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**THE TRANSFER OF TECHNICAL KNOWLEDGE:
REMOTE SENSING FOR THE MANAGEMENT OF THAILAND'S MANGROVES**

By

HELEN JENKS CLARKE, B.A.

**A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfilment of
the requirements for the degree of**

Master of Arts

Norman Paterson School of International Affairs

Carleton University

Ottawa, Ontario

January, 1992

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ABSTRACT

The transfer of a technology is influenced by the social, economic and political context in which it developed, and to which it is transferred. When Official Development Assistance is shifting to sustainable development, policy conflicts in the application of a transferred technology will arise. In a case study of two Canadian projects in the transfer of remote sensing technical knowledge, the questions of gaining and promoting access to the technology, interpretation and verification, its use in national development planning, and in policy formation are examined. Policy conflict is observed in the application of the technology to the management of Thailand's diminishing mangrove resources; this situation could be avoided by making explicit the goals and expectations involved in the transfer of technical knowledge.

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ACRONYMS

AIT	Asian Institute of Technology
CIDA	Canadian International Development Agency
CCRS	Canadian Centre for Remote Sensing
EOSAT	Earth Observation Satellite Company
ESCAP	Economic and Social Commission for Asia and the Pacific
GIS	Geographic Information System
GDP	Gross Domestic Product
GNP	Gross National Product
HRD	Human Resource Development
IDRC	International Development Research Centre
MOS	Marine Observation Satellite
MSS	Multispectral Scanner
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency of Japan
NESDB	National Economic and Social Development Board
NIC	Newly Industrialized Country
NOAA	National Oceanic and Atmospheric Administration
NRCT	National Research Council of Thailand
ODA	Official Development Assistance
RIMS	Resource Information Management System
RSD	Remote Sensing Division of NRCT
RRSP	Regional Remote Sensing Programme of ESCAP
SAR	Synthetic Aperture Radar
SLAR	Sidelooking Airborne Radar
SPOT	Système pour l'observation de la terre

TDRI	Thailand Development Research Institute
TM	Thematic Mapper
TRSC	Thailand Remote Sensing Centre of NRCT
USAID	United States Agency for International Development
WCED	World Commission on Environment and Development

Chapter I. The Transfer of Technical Knowledge and Sustainable Development

Introduction

Technology transfer is a complex process which entails more than the physical transfer of hardware between countries. Technologies are developed in a particular social, economic and political milieu. In the transfer process the recipients receive knowledge about how the technology is used, for what ends, and by whom, all of which compose the context in which it was developed. This study examines the transfer of remote sensing technology between Canada and Thailand. Sponsored by the Government of Canada as a part of its Official Development Assistance (ODA), and requested by the Government of Thailand, the transfer is a reflection of Canadian expertise and Thai interest in the use of remote sensing for natural resource management. The transfer process has been affected by the social, economic and political context in which both parties come together.

For many years, economic development has been defined in terms of growth, measured by such devices as Gross National Product (GNP). Currently, in Canada, there is a change occurring in international development assistance, with a de-emphasis on the concept of growth. The language of sustainable development has become popular in ODA, but its meaning is yet to be made clear and operationalized. The transfer of remote sensing technology reflects this change.

How the concepts of growth and of sustainable development are used in remote sensing projects in the management of Thailand's natural resources is indicative of the complexity of the transfer process. The implications for technology transfer policy and for natural resource management policy are numerous.

In this chapter, a brief discussion of sustainable development will be followed by a consideration of the transfer of technical knowledge. The two will be brought together in the thesis that when technical knowledge transfer occurs in a context in which development goals, values and expectations are in a state of flux, a conflict is reflected in policy to which the technology contributes. A description of the methodology for the case study will follow.

Sustainable development

Development cannot subsist upon a deteriorating environmental resource base; the environment cannot be protected when growth leaves out of account the costs of environmental destruction. (World Commission on Environment and Development 1987: 37).

Economic growth in the Third World was high during the 1960s and 1970s. It stopped - and actually reversed (World Bank 1990) - in some parts of the Third World during the 1980s, due to debilitating economic, political, structural and environmental problems. Increasing levels of poverty now accompany increasing environmental degradation in some developing countries. Development efforts have resulted in

little change, and in some cases, have been implicated in damage done to the very people they were intended to help. The mounting inequities between the First and Third Worlds have resulted in a rising call for a new strategy. Some treat renewed economic growth as the solution, others call for a strategy based upon the concept of sustainable development (MacNeill 1989).

