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A Development Assistance Program in Remote Sensing*

The goal of AID's program is to assist developing countries in improving their capabilities for assessing and managing resources through the use of remote sensing and other appropriate technologies.

INTRODUCTION AND BACKGROUND

MOST PERSONS will agree that technology has been a boon for humankind. Most also will agree that the world-wide application of new technologies is not without peril. In some cases, the introducing of new technology in a developing society is not unlike investing in a new business venture. A partial effort or one without adequate follow-through could have disastrous consequences.

The purpose of this paper is to review the experiences of the Agency for International Development during its five, or so, years of experience in the application of remote sensing technology to development problems. During this time AID has collected valuable information on the needs of developing countries for resource data. This information is being utilized in the development of projects, programs, and policies designed to make the benefits of U.S. space technology available to all nations.

Many developing countries are now at the point where they have reaped the benefits of some technologies but are in serious need of others in order to prevent upsetting imbalances in the development process. For example, medical and nutritional technologies have extended life expectancies, resulting in burgeoning populations in many countries. In some of these countries the arable land has already become exhausted, and further increases in population without changes in agricultural practices could result in widespread famine. In fact, this has already happened in some African countries where recent widespread changes in weather have caused sudden reductions in the available food supply.

The Agency for International Development has recognized the need for a balanced approach in the introduction of new technologies in developing countries. In 1970, the Office of Science and Technology was formed within the Technical Assistance Bureau to complement the Offices of Agriculture, Food and Nutrition and others by providing a basis for exploring new technologies that might be needed to achieve a proper balance.

Even though the launch of ERTS-1 (later renamed Landsat-1) was still two years away when the Office was organized, it recognized that remote sensing is one of these new technologies that could have a substantial impact on development. Accordingly, the office began to develop a program of cautious testing and experimentation designed to create an understanding of the needs and appropriate applications.

The first of these activities was the sponsorship of the Smithsonian Symposium in Remote Sensing in 1971. This was followed by the development of a modestly funded project which, during the period from 1972 to the present, has provided limited technical assistance to several countries, some of which led to these countries' participation in the Landsat investigation program.

Training in remote sensing was early recognized as a vital element of a development assistance program, not only to train analysts but also to raise the level of awareness of both the potential and limitations of the technology so that appropriate choices could be made. Four regional workshops were held in addition to two U.S. Information Agency sponsored seminars. This project

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also provided for the development of the International Training Course at the EROS Data Center in Sioux Falls and the sponsorship of the first two courses. This course is being successfully carried on under U.S. Geological Survey sponsorship.

During 1975 and 1976, AID awarded small grants to ten countries to assist them in increasing their level of utilization of the technology. These grants, which cover a broad range of applications, were awarded on the basis of a competitive evaluation of proposals and have greatly expanded our knowledge of developing country needs and capabilities.

In addition to training and technical assistance, special studies have been undertaken to provide guidance for the development of future programs. The most ambitious of these was recently completed by the National Academy of Sciences. It contains a review of all aspects of remote sensing technology in development and is expected to provide useful guidance, not only to AID, but also to other development assistance organizations as well. This study goes well beyond the provision of development assistance guidelines. It examines some of the broader policy implications of the international development of space technology and reviews several management alternatives for both the space and ground segments. The final report, entitled "Resource Sensing from Space: Prospects for Developing Countries," is available from the National Academy of Sciences or the AID Office of Science and Technology.

Recognizing that there are certain areas of application that are of particular benefit to developing countries, AID has undertaken a research program in order to explore those which otherwise might be overlooked. Two studies undertaken to date include an analysis of the use of Landsat imagery in demographic studies and a search for spectral anomalies in vegetation that would indicate the presence of mineralization. Whereas the mineral study would appear to hold promise, the results obtained thus far have been inconclusive. The demographic project, being undertaken in Kenya and Bolivia, holds substantial promise for improving census techniques in those countries where demographic data are inadequate.

Finally, AID supports many resource and land-development projects. These projects include a range capability analysis in Tanzania, a resource inventory in Mali, a regional development planning project in West Africa, and settlement planning project in Bolivia. Whereas most of these projects include some on-the-job training of local counterparts and technical assistance, the emphasis is on the development of a product such as a resource inventory or land-use plan. Landsat imagery in these projects is used as an operational tool.

