Appendixes

Appendix A

Remote Sensing in the Developing Countries

Commercialization of Remote Sensing and U.S. International Relations*

Understanding the international effects of U.S. policy to transfer satellite remote-sensing systems to the private sector requires placing them in the context of 25 years of "space relations" as well as overall U. S.-developing country relations. U.S. actions with respect to outer space may affect negotiations over Law of the Sea, Trade, and other international areas. In addition, they must be placed in the context of overall U.S. foreign policy and policy towards the United Nations and other international organizations, Finally, they must be understood in the context of the perceptions of the foreign policy community, as distinct from the user community, in developing countries.

Historical Perspective and Developing Country Perceptions

The utilization of space has always raised political questions. However, initial discussions within the United Nations over rules governing outer space often found the United States and the U. S. S. R. on the same side, Neither desired international regulation of its space activities. The Outer Space Treaty formalized that point of view by allowing countries open access to space, with the caveat that no weapons of mass destruction would be placed in outer space, and the understanding that benefits from space-related activities would be used to the benefit of all countries, and particularly the developing countries. The political tradeoff between the two space powers and the developing countries during these early stages of space exploration was straightforward, In exchange for sharing of benefits and explicit promises that space would be reserved for peaceful purposes, there would be little international regulation.

Space applications, especially remote sensing, were first discussed in this context. The United States took the position in the U.N. Committee for the Peaceful Uses of Outer Space (COPUOS) that no international regulations were necessary for an experimental remote-sensing system (or any other space application), and promised that when the system was proven and became operational the developing world would share in its benefits. At the same time, the United States, while not directly supporting U .N. technical assistance, developed extensive bilateral agreements with, and technical assistance to, the developing world.

The developing countries have been particularly concerned about the possible use of satellite data by multinational companies to exploit the resources of developing countries. These countries have also expressed concern over the possibility that such data could be used for military purposes to the detriment of their own national security. Thus, they argued for restricted dissemination of the data and for technical assistance to aid them in developing their own ability to use them. These concerns, while mitigated to some extent in the mid-1970's, are still at the forefront of the international debate regarding remote-sensing satellites,

International negotiations to establish a regime to govern the distribution of remote-sensing data from space slowed to a near standstill early in the 1970's. The United States, for its part, was opposed to the establishment of any regime restricting the open development of satellite systems and the open dissemination of information. Many developing countries and the Eastern bloc countries, for their part, argued for regulating the distribution of remote-sensing data.

Over the course of these negotiations, the United States mitigated some concerns of the developing countries by disseminating data on a nondiscriminatory basis and by continuing its own technical assistance programs. However, as it became clear in the late 1970's that the United States was beginning to think in terms of an operational (and perhaps commercial) system, the position of the developing countries once again hardened, and the rhetoric of the debates became increasingly harsh. Ironically, one of the key concerns of the developing countries is that a commercial system might mean the end of open and nondiscriminatory access to data—the very policy they argued forcefully against for so many years. However, they see a policy of nondiscriminatory distribution as far better than one in which a U.S. company would own and control data acquired by remote-sensing satellites.

The issue of commercialization comes to the international arena in the context of over 100 years of international cooperation in forecasting and reporting

* Based in part on discussions with Marvin Robinson, former chief of the Outer Space Affairs Division of the United Nations, fall 1983.

the weather and 25 years of U.S. assurances that space would be developed for the benefit of a]], particularly developing countries. It also must be seen in the context of 15 years of discussion regarding land remote sensing in which the United States has argued against regulation of remote-sensing satellites and has promised that remote-sensing data would continue to be available on an open, nondiscriminatory basis.

Interdependence

Durin$_g$the past decade, the nations of the world have become increasingly interdependent. This has affected international negotiations and organizations by creating linkages between issues which make it increasingly difficult to treat any issue in and of itself. Discussions on the distribution of satellite remote-sensing data carry over into the debate over such issues as direct broadcast satellites, the use of the geostationary orb it, the Law of the Sea, negotiations in the International Telecommunication Union regarding radiofrequencies, and the regulation of transborder data flows.

This tendency is compounded by the fact that in the developing countries, it is often the same individual who negotiates a wide range of issues. Hence, on a very personal, as well as substantive, level, what is said and done in one forum carries over into others. In understanding the broader ramifications of U. S. policy towards increased private sector involvement i n, space, one must consider not only remote sensing, but a broad range of other issues.

U.S. Foreign Policy Objectives

Delegates from some developing countries regard U.S. actions at the U.N. and in other international organizations as increasingly insensitive to the needs of developing countries. They suggest that the United States has missed excellent opportunities to generate good will and strength in international organizations.

The UNISPACE '82 conference, which was organized in part to discuss the potential benefits of space for the developing countries, was the latest example of U. S. policy i n this area. The Department of State approachcd the conference from the perspective of limiting the damage to U.S. policies. In that, they were successful. However, developing countries view the c(lnf~~rc'net' as d failure because i t did not result in d plan of action.

