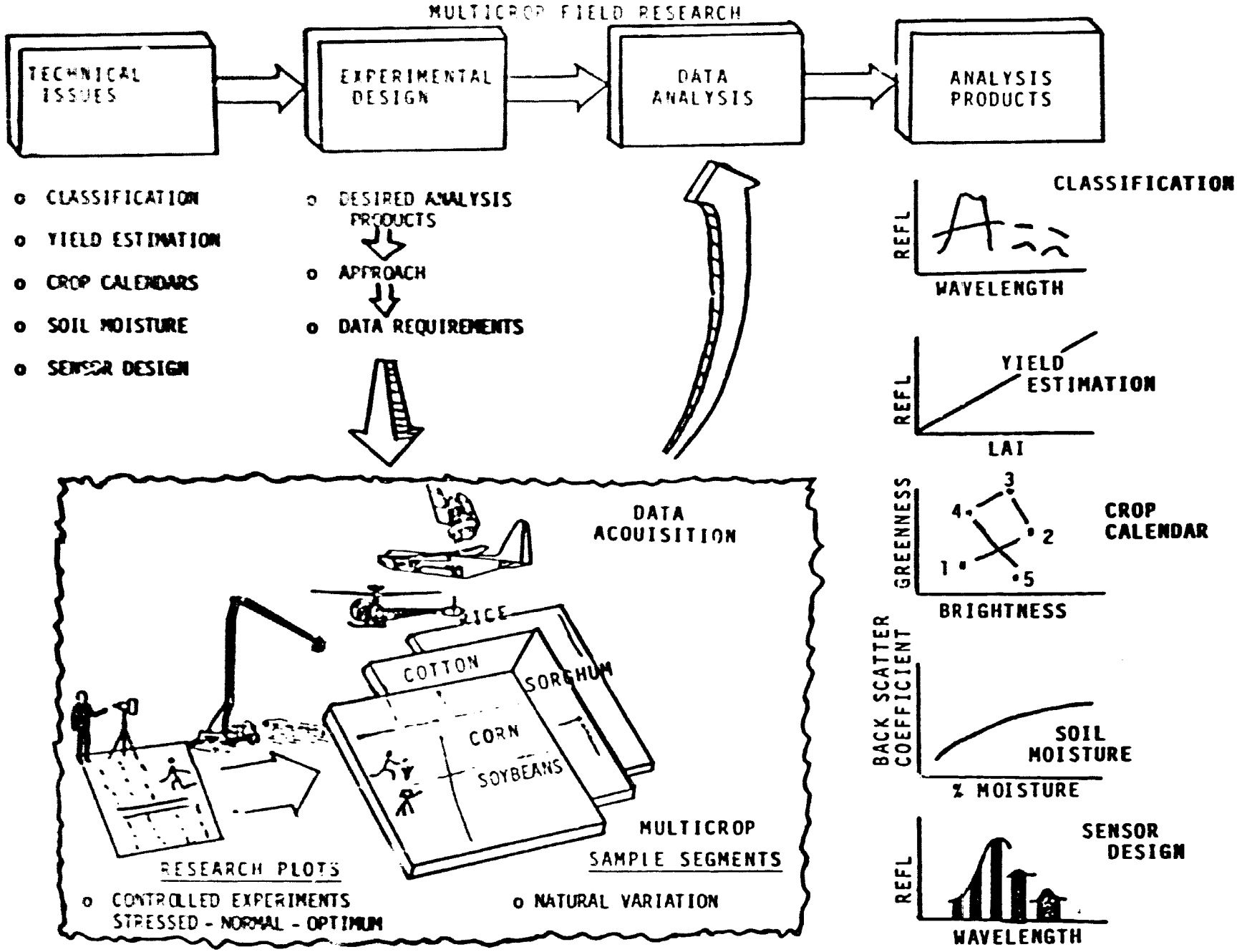
- regional and large area renewable resources inventory and assessment.

For each of these major areas the program will concentrate on developing methods and procedures for using remote sensing data not only to provide applicable inventory information but also to assist in the day-to-day management activities of the resource manager(s). For example, applications of remote sensing for detecting, identifying, and measuring extent of both natural (drought, disease, insects, etc.) and manmade (clearcuts, controlled burns, etc.) phenomena are expected to provide managers with information upon which decisions can be made.

The entire renewable resources effort will involve an integrated program of research, including studies and evaluation of existing and planned sensors. Research which can potentially meet needs in more than one of the three broad renewable resources areas has been identified. Also, some of

FIGURE 8

MULTICROP FIELD RESEARCH



the research planned for crops (acreage estimation, soil moisture, vegetation stress) and land use will be coordinated with the renewable resources effort to avoid possible duplication and less than optimum use of available resources.

Renewable Resources Activity
(FY 80 $M)

	80	81	82	83	84	85	Total
NASA	1.6	2.2	1.8	1.6	1.1	.5	8.8
NOAA	.03	.06	.03	.008	.008	.008	.1
USDA	.7	.9	.5	.8	.8	.9	4.6
Total	2.3	3.2	2.3	2.4	1.9	1.4	13.5

C. Land Use

The land use program will develop, test, evaluate, and implement an integrated satellite/ground data periodic monitoring capability for classification and improved acreage measurement of major agricultural and other land uses throughout the U.S.

Through 1984 such a capability will have been demonstrated and evaluated in 12 states. Several USDA agencies have legislative mandates which require information on land use in the U.S. The land use information is critical to the estimation of agricultural production and the collateral determination of production potential. It also provides some of the base information for determining conservation needs and requirements for future conservation programs.

As the program develops, it will consider the following key research and development areas:

- improvement of land use classifications through multi-temporal techniques;

- finding the optimum approach and system for change detection and monitoring;

- finding the most effective means to perform large area classification, considering sampling and wall-to-wall classifications; and,

- develop procedures and determine the utility of advanced satellite systems (Landsat-D).

The desired capability will include land use classification and measurement, location and mapping of land uses, and change detection for periodic updates. Land use information emphasized for this program will be cropland, forestland, rangeland, urban, water, and others.

Methodology for using remote sensing to address land use questions is intimately tied to crop acreage estimation, as well as some of the approaches being developed for natural resource inventory and monitoring needs. Figure 9 shows this connection, which will be fully exploited in the domestic land use and inventory program to minimize costs. This program will utilize a basic technology foundation developed in the crops program. Resource requirements by fiscal year are:

Land Use Classification
(FY 80 $M)

	80	81	82	83	84	85	Total
NASA	.7	.4	.4	.2	0	0	1.7
USDA	1.0	1.4	1.9	2.1	2.6	2.4	11.4
Total	1.7	1.8	2.3	2.3	2.6	2.4	13.1

D. Pollution

The program for pollution is to develop, test, and evaluate a capability to detect, identify, and map sources of pollutants related to agricultural and forestry practices within the U.S. using an integrated satellite/ground data system. This capability is essential to the control and elimination of effects of pollution on production potential and on natural resources. This is an important information requirement to the USDA and will support several of the USDA agencies.

Through 1984 the program will consist predominantly of R&D activities in water and air pollution, including specific research on non-point sources of pollution. Water pollution, both point and non-point, will be associated with run-off predictions and impacts. By 1984 the capability to monitor distribution, turbidity, and movement of water pollution (sediment) will be demonstrated and evaluated in various water bodies throughout the U.S. Other promising remote sensing techniques from non-point, water, and air pollutant measurements will evolve and be ready for evaluation and testing. The key research and development areas include:

- basic research for development of in-situ sensors with associated communications;

Figure 9

Land Use Program Framework

Crops

Parameters

Corn
Soybeans
Wheat
Etc.

Capability Desired

Classification
Acreage Estimation

R&D (Exploratory)

Product Improvement
Expected Precision

R&D (Pilot Experiments)

4 states

LSAT

10 states

BASIC CAPABILITY

- o Classification
- o Acreage
- o Location
  8-11 Classes

Using Same Test Areas and Data Sets

Land Use

Parameters

Forestlands
Rangelands
Urban
Cropland
Water
Other

Capability Desired

Classification
Acreage
Change Monitoring
Location and Mapping

R&D (Exploratory)

Change Monitoring
Assess Existing Capability
Additional Land Use Classes
Multitemporal Application
Assess Pixel by Pixel vs. Sampling or Combinations
Product Improvement for Landsat-D and Advanced Sensors

R&D (Pilot Experiments)

4 states

LSAT

12 states

- adapting pollution models, hydrologic and water quality models to accept remotely sensed data;

- developing procedures for location and mapping of saline seeps, saline soils, swamp areas, and high-erosive areas; and,

- developing techniques and sensor concepts to detect gaseous and particulate air pollutants and their impacts.

Pollution
(FY 80 $M)

	80	81	82	83	84	85	Total
NASA	.9	1.4	1.3	1.2	.8	.4	6.0
NOAA	.1	.1	.1	.1	.1	.1	.6
USDA	.8	.8	.8	.7	.7	.4	4.2
Total	1.8	2.3	2.2	2.0	1.6	.9	10.8

E. Conservation

The Conservation program will develop, test, and evaluate an integrated satellite/aircraft/ground data capability to supply accurate information on conservation practices and potential in the U.S. The ability to monitor and assess the effects of conservation practices represents a major information need required by several USDA agencies.

Conservation of both soil and water resources is addressed in the plan. Water resources capabilities and procedures will be developed that use remotely sensed data for measuring snow resources, soil moisture, assessing water management practices, and application of hydrologic models. For soils, the conservation program will focus on developing the capability to inventory conservation practices by remote sensing, and identify and measure areas where conservation practices are needed.

Through 1984 a capability will be achieved for determining soil erosion potential in selected areas of the U.S. Although conservation is predominantly a Research and Development program, demonstrations and evaluations will take place for more promising techniques, for example, monitoring snow resources for input into hydrologic model predictions.

The key research and development areas within the Conservation program include:

- soil moisture sensor development;

- procedures development to determine snowpack characteristics such as snow depth, density, and water equivalent;

- determining soil and spectral indicators from remote sensing techniques for input to soil erosion models; and,

- optimizing procedures and developing analysis system for monitoring change of conservation practices.

Resource requirements by fiscal year are as follows:

Conservation
(FY 80 $M)

	80	81	82	83	84	85	Total
NASA	.9	1.0	.8	.6	.4	.3	4.0
NOAA	.2	.2	.1	.1	.1	.1	.8
USDA	.8	1.0	.9	1.0	.8	.6	5.1
Total	1.9	2.2	1.8	1.7	1.3	1.0	9.9

IV. MANAGEMENT AND ORGANIZATION

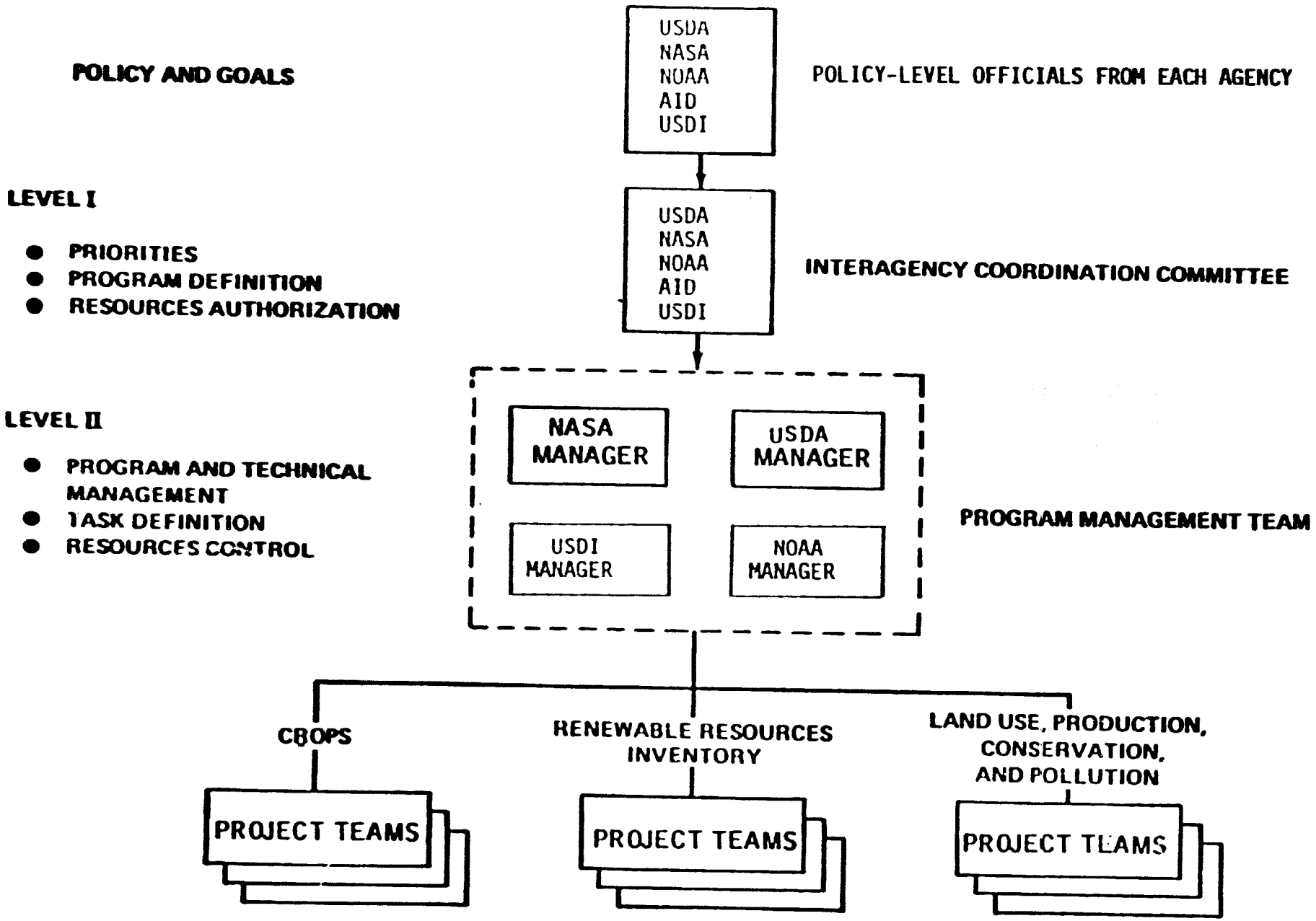
The organization and management philosophy reflected in this plan (figure 10) recognizes that each government agency involved enters into an agreement to support the information requirements defined by the Secretary of Agriculture. Each government agency budgets, manages, and maintains control of resources necessary to meet its own responsibilities as defined in the plan. Three levels of management coordination are established for the conduct of the joint program.

A. Program Review and Policy Guidance

The activities under this agreement shall be under the overall policy guidance of appropriate policy-level officials from each Agency at the Assistant Secretary or equivalent level and shall be jointly reviewed at least annually.

FIGURE 10

MANAGEMENT STRUCTURE



B. Interagency Coordinating Committee

This Committee will be composed of one senior representative from each Agency, and operating within the overall policy guidelines, will:

1. approve program objectives and establish priorities;

2. approve the detailed joint program plans and schedules and changes thereto:

3. coordinate the use of resources assigned to the joint program; and,

4. approve all press releases.

C. Program Management Team

- Single program manager for each agency/department.
- USDA, NASA, NOAA, USDI.
- Each agency manager controls his agency's/department's efforts.
- Manage overall program, including content, schedules, and budgets.
- Assure that research and development and test elements adequately support USDA requirements and priorities.
- Request and review periodic update of user needs.
- Resolve all issues among subordinate elements of the program.

The agency program managers will meet monthly for working coordination and management of their respective programs. These meetings will consist of technical and management progress reviews, and change control boards. Change control decisions will be made by the program manager of the agency whose project and resources are affected. Advice and recommendations will be sought from the other participating agency program managers.

The Status of Existing Global Crop Forecasting

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INTRODUCTION

The agricultural analyst of today has at his disposal an extremely broad range of agricultural data. Unfortunately, this same analyst does not have a storehouse of agricultural information. Data or observations of economic activity must be transformed into meaningful decision-related inputs before they can accurately be classified as information. This paper will discuss the need for and the approach to improving one set of specific agricultural data—crop production estimates. The agricultural community is flooded with a great number of crop estimates from all over the world, some of which are well founded and others very questionable. The nature of today's highly interrelated agricultural world has promoted an overemphasis on highly suspect data (i.e., U.S.S.R. crop estimates) as major market determinants. The agricultural community must move toward the evolution of a fully integrated agricultural information system that includes crop production estimates with continuous adjustments in these estimates as a key component. Existing crop inventory systems do not meet this goal; consequently, the redevelopment and the use of these systems have been haphazard, and, more importantly, they have served as major sources of misinformation for agricultural analysts.

A review of current crop inventory systems requires a statement of their purpose and a description of the analytic environment in which they exist. The authors will assume that most agricultural decision needs can be cataloged under four main headings: (1) market analysis and business decisions, (2) policymaking, (3) use and development of resources, and (4) technology assessment and development. A number of country-specific crop inventory systems that are currently in operation around the world are described. It is clear from the discussion of these systems that agriculture has evolved into an interrelated world process and that the distinct and separate nature of the information systems is inadequate for decisionmaking purposes. Furthermore, world agriculture has become much more dependent on nonagricultural forces (i.e., economic, social, political) which influence the process of producing and distributing food and fiber.

The most pressing problem limiting the effectiveness of existing crop inventory systems is that these systems were evolved largely apart from an overall information system for world agriculture. Little attention is paid to the crop production estimate as an integral component of the total agricultural economic situation or to the risks or opportunities that surround the estimate. Today's crop reporting systems are rightfully concerned with the accuracy of their estimates but these systems should also be designed to describe the status of the crops. The user of crop estimates, in most cases, is not so naive as to expect perfection in crop estimates but does require estimates based on sound assumptions accompanied by a description of the factors that generated the estimate. Moreover, the user desires a tracking of the estimate to allow for continual reevaluation of related decisions.

A NORMATIVE VIEW OF AGRICULTURAL INFORMATION SYSTEMS

Information about the area, yield, and production of a particular agricultural commodity is used in a wide variety of ways in the context of business and market analysis, domestic and international agricultural policymaking, resource use and development, and agricultural technology. Therefore, the crop inventory systems described in this paper represent an integral component of the much larger information system required for agricultural decisionmaking.

A brief account of the structure and dynamic

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nature of an effective information system is appropriate, since this discussion is in essence the conceptual foundation on which an operational system can be based (refs. 1 to 7). Clearly, the entire system is developed for the purpose of meeting well-defined decision needs. The decision needs are initially handled by developing a conceptual or working model. Conceptual work is followed by a process of data management, analysis, and exposition that provides the decisionmaker a series of alternative solutions to the stated problem. The decision made becomes a critical element in the development of new or restated decision needs, and these needs serve as a catalyst for the data-reconfiguration, analytic, and report-writing activities. The process is shown schematically in figure 1.