Industrialization and wealth in the First World have been achieved by economic growth, but at the cost of tremendous ecological destruction. The damage done to resources while extracting their value was not taken into account when measuring assets and economic growth. The point was to control natural resources, not to manage them. "Neo-classical economics assumes that resources are divisible and can be owned. It does not acknowledge that resources bear a relationship to each other in the natural environment, as part of environmental systems" (Redcliff 1987: 40). But as evidence mounts of the link between increasing environmental degradation and poverty, there has been a recognition of the need for a revision in our thinking about economic activity and development, which Lélé describes as "... a process of directed change" (1991: 609). Although high rates of economic growth have resulted in the provision of most basic human needs in the industrialized countries and in some developing countries, it is increasingly recognised that economic growth as a model of development is incomplete. It fails to treat as

a high priority objective the needs of the poor, of this generation or the next. Moreover, the environmental degradation-poverty link makes it apparent that further development should be made sustainable.

The United Nations Stockholm Conference on the Human Environment in 1972 and the World Conservation Strategy of 1980 resulted in awareness and concern for environmental issues by aid agencies. A synthesis between what at first appeared to be contradictory objectives - economic development of the Third World and concern for the environment - began to emerge (Gawn 1985). The popular report of the WCED, Our Common Future defined this synthesis, sustainable development, as development which "...meets the needs of the present without compromising the ability of future generations to meet their own needs" (1987: 8). Keeping in mind the resource needs of future generations is not a new practice, but one that had been put aside in the quest for economic growth.

In addition to the mounting despair and frustration, in the 1980s, in reaction to declining and negative growth rates in many Less Developed Countries, came recognition of the tremendous environmental costs to these countries. The Third World now faces the bleak prospect of attempting economic growth while the resource base is decreasing (MacNeill et al. 1989). Sustainability is now understood to be about sustaining the resource base for production, yet the dilemma is that " ... the environmentally sustainable use of natural

resources for economic growth demands a high rate of 'saving' for the future, only sometimes with immediate benefit in terms of production and profit" (Brookfield 1988: 133). The immediate demands of economic growth conflict with the recognition that resources consumed or overused today will not be available for growth in the future.

Even middle income countries, such as Thailand and other Southeast Asian countries, are at risk of experiencing a slowdown in economic growth as their resource base declines. The dramatic declines in timber resources which accompany large scale harvesting have already resulted in the shutdown of the industry in Thailand. Combined with the need for foreign exchange, earned by the export of aquaculture products, the decline of Thailand's timber resources puts more pressure on the resources of the country's mangrove forests. Economic development of the mangroves in Thailand is intensive. It is now apparent that the exploitation of these marginal resource areas cannot sustain a high rate of economic growth, either on a nationwide basis or in the coastal regions. Sustainable development of the remaining mangroves must take into account the needs of the mangrove dwellers, and the ecological interactions which occur in the resource base.

A multiplicity of factors, including external ones, determine the sustainability of an ecosystem. With ecological and structural limitations placed on an already overtaxed economic system we need to recognise that "... human economies

on the finite earth cannot grow indefinitely, but they can develop" (Goodland 1989: 10). Sustainable growth is a contradiction in terms. Economic growth is based on an equilibrium model and cannot deal adequately with the dynamics of ecological and social changes brought about by environmental degradation. Sustainable development is based on evolution and change (Jacobson and Price 1990); qualitative, rather than quantitative, progress is required to make development sustainable. While neoclassical economics has been based on the management of scarcity, bringing consideration of future generations into the equation calls for "... not only choice under scarcity but under diachronic scarcity..." (Galtung 1987: 69) as the ecological balance changes further.

The operational definition of sustainable development proposed by the World Commission on Environment and Development included the following national objectives:

- reviving growth;
- changing the quality of growth
- meeting essential needs for jobs, food, energy, water, and sanitation;
- ensuring a sustainable level of population;
- conserving and enhancing the resource base;
- reorienting technology and managing risk; and
- merging environment and economics in decision making (WCED 1987: 49).

Most recent discussions would add the objective of "... making development more participatory" (Lélé 1991: 611). Lélé convincingly argues that the first objective listed above, reviving growth, cannot truly be part of an operational

definition of sustainable development. It has been observed that "... economic growth per se could not ensure the removal of poverty ..." and that growth can be associated with "... either an improvement or a deterioration in environmental quality" (ibid.: 614). Therefore, economic growth could result from sustainable development, but could not be the means to its achievement.

Despite the continuing popularity of using growth indicators as measures for development the concept's static nature and its lack of focus upon either poverty or environmental degradation have resulted in a search for a concept with greater utility for long-term economic development. Sustainable development has the potential to form the basis of a new international development assistance strategy.