According to some conference participants, the United States left them with the image of a nation unconcerned about the functioning of the U. N., pushing commercialization without consultation with the inter-national community, and preparing to militarize space. Although these perceptions are not shared by all countries, they may well influence developing country activities in future international negotiations.

Although the issue of commercialization of satellite remote sensing appears of little consequence compared with the major troubles facing the world today, the development of space policy now depends on military policy, natural resources and economic development, and global environmental problems. In addition, as the national papers contributed to UNISPACE '82 illustrate, it is **a** highly visible arena upon which the developing countries have placed a tremendous amount of national prestige. As such, space cannot be seen as an issue of little consequence, even though it, in and of itself, may not be of the highest national priority.

Some developing countries view the commercialization of space as a hostile action because it removes the U.S. Government one step from its responsibility for U.S. actions in outer space. This ultimately may place the United States in a weakened position in the U.N. and other international forums.

Organizational Infrastructure

The ability of a country to adopt remote-sensing technology depends on its capacity to create appropriate institutions for its use and management. This is particularly at issue in the developing world, where space-related organizations have only recent] y emerged as part of the governmenta] institutions. Although there is no single best way to organize satellite remote-sensing programs, the successful adoption of the technology coincides with the development of a strong institutional infrastructure, including effective organiza - tion, equipment, and personnel.

Thailand'

The Royal Thai Survey Department, through the use of aerial photography, has benefited from remote-sensing technology for nearly 30 years, In 1971 , the Royal Thai Government became aware of the possibility y of using Landsat data to supplement its aerial survey data and joined the NASA-sponsored ERTS-I * international investigators.

Since that time, the United States has contributed to three U.S. Agency for International Development

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[1] *UNISPACE '82: A Context for International Cooperation and Competition—A Technical Memorandum* (Washington, D.C.: U.S. Congress, Office of Technology Assessment, OTA-TM-ISC-2e, March 1983).

[2] Muscat, Craib, Elletsen, and Willard, "USAID Assistance for Remote Sensing in Thailand: An Evaluation" (Washington, D.C.: USAID, June 1983).

*Later the name of this satellite system was changed to Landsat 1.

(AID) projects related to developing Thailand's capacity to use remote sensing from space. The first provided seed money for Thai scientists to undertake work in applications of remote-sensing technology. AID also funded a second ERTS program by providing some equipment and much training. Ten Thai's were trained in the United States and over 70 received training in Thailand. In the third project, AID funded the Remote Sensing Technology for Development Project, which concentrated more on building up equipment than on training. Since then, training programs have continued. The result is that hundreds of Thai scientists and technicians have now been exposed to the use of remote-sensing technology.

The primary institution for remote sensing in Thailand is the National Remote Sensing Program, which is housed within the National Research Council (NRC). NRC has recently been moved into the Ministry of Science, Technology and Energy after having been an independent agency. In this transfer, the remote-sensing program has been left intact. The National Remote Sensing Program makes up about half of the total NRC budget and continues to grow – particularly with the development of a ground receiving station. Its Remote Sensing Program is overseen by the National Remote Sensing Coordinating Committee, which consists of members from the primary user agencies in the Thai Government.

Figure A-1 illustrates the wide range of interest in remote sensing within the Thai Government. Twenty-three agencies are represented on the National Remote Sensing Coordinating Committee. Of those 23, 12 are active in providing or using remote-sensing data. At the same time, this chart shows the extent of international interest. Canada has now become the largest remote-sensing aid donor to Thailand, and the French are showing increasing interest in the Thai program. Remote sensing has clearly become a part of the Thai Government institutional structure.

Of major importance to the Thai National Remote Sensing Program was the construction of a ground station for receiving Landsat and metsat data. This ground station, built at a cost of over $10 million, represents Thailand's commitment to building technological as well as institutional infrastructure. This station has attracted much national attention and is a strong source of national pride. The Thai National Remote Sensing Program has also established brand-new building facilities at the site of the satellite ground station.

Other Thai Government agencies have also developed strong commitments to the use of satellite data. It is in these user agencies that the real payoff from remote-sensing technology comes. Without successful adoption of the technology within the user agencies, the institutional commitment to remote sensing in NRC will not help Thailand in its national planning.