CROP INVENTORY INFORMATION: HOW IS IT USEFUL?

Decision Needs

The purpose of the entire information system is derived from the decision needs generated by the full range of agricultural decisionmakers. In this section, a selected set of agricultural commodity information—area, yield, and production—as it relates to a broad range of agricultural decision areas is examined.

Market analysis and business decisions—The informational needs of the business and farm communities cover a multitude of production, consumption, distribution, and pricing problems. Regardless of the position of the decisionmaker in the vertical chain from the farm to the consumer, the information imparted to him by crop estimates is a starting point and not an end in itself. The impact of new-crop expectations is seen in inventory movements, demands, and, ultimately, prices. In short, the market is probably the most important information system serving the business and farm communities today. It would be a more efficient market if better, more timely, and more accurate information were available to all participants.

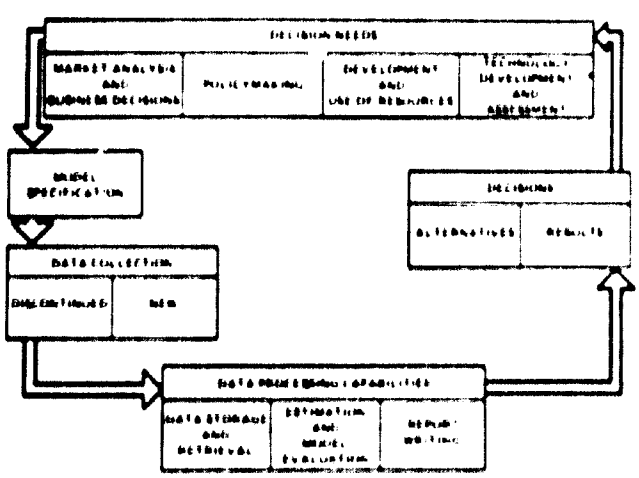

FIGURE 1.—An agriculture information system.

Improved information about the magnitude and timing of production of major crops, on a worldwide basis, is an essential input to the agribusiness decisionmaker. Agribusiness decisions include those related to the supply of machinery, chemicals, fertilizer, and other products to the farmer. In addition, there are many decisions related to the distribution and assembly of food products once the commodity leaves the farm (i.e., transportation issues, purchasing issues, processing and packaging issues). Given the state of existing agrometeorological arts, an improved status and tracking system that brings timely and accurate crop production information to the decisionmaker is of great benefit.

Some of the problems of timeliness of information and updating of obsolete information can be met by the use of satellite-based remote-sensing and supporting crop information data bases. The continuous nature of the Landsat technology is clearly a means of providing routine monitoring of worldwide crop production. Furthermore, Landsat can provide information about major crop production in particular areas of the world where the current infrastructure for crop inventory assessment does not exist. This paper deals specifically with the use of crop area estimates as an input which can assist in formulating improved new-crop expectations and ultimately improved estimates of market price movements for agribusiness decisions. Once again, it must be emphasized that the crop production detail is useful *only* if the data are developed as part of a larger analytic network, i.e., a fully integrated agricultural information system. The agribusiness decision must, of necessity, focus on factors that relate to the firm's profitability, therefore, commodity production details must be translated clearly into business terms, such as sales or costs of production.

Policymaking—The policymaker is faced with the task of analyzing legislative alternatives which have both short- and long-term impacts. The use of an

agricultural information system is for "baseline" analysis of alternative initiatives. Further analysis follows the development of the baseline in analyzing the risks and opportunities that could surround the baseline. The dynamic nature of the system is essential for the reconfiguration of farm and agricultural trade policy as the world agricultural and general economies change.

The capability to monitor domestic crop production has become increasingly important to the U.S. farm policymaker since the establishment of the Government grain reserve. Under current law, wheat that was placed in the long-term reserve cannot be withdrawn until the market price at the farm reaches 140 percent of the established loan rate. When the market price is below 140 percent of the loan rate, the wheat must stay in the reserve, while the Federal Government pays both the costs of storage and interest charges for the farmer in addition to providing the loan for cash-flow needs. With market prices at 140 percent of the loan rate, the Government will not pay the costs of storage or the interest charges associated with the loan. Therefore, a considerable amount of the wheat will be withdrawn from the reserve and placed on the effective market. When market prices at the farm are 175 percent of the loan rate, the Government will recall the loan and the entire reserve will be placed on the effective market. There are two major concerns associated with these Government inventory movements: (1) the placement of the added supply will depress market prices, and (2) the buffer against future shortages is removed. The Secretary of Agriculture must determine by August 15 of each crop year whether land should be placed into an acreage set-aside program. This decision obviously establishes limits on the capacity available for wheat production and on future wheat prices and must be based on the most up-to-date and accurate estimate of the supply and use of wheat for the following four calendar quarters.

Clearly, more and better decisions related to trade policy can be made as improved assessments of worldwide crop production become available. In essence, the implementation of domestic production policies (i.e., price supports, acreage programs, farm credit) can be fine-tuned on the basis of improved monitoring of crop production in countries such as the U.S.S.R., the People's Republic of China, and Brazil. The U.S.S.R. November 1977 announcement of a total grain output of 194 million metric tons for 1977 was a shocking 21 million metric tons below current U.S. estimates of their crop. This announcement was made just before the November 15 deadline for a feed-grain set-aside program for 1978. The announcement served as an additional source of uncertainty in the already uncertain policy situation which then prevailed through May of 1978. With better preharvest information on foreign crop outputs, the domestic farm policymaker can judge the export drawdown of U.S. supplies and the overall supply and use outlook for major crops.

Development and use of resources.—The range of problems relating commercial agricultural activity with land use, water resource development, environmental issues, and community development is wide. A dynamic agricultural information system enables the planner to evaluate more accurately the current economic impact of alternative initiatives, but, more importantly, a viable information system allows a continuous monitoring of the results.

The informational requirements associated with this area are extremely broad. Land use classification and the changes in land use over a period of years, the monitoring of water quality and availability, and a catalog of alternative farming practices during particular time periods are good examples of such requirements.

Technology development and assessment.—The analysis of technological issues for agricultural production and marketing requires a dynamic information system. The continued reconfiguration and technological changes associated with agricultural data and information must be evaluated as part of the overall complex.

Some of the informational needs associated with agricultural technology relate to the mechanization of planting, crop cultivation, and harvest. The concern over poor weather conditions during the 1978 planting period led to much speculation about reduced crop production, due to delays in planting progress. There is contradictory information about just how quickly the U.S. corn crop can be planted. Therefore, a means of continually monitoring planting progress at as high a frequency as possible would greatly improve market knowledge. In fact, the current survey method used to determine plantings could not fully account for plantings in 1978 as of the June 30 deadline, since planting progress during the survey period was lagging and many producers still had to respond with intentions.

Another technological consideration relates to the ability of the general agricultural sector to incorporate the most effective information technology. The remote sensing of agricultural land is a good

example, since this information must be properly collected and disseminated to users in order to achieve the benefits of the high-frequency data.

Model Specification and Data Collection and Processing

The data processing capabilities of the system represent the "cement" that holds the various components together. A fully integrated complex of data collection, storage, and retrieval and analytic and report-writing tools is a necessary input to the effective maintenance and evolution of an information system. The timeliness and accessibility of the information are extremely important. Even if the analyst clearly defined his needs, the mechanics of providing the decision inputs could block the success of the overall system. In this section, some of the general issues associated with the processing of data and information are described.

Once an understanding of the decision need is achieved, the process of specifying an analytic framework is undertaken. Either the specification of a mental model or the processing of a mathematical scheme is a means of organizing the cause and effect of the problem area. The model specification activity is followed by data considerations. The primary criterion for data collection is that the data be obtained with specific purposes in mind. The discovery of decision needs and the development of analytic filters for use with the data are additional considerations. Vested interests in certain historical data are difficult to break down, but the viability of the overall information system requires that data collection and storage be constantly reevaluated in terms of the benefits derived from their use.

The storing of data is a costly and time-consuming effort. Therefore, the continued storage of useless or obsolete data must be avoided. The capability to add new sources of data and to mesh old and new sources of data is essential to the storage process. In short, the vested interests in a particular set of data must be challenged in terms of the benefits and costs of the continued maintenance of those data.

Another important aspect of data collection is the mechanical process of bringing the data into the system. Clearly, a timely and accurate information system must use state-of-the-art data collection and storage processes. The collection of the data cannot be accomplished properly unless the means of storing and updating the data meet the time requirements of the analyst and, more importantly, of the decisionmaker.

Storage is the first element of an effective data reservoir. The capability to access the data easily allows the system to be exploited more fully. Therefore, well-documented and easy data retrieval is of the utmost importance. The retrieval mechanisms must be developed concurrently with the analytic tools to avoid wasteful data storage.

In today's world of advancing analytical techniques, discussions concerning data manipulation often begin with models. The place to start is with data organization and the capability to exposit the information available to the analyst and the decisionmaker. The user must also have the capability to develop and reconfigure data displays, either graphically or in tabular form. Given a well-defined and well-documented data set, model building and statistical analysis can help the user derive further benefits from the system. The statistical and mathematical developments and outputs from the modeling effort are a major input to the decision process, but these results are also useful as redevelopment feedback, both in terms of the overall data processing capabilities and in the discovery of new decision needs.

The Decision

The decision alternatives and the results of the ultimate decision are important not only intrinsically but also as a catalyst for the dynamic adjustment of the entire system. The feedback based on the evaluation of the decision helps to determine new data needs, data collection that should be discontinued, and the need for new models or means of expositing the information. It may well be that the decision results will focus on a different set of decision needs and the attendant changes in the data processing component of the system.

A REVIEW OF EXISTING CROP INVENTORY SYSTEMS

Information about agricultural production is of the utmost importance to all countries in conducting their domestic and international affairs. It is also important in managing natural resources and providing for human nutritional needs by improving allocation of the means of food production, processing, marketing, and distribution.

Some factors that must be considered in evaluating the strengths and weaknesses of agricultural information are objectivity, reliability, timeliness, adequacy in terms of coverage, efficiency, and effectiveness (ref. 5). Agricultural production statistics in many very important agricultural countries will not meet any of these quality standards. In fact, several very important agricultural countries have no formal system for acquiring agricultural statistics. Fewer than 10 countries have what can be classified as a relatively sophisticated system that provides crop production estimates considered satisfactory for most of the characteristics listed. A much larger number of countries have what might be described as a system of medium complexity that provides reliable annual production data for major crops. Close to half the countries of the world have either very simple or no agricultural production estimates except those provided by a census of agriculture conducted every 10 years (ref. 8). The United States, which recently started issuing measures of precision for its domestic crop production forecasts, is the only country that publishes information on survey methodology and reliability of estimates. The chief reasons for the absence of quality agricultural production statistics are (1) lack of funds for collecting and tabulating data, (2) inadequate technical capability to formulate sound sampling and data-collection procedures, (3) absence of a suitable sampling frame, and (4) difficulty in quantifying the benefits of improved information. The accuracy of the current U.S. Department of Agriculture (USDA) forecasts of foreign commodity production and the USDA accuracy goals for 1985 are given in table 1. For example, in the U.S.S.R., at-harvest estimates are of 65/90 accuracy. This means that in only 65 percent of the years will the USDA at-harvest estimate be within ±10 percent of the final U.S.S.R. estimate. Note that the most accurate system is in the United States.

The following are brief descriptions of several national agricultural statistical systems that vary in quality.

U.S.S.R.

The Central Statistical Administration (CSA) is responsible for all statistical work in the U.S.S.R. The CSA has the status of a ministry in the U.S.S.R. government. It includes central statistical administrations in each of the union republics and oblasts as well as statistical inspectorates in each raion. The U.S.S.R. statistical organization is responsible for collecting, processing, and publishing data. Many data collected are not published but are made available to the various administrative, planning, and economic organizations of the government.

Statistical work is centrally planned. The characteristics of the U.S.S.R. statistical system parallel those of an accounting or inventory recordkeeping operation and include little or no statistical sampling and estimation. Recordkeeping at the farm level is designed to provide the data required by CSA, with each collective or state farm having a bookkeeping unit to provide basic data. With roughly 50 000 collective and state farms reporting through the raion-oblast-republic chain, each administrative unit contains 15 to 20 subordinate units. The system includes built-in checks by inspectors on the validity of data and severe penalties for falsification of records. It also provides a timely way of aggregating data through the various administrative levels. Sampling is used only to provide data on food consumption and private-plot crop and livestock production.

The system provides a large volume of data at

TABLE 1—USDA Current Forecast Accuracies and 1985 Goals for Wheat Production Estimates in Six Countries

Countries	Forecast			
	Early season[a]	Midseason[b]	Preharvest[c]	At harvest
	Current accuracy			
Argentina	46/90	—	61/90	64/90
Brazil	8/90	—	31/90	31/90	
Canada	26/90	—	45/90	94/90
India	57/90	64/90	88/90	--
U.S.S.R.	23/90	31/90	34/90	65/90
U.S.	[d]90/90	100/90	100/90	100/90
	1985 goal			
Argentina	60/90	—	75/90	80/90
Brazil	30/90	—	50/90	60/90
Canada	50/90	—	60/90	95/90
India	70/90	75/90	90/90	90/90
U.S.S.R.	50/90	60/90	65/90	85/90
U.S.	90/90	95/95	99/95	99/95

[a] [illegible] days before harvest
[b] [illegible] days before harvest
[c] [illegible] days before harvest
[d] [illegible] (table 1)

various intervals throughout the year. Data on spring and fall seeding, plowing, and harvest progress are submitted weekly. Spring seeding progress reports are made from April 1 to June 15 and reports on harvesting progress are made from July 1 to October 1. A special report on area sown to crops, which is prepared following spring seeding, contains more detailed data than do the weekly progress reports. Compilation of the crop area and production data is completed during the second half of October and publicly announced shortly thereafter. Special surveys on grain production at other times during the growing season can be developed if authorized by the CSA.

The estimates of U.S.S.R. crop production have been extremely important in international grain markets since the large and unexpected U.S.S.R. purchases of U.S. grain in 1972. Market analysts have speculated about both the objectivity and the reliability of the U.S.S.R. crop projections and it seems proper in this paper to devote added attention to the U.S.S.R. system. An analysis of the U.S.S.R. purchases of U.S. wheat and corn since 1972 would indicate that their ultimate decision to buy is delayed until there is reasonably clear evidence that their domestic supply will not be adequate to meet their demand in the coming year. It would appear that U.S.S.R. trading activity may not be as well informed as purported by most U.S. analysts who in some cases place an inordinate degree of importance on data about which very little is known. The smoother adjustments of the U.S.-U.S.S.R. grain trade agreement of 1976 offer further evidence of this exaggerated U.S. response to earlier U.S.S.R. crop estimates. Given this, one might conclude that the degree to which the U.S.S.R. "politicizes" its estimates for specific market purposes is overstated.

No quantitative data are available regarding the reliability and accuracy of the U.S.S.R. crop estimates. However, as was stated earlier, this is largely the case for most countries except the United States. Therefore, the following comments are based on analyses of the U.S.S.R. agricultural reporting system (ref. 9).

Twice each year, the U.S.S.R. makes a complete inventory of the use of all cultivated land on each collective and state farm. The first inventory is, in essence, a statement of intentions since each farm manager answers the question, "As of June 30, what use do you plan to make of the cultivated land on your farm?" The next survey is not taken until late October, when each manager states the use made of the cultivated land on his farm. The major problem apparent from the description of this system is that there is little or no survey of yield, which is derived after the fact from area and production data. Furthermore, there is a complete lack of harvested area data. As a result, hectarage data appear to be rather constant from year to year, whereas production varies widely.

An additional consideration concerning U.S.S.R. crop data is that the U.S.S.R. reports yield and production in terms of bunker weight, which can be as much as 15 percent greater than barn weight (grain weight after cleaning and drying to a standard moisture content). Thus, in comparing U.S.S.R. and U.S. crop production figures, there is an important difference in grain quality resulting from differences in trash and moisture content (ref. 10).

Currently, the U.S.S.R. crop inventory system does not make use of advanced data processing technology. Some research is being conducted to develop techniques for making quantitative crop forecasts during the growing season, but, to date, the system relies on manual compilation of data. This might imply a rather limited objective in terms of the detail to be publicly provided about U.S.S.R. crop production. Clearly, the publication of a final yearend report of area sown and crop production can be handled in this fashion, but, if more timely and detailed data were to be provided, there would be a need for improved data processing capabilities. Furthermore, it is not known to what extent the U.S.S.R. crop inventory data are analyzed in more depth without public release of the results.

In providing crop inventory data, the U.S.S.R. system has a series of objectives to meet which are distinctly different from those in the United States. Their projections are not intended to support a broad range of private and public interests. For example, they do not publish a report of the total country-level production of a crop until after harvest (about November 1). It is very likely that they compile these data as part of the preharvest progress reports but simply find it in their national interest not to release the data publicly until later. In essence, the most important distinction to be made between U.S.S.R. and U.S. crop reporting systems is a clearly disparate set of objectives. One can criticize the U.S.S.R. system for not meeting U.S. data needs, but it is difficult to claim that their own internal information is inadequate.

United States

The U.S. Department of Agriculture collects information on the production and supply of crops on a worldwide basis and publishes regular crop reports on domestic and foreign crop production. USDA activities include data collection, tabulation, and summarization; data analysis and publication of production forecasts during the growing season; and estimates after harvest.

Foreign crop production estimates are prepared and published quarterly by the Foreign Agricultural Service. The Foreign Commodity Analysis Office has primary responsibility for preparing production estimates of wheat and other grain crops for all major crop-producing countries. Commodity analysts receive information on crops from several sources: agricultural attaches, foreign statistical publications, commodity periodicals, Reuters commodity reports, the commodity trade, foreign newspapers, and the wire services. Commodity analysts base their crop production estimates on information provided by these sources. They depend primarily on the attaches' scheduled reports, prepared quarterly and developed from information obtained from foreign governments and trade contacts. Analysis is also based on an attache's own observations, information from grain importers, grain processors, and farm organizations, and various published reports available in the country. The World Food and Agricultural Outlook and Situation Board reviews and approves all estimates of production, disposition, and trade.

The major constraints within the foreign crop estimating process are (1) the quality of the data received for analysis, (2) the time required to collect, receive, review, and report, and (3) the limited application of data processing to the crop estimating process.

The existing system for collecting, maintaining, and analyzing data to estimate foreign crop production could be improved significantly by exploiting advanced data gathering techniques and by applying more advanced data processing techniques. Improvement of data processing techniques will require the development of an integrated crop production information system.