Changing international development assistance

Our Common Future gave impetus to efforts to bring sustainability into international development assistance. In 1984 the World Bank, the largest international financial institution involved in development, had advocated the sustainable management of natural resources for all generations, and instituted the use of Environmental Impact Assessments and a modified Cost Benefit Approach for development projects. While praised for its initiatives in environmentally-sound development activities, the Bank was

also criticized for putting aside environmental concerns for the sake of flexibility (Gawn 1985).

In the same year as the publication of Our Common Future, the World Bank stated its willingness to abandon traditional economic techniques of discounting resources in situations in which it is determined that environmental effects of development activity may cause irreversible damage or where the future generations involved can be expected to live in much deteriorated circumstances. Rigorous quantitative analysis would have to be applied. "The tremendous uncertainties in predicting events that will occur many years hence should not deter governments from serious consideration of the results of such analysis" (World Bank and IMF 1987: 8). The effect that political resistance by powerful interests can bring to bear on the distributional effects of environmental degradation should be recognized also. These factors require a "... major political commitment ... to improve substantially the management of natural resources" (ibid.: 9), the strengthening of human resources and institutions, and public education. The Bank would design new economic instruments "... to reconcile environmental, growth, and poverty alleviation objectives" (ibid.: 31-32).

Canadian support for environmental concerns emerged in the early 1980s with the adoption of the World Conservation Strategy, sponsorship of the WCED, and contributions to the United Nations Environmental Program. By the mid-1980s

concern for the environment became an official element of Canadian foreign policy, resulting in a similar move in foreign aid policy (Gawn 1985). During this period, environmental issues became prominent in strategy and project selection in some country programs (Rudner 1991a)

Soon after the publication of Our Common Future and the shift in position by the World Bank, CIDA brought out a new environmental policy, the result of a long policy development process. Canada would make the environment a part of its international development planning by:

1. requiring impact assessments on all projects likely to involve risks to the environment;
2. giving high priority to environmental projects and natural resource restoration;
3. stressing public awareness of environmental protection;
4. supporting institutions in the Third World active in environmental concerns; and
5. emphasizing data collection activities and increasing capacity in developing countries (CIDA 1987a; CIDA 1990).

The following year, the Agency recognised that its policy needed to be made more effective. A study commissioned by CIDA recommended four ways the Agency can operationalize its environmental concerns:

1. country program plans and funding for sustainable development;
2. procurement policies for sustainable development;
3. increased donor co-operation; and

4. staffing and training policy within CIDA and its external support groups (MacNeill et al. 1989).

The language of sustainable development now is becoming a part of Canadian ODA strategy. During the past decade, development projects have been formulated in a mixed context; "sustainable development" has competed with "economic growth" as a goal of development. The ambiguity of the strategy results from a context in which both growth and sustainability are goals of Canadian international assistance.

Technology transfer and the transfer of technical knowledge

Technology is often thought of as hardware, but its definition is much more than machines and new seeds. Using a broad definition, Stewart says that, "Technology is knowledge - knowledge of how to do and make useful things" (1979: 1). In the transfer of technology between parties it is essential that communication of the software element, the "knowhow," occurs as well as the transfer of the hardware or technological product. Technology transfer can occur in three ways: 1) informal transfers by means of reading, personal contacts in meetings and conferences, and as trained people move from job to job; 2) direct transfers between suppliers and purchasers of technology; and 3) indirect transfers in which an intermediary delivers the technology (ibid.). Training may be a part of either direct or indirect transfers.

Transfers of industrial technology between countries can be either direct or indirect. In higher income developing countries, which have the capacity to put a technology package together and command some bargaining power, the transfer mechanism is likely to be indirect. "The more technologically sophisticated [the industry], the more difficult it is for countries to rely on direct transfer" (ibid.: 14). The greater complexity of technology means that licensing agreements will entail the inclusion of multiple parties in the transfer; agreements often include a separate party to oversee the transfer of technical knowledge.

The North-South transfer of technology presents a problem to developing countries: how this transfer can be made without increasing dependence on the First World which will restrict the path of development suited to the particular country. Among developing countries which need new technology quickly, under conditions requiring adaptation, "... the transfer of skills and knowhow through the training of local personnel is often incomplete" (McKinley and Young 1979: 12). Although the transfer of First World technology may be seen as the key to modernization in the Third World, if the transfer is incomplete or inappropriate the result will be a continuing or increased dependence. When development aid is based only on the transfer of technological hardware, technological control cannot be achieved (Dube 1988). The transfer of technology, which is basic to the process of development, requires a

transfer of technical knowledge and hands-on learning situations.