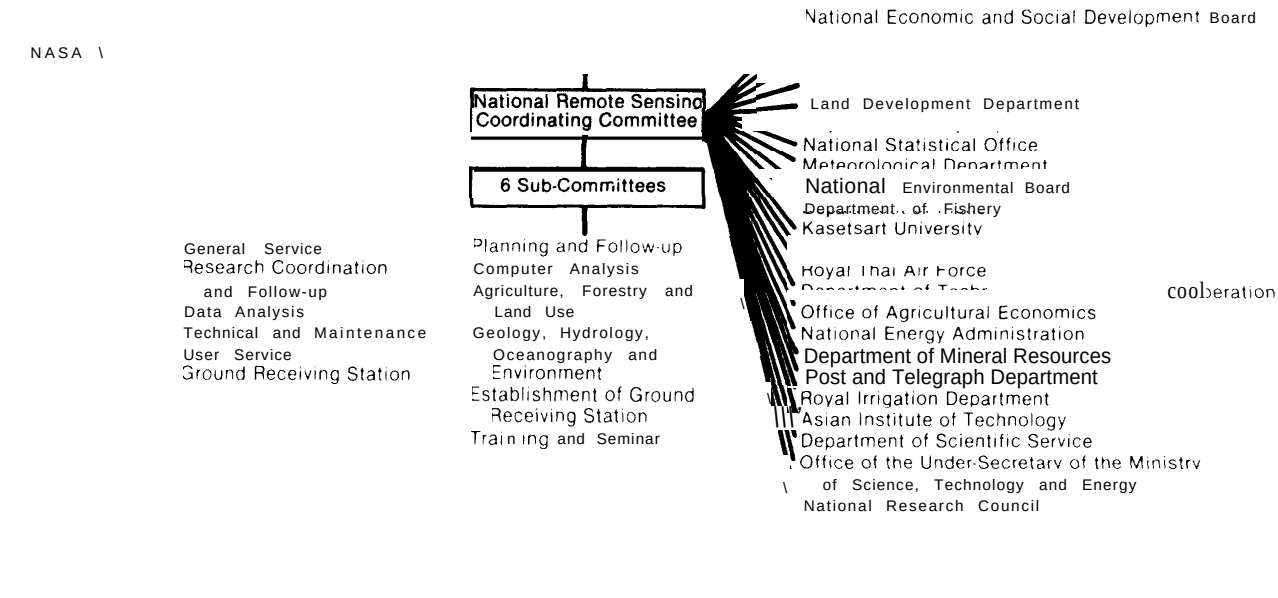
In particular, the Royal Forestry Department, the Office of Agricultural Statistics, the Soils Science Division of the Department of Agriculture, the Royal Irrigation Department, and the Land Development Department have all made commitments of equipment and manpower to the use of satellite remote-sensing technology. For instance, within the Royal Forestry Department, Forest Mapping and Remote Sensing Subdivision, 20 people are directly involved with remote sensing ---10 using aerial photography and 10 using satellite data. The latter have received training in the United States, at ITC/ Netherlands, in Canada and at Thai NRC training programs. The Forestry Department's use of the data is limited by its equipment (which includes adequate visual interpretation equipment hut not computer analysis equipment) and by the availability of satellite data, The Office of Agricultural Statistics has within i t a Remote Sensing and Service Branch that is working on an Area Frame Sampling Program in which satellite data will play a minor role. Its commitment to Landsat data is less than that of the Forestry Department because it has found the data less useful. Within the' Soils Science Iii\'isi[ln of the Department of Agriculture, three people are currently working with satellite remote-sensing data. In addition, eight to ten masters theses have been written applying satellite remote sensing to soils survey in Thailand.

The Thai Government user agencics, then, constitute the beginnings of an institutional infrastructure to support the use of satellite data. The use of those data is limited by the data themselves, slow data turnaround time, * and the lack of computer analysis equipment, as well as by organizational impediments,

These organizational impediments are the result, in part, of the manner in which the Thai Government has approached the organizational development of its remote-sensing program. Creating a separate entity within an existing institution separated the technology from institutions which have as their primary focus the solving of resource and environmental problem. Instead, it was housed in a sevrice agency and this generated problems in data availability and the application of satellite data by user agencies.

* The use of the data may be limited by the fact that they do not have high enough resolution for a specific application, by extensive cloud cover, or by technical problems which have occurred with the Landsat sensors. In addition, the data may not be available promptly enough for time-critical applications.

Figure A-1 .—Organization of the Thailand National Remote Sensing Program



SOURCE U S Agency for International Development

Bangladesh

The Bangladesh Landsat Program (BLP) was created in 1971, following Bangladesh's War of Independence, within the Science and–Technology Division, Cabinet Secretariat. BLP was created as a multiuser program covering agriculture, forestry, land use, fisheries, water resources, etc., and was overseen by the National Landsat Committee of Bangladesh, an advisory group representing government user agencies, universities, and the Planning Commission. In addition, Bangladesh has a Landsat Task Force, consisting of over 30 investigators from user agencies, which works under the National Landsat Committee.