Analysis

From these varied experiences with different applications of remote sensing in many parts of the world, certain patterns have been observed which are useful in planning further development assistance activities. It is possible now to construct a rough profile of developing country needs and capacities to absorb the technology. While recognizing that levels of development in the countries with which AID had bilateral programs range from the primitive to the relatively advanced, parts of that profile are applicable in almost all cases.

Geographically, most developing countries lie in the tropics. Centuries of tropical living have created different relationships between man and his environment than are found in temperate latitudes. Obviously there is a much greater dependence upon agriculture and grazing as means of livelihood. Because both of these activities provide a more or less year-around food supply there has traditionally been less emphasis on food storage and the acquisition of supplemental income for purchasing food. This results in a critical balance between production and consumption which can subject millions to famine with only slight shifts in weather patterns.

The rapidly expanding populations in many developing countries further exacerbates the problem. The productive land in many parts of the world is used up and people are increasingly being forced into the marginally productive areas. Kenya, where the population growth is a high 3 percent, is a typical example. People are migrating into arid and semi-arid lands where, because of the delicate ecology, erosion problems already are becoming evident. AID has recognized this problem and has funded a project to develop remedial measures. As in any study of this nature, the physical elements must be known. The total area, the degree of erosion or erosion potential, soil types, land use, climatic characteristics, and population density are all elements which, in varying degrees, can be determined with the aid of remote sensing.

In many developing areas, large tracts of potentially productive land are uninhabita-

ble due to the presence of disease. The tsetse fly areas of East and Central Africa and the onchocerciasis or river-blindness-plagued areas of West Africa are examples. Work is now underway to determine the habitat and breeding characteristics of these pests through the use of remote sensing so that control measures can be implemented. In the areas already freed from river blindness in West Africa, AID will soon be cooperating with the African Development Bank and other donors in the development of land-use plans designed to lead to the orderly resettlement of these areas.

Only a few developing countries are fortunate enough to be able to supplement their incomes with the sale of minerals or petroleum. There is no reason to believe, however, that mineral wealth is not evenly distributed over the surface of the earth. The fact that most mineral production is in the temperate latitudes suggests the need for more intensive exploration and the development of techniques which are more appropriate for tropical areas.

Obviously, there is a need to improve the stability of agricultural production while at the same time increasing output. Remote sensing can contribute in many ways. Water is perhaps the greatest immediate need. Both improved management of surface water and the exploration for new sources of ground water are of highest priority. The use of multiband Landsat imagery on both of these problems has been demonstrated successfully many times. In order to assess the agricultural potential of a given country, planners need to know the suitability or capability of land for various kinds of production. Thus, soil mapping and vegetation cover mapping are also high priority needs which can be satisfied more rapidly through the use of Landsat imagery. Some experts tell us that on a world-wide basis the improved distribution of food is as important as increasing production. Thus, crop forecasting is as vital to agricultural planners in the developing countries as it is in the developed countries.

Comprehensive development planning needed to effect improvements in these and other sectors requires data from many sources. Statistical data on crop production, price fluctuations, and population changes are only a few of the many kinds required. Data on crop vigor or plant diseases, areas and distribution of productive land, as well as eroded or desertified land are also of vital importance. In most developing countries, the analysis of areas, including land-use classification and land suitability, is hindered by the lack of comprehensive map bases at appropriate scales. It has already been demonstrated that Landsat imagery can be effective as a basis for medium- and small-scale mapping. Because of the large area of coverage and the relatively distortion-free nature of the imagery, the cost and complexity of producing Landsat image maps is substantially less than mapping from conventional aerial photography. There is need for additional research on the application of satellite imagery in cartography aimed specifically at providing base maps for those countries and regions which are inadequately mapped and have little or no accurate geodetic control. This research also would provide useful information on the relative costs and accuracy of using Landsat imagery for mapping.