The USDA Economics, Statistics, and Cooperatives Service (ESCS) is responsible for collecting, maintaining, and analyzing data and reporting crop production estimates within the United States. By regulation, ESCS is required to prepare and issue official state and national estimates and USDA reports relating to crop production, livestock and livestock products, stocks of agricultural commodities, local market prices, value of farm products, and other subjects. Crop reports prepared by ESCS include estimates of the acreage farmers intend to plant, acres planted and harvested, production, disposition of crops, and crop stock levels, both on and off the farm.

The preparation of crop production estimates by ESCS requires that various types of information be collected and analyzed. This information is usually collected at the state level through the ESCS state statistical offices by a variety of methods, including both nonprobability and probability surveys, field observations, and personal interviews. The data then are processed, reviewed, and summarized by the state office and forwarded to Washington, D.C. The summarized data are received by the Survey Division of ESCS for further processing and distribution to the appropriate offices within the Estimates Division.

Nonprobability surveys are currently limited to mail surveys, in which questionnaires are sent to farmers asking for specific information about their agricultural activities. Today, mail surveys also supplement probability surveys. Probability surveys, first initiated by ESCS in 1954, include both enumerative and objective yield surveys. Probability sampling techniques used include the area frame, list frame, and multiple frame samples, depending on the type of crop or other agricultural product being surveyed.

If the incoming state information concerns a commodity defined by law as speculative, the information is handled according to special security procedures and is delivered to the Crop Reporting Board, consisting of a chairman, other appointed members selected for their specialized knowledge of a particular crop, and individuals from the field and Washington, D.C., staffs who analyze the data and prepare the official production estimate. This crop reporting process takes place in what is termed a "lock-up," wherein the Crop Reporting Board and other support personnel are restricted from outside contact until the crop report has been released.

The ESCS crop reporting estimates are accurate, reliable, and impartial when compared to those in most foreign countries. Based on these ESCS estimates, farmers, businessmen, and the U.S. Govern-

ment make decisions each year that can involve billions of dollars. Constraints within the ESCS crop reporting process present less of a problem than those within the USDA foreign crop estimating process.

The ESCS Survey Division currently maintains production estimates for most commodities from the 1800's to 1959 and area, yield, and production estimates from 1964 to the present time. The more recent data on area, yield, and production include all reported commodities; however, only the official final estimate for the year is available. In addition to this limited data base, data input from some state offices is constrained by mail delivery. However, 48 states can now enter data using the Infonet system or transmit the data using teletype or facsimile.

At this time, a development effort is underway within ESCS to create a data system that will eliminate these data handling constraints. The new ESCS data system will be composed of various subsystems related to ESCS functional areas. The crop subsystem will include an official-estimate data base that will contain estimates made by the Crop Reporting Board at each scheduled report date. It is also anticipated that state estimates will be entered directly as recommendations, by way of telecommunications, and the data base will aid the Crop Reporting Board in its review process. Special computer security procedures and techniques also will be used extensively in this system. This development effort appears to be well planned and logically organized for supporting ESCS information and reporting needs.

The limited use of meteorological data by ESCS in making current forecasts and estimates is a result of the ESCS reporting methods, which are designed to reflect the effects of weather on crop production to the date of the survey. Short-term and long-term weather forecasts have not been used because they lack the precision needed to evaluate prospects at the state level. Objective yield models used by ESCS rely on actual measurements rather than on subjective appraisals of crop development.

Canada

Canada's statistical service is organized on a highly centralized basis under Statistics Canada, formerly known as the Dominion Bureau of Statistics. The agency is responsible for developing an integrated system of social and economic statistics pertaining to the whole of Canada and its provinces. This procedure involves the collection, analysis, and publication of regular statistical information on social, economic, and general activities.

The Agriculture Division is responsible for the collection of farm-based agricultural data on a regular basis each year. Two methods of data collection are used: the mail questionnaire, because of its low cost, and the personal interview, because of improved responses. About 55 separate surveys are performed during the year. Most of these surveys are conducted by mail, with response being on a strictly voluntary basis for most crops.

The major surveys are the semiannual June and December surveys designed to collect information on crop acreages and livestock numbers. Questionnaires are mailed to all 350 000 farmers. About 15 to 20 percent of the farmers respond. The information from these surveys is used in conjunction with 5-year census benchmark data to provide annual estimates.

With rapid structural changes taking place in agriculture and the trend toward fewer and larger farm units, this method no longer meets the requirements for reliable data collection. A nationwide annual survey covering a probability sample of about 6500 farms has been tested experimentally for several years. It will ultimately become an integral part of the survey system, and, when the sample is expanded, it will provide data at the national level similar in quality to that provided by the 5-year census of agriculture.

A sample of farmers is surveyed in March each year to estimate the acreage farmers intend to plant. The June survey collects actual plantings. Three times each year, a sample of 13 000 farms is contacted by mail and asked to report yield per acre for major crops. These surveys are conducted in mid-August, in mid-September, and after harvest. Some experimental work has been done with objective yield counts for potatoes and several fruit crops in an effort to overcome the subjective nature of forecasts made from the mail survey. Work is continuing in training enumerators, improving field instruction, and refining procedures for this work in an effort to resolve the differences that exist between objective yield data and census information.

The census of agriculture is taken every 5 years for crop years ending in 1 and 6. It consists of a personal enumeration of every farm holding that is at least an acre in size or has sales of $50 or more. It provides basic data on land use, crop acreage, livestock number, and sales of farm products. A quality check survey of about 15 000 farms is done

several weeks after completion of the census interviews. This survey provides information on the quality of the census data and its data collection procedures. The presence of this accurate 5-year benchmark strengthens the capability of the mail survey to provide satisfactory current statistics. The Special Surveys Division, through its regional offices, is responsible for collecting the data for many of the surveys.

Australia

The Australian Bureau of Census and Statistics is responsible for the collection, compilation, and publication of all official statistics, including those relating to agricultural industries. The basic framework of the system is a nearly complete annual self-enumeration agricultural census conducted in March of each year covering the 250 000 rural holdings. It covers about 500 individual items including land use, crop acreage and production, crop varieties, and irrigation.

Annual probability sample surveys are conducted at designated times throughout the growing season to obtain early estimates of acreage and production for major crops. Acreage data are collected at the end of the sowing period, and production data are obtained during the harvest period. The annual census uses state registers and rural holdings for the distribution of forms and the collection of completed forms. Comprehensive coverage is checked through governmental authorities and departments and through marketing boards to ensure that the registries are complete. The returns are edited, tabulated, and published about 12 months after collection. Post-enumeration surveys are used to check the accuracy of reporting and to improve the design of the forms.

The complete census is possible because the number of rural holdings is small and their average size large. This characteristic limits the time and expense required for collection and processing. The register is kept current and provides a very suitable sampling frame for the annual sample surveys of crop production and other rural development statistics.

The system has some nice advantages as the census provides an annual benchmark for both efficient sampling and current estimation of the production of major crops. Quality checks of survey procedures are performed routinely to ensure reliability and objectivity. Statistics are collected under the Commonwealth Census and Statistics Act, which requires that questionnaires be returned within a specified period and provides for the confidentiality of individual reports.

Brazil

The Brazilian Institute of Geography and Statistics in the Ministry of Planning is responsible for statistical programs. Statistics on crop acreages and yields have been collected through municipio agents in each of the 4000 municipios for about 30 years. At about 3-month intervals (April 1, July 1, September 1, and January 1), each municipio agent completes questionnaires on temporary and permanent crops.

The first part of each questionnaire deals with crops harvested during the previous 3 months and the second part with crops still in cultivation. The agent reports area harvested, yield, production, price, area planted during the quarter, expected yield, stage of growth, and month of sowing. Agents are instructed to consult with knowledgeable people in the municipio before completing the questionnaire. Two copies of the questionnaire are completed, one being sent to the state government and the other to the federal government.

A number of problems arise with this statistical system. No rigorous control is maintained over respondents, and the survey process is time consuming and incomplete. Often, statistics developed at the feueral level are different from those published by the state governments and the two are never reconciled. Little or no systematic work has been done to evaluate the ability of agents to report accurately.

Some preliminary work has been done in trying to forecast yields. Statistically, Brazil is divided into three major regions, and two forecasts—at the time of sowing and at harvest—are issued for each. A probability sample of 1000 municipios is selected with probability proportional to size for all crops. Forecasts are collected on the basis of group interviews with knowledgeable people at the municipio headquarters. Again, wide differences between data obtained in this survey and from the municipio agent exist, but no attempts have been made to reconcile these.

Some attempts have been made to collect agricultural statistics from a probability sample of producers. The State Department of Agriculture in São Paulo has developed its own modern and effective system of collecting current agricultural statis-

tics. Sampling frames similar to those in the United States have been used, with the data being collected by interviewing producers. These data are used to prepare state estimates but are not used to establish national totals. The last benchmark census data available were obtained in 1960.

Sweden

The National Central Bureau of Statistics (SCB) is the central administrative agency for official statistics in Sweden. In agricultural statistics work, the SCB collaborates closely with the National Board of Agriculture and the National Agricultural Marketing Board. The agricultural data system is built around the farm register system and has three principal components: current agricultural statistical activities, agricultural censuses, and special statistics surveys.

The current agricultural statistics are composed of (1) data on units with agricultural operations, their size, commodities produced, and specialized agricultural items, provided through an annual survey by the farm register system of all holdings of 2 hectares or more; (2) data on the agricultural structure of units and their resources of land, machines, animals, labor force, etc., obtained from the farm register; (3) data on crop area for 25 crops, available land, natural pastures, grass-sown land, and forest land, obtained from the register; (4) qualitative information on crop outlook and development of crops during the growing season, developed on the basis of three surveys made by the county agricultural boards; (5) quantitative data on probable crop yields, developed from objective surveys that cover the 9 principal crops; (6) livestock statistics on numbers of livestock by category, animal production, and milk production, obtained from a sample of 12 000 register units; (7) data on agricultural requisites, such as the consumption of fertilizer, pesticides, and feedstuffs, and (8) data on economic factors, such as labor, farm wages, real estate and buildings, cash income and expenditures, and price statistics.

The agricultural census is conducted annually using a sampling method that ensures that each unit will be included at intervals of about 5 years. Using the farm register, it provides general agricultural statistics similar to the current agricultural statistics for individual parishes and communities.

The farm register system provides a very precise sampling frame for all statistical surveys using holdings (individual farms) as the reporting unit. Crop acreages are established on the basis of complete information collected in the farm register. A complete and objective yield sample survey system establishes biological yields, harvesting losses, and data on harvest quality and is similar to the U.S. system (ref. 11). Subjective reports of crop outlook during the growing season are submitted in May, July, and October for each of the 2500 parishes. Data on crop yield prospects are expressed numerically on a scale of 0 to 5.

Kenya

The Statistics Division in the Ministry of Planning and Development of Kenya is responsible for collection, tabulation, and publication of all agricultural statistics through its Agricultural Branch. The Branch has two principal units: (1) General Statistics, which deals with commodity prices and quantities and the value of marketed agricultural products, and (2) Field Data Collection, which is responsible for all data collection.

Basic agricultural statistics are available for large-scale farms (20 or more acres) through an annual census that is more than 85-percent complete. For small-scale farms, a probability sample of geographic subdivisions is selected annually for enumeration. Field enumerators collect the basic acreage data, using the farm holding as a reporting unit. Crop and farm acreages are measured using compasses and measuring wheels.

Thus, historical crop acreages are available on an annual basis but are derived using less than satisfactory statistical procedures. No statistics on crop yields are available for Kenya. Significant portions of the most important crops, such as corn, pass through a marketing board, where quantities and prices are recorded and provide estimates for the monetary sector. Estimates for the nonmonetary sector are now based on projections that are factored up by population growth from a 1957 survey.

A census of agriculture was attempted in 1960-61, but deficiencies in sampling frames, measurement techniques, and staff quality and training, noncooperation of respondents, and unfavorable weather made the results inaccurate. A relatively complete current agricultural census would be very helpful for establishing benchmark production and acreage data. Forecasts of crop conditions during the growing season are not attempted. Limited resources are spread thin in an attempt to also collect some in-

formation on livestock and livestock products, enterprise costs, and rural households. No measures of precision or reliability can be computed for any of the statistics.

United Nations

The United Nations Food and Agriculture Organization (FAO) published the "Food Quarterly" for the first time in 1975. Issued under the Global Information and Early Warning System on Food and Agriculture, it provides information on current world food production based on data from official and nonofficial sources and gives the latest developments and short-term prospects for food crops, livestock, and fertilizers, trade availabilities and requirements, and stocks and prices. This quarterly report was supplemented on a monthly basis through the Early Warning System in 1976 as a trial undertaking and in an effort to fill many critical data needs.

In addition, FAO annually publishes two volumes of the "Production Yearbook," giving agricultural statistics for major geographic areas of the world and for more than 200 countries. Volume I provides data related to land, population, and crops; livestock numbers and livestock products; the means of production; and index numbers of food and agricultural production. Volume II contains data on prices of agricultural products, prices of certain production means, freight rates, farm wages, and index numbers of prices. These volumes are made possible by the cooperation of those governments that supply most of the information to FAO.

NEED FOR IMPROVED ACREAGE INFORMATION: THE POTENTIAL OF LANDSAT

Economic Realities

The hard evidence facing either private or public agricultural analysts is that new-crop expectations affect the agricultural economic activity during the marketing year for crops already in the bin. Once a crop is harvested, there is a limited crop-year supply available for use. The inability to produce most major crops on a year-round timetable produces this problem.

Given the available crop-year supply, this inventory is drawn down on the basis of price expectations of both the storer of the commodity and the user. Simply stated, if the expectations are of low prices for the commodity in future months, it may well be in the interest of the inventory holder to liquidate his holdings and, conversely, good for the buyer to wait. The expectations about future crop prices are determined largely by the anticipated size of the new crop. The future size of the new crop can be analyzed in terms of the land devoted to production (i.e., acres planted) and the potential yield. The uncertain and unpredictable nature of weather and the impact of this weather on crop yield suggest that the acreage component of production variation is extremely important as an early-season indicator of crop output.

The most extreme example of acreage planted as the "key" indicator of new crop production is winter wheat. The crop is planted in the fall and remains dormant until revitalized by warmer spring weather. There are certain weather conditions, such as damaging wind or lack of winter moisture, which determine future output expectations, but past experience has shown that such information can be greatly misleading. Therefore, truly good estimates of the size of the new winter wheat crop cannot be made until March-April weather impacts are known. The acreage-planted figure serves as the only "hard" piece of evidence about new-crop production until late spring. Of course, yield models do provide considerable information as to the crop output, but these models are limited by the capability for forecasting weather. The case is similar for spring-sown crops but over a shorter period of time.

Empirical Evidence

An examination of the historical data concerning wheat production and stocks indicates the drawdown situation described previously. Given that wheat is harvested during the third calendar quarter of each year, the USDA supply and use data account for new crop production in the third quarter and consider it to be zero in all other calendar quarters. Therefore, the available quarterly supply of wheat during any quarter of the year is the beginning inventory of that quarter plus the new production if that quarter is the third. These data manipulations are described in table II. The drawdown levels for wheat stocks are then described as the available quarterly supply minus the ending stocks for that quarter. Finally,

TABLE II.—Wheat Stocks and Production (by Calendar Quarter)

[In bushels]

Year: quarter	Wheat production	Available quarterly supply	End-of-quarter stocks	Quarterly use of stocks	Percent quarterly drawdown
1967:1	0	1 047 400	699 200	348 200	33.2
1967:2	0	699 200	512 800	186 400	26.7
1967:3	1 507 598	2 020 398	1 556 100	464 298	23.0
1967:4	0	1 556 100	1 209 700	346 400	22.3
1968:1	0	1 209 700	838 100	371 600	30.7
1968:2	0	838 100	630 200	207 900	24.8
1968:3	1 556 635	2 186 835	1 679 300	507 535	23.2
1968:4	0	1 679 300	1 341 400	337 900	20.1
1969:1	0	1 341 400	1 109 500	231 900	17.3
1969:2	0	1 109 500	904 000	205 500	18.5
1969:3	1 442 679	2 346 679	1 872 400	474 279	20.2
1969:4	0	1 872 400	1 532 800	339 600	18.1
1970:1	0	1 532 800	1 197 200	335 600	21.9
1970:2	0	1 197 200	982 600	214 600	17.9
1970:3	1 351 558	2 334 158	1 788 500	545 658	23.4
1970:4	0	1 788 500	1 410 000	378 500	21.2
1971:1	0	1 410 000	1 060 400	349 600	24.8
1971:2	0	1 060 400	822 800	237 600	22.4
1971:3	1 618 636	2 441 436	1 873 800	567 636	23.3
1971:4	0	1 873 800	1 547 600	326 200	17.4
1972:1	0	1 547 600	1 210 700	336 900	21.8
1972:2	0	1 210 700	983 400	227 300	18.8
1972:3	1 546 209	2 529 609	1 870 200	659 409	26.1
1972:4	0	1 870 200	1 398 600	471 600	25.2
1973:1	0	1 398 600	927 200	471 400	33.7
1973:2	0	927 200	597 000	330 200	35.6
1973:3	1 710 787	2 307 787	1 451 600	856 187	37.1
1973:4	0	1 451 600	928 300	523 300	36.0
1974:1	0	928 300	548 100	380 200	41.0
1974:2	0	548 100	340 100	208 000	37.9
1974:3	1 781 918	2 122 018	1 562 100	559 918	26.4
1974:4	0	1 562 100	1 107 500	454 600	29.1
1975:1	0	1 107 500	662 100	445 400	40.2
1975:2	0	662 100	435 000	227 100	34.3
1975:3	2 122 500	2 557 500	1 884 544	672 956	26.3
1975:4	0	1 884 544	1 385 650	498 894	26.5
1976:1	0	1 385 650	936 800	448 850	32.4
1976:2	0	936 800	665 300	271 500	29.0
1976:3	2 142 362	2 807 662	2 188 200	619 462	22.1
1976:4	0	2 188 200	1 781 800	406 400	18.6
1977:1	0	1 781 800	1 389 500	392 300	22.0
1977:2	0	1 389 500	1 112 200	277 300	20.0
1977:3	2 025 793	3 137 993	2 397 600	740 393	23.6
1977:4	0	2 397 600	1 990 800	406 800	17.0

table II shows the percentage of wheat inventories drawn down each quarter.

The drawdown process is shown in figure 2. The movement from point A to point B represents a quarterly reduction of available wheat supply described by the following data (in bushels), which were extracted from table II.