BLP recently merged with the Space and Atmospheric Research Center of the Bangladesh Atomic Energy Commission to form the Space Research and

'Space and Remote Sensing Activities in Bangladesh, " SPARRSO, Bangladesh, 1980 and 'National Paper Bangladesh UNISPACE 82 Vienna, June 1981

Remote Sensing Organization (SPARRSO). This new entity is responsible for both research and operations for space science and remote-sensing technology in Bangladesh. SPARRSO currently operates an Automatic Picture Transmission (APT) meteorological ground station to receive signals from international weather satellites. With the aid of the United States and France, SPARRSO will soon be building a new ground-receiving facility capable of receiving both Landsat and SPOT data, as well as Advanced High Resolution Meteorological Satellite Data. Bangladesh has recently completed a new applications laboratory that contains visual and digital image-processing equipment, color and black-and-white photographic processing equipment, and photo-interpretation facilities. At the same time, the United States and SPARRSO have trained a nucleus of over 25 resource specialists in handling and interpreting satellite data. This training will continue under the upcoming U.S. and French programs.

The Department of Meteorology in Bangladesh is the government's weather forecasting agency. It integrates data accumulated by conventional methods with satellite data collected by SPARRSO. Most of the user agencies in Bangladesh use satellite data collected and disseminated by SPARRSO. In this way, SPARRSO has been and will continue to be a service organization *for* the rest of the government's user agencies. SPARRSO has attempted to avoid becoming isolated from the user agencies by bringing personnel from those agencies to work within SPARRSO. This approach seems to have been fairly successful in spreading the use of remote-sensing technology throughout Bangladesh. Bangladesh has developed a solid institutional commitment to the use of satellite data.

Kenya and Peru'

While both Bangladesh and Thailand have created new entities overseen by national coordinating committees to develop remote-sensing capabilities, they do not represent the only form of institutional development in the developing world. Both Kenya and Peru present examples of an alternative way of developing remote-sensing capabilities.

Kenya's initial interest in satellite remote sensing came from the Ministry of Natural Resources, which formed a national steering committee composed of representatives from agencies throughout the Kenyan Government. Until recently, however, no central focus for remote-sensing activities developed in Kenya, as primary responsibility for the new technology shifted from the Survey of Kenya to the Central Bureau of Statistics to the National Environment Secretariat to the Kenyan Rangeland and Ecological Monitoring Unit (KREMU). Outside funding of specific projects within each of these agencies caused these shifts of emphasis.

Today, KREMU functions as the national remote-sensing agency within Kenya. With a World Bank loan, KREMU is installing a digital processing system. This is a key step in Kenya's ability to use remote-sensing data, since up to this point Kenya has relied solely on visual analysis. This also marks a further, and substantial, commitment by Kenya to the continued use of satellite data. Kenya is studying the potential for establishing a regional remote-sensing center and ground facility in Nairobi. Intergovernmental coordination is the responsibility of the Committee on the Application of Satellite and Space Technology (COASST).

Kenya is also the host country for AID's Regional Remote Sensing Facility in Nairobi. This facility, serving the whole of East Africa, has benefited from the active participation of the Kenyan Government, which has cosponsored several training courses and symposia and helped to set up the center.

In addition to its work in land remote sensing, Kenya is actively using meteorological data from satellites. The Kenyan Meteorological Department receives APT images from the NOAA-6 polar-orbiting satellite, which it uses in determining cloud formation, type, location, and general cloud movement. The Department uses these data to map and monitor tropical cycles and to forecast hurricanes. Kenya hopes to improve its meteorological forecasting from satellite data, and plans to train more technicians in the near future.

Kenya is just beginning to develop an organizational context for incorporating remote-sensing technology into national planning. It is also securing the necessary equipment and personnel, a fundamental link in using remote-sensing data. Kenya has also shown a strong commitment to the use of remote-sensing technology through its participation in the African Remote Sensing Council and the AID regional training facility in Nairobi. More than 200 Kenyans have received training in satellite remote sensing and photo-interpretation techniques since the mid **1970's.**

Kenya has taken a different approach to the development of remote-sensing capability than have either Thailand or Bangladesh. KREMU is not a space-oriented agency, but much more a user of satellite data and a provider of resource surveys to other Kenyan

[4] "National Paper: Kenya," UNISPACE '82, Vienna, June 1981; and private discussions with Merrill Conitz, formerly head of the Regional Remote Sensing Program in Nairobi. The discussion of Peru is based on Campbell, Sader, and Elletsen, "Land-Use Inventory and Environmental Planning Project: Peru" (Los Altos, Calif.: Resources Development Associates, April 1980); and "Remote Sensing for Resource Assessment and Management: An Evaluation" (Los Altos, Calif.: Resources Development Associates, 1979).

agencies. This type of organizational structure ties the use of satellite data more directly to actual resource and environmental problems, but it may make it more difficult to establish a focal point for remote-sensing activities. Nonetheless, Kenya's commitment to the future use of satellite remote-sensing data and the necessary manpower, equipment, and organizational infrastructure is strong.