Underlying the needs in all of the functional areas is the need for trained personnel. The limited number of trained resource managers is, of course, a factor in the amount of training and technical assistance that can be absorbed because short-term training is usually aimed at those who already have college degrees in the application areas. Another general need is for coordination and communication among the various resource oriented ministries and agencies. All too frequently, in those developing countries where remote sensing has taken hold, it has often been confined to a single agency under the direction of a single dedicated specialist. Thus, there is a need to develop networks and linkages both internally and externally. Internal linkages are necessary to insure that all potential user agencies have access to the technology and to avoid costly duplication. External linkages to sources of expertise such as NASA, the U.S. Geological Survey, interested United Nations agencies such as FAO, the World Bank, universities, and private industry are also vital. A new technology can be introduced with great excitement and expectation but in order to survive it must be nourished by continuing contacts with other scientists and access to up-to-date literature.

AID's Response

In response to these needs, AID has dedicated itself to an expanded role in the transfer of remote sensing technology to developing nations. During August, September, and October 1976, AID and NASA completed an unprecedented world-wide demonstration of the benefits of space technologies. Called AIDSAT for Space Age Technology, the dem-

onstration took place in 27 developing countries on three continents. It used the facilities of the ATS-6 broadcast satellite to transmit messages and live two-way panel discussions on the many applications of both remote sensing and communications satellites. Most importantly, however, the demonstration committed the Agency to the development of a program of sharing of these technologies with poorer countries of the world. This commitment had earlier been voiced by then Secretary of State Kissinger who said at the United Nations Conference on Trade and Development in Nairobi: "Satellite technology offers enormous promise as an instrument for development. Remote sensing satellites can be applied to survey resources, forecast crops, and monitor land use. We are prepared to cooperate with developing countries in establishing centers, training personnel and, where possible, adapting our civilian satellite program to their needs."

Based on the profile of needs previously outlined, a program of assistance in remote sensing has been constructed which is expected to contribute substantially to the solution of development problems. The major elements of the program are training, technical assistance, grants to support local initiatives and institutional development, and research to explore application areas of particular importance to developing countries. In addition, AID will continue to use Landsat imagery as a tool in its programs of resource inventories, land developing, resettlement planning, and mapping.

The backbone of AID's technical assistance program will be the development of regional centers which will be focal points for most of these activities. The first of these centers will be established in Kenya in cooperation with the new Economic Commission for Africa sponsored Regional Centre for Services in Surveying and Mapping. It is particularly important to establish a close working relationship between the multidisciplinary remote sensing community and the traditional mapping community. Many of the newly ordained remote sensing specialists have tended to focus on the extraction of data from satellite imagery and aerial photography, often through the use of relatively sophisticated techniques. It is felt that it is of equal, or perhaps greater, importance first to develop the capability for presenting those data in cartographic formats useable by planners. To do this requires a knowledge of cartographic processes such as establishment and use of ground control, image rectification, the use of various map projections, and others. It is also important to develop means of systematically storing, retrieving, and analyzing data such as in a cellular mapping system.

The Nairobi center is expected to begin operation in the Fall of 1977. Other centers will be developed in West Africa, Asia, and Latin America in the following years. AID in cooperation with the National Science Foundation has already supported a center in Egypt which could be expanded to supply assistance to countries in North Africa and the Middle East.

Each center will be staffed by four or five specialists representing different disciplines, plus local technicians. Each center will also contain analytical equipment, imagery files, a technical library, and ground-truth equipment. In addition to being able to provide workshops and other training, each center will have a strong outreach or extension capability. The staff will be encouraged to acquire familiarity with the needs of the countries of the region in order to provide the kind of assistance that will directly satisfy those needs.

The regional centers will be focal points for the development of networks and linkages. They will be important contact points between local resource managers and experts in the U.S. and elsewhere. The personnel of the centers will work closely with national universities in the introduction of remote sensing into their curricula. Remote sensing is seen as a tool in resource management just as mathematics is a tool in science or engineering, and the objective is to have remote sensing taught in the same way, that is, as an integral part of any resource oriented curriculum. Accordingly, in establishing these centers the Agency is not attempting to create permanent new institutions but, rather, temporary organizations which can satisfy an immediate need.