Year: quarter	*Wheat production*	*Available quarterly supply*	*End-of-quarter stocks*	*Quarterly use of stocks*
1968:3	1 556 635	2 186 835	1 679 300	507 535
1968:4	0	1 679 300	1 341 400	337 900

Note that the movement from point A to point B represents the 507 535-bushel usage of the available quarter supply, which was 2 186 835 bushels. Furthermore, the 1968:4 available quarterly supply is the 2 186 835 bushels minus the 507 535 bushels, or 1 679 300 bushels.

Points C and D represent the change from year to year in available quarterly supply of wheat. In other words, this change is described by the following data.

Year: quarter	*Available quarterly supply, bushels*
1974:3	2 122 018
1973:3	2 307 787
Change	−185 769

In this case, the new crop production in 1974 was 71 131 bushels larger than that of the previous year,

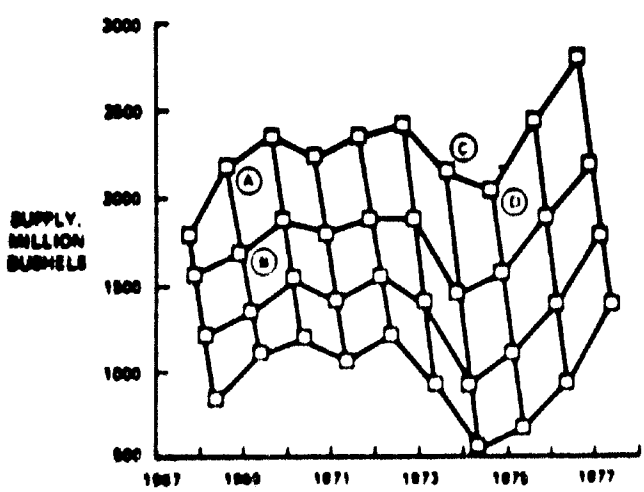

FIGURE 2.—Drawdown of U.S. quarterly supply of wheat.

but total domestic use was very high at 1 967 687 bushels and the 1973-74 carryover of wheat was a mere 340 100 bushels. Thus, the total available quarterly supply for 1974:3 (the first quarter of the new crop year) indicates a decline of 185 769 bushels.

In work done at Data Resources, Inc., quarterly wheat inventory drawdown was modeled econometrically.[1] The time series of the quarterly use of stocks in table II was modeled in terms of new-crop expectations, which were expressed as acreage-planted variables for winter wheat and all wheat as well as prices and seasonal factors. The model was developed by using ordinary least squares. The model is described in the following equation, where the values in parentheses are t-statistics.

$$\frac{(K_{t-1} + PRD_t) - K_t}{(K_{t-1} + PRD_t)} = \frac{\text{quarterly utilization of stocks}}{\text{available quarterly supply}} = Y \qquad (1)$$

$$K_{t-1} + PRD_t = \text{available quarterly supply} = AQS \qquad (2)$$

$$\begin{aligned} Y = & \underset{(6.09)}{-0.1471} - \underset{(-12.78)}{0.9373}\left(\frac{X_t}{AQS}\right) - \underset{(-4.46)}{0.0007}\left(\frac{ACPW_t}{AQS}\right) \\ & - \underset{(-3.64)}{0.0018}\left(\frac{ACPWW_t}{AQS}\right) - \underset{(1.47)}{0.0069}\, PW_t \\ & + \underset{(2.84)}{1.15 \times 10^{-5}}\left[\frac{PRD_t}{K_{t-1}}\right] + \underset{(1.52)}{0.0295}\, Q1 + \underset{(3.28)}{0.0456}\, Q2 \\ & - \underset{(-4.06)}{0.0508}\, Q3 + \underset{(1.92)}{0.0005}\, QT \end{aligned} \qquad (3)$$

[1] A discussion of the development of inventory equations in the Data Resources, Inc., Agriculture Model was done by Roger E. Brinner and Leonard E. Burman in "The Crop Sector," DRI Agriculture Service Working Paper 2, May 1976. The work was refined further by Burman in "The 1977 DRI Agriculture Model: New Developments in the Domestic Crop Sector," DRI Agriculture Service Working Paper 6, October 1977.

Interval of the regression–Quarterly 1966:1 to 1976:4

Correlation coefficient $R = 0.95$

Durbin-Watson statistic = 1.83

Sum of squared residuals = 0.0069

Standard error (SE) of the regression = 0.014; normalized SE = 5.40 percent

where K	= quarterly stocks of wheat
PRD	= production of wheat
Y	= the drawdown of crop-year supply
X	= quarterly exports of wheat
$ACPWW$	= number of acres planted in winter wheat
$ACPW$	= number of acres planted in all wheat
PW	= cash price for wheat
$Q1,Q2,Q3$	= seasonal factors
QT	= trend factor
t	= calendar quarter

(Note: K_{t-1} = beginning stocks for a quarter and K_t = ending stocks for the same quarter.)

The information germane to this discussion, which is aptly shown in the regression, is the inverse relationship of the amount drawn down (i.e., decumulation of stocks) to the acreage-planting intentions for winter wheat and all wheat. In short, the model indicates that if new-crop expectations are for a large harvest, currently held inventories will be depleted faster since future prices of wheat are expected to be lower. Therefore, information about new-crop production which becomes available well before harvest is extremely important. A good device for monitoring acreage planted would enable analysts to fine-tune their expectations of future supply and other economic factors associated with the crop.

REMOTE SENSING AND CROP PRODUCTION ASSESSMENT

In view of the previously discussed need for improved early-season assessments of commodity production, how can the agricultural remote-sensing technology augment the current crop estimation systems to provide improved information? The capabilities demonstrated to date indicate that improvements can be achieved in the following areas: (1) early-season forecasts of total harvested area for a crop; (2) early-season estimates of the changes in a crop area (planted or standing) relative to previous years; (3) early-season estimates of changes in the quantities of major classes within a crop (i.e., classes with significantly different production potential, such as winter wheat and spring wheat); (4) monitoring of an area affected by a critical meteorological event, such as drought; and (5) additional data to help make midseason and late-season forecasts of crop yield. The major constraint associated with yield forecasts is that early-season yield-forecast accuracy is limited by the ability to adequately forecast the major variables which determine yield, mainly weather. Therefore, area estimates serve as the single "hard" piece of early evidence available for production assessments.

Since 1974, satellite remote sensing technology, developed in the previous decade and assembled into an experimental crop inventory system (the Large Area Crop Inventory Experiment (LACIE)), has been tested for wheat in several countries. The capability of this first-generation technology to provide improved commodity forecasts at a country level outside the United States was evaluated by LACIE. The experiment has clearly shown that satellite data can be used to improve foreign wheat production estimates (in particular, those for the U.S.S.R.). In a separate experiment, the USDA Statistical Reporting Service (SRS) (now part of the ESCS) evaluated remote sensing as an additional tool for their ground enumerative survey. This experiment was aimed at testing the technical capability to produce estimates with significantly improved accuracies at the state and lower levels. These experiments have demonstrated that Landsat data could be used to augment the existing ground data to obtain accurate area estimates for several commodities at the state level and below.

What is the status of remote-sensing technology in terms of obtaining better early-season estimates of yield and production? LACIE has conducted quantitative tests over large areas and evaluated the use of simple, first-generation, pure-regression-type yield models based on an approach which utilizes monthly averages of temperature and precipitation to assess the impact of weather on yields. Results of these tests proved that reasonably accurate forecasts of crop yields can be made before harvest, provided there are no extreme deviations in the weather conditions. This qualifier is important because it is the

historical data series which permits estimates through regression analysis of the crop yield. Thus, in years greatly different from the average, these simple yield models cannot respond fully. Many improvements can and should be made in these crop yield models. However, the magnitude of the pursuit of these improvements must be tempered by the fact that a large source of the yield prediction error is the unpredictability of the weather. Thus, there is a limit to the reduction in the preharvest forecast uncertainty that can be accomplished through yield model improvements. For example, in Oklahoma, the 1976 wheat crop survived the early concerns about "dust bowl" conditions as a result of late April rains. The timely rains came only 1 month before harvest and the crop recovered to a near-record level. In short, even with a perfectly specified yield model, yield estimates are really no better than the weather forecasts which drive them.

Given that extremely accurate early-season yield forecasts are not expected to be technically possible in the near future, how does the remote-sensing capability augment existing crop forecasting capability? First, Landsat data can be used to quantify the total wheat area within a country or region. It also can be used to quantify the proportion of wheat classes within the region—that is, the amount of winter wheat compared to the amount of spring wheat—which is a critical input to forecasting total wheat production since winter wheat hectarage has twice the average productivity (yield) of spring wheat. In addition to the information associated with the type of wheat, geographic delineation of the area is important. For example, the eastern half of the Ukraine can be experiencing extreme drought, but if there has been a recent shift in planting toward more westerly regions, then production may not be as radically affected as one might forecast using historical data to ascertain the amount of hectarage affected by the drought. Finally, Landsat data can be used to monitor the condition of the crop in an ongoing program. The monitoring of a crop can be achieved since Landsat data can be used to quantify the amount of hectarage affected by currently poor growing conditions, and, therefore, the potential impact on harvest production can be estimated.

SUMMARY

The current systems providing crop inventory information are deficient mainly in two ways: (1) there is a need for more frequent information and (2) the crop production data are not well incorporated into the total agricultural information system for each country, with the exception of the United States. Moreover, the capabilities associated with international crop production assessment are greatly lacking in content, accuracy, and timeliness. Remote-sensing technology clearly constitutes a new tool for the crop assessment analyst, but the system that has been developed is devoted largely to wheat and has not been integrated into the overall agricultural information system of any country. Empirical analysis has clearly shown the potential of integrating the area, yield, and production capabilities of remote sensing into the total agricultural information program of the United States. The ultimate objective to be served by the crop production data is to better anticipate the supply and usage of a commodity during future periods. Crop production estimates represent a key component of a general agricultural information system. Crop estimates cannot be evaluated as a distinct part of the system but rather as a force which critically influences the supply/usage and prices of agricultural commodities. The discussion concerning the impact of acreage data focuses on a very particular use of agricultural data in a forecasting mode. Currently, agricultural analysts study the alternative drawdown patterns for a crop in terms of the USDA prospective plantings and acreage reports. The use of continuously monitored crop area data, which could be provided by remote sensing, would improve information about new crop production and, ultimately, be a force which would promote more efficient market activity.

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ANNEX 5

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT IDENTIFICATION DOCUMENT FACESHEET

TO BE COMPLETED BY ORIGINATING OFFICE

1. TRANSACTION CODE: A (A = ADD, C = CHANGE, D = DELETE)

PID

2. DOCUMENT CODE: 1

3. COUNTRY/ENTITY: DS/ST

4. DOCUMENT REVISION NUMBER: 0

5. PROJECT NUMBER (7 DIGITS): 931-1224

6. BUREAU/OFFICE: a. SYMBOL: DS; b. CODE: 08

7. PROJECT TITLE (MAXIMUM 40 CHARACTERS): Remote Sensing for Agriculture

8. PROPOSED NEXT DOCUMENT: A. 3 (2 = PRP, 3 = PP); B. DATE MM YY: 10 78

9. ESTIMATED FY OF AUTHORIZATION/OBLIGATION: a. INITIAL FY 79; b. FINAL FY 82

10. ESTIMATED COSTS ($000 OR EQUIVALENT, $1 = $1,600)

FUNDING SOURCE	AMOUNT
A. AID APPROPRIATED	
B. OTHER U.S. 1.	
2.	
3.	
C. HOST COUNTRY	
D. OTHER DONOR(S)	
TOTAL	$1,600

11. PROPOSED BUDGET AID APPROPRIATED FUNDS ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C. GRANT	PRIMARY TECH. CODE D. LOAN	E. FIRST FY 79 F. GRANT	E. FIRST FY 79 G. LOAN	LIFE OF PROJECT H. GRANT	LIFE OF PROJECT I. LOAN
(1)						1,600	
(2)							
(3)							
(4)							
			TOTAL			1,600	

12. SECONDARY TECHNICAL CODES (maximum six codes of three positions each)

13. SPECIAL CONCERNS CODES (MAXIMUM SIX CODES OF FOUR POSITIONS EACH)

14. SECONDARY PURPOSE CODE

15. PROJECT GOAL (MAXIMUM 240 CHARACTERS)

To improve agricultural land utilization and crop forecasting in LDCs through assistance in the use of remote sensing and related technologies.

16. PROJECT PURPOSE (MAXIMUM 480 CHARACTERS)

To demonstrate the application of satellite imagery and aerial photography to statistically delineate sample fields representative of a nation's total agricultural crop production.

17. PLANNING RESOURCE REQUIREMENTS (staff/funds)

Consultant's study completed during FY 1977 has provided most of the data needed for PP. 1 DH person-month required FY 1978 to develop PP.

18. ORIGINATING OFFICE CLEARANCE

Signature: Henry A. Arnold

Title: Director, DS/ST

Date Signed: MM DD YY

19. DATE DOCUMENT RECEIVED IN AID/W, OR FOR AID/W DOCUMENTS, DATE OF DISTRIBUTION: MM DD YY

AID 1330-7 (3-76)

Charles K. Paul, DS/ST

REMOTE SENSING FOR AGRICULTURE

Project Implementation Document for FY 1979 ABS

1. Project Purpose: This FY 1979 project is to demonstrate the application of satellite imagery and aerial photography to statistically delineate sample fields representative of a nation's total agricultural crop production. The specific objectives will be to measure total field acreage, estimate yield, and derive total national production estimates one month before harvest.

2. Problem to be Solved: This project will deal with the problem of estimating total supply of food in LDCs. It satisfies the Agency's criteria for agricultural programs and is significant in that it readies a country for catastrophic agricultural losses long before mass starvation is eminent.

3. Beneficiaries: The ultimate beneficiaries of this project are small farmers in those three countries where this project will be conducted. By having inventories of crop status at various times during a growing season, agricultural planners can take steps to maintain a constant supply of food to the small farmers. Thus the project addresses millions of small farmers who are essentially at the mercy of export-import planning in which they have no involvement.

4. Replicability: The technique employed, i.e., area frame sampling, is labor intensive and utilizes visual analysis of satellite and airplane

imagery. It is easily conducted in any Ministry of Agriculture in any developing country. Thus the ability of an LDC to absorb this technology exists, and many LDCs have begun to experiment, howbeit in a random and piecemeal fashion, with area frame sampling.

5. The End of Project: One month before final major crop harvest, predictions of national totals will be available. These output products will be statistical tables showing major crops and total tons of these crops by province or state.

6. Probability of Success: The probability of the success of this activity is very high, as it has already been demonstrated in developed countries and to a very limited extent in a few developing countries, such as Zaire, Bolivia and Thailand.

7. Critical Assumptions: Conditions necessary for project success are a motivated team within a Ministry of Agriculture to carry out the photo interpretation and, more importantly, in each country a team of up to 10 people to do the ground enumeration necessary to gather the detailed statistical information. The ability to learn air photo interpretation is also a critical assumption. In two of the countries where we propose this project, Thailand and Bolivia, a remote sensing trained staff is already available. In the case of the Sudan, none are available, but DS/ST is now addressing that problem with a special training project there.

8. Project Implementation: To implement this project, a PASA with the U.S. Department of Agriculture has already been discussed. They will begin on-the-job training in visual analysis in the three countries listed above. The second step will be to develop national totals based on the statistics gathered from sample fields. The third step is then to automatically classify by computer techniques the larger fields which are amenable to identification by satellite and aircraft imagery. The last step is to implement agricultural-meteorological modeling techniques to derive the yield which is fundamental in predicting final total production figures.

9. Relationship to Regional Bureaus: This project has direct relationship to many agricultural monitoring activities in all the Regional Bureaus. There have already been extensive meetings with Africa, Asia and Latin America Bureaus about this project and the go-aheads have all been given.

10. Staff Implications: 4 months effort of one full time remote sensing direct hire are necessary to produce a project paper and manage this project in FY 1979.

11. Budget: $1.6 million is necessary for this FY 1979 project. It will last three years.

12. Initial Environmental Examination: The activities do not have a direct impact on the physical or biological environment. The main activities are to develop and transfer information about the environment and natural resources. A Negative Determination, therefore, is recommended for this project.

The attached is a detailed technical description of the project as well as an initial FY 1978 pre-project activity necessary to ready the three LDCs in which this project will be implemented. The attached was submitted to USAID/Bangkok for their approval.

Attachment

A Practical Application of Remote Sensing for Crop Prediction

For the past five years AID's remote sensing program, conducted by the Office of Science and Technology in the Bureau for Development Support (DSB), has concentrated on demonstrating the applications of Landsat image interpretation and training host country resource planners how to analyze and thematically classify image data. Thailand's National Research Council represents an Asian center of excellence in this technology, thanks largely to the support provided by USAID/Bangkok and the Asia Bureau of AID. The time is ripe that something concrete and meaningful be done with this technology base to assist planning for crop scheduling, harvest, and marketing.

In this regard, DSB has a project starting this year called Remote Sensing for Tropical Agriculture; it focuses on: (1) crop prediction by monitoring pre-harvest conditions and acreages of sample fields, and (2) assessing the spatial extent of desertification and its impact on agriculture. DSB has had long discussions with the U.S. Department of Agriculture (USDA) who will be doing the technical work on (1) and with NASA who will actually be contributing both money and technical support on (2).

The crop prediction component is what DSB would like to assist with in Thailand. It would consist of four phases in succession, each subsequent phase depending upon the former. These phases include: (1) area frame sampling, (2) national totals, (3) computerized classification, and (4) agro-met modeling.

(1) Area frame sampling is a labor-intensive technique to statistically select the smallest sample of fields (the area frame) possible to obtain representative crop information for national export-import planning. The collection of data takes place on the ground at the sample fields. The sample fields are chosen by Landsat analysis, using skilled photo-interpreters. Landsat cannot see the individual small fields less than 10 acres so typical in developing countries. But it does see agricultural intensity patterns of an entire country in just a few days. By breaking out, or "stratifying," four of five of these intensities (land use themes) for an entire country, it is possible to select a sample number of fields (several hundred) which, if surveyed on the ground, can provide an accurate representation of national averages of

yield, crop acreage, livestock, etc. The USDA regularly does this in California and Illinois, where accuracies in state totals for crop harvest estimates range from 75-95 percent. As opposed to aircraft photography, which is expensive and in some developing countries impossible to obtain due to military restrictions, Landsat is available every 18 days (clouds permitting), hence the area frame can be updated when desired. At the present time the FAO is building a frame using Landsat in Bangladesh.