Peru, like Kenya, has placed responsibility for satellite remote sensing in a well-respected agency that will be a user of Landsat data and provide resource information to other Peruvian agencies. Like Kenya, Peru has chosen not to house its remote-sensing program in a special remote-sensing agency or a space agency, choosing instead to make it a part of an existing agency which sees the use of remote-sensing data as another tool for carrying out its mandated tasks.

Peru is now working with AID on a program to strengthen its infrastructure through institutional development, equipment purchases, and personnel training.

Other Programs

Several other developing countries have begun the institutional development necessary for the effective use of satellite remote-sensing data.

Egypt established the Egyptian Remote Sensing Center in 1971.[5] This center has become a focal point for remote-sensing expertise in the Middle East and North Africa. It employs more than 65 qualified/trained personnel and engages in cooperative work with many remote-sensing institutions worldwide. This center carries out its own research and is also supposed to coordinate remote-sensing activities within Egypt.

India has developed a strong national space program, with a large remote-sensing component.[6] Building on a strong organizational base and training program, India has established a full ground-receiving station and has plans to launch its own remote-sensing satellite in the near future. India's National Remote Sensing Agency is fully equipped with the latest in photographic and processing equipment. At least 65 of its employees were trained abroad in the United States and other industrialized countries.

In sum, then, whether the institutional commitment made by a developing country takes the form of a newly created remote-sensing/space organization or a newly created entity within an existing resource survey agency, it requires substantial commitment to developing institutional infrastructure.

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Remote Sensing of Natural Resources in Developing Countries The Egyptian Experience UNISPACE 82 Vienna March 1981

National Paper India UNISPACE 82 Vienna May 1981

The Use of Satellite Technology in Solving Environmental and Resource Problems

A great deal has been written about the application of satellite remote-sensing technology to the solution of environmental and resource problems of the developing world. Using examples from Thailand and Costa Rica, this section attempts to distinguish between potential and actual uses of satellite remote-sensing data.

Thailand[7]

Thailand has made numerous attempts to apply remote-sensing technology to the mapping and management of its natural resource areas. Some of these attempts have been remarkably successful and have led to operational use of the technology. Others provide good examples of innovative and adaptive use that may prove to be of significant value in the future. Still others have been complete failures.

- **Forestry. ---** The deforestation problem in Thailand is severe. Each year an average of 4,650 square kilometers (km') of forest land is cut while only 800 km^2 are reforested, resulting in a net loss of 3,800 km^2 of forested land each year. At this rate of deforestation, Thailand would deplete its forests completely in the first quarter of the 21st century.

  The first indication of the extent of the deforestation problem came from a resource inventory done in 197'3— the first year Landsat data were used to aid the Forestry Department. The results of the first full study utilizing Landsat data led to a more vigorous reforestation policy. The outcome of this policy is shown in figure A-2, which indicates an increase in the number of forest plantations throughout Thailand.

  Using Landsat data, the Forest Mapping and Remote Sensing Division of the Royal Thai Forestry Department has been able to map and summarize the status of forest lands nationwide every 3 years since 1973. Because of the high cost of aerial photography, this task would be impossible to accomplish without satellite data.

  In August of 1981, the Prime Minister's Office requested a report on the status of forest lands and deforestation throughout Thailand. The Forestry Department prepared this report using Landsat data. Since that time the Prime Minister has required reports every 3 months on the state of the forests in different parts of Thailand. The staff of the Prime