Care will be taken to select staff for the centers who are knowledgeable about developing country problems and who will not oversell the technology or stimulate expectations that cannot be fulfilled. In fact, the stated goal of AID's assistance program in remote sensing is "to assist developing countries in improving their capabilities for assessing and managing resources through the use of remote sensing and other appropriate technologies." As much of the training and technical assistance as possible will be undertaken in the recipient countries working with projects of high national priority. Skilled resource specialists are in short sup-

ply in most developing countries and cannot be diverted for long periods of training away from home or on projects that are merely designed to demonstrate new techniques. AID will, therefore, seek opportunities to work directly with resource managers on existing projects and demonstrate how various remote sensing techniques can improve the efficiency of resource data collection.

In a country which has some capacity to utilize the technology, a small grant backed up with appropriate technical assistance can often have important multiplier effects. Accordingly, AID will continue to administer grants to support local research efforts, procure equipment, and to conduct other worthwhile activities.

In addition to helping countries improve their own capabilities, AID will support research in areas that have been underexploited largely because they are of interest only to developing countries. A prime example is in demography. The demographic studies AID has sponsored in Bolivia and Kenya were designed to improve mapping and land-use analysis techniques and develop correlations between land use and population density. This information can, in turn, be used to estimate population. Studies of this nature would be of no use in developed countries where more accurate alternatives for census taking are available, but they could be extremely important in countries which do not have adequate census machinery.

Another area where research is needed is in tropical agriculture. The LACIE program and other agricultural research has focused on temperate latitudes where large homogenous fields and regular seasons make the job of crop forecasting relatively easier. Some of these techniques may be applicable in the rice growing areas of Southeast Asia but much tropical agriculture takes place on small family size plots where a variety of crops is grown year around. In order to forecast crops and otherwise aid agricultural planners in these areas, we need to know more about what kinds of agricultural data are needed by the planners and how they can be collected. Such items as sensor types, resolution requirements, and frequency of coverage need to be more clearly defined for use in tropical settings.

Desertification is another area where a great deal of research is needed. There is still insufficient evidence to state with authority the relative impact of human activity versus weather changes in areas, such as the Sahel in West Africa, where desert encroachment is said to be taking place. We also need to know more about rainfall characteristics and recurrent weather patterns in arid regions for more efficient land management. World-wide attention was focused on these problems during the United Nations Desertification Conference which was held in Nairobi, Kenya in August and September, 1977. AID is expecting to join with other nations of the world in seeking solutions to the problems of desertification.

The need for further research in mapping has already been mentioned. Experimental Landsat photomaps have been constructed by the U.S. Geological Survey. Whereas the United States, like most developed countries, has not had to depend on these as a primary map base, they could be of vital importance in countries where little or no recent mapping has taken place.

America's development assistance program for the next few years will, therefore, include a certain amount of pioneering in addition to the more routine training and technical assistance. As our space program expands we expect to find many more applications that will directly benefit the poorer countries. Seasat is sure to be of interest to coastal zone countries and countries where cloud cover makes sensing in the visible spectrum difficult. The Heat Capacity Mapping Mission offers interesting opportunities for ground water exploration—an exciting prospect for the water-starved areas of the world.

In order to accomplish the many tasks before us, the Agency for International Development will have to further tap the vast reservoir of technical expertise available in other Government agencies, U.S. universities, and private industry. In fact, AID looks upon the scientific community not only for assistance in implementing these programs but also as a source of consultation in further defining our programs in order that our limited development assistance funds may be spent as productively as possible.

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2. Ordinarily *two* copies of the manuscript and two sets of illustrations should be submitted where the second set of illustrations need not be prime quality; EXCEPT that *five* copies of papers on Remote Sensing and Photointerpretation are needed, all with prime quality illustrations to facilitate the review process.
3. Each article should include an abstract, which is a *digest* of the article. An abstract should be 100 to 150 words in length.
4. Tables should be designed to fit into a width no more than five inches.
5. Illustrations should not be more than twice the final print size: *glossy* prints of photos should be submitted. Lettering should be neat, and designed for the reduction anticipated. Please include a separate list of captions.
6. Formulas should be expressed as simply as possible, keeping in mind the difficulties and limitations encountered in setting type.