(2) National Totals: The power of Landsat becomes more apparent in this second phase. Aerial photography, even if one had it for an entire country, would have to have been taken over many days, with different atmospheric conditions, different sun and shadow angles, and other diurnal variations which result in inconsistent contrast, patterns, and tonal variations on the air photos. Not so with Landsat. It images everywhere on earth at the same time of day, 9:30 a.m. With a technique called ratioing, it is possible to get rid of the subtle atmospheric effects from the imagery if necessary. Thus image manifestations in southern Thailand correspond to similar features in the north. It is this feature consistency which permits one to multiply the sample statistics gathered on the ground by a ratio to obtain national estimates. The ratio is the intensity theme in the entire country to the intensity theme present in the samples. The intensity themes are quantified as hectares. This expansion to areas larger than the original samples is surprisingly quite accurate. The accuracy of the totals depends directly on the accuracy of the sample statistics and not on the magnitude of the ratio. The independence of the accuracy of the totals to the size of the expansion is due to the consistency of themes as depicted on Landsat imagery and as interpreted by trained interpreters.

(3) Computerized classification would be the next logical step. From the area frame developed under (1) the Project would have, among other things: (a) reliable average yield values for several important crops (bushels per acre), and (b) known crops growing in sample fields which, if some are large enough, can be identified on the Landsat imagery. With this data, the Project can now use the known crops to literally "train" a computer to automatically classify all sufficiently large fields outside the sample area. Then by multiplying the total hectares of each crop by the yield, total production estimates of each crop are obtained. The frame is time-consuming to construct (one to two man-years), but the automatic classification of crop hectares permits one to update the predicted totals several times during the crop growing season to take account of climatic and catastrophic events.

It will be necessary to look at field size distributions in Thailand to determine if this step makes sense. If only ten percent of the fields are larger than ten acres, but this ten percent is growing eighty percent of the crops in question, then computer techniques are obviously appropriate. If this ten percent is growing only ten percent of the crops, but the other ninety percent are all small one-quarter of an acre plots and yet consists of mile after mile of contiguous plots of the same crop (rice, for example), then again computer classification may be applicable. This classification could be done by appropriate modification or an addition to some of the computer algorithms NRC has set up at the Asian Institute of Technology.

(4) The agricultural-meteorological (agromet) models represent the final link in a viable crop prediction program. They are also the most sophisticated and expensive to use. They are computer-based, and essentially simulate the growing of a crop by inputting crop moisture, sunlight radiation, and other parameters affecting the vigor of the crop. Data collected from the field as well as remote sensing data from Landsat, weather, and other satellites are required. The important crop yield of the formula is thus determined, driving total crop production estimates up above 95 percent accuracy.

The FY 1978 activity would be phase (1) only; i.e., the construction of an area frame using Landsat in Thailand. This activity, should it be approved, would be carried out by a USDA team in Thailand who, in addition to constructing the frame, would train Thai counterparts in both the image analysis and the ground enumeration. It is proposed to start either this summer or at the beginning of a growing season, whichever is later. This activity, as well as all ensuing phases[1/] which the Mission and Government of Thailand would be interested in pursuing, would be funded by DSB since the activities are still somewhat experimental, have not yet shown conclusive benefits to the developing world, and have wide regional applicability.

The area frame for Thailand would take about six months to build. DSB is prepared to fund all expenses of the USDA team and their technical support ($67,000). USAID/Bangkok would be informed of progress and there would be no requirement on the Mission for personnel, financial or logistic support. There would be a need for the RTG to provide the following in support of this project:

1/ Project life is proposed as 4 years with termination in FY 1982.

(1) all salary, travel, and other costs of their personnel who would learn and take over the area frame construction.

(2) a laboratory space or classroom (we'll bring necessary equipment or arrange to get it there).

(3) a graduate level or professional statistician, preferably from Ministry of Agriculture. He would be in charge.

(4) 3 university students, undergraduate, or equivalent - representing fields of soils mapping, agriculture, and remote sensing.

(5) 20 non-skilled, motivated people for the ground surveys. These could be trainees under an education project looking for a relevant task to test newly-acquired literacy skills.

DS/ST:CKPaul:ep:3/16/78

ANNEX 6

1. INITIAL STARTING DATE (Mo., Day, Yr.) August 15, 1978	PASA PARTICIPATING AGENCY SERVICE AGREEMENT BETWEEN THE AGENCY FOR INTERNATIONAL DEVELOPMENT AND U.S. Department of Agriculture	6. ☐ PASA ORIGINAL ☒ PASA AMENDMENT 1
2. PROJECTED COMPLETION DATE (Mo., Day, Yr.) September 1980		7. PASA NUMBER AG/TAB-1166-6-78
3. CATEGORY ☒ TDY ☐ ASSIGNED		8. COUNTRY/AID/W OFFICE
4. DURATION OF FUNDING ☐ CURRENT YEAR ☒ FORWARD FUNDING	5. PROJECT NO. AND TITLE 931-1166 Remote Sensing for Resource Assessment	9. TYPE ☐ REIM. ☒ GRANT ☐ LOAN — 10. YEAR FY 19 78, 79, 80

11. FUNDING

A. CITATIONS	(1) APPROPRIATION NO. 72-1181021.3	(2) ALLOTMENT NO. 843-36-099-00-20-81	(3) PIO/T/OBLIGATION NO. 931-1166-3188666
B. AMOUNT	(1) INITIAL OR CURRENT $796,500	(2) CHANGE (+ OR -) -$2,500	(3) NEW TOTAL $794,000
C. TOTAL PROJECT COSTS	(1) PRIOR YEARS (FOR CONTINUOUS PROJECTS)	(2) FUTURE YEARS (INCLUDE CURRENT FUNDING. BLOCKS B(1) OR B(3))	(3) ESTIMATED TOTAL

D. PRINCIPAL COST COMPONENTS (BLOCK B)	(1) SALARIES, DIFFERENTIAL AND BENEFITS	(2) TRANSPORTATION INCLUDING PER DIEM	(3) MISCELLANEOUS	(4) OVERHEAD
E. SUPPLEMENTAL AID SUPPORT	(1) INITIAL OR CURRENT $2,500	(2) CHANGE (+ OR -)	(3) NEW TOTAL $2,500	

12. STATEMENT OF PURPOSE

The purpose of this amendment is to decrease the funding provided to the U.S. Department of Agriculture by $2,500 and make this amount available to USAID/Bangkok (per STATE 261328, dtd. 14 October, 1978) to fund travel and per diem of one Thai designate to attend Lacie Symposium at NASA Johnson Space Center, Clearlake, Texas, between November 28 - December 3, 1978.

All other provisions remain unchanged.

13. GOVERNING PROVISIONS: PURSUANT TO THE GENERAL AGREEMENT DATED Feb. 15, 1966 BETWEEN AID AND THE USDA, THE AGENCY NAMED ABOVE AGREES TO PROVIDE THE SERVICES OUTLINED IN BLOCK 12 AMPLIFIED AS NEEDED BY APPENDIX A UNLESS OTHERWISE AUTHORIZED BY AID. ALL SERVICES SHALL BE OF U.S. ORIGIN. ANY APPENDICES ATTACHED HERETO ARE CONSIDERED PART OF THIS PASA.

14. SIGNATURES

NAME: William A. Hoagland	NAME: J. William Miller
TITLE/OFFICE: Acting Director	TITLE/OFFICE: CHIEF, PARTICIPATING AGENCY BRANCH CONTRACT MANAGEMENT, AID
DATE: Nov. 2, 1978	DATE: October 31, 1978

15. APPENDICES

☐ APPENDIX A - SCOPE OF WORK
☐ APPENDIX B - BUDGET PLAN
☐ OTHER REFERENCE

16. NEGOTIATING OFFICERS

AID: CM/SOD/IIA: WTSchroeder
AGENCY: USDA/OICD: HMattox

AID 2-2 (11-78)

1. INITIAL STARTING DATE (Mo., Day, Yr.) August 15, 1978	**PASA** **PARTICIPATING AGENCY SERVICE AGREEMENT** **BETWEEN THE AGENCY FOR INTERNATIONAL DEVELOPMENT AND** U.S. Department of Agriculture	6. [x] PASA ORIGINAL [ ] PASA AMENDMENT ____
2. PROJECTED COMPLETION DATE (Mo., Day, Yr.) September 1980		7. PASA NUMBER AG/TAB-1166-6-78
3. CATEGORY [x] TDY [ ] ASSIGNED		8. COUNTRY/AID/W OFFICE AID/W/DS/ST - WW
4. DURATION OF FUNDING [ ] CURRENT YEAR [x] FORWARD FUNDING	5. PROJECT NO. AND TITLE 931-1166 Remote Sensing for Resource Assessment	9. TYPE [ ] REIM. [x] GRANT [ ] LOAN 10. YEAR FY 1978-79,

11. FUNDING

A. CITATIONS	(1) APPROPRIATION NO. 72-1181021.3	(2) ALLOTMENT NO. 843-36-099-00-20-81	(3) PIO/T/OBLIGATION NO. 931-1166-3188666
B. AMOUNT	(1) INITIAL OR CURRENT $ 796,500	(2) CHANGE (+ OR -) ---	(3) NEW TOTAL $796,500
C. TOTAL PROJECT COSTS	(1) PRIOR YEARS (FOR CONTINUOUS PROJECTS)	(2) FUTURE YEARS (INCLUDE CURRENT FUNDING. BLOCKS B(1) OR B(3))	(3) ESTIMATED TOTAL

D. PRINCIPAL COST COMPONENTS (BLOCK B)	(1) SALARIES, DIFFERENTIAL AND BENEFITS	(2) TRANSPORTATION INCLUDING PER DIEM	(3) MISCELLANEOUS	(4) OVERHEAD
E. SUPPLEMENTAL AID SUPPORT	(1) INITIAL OR CURRENT	(2) CHANGE (+ OR -)	(3) NEW TOTAL	

12. STATEMENT OF PURPOSE

A. Summary

The purpose of this Agreement is to fund services by experts of the Department of Agriculture/Economic and Statistical Research Service (ESRS) to provide technical assistance in implementing remote sensing area frame sampling in eleven developing countries. Funding is provided for approximately 25 person months through September 1980. The technicians will develop area frame samples by remote sensing techniques, specifically Landsat imagery and air photos, for the purpose of enabling LDCs to improve crop prediction accuracies.

13. GOVERNING PROVISIONS: PURSUANT TO THE GENERAL AGREEMENT DATED Feb. 15, 1966 BETWEEN AID AND THE USDA, THE AGENCY NAMED ABOVE AGREES TO PROVIDE THE SERVICES OUTLINED IN BLOCK 12 AMPLIFIED AS NEEDED BY APPENDIX A UNLESS OTHERWISE AUTHORIZED BY AID. ALL SERVICES SHALL BE OF U.S. ORIGIN. ANY APPENDICES ATTACHED HERETO ARE CONSIDERED PART OF THIS PASA.

14. SIGNATURES

NAME:	NAME: [illegible]
TITLE/OFFICE: Sol / 8/28/78	TITLE/OFFICE: CHIEF PARTICIPATING AGENCY BRANCH CONTRACT MANAGEMENT, AID
DATE:	DATE: AUG 22 1978

15. APPENDICES [x] APPENDIX A - SCOPE OF WORK [x] APPENDIX B - BUDGET PLAN [ ] OTHER REFERENCE ____	16. NEGOTIATING OFFICERS AID: CM/SOD/IIA:[illegible] AGENCY: USDA/OICD:HMattox

AID 3-8 (11-78)

PARTICIPATING AGENCY SERVICE AGREEMENT
BETWEEN
THE AGENCY FOR INTERNATIONAL DEVELOPMENT AND
U.S. Department of Agriculture

[X] ORIGINAL [ ] AMEND NO. ____
PASA NO. AG/TAB-1166-6-78
FISCAL YEAR 1978,79,80

B. Scope of Work

The team of PASA experts will transfer technology to construct Area Sampling Frames in selected Less Developing Countries (LDC's) using LANDSAT Multi-Spectral Scanner (MSS) imagery, available aerial photography, maps, and field enumeration. The USDA, in cooperation with the recipient countries and subject to USAID Mission concurrences in those countries, will provide on-the-job (OTJ) training to their host country counterparts in both the visual analysis of images and maps for area frame technology and field sampling techniques. The products left in each recipient country will include agricultural intensity theme maps, comprising the material useful for an area frame stratification, materials to carry out sampling that are representative of the country's total agricultural potential, and a report of the procedures necessary to carry out, and update, the developed area frame. In addition, a host country staff of from 3 to 6 persons would be trained in the techniques of area frame construction by LANDSAT and aircraft imagery, and maps, as well as the methodology of choosing appropriate land units for ground sampling. This project does not envision a total agricultural census of the countries involved.

The candidate countries for this activity are the Dominican Republic, Philippines Thailand, Bolivia, Paraguay, Indonesia, Jamaica, Eucador, ~~Chile, Guyana,~~ Costa Rica Morocco, ~~Zaire~~, and the ~~Sudan~~. Tentative mission and country approvals have been obtained in Thailand and Bolivia. Expressions of interest for the project have been received from the Dominican Republic, Jamaica, Paraguay, Indonesia, Ecuador, and ~~Guyana~~. The USDA has begun area frame sampling in Zaire. The Mission Director in the Sudan is holding up his decision on the project until the return of Sudanese presently undergoing training at South Dakota State University.

The PASA team will be responsible, with AID/W, DS/ST and AID Mission assistance where necessary, for negotiating final agreements with the nine to eleven host countries. This should be done during initial visits to the host countries by either the project leader or his staff, with AID/W or Mission assistance when necessary. This has already been done in Thailand and is expected to occur in Bolivia during July.

The PASA technicians will then acquire all recent LANDSAT imagery of the agriculturally productive areas of the countries involved. Where recent (within last year) imagery is not availab le and where a Landsat receiving station covers the country in question, USDA will make arrangements to purchase imagery via a foreign ground station. If the country falls outside of the area of existing ground station coverage, AID/W will make every possible effort to request NASA to turn on the MSS sensor during the crop growing season. The USDA will also attempt to acquire through the host governments, all available aerial photography and maps. The maps must be put on clear acetate overlays at the same scale as the

LANDSAT imagery (preferably 1:250,000). Other materials used in area frame construction that the USDA would require are light tables, planimeters, storage cabinets, color pencils, rolls of acetate, etc.

Some of the frame construction will be in the U.S. where country counterparts can visit for training. Some of the travel money allocated for photo interpreters can be used for this purpose.

The USDA team, consisting of photo-cartographers and statisticians, will classify land use themes from imagery and select sample land units for a demonstration area. This demonstration survey can be run while the area frame for the whole country is being completed. Questionnaires and field procedures can be worked out for the demonstration areas.

The sample selection and a portion of the image analysis will be done in the respective countries in conjunction with the appropriate agricultural agency. The sample selection will be followed by the field enumeration, with host country counterparts being trained in the field by the USDA advisory personnel. Selected data on crop type, field hectarage, yield, livestock, and other land associated characteristics will be obtained for the sample areas by the field teams and left with the appropriate host country agency. The techniques of area frame sampling will be imparted to the host country agricultural ministry.

The USDA would appoint one project leader who would be responsible for the area frame activity in all eleven countries. (S)He would spend about one month in each country negotiating the agreement and directing the development of the area frame. There would be a total of up to 5 photo-cartographic assistants and 5 statisticians. There would be teams of field sampling technicians which would visit each country. A team would spend approximately 2 months in each country. The team distribution for a representative 9 countries is shown in the attached "Schedule of Country Events." In addition, one of the countries, Thailand, is about ready to attempt digital classification of fields, and it will be desirable to send a Thai to the U.S. for advanced training.

~~As part of this activity, the USDA will provide training in the U.S. for approximately 10-15 members of a U.S. Southeast consortium of black universities, headed by Alabama A&M University. The purpose of this training is to develop a cadre of area frame sampling personnel for attempting to use this technique to monitor desertification in the Sahel.~~

C. Background Information

Tentative Mission approvals for this activity have been obtained for Thailand Bolivia, ~~and Ecuador~~ In addition, the USDA has carried out limited area frame sampling using outdated aerial photography in the Dominican Republic Thailand, Bolivia, Chile, and Zaire. Expressions of interest in learning more about this project have been received from Paraguay, Indonesia, and

Guyana. DS/ST and USDA staff have already visited Thailand, Bolivia, and Chile regarding this activity. After initial visits, several countries, such as Jamaica, Ecuador, Guyana, and Zaire, may be dropped and substituted with Costa Rica, Senegal, and Ivory Coast.

D. Reports

10 copies of individual country reports will be furnished to DS/ST outlining crop and other agricultural statistics based on the sample frame, an assessment of the training provided to host country technicians and their capacity to enter into the advanced phases of the DS/ST Agriculture Project, and the USDA conclusions regarding each country's present and potential future motivaton in maintaining and updating the frame. In addition, a final report in 10 copies will be submitted describing the overall activity for all countries and how the data and conclusions obtained can be used in developing an LDC crop forecasting system supplementing the FAO's activities in this area. 35mm slides should be provided to DS/ST indicating the more interesting applications in each of the nine to eleven countries. USDA shall submit three copies of all reports listed as being a product of the PASA (administrative, progress, final and technical reports containing RCD findings) to the Documentation Coordinator, DS/DIU, Development Support Bureau, Agency for International Development, Washington, D.C. 20523, or his designee. Such reports shall include a title page showing the title of the report, project title as set forth in this contract (or grant) and the contract number. One copy of each report shall be clearly typed or printed on white paper so that it may be photographed to produce a microfilm master. Technical reports shall be accompanied by an author-prepared abstract.

E. Liaison and Guidance

AID/W/DS/ST - Dr. Charles K. Paul

F. Equipment and Supplies

USDA is requested to purchase the following equipment:

300	Landsat images	$90,000
	Maps and Supplies	10,000
	Computer equipment (note --these are small, portable desk computers for aggregating agricultural statistics)	64,100

G. Logistic Support

The cooperating countries will provide in kind — office space and equipment, transportation in cooperating country, official vehicles and interpreter/secretarial services.

H. International Travel

International travel, originating in the U.S. must be cleared by CM/SOD/IIA, before undertaken.

Prior to making visits to LDCs, the PASA technician will review his plans with DS/St. He will clear visits to host countries with DS/ST at least 30 days in advance. DS/ST will then obtain country concurrence of the visit prior to commencement of travel. He will call on AID Missions upon arrival, keep Mission personnel fully informed, ask them to participate in discussions if they desire and will inform Missions of the outcome of consultation. Normally, he will make his own appointments and logistical arrangements.

I. Language Requirements

Working knowledge of Spanish helpful, but not required.