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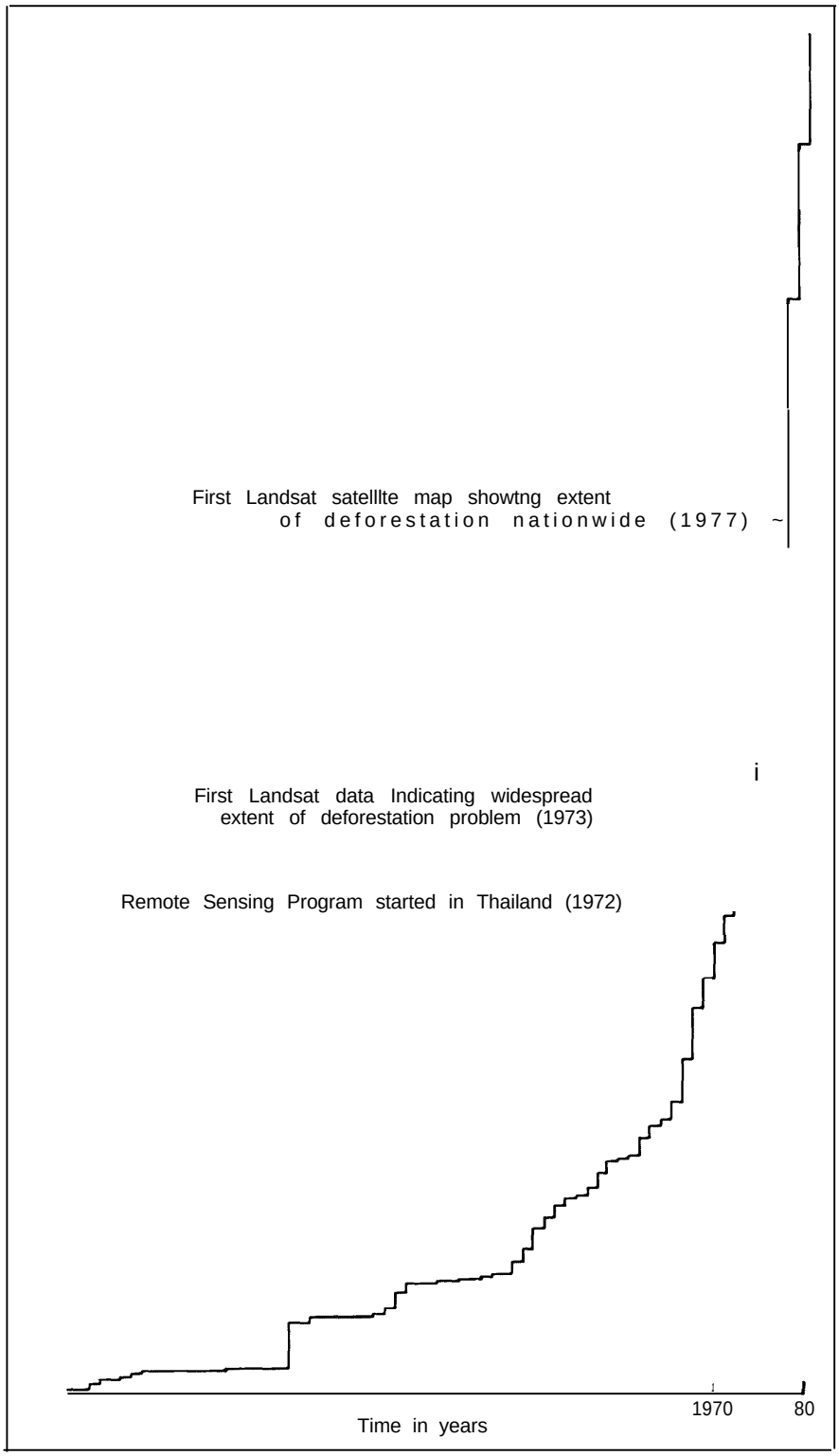
Muscat (raib Elletsen and Willard op cit June 1983

Figure A-2.— Relative Number of Forest Plantations in Thailand



SOURCE Off Ice of Technology Assessment

Minister then works with the Ministry of Agriculture and Cooperatives on agricultural development projects designed to settle farmers in already deforested areas rather than having those farmers move onto still-forested land.

Without Landsat data, Thailand would be unable to maintain an ongoing and up-to-date inventory of its forested lands and the level of deforestation. In fact, without the use of Landsat it is possible that the magnitude of the deforestation problem would not have come to the attention of decisionmakers in Thailand at all. This is one of the most dramatic examples of the successful use of Landsat data anywhere in the world.

- **Environmental Impact .—Thailand** has been less successful in using remote sensing to monitor the environmental impact of tin mining and offshore dredging near Phuket in southwestern Thailand. In 1980, the National Environmental Board started a program to monitor sedimentation, water pollution, and destruction of coral reefs in this area. The Environmental Remote Sensing Section has conducted extensive field-sampling surveys here, many timed to correspond with Landsat satellite passes over this area. They have also ordered satellite data over the Phuket region from September 1982 until the present. Unfortunately, although it is likely that the required information could be extracted from Landsat data, this project as been unsuccessful because the data have not been available from the Thai ground station or from the United States because of problems in the satellite sensor and tape recorders (of Landsat 3).

  Landsat data have been useful in evaluating the extent of soil erosion problems. One project, completed in 1982, identified several areas of severe erosion near the Pitsanuloke-Lomask Highway and in the Phumipol Dam Region. Some of these areas have lost upwards of 20 cm of topsoil on steep slopes. This study led to a bill, introduced in the Thai Parliament, to prohibit agriculture on steep slopes.
- **Crop Forecasting.—Thai use of the Landsat system for agricultural crop production forecasting has not been nearly as useful as had** been expected. Members of the Office of Agricultural Economics who have applied remote-sensing techniques to agricultural crop production forecasting believe that the technology is far from operational and that it is still in the research stage in Thailand. Impediments to using Landsat for crop yield forecasting in Thailand include:
  - **—Small field size.—The practices of interspersing different crops on adjoining fields and planting** adjoining fields with the same crops at different times makes it very difficult to use satellite data from the multispectral scanner (80-meter resolution).
  - **—Cloud cover .—The presence of cloud cover dur**ing the growing season prevents substantial use of Landsat data.
  - **—Lack of timely delivery.—In order to evaluate the state of the crops and take necessary remedial action, remote-sensing data** need to be delivered within a few days.