BUDGET PLAN APPENDIX B PAGE __ OF __	PARTICIPATING AGENCY SERVICE AGREEMENT BETWEEN THE AGENCY FOR INTERNATIONAL DEVELOPMENT AND U.S. Department of Agriculture	1. PASA NO. AG/TAB-1166-6-78	2. AMENDMENT NO.	3. FISCAL YEAR 1978,79,80
		4. APPROPRIATION 724181021.3	5. ALLOTMENT 843-35-099-00-20-81	6. AMOUNT CURRENTLY FUNDED $796,500

7. FUNDED BY	PIO/T-OBLIG. NO.	AMOUNT	PIO/T-OBLIG. NO.	AMOUNT	PIO/T-OBLIG. NO.	AMOUNT
	931-1166-3188666					

8. PASA BUDGET PLAN - FUNDING

DESCRIPTION	AMOUNT
SALARIES	$186,414
5.5% pay increase	10,253
BENEFITS (9.5 % OF SALARIES)	17,704
DIFFERENTIAL (_____ % OF SALARIES)	
LEAVE FACTOR (TDY: ONLY) (18.5 % OF SALARIES & BENEFITS)	36,383
TRAVEL (EXPLAIN BELOW)	100,000 1/
PER DIEM (EXPLAIN BELOW)	100,000 2/
SUPPLIES & MATERIALS	10,000 3/
EQUIPMENT	64,000 4/
OTHER	90,000 5/
CONTINGENCY	2,446 6/
OVERHEAD ☐ SALARIES & BENEFITS 25 % ☐ PERSONNEL COSTS ☒ ALL COSTS	159,300
TOTAL (INCLUDES _____ TO BE FUNDED BY FUTURE PASA AMENDMENTS)	$796,500

9. STAFFING

NAME AND TITLE	GRADE	PERIOD (PEOPLE-DAYS/MONTHS)	AMOUNT
	GS	DAYS	
Economist, Project Leader	14/3	110	$13,876
Photo-Cartographers	13/1	440	44,037
Sampling Statisticians	14/3	417	52,606
Field Survey Statisticians	13/1	702	70,259
Secretary/Clerical	6/1	132	5,636

EXPLANATORY COMMENTS

1/ $90,000 includes various international travel to eleven LDCs - Thailand, Indonesia, Bolivia, Chile, Guyana, Dominican Republic, Paraguay, Zaire, Senegal, Ivory Coast, Costa Rica and Sudan. Also includes approximately $10,000 for domestic travel to various institutions.

2/ Includes domestic per diem, international peridme, in-transit and miscellaneous expenses.

3/ Maps and supplies

4/ Computer equipment, small portagle desk computers, light tables, plainimeters, etc.

5/ Landsat images

6/ Contingency for possible pay increase and inflation factor

AID 2-2A (11-78)

PROJECT AGREEMENT

931-1166
Remote Sensing for
Resource Assessment

Project Agreement

January , 1979

Between

The Kingdom of Thailand, acting through the Department of Technical and Economic Cooperation (DTEC)

and

The United States of America, acting through the Agency for International Development ("A.I.D.")

Article 1: The Agreement

The purpose of this Agreement is to set out the understandings of the parties named above ("Parties") with respect to the undertaking of the Project described below, and with respect to the resources to be contributed to the Project by the Parties.

Article 2: The Project

SECTION 2.1 Definition of Project. The Project which is further described in Annex A, will consist of the provision of U.S. Government technical services and materials to the Royal Thai Government to support and further Phase I of a project designed to develop and implement a program of area frame sampling for crop statistics. Annex A, attached, amplifies the above definition of the Project. Elements of the amplified description stated in Annex A may be changed by written agreement of the

authorized representatives of the Parties named in Section 5.2 without formal amendment of this Agreement.

Article 3: Resources for the Project

SECTION 3.1 United States Government. To assist the DTEC in carrying out the Project. The United States Government, pursuant to the Foreign Assistance Act of 1961, as amended, and Participating Agency Service Agreement No. AG/TAB-1166-6-78, agrees to provide through the U.S. Department of Agriculture, the services and materials specifically identified in Attachment I of Annex A hereto. The costs of these services and materials shall not exceed 100,000 United States ("U.S.") dollars.

SECTION 3.2 Royal Thai Government

(a) The Royal Thai Government agrees to provide or cause to be provided for the Project all other resources that are required to carry out the Project effectively and in a timely manner.

(b) The resources provided by the Royal Thai Government for the Project will be not less than the equivalent of 30,000 U.S. Dollars.

SECTION 3.3 Project Assistance Completion Date

(a) The Project Assistance Completion Date (PACD) is September 30, 1980, or such other date as the Parties may mutually agree to in writing. The PACD is the date by which all services and materials to be provided by the Parties under this Agreement will have been performed and furnished for the Project as contemplated in this Agreement.

SECTION 4.1 Project Evaluation. The Parties agree to establish an evaluation program as part of the Project. Except as the Parties otherwise agree in writing, the program will include, during the implementation of the Project and at one or more points thereafter:

(a) evaluation of progress toward attainment of the objectives of the Project;

(b) identification and evaluation of problem areas or constraints which may inhibit such attainment;

(c) assessment of how such information may be used to help overcome such problems; and

(d) evaluation, to the degree feasible, of the overall development impact of the Project.

Article 5: Miscellaneous

SECTION 5.1 Communications. Any notice, request, document, or other comunication submitted by either Party to the other under the Agreement will be in writing and will be deemed duly given or sent when delivered to such party at the following addresses:

To the DTEC:

Mail Address: Department of Technical and Economic Cooperation
Krung Kasem Road
Bangkok, Thailand

To A.I.D.:

Mail Address: USAID/Thailand
American Embassy
Bangkok, Thailand

SECTION 5.2 Representatives. For all purposes relevant to this Agreement, the DTEC will be represented by the individual holding or acting in the Office of Director-General, Department of Technical and Economic Cooperation and AID will be represented by the individual holding or acting in the Office of Director, USAID/Thailand. DTEC and

AID may, by written notice, designate additional representatives for all purposes other than exercising the power under SECTION 2.1 to revise elements of the amplified description in Annex A. The names of the representatives of DTEC with specimen signatures will be provided to AID, which may accept as duly authorized any instrument signed by such representatives in implemenation of this Agreement, until receipt of written notice of revocation of their authority.

IN WITNESS WHEREOF, the Kingdom of Thailand and the United States of America, each acting through its duly authorized representatives, have caused this Agreement to be signed in their names and delivered as of the day and year first above written.

For the Government of Thailand:

Signature:_____ Date_____
Xujati Pramoolpol
Director-General, DTEC

For the Agency for International Development:

Signature:_____ Date_____
Donald D. Cohen
Director, USAID/T

Accepted:

Department of Agricultural Economics

By:_____ Date_____

Title:_____

National Research Council

By:_____ Date_____

Title:_____

U.S. Department of Agriculture

By:_____ Date_____

Title:_____

PROJECT AGREEMENT

ANNEX A

931-1166
Remote Sensing for
Resource Assessment

This document records the agreement of the signatory parties to participate in area frame sampling construction activities of the Remote Sensing for Resource Assessment Project during the period starting on the date of execution of this Agreement to final contribution date as shown on face sheet for the conduct of the project.

Of all the applications of satellite remote sensing technology, the most promising, yet most elusive to date, has been the monitoring for prediction of crop harvests. Crop area and yield monitoring are difficult to carry out due to the dynamically changing conditions of crop status over short periods of time. Yet every country attempts to estimate total area (hectares) and average yield (bushels per hectare) for selected crops to derive an estimate of the product of the two; i.e. total production equals area times yield. The degree of precision obtainable in deducing this estimate depends upon the tools available to measure area and yield. And this precision translates to stabilizing food inventories for consumption, if the precision is good; or to hoarding of grain inventories with subsequent loss to those in need, if the precision is bad. In some developing countries of the world, imprecision translates to famine.

Agricultural statistics for many countries is achieved by a full or complete inventory of all farms; i.e. a farm-to-farm survey

of an entire country. This method of acquiring statistics is still carried out by the U.S. Bureau of the Census, in the U.S. and in other countries throughout the world. The method has two serious drawbacks: (1) it relies totally on questionnaires which obtain information from farmers every 5 or 10 years, but with no data acquired by objective mensuration; (2) it can take three years to plan and conduct the census and three more years to compile and publish all the statistics in a country such as the U.S. or Bolivia. Needless to say, crop information every six years is inadequate for food distribution and marketing when production varies between years.

In recognition of the importance of accurate crop statistics in a timely manner, the United States Department of Agriculture (USDA) has conducted enumeration of selected representative sample fields and farms to derive a representative portion of the land area, yield, and other agricultural data. Data collected from these sample areas when multiplied by an appropriate factor to convert the sample to the total country, will provide accurate estimates of crop and livestock by county, state, and the entire country. For over a century, total production estimates were subject to errors due to the problems of selecting fields which were not truly representative of the Nation's crop status, and the lack of knowledge of the appropriate factor by which the sample statistics were to be muliplied.

Beginning with the early 1930's, the operational use of air force and commercial cameras, and notably the early 1970's, with the advent of the LANDSAT earth survey satellite, witnessed the introduction of new technology which minimized both of these problems. By using both aircraft photograph and LANDSAT imagery with field

enumeration, the Economics, Statistics and Cooperatives Service (ESCS) of the USDA carries out the June Enumerative Survey (JES) of agricultural production in all states of the U.S. The ESCS area frame estimates are recognized as the best estimate of the current status of U.S. crops, and are used as the calibrating standard in the U.S. for all official agricultural statistics.

Because of the solid statistical base of the area frame sampling technique, as well as the future promise of the advanced technology manifested by processing digital LANDSAT data the office of Science and Technology in AID/Washington has implemented a global activity to transfer this technology to twelve developing countries. This activity consists of four phases: (1) construction of an area sampling frame, (2) national crop estimation, (3) automatic field classification, and (4) agricultural - meteorological crop yield and production modeling.

This Project Agreement covers only phase (1), area frame sampling. Conditional on the Royal Thai Government (RTG) successfully completing this phase; i.e. the establishment of a full frame for Thailand as described under Project Description, and conditional on Washington funds released for a subsequent project to cover costs of phases (2) (4), this Project Agreement will be amended at a later date to permit USAID and RTG to enter into phases (2) - (4)

Project Description

I. Remote Sensing Background in Thailand

In 1972, Thailand was selected to participate in the NASA Principle Investigator Program for LANDSAT - 1. At that time, USAID

and the RTG signed a Project Agreement to provide Thailand with technical assistance and training in the interpretation of the LANDSAT imagery acquired by NASA over southern Asia. Initially, between 1972 and 1974, sixty Thai, twelve Mekong Committee staff, and other Indochina participants received training both in Thailand and the U.S. This national Thailand program was extended in 1974, providing additional training to carry out applications in forestry, watershed management, coastal monitoring, rubber plantation surveys, and crop assessment. In addition, two digital image analysis programs were set up in Thailand - the RECOGX program from Colorado State University was installed on the IBM 370/145 at the Asia Institute of Technology (AIT), and the LIGMALS program, developed by Harvey Wagner of the University of Michigan, was set up on the Burroughs 1710 at the Burroughs Corporation in Bangkok.

The RTG National Research Council (NRC) which controls and directs remote sensing in Thailand, is a major participating agency in the establishment of the Asia Regional Remote Sensing Center at AIT. Funded mostly by USAID, with contributions from AIT and UNESCAP, NRC will supply instructors and the use of their photographic facilities to the Regional Center. They will make available selected aerial photography and access to ground sites for training in multi-stage sampling techniques.

The RTG cabinet has recently approved the funding of 80 million baht for the development of a LANDSAT receiving station. This station will permit periodic (9 day) acquisition of image data from both of the LANDSAT-2 and 3. These data will be transmitted to the

Thai station whenever the satellites are within a 2700-km, horizontal radius of Bangkok. It is planned to channel these data directly to the Regional Center where rapid assessment of crop status, flooding, and other dynamic phenomena is necessary. Already, USAID has made available a NASA computer specialist to advise the RTG on station hardware and will issue invitational travel orders to a second NASA antenna and station specialist to further elaborate on station equipment and costs, as well as advise on appropriate sites for the receiving station. It is expected that the RTG will sign NASA's Memorandum of Understanding (MOU) in January, 1979. Among other conditions, NASA agrees under the MOU to turn on the LANDSAT sensors whenever the satellites are within range of the RTG station in turn for the RTG selling the data products to whomever desires to purchase them.

II. Agricultural Applications

MOU closely tied to agricultural applications was a project to initiate LANDSAT-based area frame sampling in Thailand. Conducted in 1976, this was a small grant actively funded by USAID's Office of Science and Technology in Washington. The grant was administered by the Environmental Research Institute of Michigan (ERIM). Due to the funding limitation of a $20,000 grant plus about $40,000 in technical assistance, this activity had only minor impact in Thailand on-going area frame sampling conducted with the assistance of Iowa State University to the Division of Agriculture Economics (DAE) of the Ministry of Agriculture & Cooperatives (MOAC). The present area

frame sampling in Thailand depends upon aerial photography which is flown irregularly over limited portion of the country. The use of LANDSAT will provide a means to rapidly update the frame, redistributing sample fields as agricultural patterns change.

Area frame sampling is a labor-intensive technique to scientifically select the smallest sample of fields or other land areas possible to obtain representative crop information for national decision making, such as, export-import planning. The collection of data takes place on the ground at the sample fields. The sample fields are chosen by statistical procedures, using skilled photo-interpreters and statisticians. LANDSAT cannot see the individual small fields less than 10 acres so typical in developing countries. But it does see agricultural intensity patterns of an entire country in just a few days. By breaking out, or "stratifying," four of five of these intensities (land use themes) for an entire country, it is possible to select a small sample of fields (several hundred) which if surveyed on the ground, can provide an accurate representation of the national averages of yield, crop acreage, livestock, etc. The USDA regularly does this in all states within the continental U.S., where accuracies in state totals for crop production have coefficients of variation between 3 to 10%. Aircraft photography is expensive and in some developing countries impossible to obtain due to military restrictions. LANDSAT satellites are potentially available every 9 days (clouds permitting), hence the area frame can be updated when desired. Outside the U.S., the USDA is providing assistance in building frames in Tunisia,

Zaire, Jamaica, Dominican Republic, and other developing countries under USAID funding.

III. U.S. Government (USG) Contribution to the Support of of the Area Frame Sampling Activity

The U.S. Department of Agriculture (USDA) ESCS will transfer technology to construct Area Sampling Frames in selected Less Developed Countries (LDC's) using LANDSAT Multi-Spectral Scanner (MSS) imagery, available aerial photography, maps, and and field enumeration. The USDA, in cooperation with the recipient countries and subject to USAID Mission concurrences in those countries, will provide on-the-job training (OJT) to their host country counterparts in both the visual analysis of images and maps for area frame technology and field sampling techniques. The products left in each recipient country will include agricultural intensity theme maps, comprising the material useful for an area frame stratification, materials to carry out sampling that are representative of the country's total agricultural potential, and a report of the procedures necessary to carry out, and update, the developed area frame. In addition, an RTG staff of from three to six persons would be trained in the techniques of area frame construction by LANDSAT and aircraft imagery, and maps, as well as the methodology of choosing appropriate land units for ground sampling. This project does not envision a total agricultural census of Thailand.

The USDA will acquire all recent LANDSAT imagery of the agriculturally productive areas of the RTG. AID/W will request

NASA to turn on the MSS sensor during the crop growing season until the RTG LANDSAT receiving station is operational at which time RTG will be able to acquire their own imagery. The USDA will also use and acquire all recent available aerial photography and maps. The maps will be put on clear acetate overlays at the same scale as the LANDSAT imagery (preferably 1:250,000) by the USDA. Other materials used in area frame construction that the USDA would require are light tables, planimeters, storage cabinets, color pencils, rolls of acetate, etc.

Some of the frame construction will be in the U.S. where country counterparts can visit and assist with as part of their training. Some of the travel money allocated for photo interpreters can be used for this purpose.

The USDA team, consisting of photo-cartographers and statisticians, will work with the RTG staff to classify land use themes from imagery and select sample land units for a demonstration area. The field survey for the demonstration area will be run while the image interpretation for the whole country is being completed. Questionnaires and field procedures will be worked out for the demonstration area.

Once the results of the demonstration area are verified for accuracy and the procedure appears operational, the remainder of the country's sample fields will be enumerated by a DAF field team with minimal consultation by USDA staff. Selected data on crop type, field hectarage, yield, livestock, and other land associated characteristics will be obtained for the sample areas

by the DAE field teams and USDA staff. The techniques of area frame sampling will thus be imparted to the DAE.

The USDA will appoint one project leader who would be responsible for the U.S. assistance in area frame sampling. He will spend a total of one month in Thailand directing the development of the area frame. One USDA photo-cartographer will spend 2 months in Thailand, one statistician 1½ months, and one team consisting of three field sampling technicians will spend 3 months in Thailand. The same person may be involved in several of these activities.

The USDA team will bring hand-drafting equipment to build an area frame when they come. In addition, if the RTG manages to develop the area frame for the country and elects (conditioned on AID/Washington funding) to proceed to phase 2 as described above, USAID can, if necessary, equip the RTG with a small, desk-top computer for aggregating crop statistics. Again, conditioned on AID/Washington funding for later phases (which should be known by April 1979) and RTG interest, USAID will send, under this project agreement, an RTG remote sensing scientist to the U.S. for training in advanced computer classification techniques applied to crop area measurements.

IV. <u>RTG Contribution to the Area Frame Sampling Activity</u>

Under this activity, the RTG will furnish one full time agriculture statistician to manage the frame development. (5)He would preferably be an employee of the Division of Agriculture Economics routinely carrying out responsibilities similar to that required by this project. The job duration is 20 months. DAE

will need 3 additional employees to complete the project for 1 year. A remote sensing scientist, preferably from the National Research Council, will work on the project for 6 months. Initially, for the demonstration area, 10 field enumerators should be assigned to the project for one month each or a total of 10 work-months. For the full country, sample field enumeration, the RTG should be prepared to put 20 more enumerators for one month each on the job. The reason for the large number (20) of field enumerators during the demonstration phase is for training purposes; this permits each of them in turn to train one additional enumerator, thus providing a total of 30 enumerators for the full country sampling. Although trained enumerators are available in DAE, they do not have experience in finding fields from aerial photography and must be taught map-reading from this imagery.

The RTG will make available a total of 4 months use of a 4-wheel drive vehicle for access to, and transportation between, sample fields. In addition, for sample fields in the far northern and southern provinces of Thailand, it may be necessary to fly RTG staff from Bangkok to other cities in Thailand. The RTG will fund domestic travel for RTG staff. USDA team travel, both domestic as well as international, will be funded by USAID.

The RTG will make available, at no cost to the USG, drafting and class rooms necessary to carry out the photo interpretation associated with area frame sampling. The drafting room should be equipped with light tables, planimeters, storage cabinets, color

pencils, rolls of acetate, and other common drafting equipment used in cartography.

V. Objectives

As a result of this project, the RTG will have ground-verified statistics of agricultural parameters such as crop area, yield, livestock, etc. of a number of selected sample fields in the country. The number of fields, and their manner of selection, will be statistically significant in future extrapolation to country totals.

VI. Reporting Requirements

A. Final Report

The USDA and RTG are required to furnish 10 copies of a final report on the Thailand Area Frame Sample Development to the Office of Science and Technology, Development Support Bureau, Agency for International Development, Washington, D.C. 20523, USA, marked Attn. Dr. Charles K. Paul, Manager Remote Sensing Programs. Five copies of the report should be sent to USAID/Thailand. The report should tabulate crop and other agricultural statistics based on the sample frame, and should assess the training provided to RTG technicians and the RTG capacity to enter into the advanced phases of the Remote Sensing for Agriculture Project. The report will provide a USDA conclusion regarding the RTG present and potential future motivation in maintaining and updating the frame. The USDA is under separate reporting requirements by contract law to AID/Washington's Development Support Bureau. However, for

clarification both parties to this project agreement, USDA, with appropriate inputs from RTG, must submit three copies of all reports listed as being a product of the contract (administrative, progress, final and technical reports containing R&D findings) to the Documentation Coordinator, DS/DIU, Development Support Bureau, Agency for International Development, Washington, D.C. 20523, or his designee. Such reports shall include a title page showing the title of the report, project title as set forth in this contract (or grant) and the contract number. One copy of each report shall be clearly typed or printed on white paper so that it may be photographed to produce a microfilm master. Technical reports shall be accompanied by an author - prepared abstract.

B. Interim Technical Communications and Progress Reports

These informal contacts will take place on a regular basis between the project managers in the U.S. and RTG. Each month progress, problems and short term plans will be discussed by telephone, cable or written correspondence depending on the urgency requirements to insure time tables for project milestones will be met.

ATTACHMENT I

Budget Requirements

Category	US$ AID	US$ RTG
I. Salaries		
1 U.S. team leader (1 mm)	4,000	-
1 photo-cartographer (2 mm)	4,500	-
1 statistician (1½ mm)	4,000	-
3 field technicians (9 mm)	16,200	-
1 statistician - manager (20 mm)	-	8,000
1 soils mapper (3 mm)	-	1,200
1 agricultural eng. (3 mm)	-	1,200
1 remote sensing scientist (6 mm)	-	2,400
20 field technicians (20 mm)	-	6,000
Sub total	~~23,700~~ 22,500	18,800
II. Travel		
USDA - International	15,000	-
USDA - domestic U.S.	1,000	-
USDA - per diem	~~15,000~~	-
RTG - domestic - air	-	1,000
trucks - 4 months	-	4,000
RTG - training in U.S.	7,000	-
Sub total	~~38,000~~	5,000
III. Equipment		
LANDSAT products	12,000	-
Maps and supplies	1,000	-
~~Computer~~	~~6,000~~	-
RTG acetate rolls, etc.	-	1,200
Aerial photo	-	5,000
Sub total	~~19,000~~	6,200
IV. USDA Overhead		
ESRS	~~10,000~~ 7,000	-
OIDC	~~4,300~~	-
Sub total	14,300	-
TOTAL:	100,000	30,000

PROJECT TITLE: REMOTE SENSING FOR RESOURCE ASSESSMENT - SUPPLEMENTAL ACTIVITIES TO CURRENT AREA FRAME SAMPLING PROJECT

This Memorandum of Understanding (MOU) is made by and between the Government of Costa Rica (GOCR), represented by Director General of Statistics and Censuses (DGEC), Agricultural Sector Planning Office (OPSA) and the United States Department of Agriculture (USDA), operating through a Participating Agency Service Agreement AG/TAB-1166-6-78 with the Agency for International Development.

The intent of this MOU is to provide supplemental support to the present Area Sampling Frame Project as described in 2 below, and will not supplant nor duplicate present or future efforts.

1. Background

Among the many applications of satellite remote sensing technology, one of the most promising has been its potential use for monitoring and estimating crop production. Since the launch of the first Earth Resources Technology Satellite (ERTS), now called LANDSAT, much research on an international scale has been conducted to evaluate the use of the data and image products collected by this system. At the current state of development, however, satellite remote sensing provides useful data only when combined with other sources of information. The Economics, Statistics, and Cooperatives Service (ESCS) of the USDA had developed a system which integrates satellite remote sensing data with "ground truth" data collected for an operational area sample survey. This system utilizes the synoptic coverage aspect of the satellite data in combination with accurately recorded ground information collected for a very small sample of land parcels (about ½ to 1 percent sampling rate). This combined use of satellite data and ground infomation provides significant improvements in the accuracy of area estimates of major crops.

For more than a decade ESCS, through AID sponsored projects, has provided technical assistance to several developing countries for starting an agricultural data system or improving the existing system. In most of these countries the projects have involved the construction of an Area Sampling Frame (ASF), followed by conducting surveys using samples drawn from the ASF. These surveys have provided significantly improved agricultural data both from the standpoint accuracy and timeliness.

It has been demonstrated that satellite remote sensing image products can be used to effectively differentiate between broad land uses. Frequently maps and conventional photography are either out-of-date or non-existent. In these cases satellite imagery is particularly valuable. Also, if satellite digital data is ever to be used to estimate land cover, it is essential to have an ASF to provide the statistical basis for correcting bias that exists in spectral data.

2. Project Purpose

The overall project purpose is to develop an ASF for Costa Rica and following this activity, conduct a national agricultural survey. Work on area sampling frame construction began in the fall of 1976 and was funded by USAID/CR. An area frame has been developed for the Pacifico Central Region which is one of seven agricultural regions in Costa Rica. A pilot agricultural survey was conducted in the summer of 1978 as part of the original project. The results of this survey were published by GOCR Department of Census and Statistics in February 1979.

It is the intent of this MOU that the area frame construction be continued to completion for the rest of the land area of Costa Rica. LANDSAT imagery now available is more current than much of the aerial photography used for land use determination completed during the first part of the

overall project. Using LANDSAT imagery, USDA will provide technical assistance in interperting the imagery to provide an up to date area frame for all of Costa Rica.

3. Agency Responsibilities

Costa Rican agencies (DGEC and/or OPSA) have the overall responsibility for completing the ASF in accordance with previously agreed and understood specifications as described in Annex B. USDA (through, Statistics) will provide satellite image products and the necessary technical assistance to use these products with existing materials for ASF completion. Monitoring of this project and disbursement of USDA funds for the project will be the responsibility of the designated USDA manager in ESCS, Statistics, Washington, D.C.

4. Resources/Services

The parties to this MOU will provide the following resources to the extent specified in Appendix A hereto:

a. USDA, with AID funding will provide

i. Personnel

Personnel for consultation to supplement the existing project

ii. Equipment and Supplies

LANDSAT imagery MSS	3-4 scenes 1/
LANDSAT imagery RBV	3-4 scenes 1/

iii. Travel

All international travel, including travel and per diem for USDA personnel involved in technical assistance.

b. DGEC, through OPSA will provide:

i. Personnel

Project Director

Frame Construction Supervisor

1/ As may be available

Sampling Frame Construction Technicians

Secretarial and Clerical Support

ii. Maps and Aerial Photos

As required

iii. Space

Frame construction, storage and office as required

iv. Transporation

Funding for in-country travel

5. Reporting

The Project Direcotr, with the assistance of the USDA Resident Agent, is responsible for the preparation of quarterly progress reports to be submitted to the signing authorities of the Costa Rican Ministries and USDA and the USDA manager.

6. Amendment

This MOU may be amended by agreement of the parties in writing.

7. This MOU shall become effective upon the final signature hereto and shall remain in effect until September 30, 1981, unless terminated sooner by mutual agreement of the parties.

United States

_____ Date: _____
Special Assistant for International
Scientific and Technical Cooperation,
USDA

Costa Rica

_____ Date: _____
Director, OPSA

_____ Date: _____
Director General, DGEC

Concurrence:

_____ Date: _____
Mission Director, USAID, Costa Rica

Estimated Budget for the Period April 1, 1979 through March 31, 1980

Category	U.S. Contribution (U.S. $ Equivalent)	C.R. Committed (U.S. $ Equivalent)
I. Salaries		
Math Statisticians	5,100	-0-
Frame Construction Supervisor	-0-	8,000
Area Frame Technicians	9,000	24,000
Administrative and Secretarial Support	-0-	5,000
Subtotal	14,100	37,000
II. Travel		
USDA-International	2,100	-0-
USDA-Per Diem	2,500	-0-
Domestic Field Travel	-0-	5,000
Subtotal	4,600	5,000
III. Equipment and Supplies		
Maps and Photography 1/	-0-	25,000
LANDSAT Products	2,000	-0-
Frame Supplies	-0-	1,000
Subtotal	2,000	26,000
IV. Space and Facilities	-0-	5,000
V. Overhead	5,175	-0-
Total	25,875	73,000

1/ Available from existing Area Sampling Frame Project.

Area Frame Specifications for Project Completion

Stratum number and map (photo coloration) used to delineate the several stratum as defined below:

Stratum	Definition
01 (Purple)	60-100 percent cultivated for crop production. Target, about 80 percent. Include tree crops. Other crops will include sugarcane, rice, beans, corn, vegetables, etc.
02 (Bright Blue)	30-60 percent cultivated for crop production. Include tree crops. Other crops will include sugarcane, rice, beans, corn, vegetables, etc.
03 (Orange)	1-30 percent cultivated for crop production. Will include pasture (grazing) land and land with a low (target 15) percent of cultivation.
04 (Brown)	Non-Agricultural Land No visible cropland or agriculture of any kind (including grazing). Examples would be coastal marsh, swamps, lava fields, mountains above tree lines, canyons, national parks and military land where no agriculture is permitted.
05 (Green)	Cities and towns - Population density of 50 or more dwellings per square kilometer. This would be determined from either quad maps or the photographic mosaics primarily photographs. The size would be usually 12 or more

Stratum	Definition
	city blocks. There should be no agriculture in this stratum or else the town would go in the agricultural urban stratum (06).
06 (Green)	Agricultural Urban - Land with the required population density and number of city blocks but can also contain some agricultural land.
07 (Dark Blue)	Water - Lakes, natural and man made, major rivers.

Stratum	Minimum size for stratum block (in km^2)
01	1
02	2
03	6
04	8
05	½
06	½
07	½

Boundaries - priority

roads

trails - where washout and movement are unlikely

canals - for drainage and irrigation

railroads

rivers - of continous annual flow

Use field boundaries, minor streams and other visible features when boundary dilineation is required and no priority boundaries exist.

Note: County, agricultural region, and province boundaries will be honored.

FRAME UNIT (COUNTY UNIT) SIZE

Stratum	Desired Size km 2	Limitation Size km 2
01	4 - 6	1 - 9
02	7 - 11	2 - 16
03	22 - 32	6 - 48
04	30 - 42	8 - 64
05	2 - 6	½ - 8
06	2 - 6	½ - 8
07	any size	½ to any size

Annex 9

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

ANNEX 9

Life of Project:
From FY 79 to FY 82
Total U.S. Funding 1,600
Date Prepared: 10/78

Project Title & Number: 931-1224 Remote Sensing for Agriculture

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: To improve agricultural land utilization and crop forecasting in LDCs through assistance in the use of remote sensing and related technologies.	**Measures of Goal Achievement:** Pre-forecast estimates, with accuracies greater than 90%, of selected major crops in demonstra-areas of four LDC's.	Check with post-forecast production reports.	**Assumptions for achieving goal targets:** Some type of crop production reporting system (farmer questionnaires) must be available or implemented to calibrate accuracy. If not, host country ministry will have to rely on USDA assurance that area frame statistics are sufficiently reliable to make food planning decisions based therefrom.
Project Purpose: To demonstrate the application of satellite imagery and aerial photography to delineate sample fields representative, in a statistically significant sense, of a nation's total agricultural crop production	**Conditions that will indicate purpose has been achieved: End of project status:** 1. Sample field statistics (97 - 100% accurate) based on satellite and air photo analysis. 2. Land use ratios of total area to sample area for expansion to national estimates, based on satellite imagery.	1. USDA spot checks to verify accuracy of field data collected on the ground by trained LDC enumerators 2. Comparison of Landsat derived land use maps with recent air photos or with field data collected under 1.	**Assumptions for achieving purpose:** 1. Host country can learn remote sensing applied to statistical sampling. 2. Landsat imagery and air photos sufficiently recent (within one year) and of sufficient coverage are available. 3. Sample fields can be delineated on satellite imagery. 4. Sample fields truly are representative of agricultural potential.
Outputs: 1. Land use theme maps 2. Enhanced Landsat satellite images. 3. Tables of Crop Production estimates 4. Field enumerator notes	**Magnitude of Outputs:** 1. Maps at 1:250,000 scale for all demonstration areas. 2. Landsat images at same scale and coverage as maps. 3. Estimates of tonnage by state or province for 4-5 major crops. 4. Page of notes for each sample field . Several hundred sample fields for LDC.	1. Visual inspection at ministries of agriculture 2. Crop reports by USDA and host countries	**Assumptions for achieving outputs:** 1. Host country commitment to provide full time personnel to project. 2. Host country provides cartographic and surveying facility for project use. 3. Host country enumerators are conscientious and objective in collecting data.
Inputs: 1. US AID: $1.4 million 2. USDA: technical assistance, equipment 3. Host Country: manpower, mapping facility and supplies, aerial photos, 4-wheel drives, computer facility	**Implementation Target (Type and Quantity):** 1. PASA w/ USDA and contract with university and/or industry 2. For each LDC, USDA will provide 1 statistician, 1 photo-interpreter, and 3 field enumerators. 3. Non-government U.S. Institute provides computer expert and network expert. 4. Host country provides statistician, photo interpreter, & 10-20 field enumerators.		**Assumptions for providing inputs:** 1. Amenable working relationship among AID, USDA, and private industry. 2. Landsat - 3 will remain operational for 2 more years. 3. Landsat D will be successfully launched in 1981, or Landsat 3 will survive 3 more years. 4. Host country has general purpose computer for project use.

5C(2) - PROJECT CHECKLIST

Listed below are, first, statutory criteria applicable generally to projects with FAA funds, and then project criteria applicable to individual fund sources: Development Assistance (with a subcategory for criteria applicable only to loans); and Security Supporting Assistance funds.

CROSS REFERENCES: IS COUNTRY CHECKLIST UP TO DATE? IDENTIFY. HAS STANDARD ITEM CHECKLIST BEEN REVIEWED FOR THIS PROJECT?

A. GENERAL CRITERIA FOR PROJECT.

1. App. Unnumbered; FAA Sec. 653(b); Sec. 671

   (a) Describe how Committees on Appropriations of Senate and House have been or will be notified concerning the project; (b) is assistance within (Operational Year Budget) country or international organization allocation reported to Congress (or not more than $1 million over that figure

   a) Committes notified by CP during FY 79 AID budget review.

   b) Yes

2. FAA Sec. 611(a)(1). Prior to obligation in excess of $100,000, will there be (a) engineering, financial, and other plans necessary to carry out the assistance and (b) a reasonably firm estimate of the cost to the U.S. of the assistance?

   a) No

   b) NA

3. FAA Sec. 611(a)(2). If further legislative action is required within recipient country, what is basis for reasonable expectation that such action will be completed in time to permit orderly accomplishment of purpose of the assistance?

   None required

4. FAA Sec. 611(b); App. Sec. 101. If for water or water-related land resource construction, has project met the standards and criteria as per the *Principles and Standards for Planning Water and Related Land Resources dated October 25, 1973*?

   NA

5. FAA Sec. 611(e). If project is capital assistance (e.g., construction), and all U.S. assistance for it will exceed $1 million, has Mission Director certified the country's capability effectively to maintain and utilize the project?

   NA

6. FAA Sec. 209, 619. Is project susceptible of execution as part of regional or multilateral project? If so why is project not so executed? Information and conclusion whether assistance will encourage regional development programs. If assistance is [illegible] newly independent country, is it [illegible] nished through multilateral organi[illegible]ns or plans to the maximum extent appropriate?

   No

A

7. FAA Sec. 601(a); (and Sec. 201(f) for development loans). Information and conclusions whether project will encourage efforts of the country to: (a) increase the flow of international trade; (b) foster private initiative and competition; (c) encourage development and use of cooperatives, credit unions, and savings and loan associations; (d) discourage monopolistic practices; (e) improve technical efficiency of industry, agriculture and commerce; and (f) strengthen free labor unions.

a) Yes, agricultural commodities will flow as a result b) No effect c) encourage use of agricultural cooperatives d) No effect e) Yes, improve agricultural efficiency f) No effect

8. FAA Sec. 601(b). Information and conclusion on how project will encourage U.S. private trade and investment abroad and encourage private U.S. participation in foreign assistance programs (including use of private trade channels and the services of U.S. private enterprise).

Output is better agricultural information in LDC's dependent upon U.S. food grains. Shortages will encourage U.S. agricultural commodity exports.

9. FAA Sec. 612(b); Sec. 636(h). Describe steps taken to assure that, to the maximum extent possible, the country is contributing local currencies to meet the cost of contractual and other services, and foreign currencies owned by the U.S. are utilized to meet the cost of contractual and other services.

Project Agreements with each country spell out host country funding arrangements.

10. FAA Sec. 612(g). Does the U.S. own excess foreign currency and, if so, what arrangements have been made for its release?

NA

11. ISA 14. *Are any FAA funds for FY 78 being used in this Project to construct, operate, maintain, or supply fuel for, any nuclear powerplant under an agreement for cooperation between the United States and any other country?*

No

B. FUNDING CRITERIA FOR PROJECT

1. Development Assistance Project Criteria

a. FAA Sec. 102(c); Sec. 111; Sec. 281a. Extent to which activity will (a) effectively involve the poor in development, by extending access to economy at local level, increasing labor-intensive production, spreading investment out from cities to small towns and rural areas; and (b) help develop cooperatives, especially by technical assistance, to assist rural and urban poor to help themselves toward better life, and otherwise encourage democratic private and local governmental institutions?

a) Project will employ up to 20 semi-skilled, underemployed in rural villages to collect ground truth information. b) NA

B1

b. FAA Sec. 103, 103A, 104, 105, 106, 107. Is assistance being made available: [Include only applicable paragraph -- e.g., a, b, etc. -- which corresponds to source of funds used. If more than one fund source is used for project, include relevant paragraph for each fund source.]

(1) [103] for agriculture, rural development or nutrition; if so, extent to which activity is specifically designed to increase productivity and income of rural poor; [103A] if for agricultural research, is full account taken of needs of small farmers;

a) Information derived from this project used to assure small farmer an equitable income from his crops.