  Still another difficulty with crop production forecasting is the lack of good yield models for crops in Thailand. It is necessary to predict both crop area and yield per acre.

  The failure to apply Landsat data effectively to agricultural crop production forecasting has been a major disappointment. Remote-sensing programs in many developing countries were justified on the expectation that they would improve agricultural forecasts. The fact that the enthusiasm for satellite remote sensing remains strong in developing countries despite the failure of Landsat with respect to agriculture, shows the strength of commitment of the developing world to the use of satellite data.

Costa Rica[8]

Costa Rica, like many developing countries, faces severe environmental and resource problems. It has experienced both rapid deforestation, as forest land is cleared to accommodate agricultural and grazing, and rapid urbanization, which destroys prime farmland.

Costa Rica is following a trend which is characteristic of all of Latin America. In 1978, Latin America was believed to possess 25 percent of the developing world's forest land area. If current trends continue, this forest area (around 550 million hectares) will be reduced by 40 percent. Most of the remaining forest will be found only in inaccessible areas. In Costa Rica alone, an estimated 50,000 to 60,000 hectares per year of forest land is destroyed, compared with a reforestation rate of only 1,000 hectares per year.

Although the Costa Rican Government was aware of these problems, it had not grasped their extent, In fact, during the 1960's and 1970's the Costa Rican Government did little to survey its resources. By the late 1970's Costa Rica realized that it needed a nationwide survey to define its current resource base and the rate

[8] "The Utility, Cost and Effectiveness of Remote Sensing for Forest and Urban Sector Assessment in Costa **Rica"** (Los Altos, Calif : Resources Development Associates, March 1978); and "Design of a Natural Resources Inventory and Information System for Costa **Rica:** The Pilot Project Report" (Los Altos, Calif. Resources Development Associates, June 1979),

of change of land use (either agricultural to urban or forested to grazing and agricultural) in the country.

In 1977, Costa Rica began an AID demonstration and pilot project to determine the feasibility of using Landsat to aid in a natural resources inventory for Costa Rica. The project was successful in confirming the magnitude of the resource and environmental problems facing Costa Rica—it created a clear picture of the rapid deforestation and rapid urbanization taking place in various "project areas" in the country. The study also showed the feasibility of integrating Landsat data into a national resources survey effort. In Costa Rica, even though Landsat data were used to illustrate the magnitude of a particular resource problem, and were shown to be a useful tool in monitoring that problem, the government did not follow up by undertaking a national survey.

Although Costa Rica has continued to use remote-sensing data, it has not adopted remote-sensing technology on the scale recommended by the studies. Two factors have brought this about: 1) there is no central institution in Costa Rica charged with remote-sensing responsibilities; and 2) in spite of the fact that each AID project had a strong training component, few trained personnel have afterward been able to devote their time to remote sensing. As the example of other developing countries has shown, the creation of a national advisory committee and the designation of a lead agency are clearly critical to the effective use of satellite data, even when the data are shown to be highly useful for monitoring serious environmental and resource problems.

Weather Satellites in Developing Countries

The flow of data from the weather satellites, rather than requiring the development of new institutions has been incorporated into the programs of existing weather agencies. The World Meteorological Organization (WMO) helped to provide the necessary receiving stations. Data have always been available at no cost.

Weather satellite data have been used for a multitude of routine tasks, from disaster and storm warnings to crop forecasting. Over $100 million has been invested worldwide in direct readout equipment and manpower, space processing, and dissemination equipment. At present, over 1,000 APT ground stations have been established in over 125 countries worldwide, including an extensive number in developing countries. Forty-four stations located in twenty-nine countries receive HRPT data.

These numbers are increasing all the time. The well-established weather-satellite user community in developing countries stands in marked contrast to the limited user community for land remote-sensing data. In fact, the "market" for Landsat data in developing countries is still in its developmental stages, primarily because the resource information programs of developing countries are only beginning to prove their worth.

Potential Effects of Commercialization

The transfer of all or part of U.S. space remote-sensing systems to the private sector would certainly affect the use of satellite data by the developing countries. The extent of its effects and how they are played out in political and scientific relationships will depend on several key factors: 1) the remote-sensing user community and the foreign policy community in the developing countries are separate, independent, entities; 2) regardless of U.S. policy in this area, France, Japan, and the European Space Agency are planning commercial remote-sensing ventures; 3) the market for remote-sensing data from space is in its early stages. While some users are clearly ready to integrate these data into their standard operations, others are still in the process of exploring the usefulness of remote-sensing data; 4) in the arena of foreign policy, the perceptions of Third World political leaders regarding transfer may be more important in determining their actions than the actual outcomes of commercialization on data users in developing countries.