(2) [104] for population planning or health; if so, extent to which activity extends low-cost, integrated delivery systems to provide health and family planning services, especially to rural areas and poor;

(3) [105] for education, public administration, or human resources development; if so, extent to which activity strengthens nonformal education, makes formal education more relevant, especially for rural families and urban poor, or strengthens management capability of institutions enabling the poor to participate in development;

(4) [106] for technical assistance, energy, research, reconstruction, and selected development problems; if so, extent activity is:

(a) technical cooperation and development, especially with U.S. private and voluntary, or regional and international development, organizations;

(b) to help alleviate energy problem;

(c) research into, and evaluation of, economic development processes and techniques;

(d) reconstruction after natural or manmade disaster;

(e) for special development problem, and to enable proper utilization of earlier U.S. infrastructure, etc., assistance;

(f) for programs of urban development, especially small labor-intensive enterprises, marketing systems, and financial or other institutions to help urban poor participate in economic and social development.

B1b

(5) [107] by grants for coordinated private effort to develop and disseminate intermediate technologies appropriate for developing countries.

c. FAA Sec. 110(a); Sec. 208(e). Is the recipient country willing to contribute funds to the project, and in what manner has or will it provide assurances that it will provide at least 25% of the costs of the program, project, or activity with respect to which the assistance is to be furnished (or has the latter cost-sharing requirement been waived for a "relatively least-developed" country)?

Yes. Through project agreements, memoranda of understanding, and budget approvals.

d. FAA Sec. 110(b). Will grant capital assistance be disbursed for project over more than 3 years? If so, has justification satisfactory to Congress been made, and efforts for other financing, or is the recipient country "relatively least developed"?

No

e. FAA Sec. 207; Sec. 113. Extent to which assistance reflects appropriate emphasis on: (1) encouraging development of democratic, economic, political, and social institutions; (2) self-help in meeting the country's food needs; (3) improving availability of trained worker-power in the country; (4) programs designed to meet the country's health needs; (5) other important areas of economic, political, and social development, including industry; free labor unions, cooperatives, and Voluntary Agencies; transportation and communication; planning and public administration; urban development, and modernization of existing laws; or (6) integrating women into the recipient country's national economy.

1) None
2) Fullest extent. Allows countries to plan for food needs by having adequate crop statistics.
3) Remote sensing and agricultural statisticians in countries must be employed for this project.
4) None
5) None
6) Many underemployed remote sensing professionals are women and this project intends to use them.

f. FAA Sec. 281(b). Describe extent to which program recognizes the particular needs, desires, and capacities of the people of the country; utilizes the country's intellectual resources to encourage institutional development; and supports civic education and training in skills required for effective participation in governmental and political processes essential to self-government.

Project recognizes the food needs of 9 LDC's and will require the best scientific minds in the later, more advanced phases.

B1

g. FAA Sec. 201(b)(2)-(4) and -(8); Sec. 201(e); Sec. 211(a)(1)-(3) and -(8). Does the activity give reasonable promise of contributing to the development: of economic resources, or to the increase of productive capacities and self-sustaining economic growth; or of educational or other institutions directed toward social progress? Is it related to and consistent with other development activities, and will it contribute to realizable long-range objectives? And does project paper provide information and conclusion on an activity's economic and technical soundness?

Project has been designed to fit into priorities of AID missions and host countries. It's goal is improved food planning. PP includes information on economic and technical soundness.

h. FAA Sec. 201(b)(6); Sec. 211(a)(5), (6). Information and conclusion on possible effects of the assistance on U.S. economy, with special reference to areas of substantial labor surplus, and extent to which U.S. commodities and assistance are furnished in a manner consistent with improving or safeguarding the U.S. balance-of-payments position.

Assures optimal export of U.S. grains under PL 480.Food for Peace Program.

2. Development Assistance Project Criteria (Loans only)

NA - not a loan

a. FAA Sec. 201(b)(1). Information and conclusion on availability of financing from other free-world sources, including private sources within U.S.

b. FAA Sec. 201(b)(2); 201(d). Information and conclusion on (1) capacity of the country to repay the loan, including reasonableness of repayment prospects, and (2) reasonableness and legality (under laws of country and U.S.) of lending and relending terms of the loan.

c. FAA Sec. 201(e). If loan is not made pursuant to a multilateral plan, and the amount of the loan exceeds $100,000, has country submitted to AID an application for such funds together with assurances to indicate that funds will be used in an economically and technically sound manner?

d. FAA Sec. 201(f). Does project paper describe how project will promote the country's economic development taking into account the country's human and material resources requirements and relationship between ultimate objectives of the project and overall economic development?

B2

e. FAA Sec. 202(a). Total amount of money under loan which is going directly to private enterprise, is going to intermediate credit institutions or other borrowers for use by private enterprise, is being used to finance imports from private sources, or is otherwise being used to finance procurements from private sources?

f. FAA Sec. 620(d). If assistance is for any productive enterprise which will compete in the U.S. with U.S. enterprise, is there an agreement by the recipient country to prevent export to the U.S. of more than 20% of the enterprise's annual production during the life of the loan?

3. Project Criteria Solely for Security Supporting Assistance

NA

a. FAA Sec. 531. How will this assistance support promote economic or political stability?

b. FAA Sec. 533(c)(1). *Will assistance under the Southern African Special Requirements Fund be used for military, guerrilla, or paramilitary activities?*

4. Additional Criteria for Alliance for Progress

NA

[Note: Alliance for Progress projects should add the following two items to a project checklist.]

a. FAA Sec. 251(b)(1), -(8). Does assistance take into account principles of the Act of Bogota and the Charter of Punta del Este; and to what extent will the activity contribute to the economic or political integration of Latin America?

b. FAA Sec. 251(b)(8); 251(h). For loans, has there been taken into account the effort made by recipient nation to repatriate capital invested in other countries by their own citizens? Is loan consistent with the findings and recommendations of the Inter-American Committee for the Alliance for Progress (now "CEPCIES," the Permanent Executive Committee of the OAS) in its annual review of national development activities?

5C(3) - STANDARD ITEM CHECKLIST

Listed below are statutory items which normally will be covered routinely in those provisions of an assistance agreement dealing with its implementation, or covered in the agreement by exclusion (as where certain uses of funds are permitted, but other uses not).

These items are arranged under the general headings of (A) Procurement, (B) Construction, and (C) Other Restrictions.

A. Procurement

1. FAA Sec. 602. Are there arrangements to permit U.S. small business to participate equitably in the furnishing of goods and services financed?	**To a limited extent - feasibility studies for phases 3 and 4 of project open to small business competition.**
2. FAA Sec. 604(a). Will all commodity procurement financed be from the U.S. except as otherwise determined by the President or under delegation from him?	Yes
3. FAA Sec. 604(d). If the cooperating country discriminates against U.S. marine insurance companies, will agreement require that marine insurance be placed in the U.S. on commodities financed?	**NA**
4. FAA Sec. 604(e). If offshore procurement of agricultural commodity or product is to be financed, is there provision against such procurement when the domestic price of such commodity is less than parity?	**NA**
5. FAA Sec. 608(a). Will U.S. Government excess personal property be utilized wherever practicable in lieu of the procurement of new items?	**Yes**
6. MMA Sec. 901(b). (a) Compliance with requirement that at least 50 per centum of the gross tonnage of commodities (computed separately for dry bulk carriers, dry cargo liners, and tankers) financed shall be transported on privately owned U.S.-flag commercial vessels to the extent that such vessels are available at fair and reasonable rates.	**Yes**
7. FAA Sec. 621. If technical assistance is financed, will such assistance be furnished to the fullest extent practicable as goods and professional and other services from private enterprise on a contract basis? If the facilities of other Federal agencies will be utilized,	**U.S. Dept. of Agricultural assistance in acquisition of crop statistics. USDA has sole charter in U.S. for this service, and thus will not be competing with U.S. private enterprise when performing this project in LDC's.**

are they particularly suitable, not competitive with private enterprise, and made available without undue interference with domestic programs?

8. International Air Transport. Fair Competitive Practices Act, 1974 — **Yes**

If air transportation of persons or property is financed on grant basis, will provision be made that U.S.-flag carriers will be utilized to the extent such service is available?

B. Construction

1. FAA Sec. 601(d). If a capital (e.g., construction) project, are engineering and professional services of U.S. firms and their affiliates to be used to the maximum extent consistent with the national interest? — **NA**

2. FAA Sec. 611(c). If contracts for construction are to be financed, will they be let on a competitive basis to maximum extent practicable?

3. FAA Sec. 620(k). If for construction of productive enterprise, will aggregate value of assistance to be furnished by the U.S. not exceed $100 million?

C. Other Restrictions

FAA Sec. 201(d). If development loan, is interest rate at least 2% per annum during grace period and at least 3% per annum thereafter? — **NA**

2. FAA Sec. 301(d). If fund is established solely by U.S. contributions and administered by an international organization, does Comptroller General have audit rights? — **NA**

3. FAA Sec. 620(h). Do arrangements preclude promoting or assisting the foreign aid projects or activities of Communist-Bloc countries, contrary to the best interests of the U.S.? — **No**

4. FAA Sec. 636(i). Is financing not permitted to be used, without waiver, for purchase, long-term lease, or exchange of motor vehicle manufactured outside the U.S. or guaranty of such transaction? — **Yes**

C

5. Will arrangements preclude use of financing:

a. FAA Sec. 114. to pay for performance of abortions or to motivate or coerce persons to practice abortions, *to pay for performance of involuntary sterilization, or to coerce or provide financial incentive to any person to practice sterilization?* **Yes**

b. FAA Sec. 620(g). to compensate owners for expropriated nationalized property? **Yes**

c. FAA Sec. 660. to finance police training or other law enforcement assistance, except for narcotics programs? **Yes**

d. FAA Sec. 662. for CIA activities? **Yes**

e. App. Sec. 103. to pay pensions, etc., for military personnel? **Yes**

f. App. Sec. 105. to pay U.N. assessments? **Yes**

g. App. Sec. 106. to carry out provisions of FAA Sections 209(d) and 251(h)? (transfer to multilateral organization for lending). **Yes**

h. App. Sec. 112. *to finance the export of nuclear equipment, fuel, or technology or to train foreign nationals in nuclear fields?* **Yes**

i. App. Sec. 501. to be used for publicity or propaganda purposes within U.S. not authorized by Congress? **Yes**

5C(1) - COUNTRY CHECKLIST

Listed below are, first, statutory criteria applicable generally to FAA funds, and then criteria applicable to individual fund sources: Development Assistance and Security Supporting Assistance funds.

A. GENERAL CRITERIA FOR COUNTRY

1. FAA Sec. 116. Can it be demonstrated that contemplated assistance will directly benefit the needy? If not, has the Department of State determined that this government has engaged in consistent pattern of gross violations of internationally recognized human rights?	Benefits mostly indirect, in that improved agricultural information can lead to constant agricultural inventories and stable prices. At the micro-level, knowledge of crop status helps needy obtain bank loans, using crop as collateral.
2. FAA Sec. 481. Has it been determined that the government of recipient country has failed to take adequate steps to prevent narcotics drugs and other controlled substances (as defined by the Comprehensive Drug Abuse Prevention and Control Act of 1970) produced or processed, in whole or in part, in such country, or transported through such country, from being sold illegally within the jurisdiction of such country to U.S. Government personnel or their dependents, or from entering the U.S. unlawfully?	No
3. FAA Sec. 620(b). If assistance is to a government, has the Secretary of State determined that it is not controlled by the international Communist movement?	Yes
4. FAA Sec. 620(c). If assistance is to government, is the government liable as debtor or unconditional guarantor on any debt to a U.S. citizen for goods or services furnished or ordered where (a) such citizen has exhausted available legal remedies and (b) debt is not denied or contested by such government?	Yes
5. FAA Sec. 620(e) (1). If assistance is to a government, has it (including government agencies or subdivisions) taken any action which has the effect of nationalizing, expropriating, or otherwise seizing ownership or control of property of U.S. citizens or entities beneficially owned by them without taking steps to discharge its obligations toward such citizens or entities?	No

A

6. FAA Sec. 620(a), 620(j); App. Sec. 107, 114. Is recipient country a Communist country? Will assistance be provided to the Socialist Republic of Vietnam, Cambodia, Laos, Cuba, Uganda, Mozambique, or Angola?

No. No.

7. FAA Sec. 620(i). Is recipient country in any way involved in (a) subversion of, or military aggression against, the United States or any country receiving U.S. assistance, or (b) the planning of such subversion or aggression?

a) No b) No.

8. FAA Sec. 620(j). Has the country permitted, or failed to take adequate measures to prevent, the damage or destruction, by mob action, of U.S. property?

No.

9. FAA Sec. 620(l). If the country has failed to institute the investment guaranty program for the specific risks of expropriation, inconvertibility or confiscation, has the AID Administrator within the past year considered denying assistance to such government for this reason?

NA

10. FAA Sec. 620(o); Fishermen's Protective Act, Sec. 5. If country has seized, or imposed any penalty or sanction against, any U.S. fishing activities in international waters,

a. has any deduction required by Fishermen's Protective Act been made?

b. has complete denial of assistance been considered by AID Administrator?

Not known for all 9 countries - Jamaica, Dominican Republic, Costa Rica, Ecuador, Bolivia Morocco, Indonesia, Thailand, and the Philippines.

11. FAA Sec. 620(q); App. Sec. 503. (a) Is the government of the recipient country in default on interest or principal of any AID loan to the country? (b) Is country in default exceeding one year on interest or principal on U.S. loan under program for which App. Act appropriates funds, unless debt was earlier disputed, or appropriate steps taken to cure default?

a) Not known b) Not known

12. FAA Sec. 620(s). "If contemplated assistance is development loan (including Alliance loan) or security supporting assistance, has the Administrator taken into account the percentage of the country's budget which is for military expenditures, the amount of foreign exchange spent on military equipment and the amount spent for the purchase of sophisticated weapons systems?" (An affirmative answer may refer to the record of the taking into account, e.g.: "Yes as reported in annual report on implementation of Sec. 620(s)." This report is prepared at the time of approval by the Administrator of the Operational Year Budget.

NA

Upward changes in the Sec. 620(s) factors occuring in the course of the year, of sufficient significance to indicate that an affirmative answer might need review, should still be reported, but the statutory checklist will not normally be the preferred vehicle to do so.)

13. FAA Sec. 620(t). Has the country severed diplomatic relations with the United States? If so, have they been resumed and have new bilateral assistance agreements been negotiated and entered into since such resumption? **No**

14. FAA Sec. 620(u). What is the payment status of the country's U.N. obligations? If the country is in arrears, were such arrearages taken into account by the AID Administrator in determining the current AID Operational Year Budget? **Not known**

15. FAA Sec. 620A. Has the country granted sanctuary from prosecution to any individual or group which has committed an act of international terrorism? **Believed not**

16. FAA Sec. 666. Does the country object, on basis of race, religion, national origin or sex, to the presence of any officer or employee of the U.S. there to carry out economic development program under FAA? **No**

17. FAA Sec. 669, 670. *Has the country, after August 3, 1977, delivered or received nuclear enrichment or reprocessing equipment, materials, or technology, without specified arrangements or safeguards? Has it detonated a nuclear device after August 3, 1977 although not a "nuclear-weapon State" under the nonproliferation treaty?* **No**

18. FAA Sec. 901. Has the country denied its citizens the right or opportunity to emigrate? **No**

B. FUNDING CRITERIA FOR COUNTRY

1. Development Assistance Country Criteria

a. FAA Sec. 102(c), (d). Have criteria been established, and taken into account, to assess commitment and progress of country in effectively involving the poor in development, on such indexes as: (1) small-farm labor intensive agriculture, (2) reduced infant mortality, (3) population growth, (4) equality of income distribution, and (5) unemployment. **Yes, by AID missions**

B1

b. FAA Sec. 104(d)(1). *If appropriate, is this development (including Sahel) activity designed to build motivation for smaller families in programs such as education in and out of school, nutrition, disease control, maternal and child health services, agricultural production, rural development, and assistance to urban poor?*

Yes, for agricultural production

c. FAA Sec. 201(b)(5), (7) & (8); Sec. 208; 211(a)(4), (7). Describe extent to which country is:

(1) Making appropriate efforts to increase food production and improve means for food storage and distribution.

All nine countries are presently striving for field area frames for crop statistics.

(2) Creating a favorable climate for foreign and domestic private enterprise and investment.

All nine countries encourage private investment in their resources.

(3) Increasing the public's role in the developmental process.

Not known in all countries

(4) (a) Allocating available budgetary resources to development.

Most are expanding development activities

(b) Diverting such resources for unnecessary military expenditure and intervention in affairs of other free and independent nations.

All countries are not excessively purchasing military arms at the expense of economic development, and none are meddling in the affairs of other countries.

(5) Making economic, social, and political reforms such as tax collection improvements and changes in land tenure arrangements, and making progress toward respect for the rule of law, freedom of expression and of the press, and recognizing the importance of individual freedom, initiative, and private enterprise.

Even those countries in Latin America, which have had military regimes (such as Bolivia), are moving toward free elections in the next six months.

(6) Otherwise responding to the vital economic, political, and social concerns of its people, and demonstrating a clear determination to take effective self-help measures.

All are effectively moving toward self help; this project is a cooperative effort.

d. FAA Sec. 201(b), 211(a). Is the country among the 20 countries in which development assistance loans may be made in this fiscal year, or among the 40 in which development assistance grants (other than for self-help projects) may be made?

Not known. Believe Indonesia and Bolivia may be two.

e. FAA Sec. 115. Will country be furnished, in same fiscal year, either security supporting assistance, or Middle East peace funds? If so, *has Congress specifically authorized such use of funds*, or is assistance for population programs, humanitarian aid through international organizations, or regional programs?

No

B

2. Security Supporting Assistance Country Criteria

NA

a. FAA Sec. 502B. Has the country engaged in a consistent pattern of gross violations of internationally recognized human rights? Is program in accordance with policy of this Section?

b. FAA Sec. 531. Is the Assistance to be furnished to a friendly country, organization, or body eligible to receive assistance?

c. FAA Sec. 533(c)(2). *Will assistance under the Southern African Special Requirements fund be provided to Mozambique, Angola, Tanzania, or Zambia? If so, has President determined (and reported to the Congress) that such assistance will further U.S. foreign policy interests?*

d. FAA Sec. 609. If commodities are to be granted so that sale proceeds will accrue to the recipient country, have Special Account (counterpart) arrangements been made?

e. App. Sec. 113. *Will security assistance be provided for the purpose of aiding directly the efforts of the government of such country to repress the legitimate rights of the population of such country contrary to the Universal Declaration of Human Rights?*

f. FAA Sec. 620B. *Will security supporting assistance be furnished to Argentina after September 30, 1978?*