The effects of transfer to private sector can be discussed in terms of five variables:

Data Type and Continuity

Development of a commercially operated Landsat system implies that all data would be available on a continuous and timely basis. If this were not the case, any commercial effort would fail. In fact, one could surmise that Landsat data would become available in a way which would compare to the current availability of metsat data. In isolation, such a development would clearly encourage the use of satellite data in the developing world.

One of the major complaints developing countries have made since the outset of the Landsat program has been that uncertainty over the future of Landsat has made it nearly impossible to develop the capacity successfully to incorporate remote-sensing data into national development planning. At the same time, the difficulty of receiving Landsat data promptly after a satellite pass has made it difficult to rely on such data. To the extent that ultimate commercialization of the Landsat system would mean the timely and continuous availability of data, it would greatly enhance the developing countries' use of satellite data.

In addition, it is likely that a private operator would also "tailor" its satellite sensors to its primary market areas. While the Government might well continue to perform R&D for advanced satellite sensors, the private sector would have to develop its own sensors in continuous interaction with the market. For instance, in the tropical areas of the developing world, a satellite sensor capable of penetrating cloud cover would greatly enhance the commercial value of remote-sensing data. * To the extent, then, that a private sector owner and operator would match satellite sensors to the needs of the market, commercialization would have a positive impact on the use of satellite data by developing countries.

Pricing

If the Landsat system is transferred to private hands, the price of data may well increase. Such a price increase, however, might have an adverse effect on the use of data and the further development of institutional infrastructure in developing countries.

This is not to say, however, that a price increase would eliminate the use of satellite data in developing countries. If the data were available promptly and continuously, then it is likely that developing countries would continue to use remote-sensing data to replace other, more expensive, means of obtaining resource information. Higher prices for satellite data would not necessarily discourage serious users of the data. They are more likely to discourage those users who are in the early stages of adopting remote-sensing technology, which would inhibit the growth of the market.

U.S. technical assistance programs have, for the past 15 years, helped developing countries adopt remote-sensing technology. If the U.S. Government wished to continue its technical assistance programs for satellite remote sensing, and thereby decrease the negative effects of a price increase, it could subsidize the cost of commercial remote-sensing data in its development projects.

In addition, a private company might well provide some incentives to developing countries to encourage them to use remote-sensing data. Many computer companies donate computers to developing country institutions to promote their products. There is no reason to think that the private sector would not operate in a like manner to develop a remote-sensing market.

Copyright and Data Protection Laws

Another key set of issues tied up with the transfer of remote-sensing data are those of copyright, proprietary data rights and data protection laws. Commercial interests generally want private ownership of data, thereby making the data a scarce resource for which the customer would pay more. As such, a commercial venture is likely to require data protection guarantees or proprietary rights to data. This is in line with traditional notions of private ownership, but goes against public notions of open access to information.

This is a key point in the entire commercialization discussion. It is clear that if a private firm, and particularly a multinational firm, were allowed proprietary rights to data acquired by satellite, many countries of the world—including the developing countries—would react negatively.

Government Technology Transfer and Technical Assistance Programs

In order to achieve success in commercializing remote-sensing technology, the U.S. Government will have to stop competing with the private sector in offering value-added services. Although they have been instrumental in spreading understanding and use of remote-sensing technology throughout the world, technical assistance and technology transfer programs may compete with the private sector.

Ever since the opening of the international debate over the future of remote sensing the United States has offered technical assistance to the developing world. This has helped to mitigate international concern over the U.S. policy of open dissemination of satellite data. If the United States were to stop providing technical assistance completely, the international debate over data dissemination might become more heated.

The U.S. technical assistance programs are largely responsible for the development of the international user community. To the extent that any market for remote-sensing data exists internationally, it exists because of U.S. aid. Discontinuing this aid would slow the further spread of land remote-sensing technology.

In attempting to provide technical assistance to developing countries U.S. policymakers will have to consider carefully the effects of their policies on the U.S. private sector. It may not be appropriate to discontinue technical assistance programs, but if the transfer is to be successful the Government will likely have to implement them at the market price for data and value-added services. As part of their marketing strategies, private sector operators might find it in their interest to assist developing countries in the use of the technology. Hence, transferring land remote sensing to private ownership would not necessarily mean an end to technical assistance, sponsored either by government or by the private sector.

*Recently the Netherlands and Indonesia have explored the possibility of building a satellite system specifically designed for use over tropical regions,

U.S. Regulation

Several forms of regulation might be used to ensure that a commercial entity would conform to U.S. foreign policy objectives. These include such things as a guarantee of open access to data, much as they are available now from the EROS Data Center, or assuring a particular country access to data collected over its own territory. Other regulations might involve pricing regulations, guarantees of technical assistance and data continuity, etc. These types of regulations would have a positive influence on the use of satellite data by developing countries—however, they might discourage private sector commercialization efforts.