The term "technical assistance" was used widely after World War II, particularly in the U.S. Point IV program of foreign aid. This type of program gave little recognition to value differences between societies or the differing goals of the donor and recipient countries (Poats 1972). "The Point IV program was based on a belief that technical assistance could make a major impact on economic development abroad without significant amounts of capital assistance" (Mikesell 1983: 2). The failure of this program to radically alter the economies of the developing countries resulted in "overcompensating corrections" (Poats 1972: 8), of both hardware and capital transfers which likewise failed to solve the problems of technology transfer for economic development. More recent analyses prefer the term technical collaboration, recognizing that "...the expanding human resource competency base in developing countries means that in many situations countries already have some of the skills and knowledge they need" (Brinkerhoff 1990: 142). Nevertheless, many ODA programs ignore the potential of the trained manpower that Third World countries do have. This jeopardizes the continuity of projects which do not include technical training for skills upgrading and the transfer of technical knowledge suited to transferred hardware (Gow 1988). Human, institutional, and natural resources must be utilized in planning for self-

reliant development. "Ultimately, technological advance depends on what those individuals who live and work in a particular society have learned, including what they have learned about how to act on what they know" (Solo 1975: 12). Effective transfer of technology will take into account the Third World country's leaders, institutions, and management systems (Poats 1972) which all contribute to policy formation and determining the ends for which the technology will be used.

It is important to distinguish between the terms transfer of technical knowledge, and technical assistance. In recent years the term "transfer of technical knowledge" has come into use as the meaning of "technical assistance" has narrowed. Girvan (1983) distinguishes ten forms of technology transfer, including technical assistance, training of personnel at home and abroad, and the individual acquisition of knowledge. He limits technical assistance to the transfer of information about a particular technology and trouble-shooting in its application; his more general terms, training of personnel, and individual self-training, are combined in the transfer of technology-related knowledge. Technical assistance is transferred by international and bilateral agencies and private firms; technical knowledge is transferred by educational institutions, recipient government agencies, and executing agencies, as well as by written materials and personal contacts.

Several points can be added: 1) the concept of the transfer of technical knowledge includes an application of skills newly, or previously acquired in a wide range of activities. The skills are not purely technological ones; they include modes and goals of application. 2) Those trained in technical knowledge may participate in policy-making situations and decisions, whereas those who receive technical assistance are unlikely to have access to policy mechanisms. 3) The context in which the transfer occurs and to which it will be applied will affect the end result of how the technology is utilized.

The bridge between technology transfer and human resource development

Technical knowledge is sometimes referred to as software technology, or "... the in-depth, global knowhow by which people manage, control, operate and maintain the complete system of a technological field" (Hawes and Kealey 1981: 250). The success of the transfer of technical knowledge, the software element, is dependent upon the context of the project, the values and expectations assigned to it (Scott-Stevens 1987). The transfer of technical knowledge can be seen as a bridge between technology transfer and human resource development (HRD). It is the software aspect of technology transfer which is directed to the human resources of developing countries.

Even when technical assistance (in its previous, wider meaning) was considered the primary means to accomplish technology transfer to developing countries, it was recognised that social factors were interfering with the long-term success of transfer programs. The problems were described as being psychological, arising from cultural differences; political, due to errors in the selection of participants; and administrative (Spicer 1966). The context of expectations in which the programs were designed or requested were ignored. Over the intervening years since then, the aid community has recognised that human resources are equally important and that HRD is an integral dimension of ODA programs:

HRD as education and technical cooperation. HRD is seen as education and other skill and knowledge transfer activities, including the provision of Canadian expertise to assist developing countries (CIDA 1987b: 4 (emphasis in original)).

If the transfer of technology through ODA is to contribute to development it should result in increased equity and the elimination of poverty. But, in the developing countries, this is usually the opposite of what actually happens: in such situations, progress in technology is accompanied by greater inequality and poverty. "...Allocations by the state [which include ODA programs] typically benefit the middle and upper-income groups rather than the poor" (Griffin 1988: 352). In that case, we must ask whether the ODA focus on poverty through the "lens" (CIDA 1987a: 36) of HRD is effective. Who benefits from HRD and technology

transfers in developing societies? Do the middle and upper classes, which are most likely to receive direct benefit from training, also receive the most benefit from the results of the technology transfers?

The recent emphasis, in Canadian ODA, on HRD, means that the targeting of poverty is undermined (Rudner 1989).

The impulse to use training to facilitate technology transfers implies a subtle but nevertheless real reorientation of human-resource development activities the educational and training orientations of human-resource development and the strategic targeting of poverty groups do not seem to converge (ibid.: 158).

Technical training and education can be the first of a two-step approach to eliminating poverty, followed by projects and services for development (Rudner 1991b). The transfer of technical knowledge, the bridge between human resources and technology transfer, can be made to direct technological inputs into the elimination of poverty. Care is required to ensure that the transfer will promote ends which will benefit poverty groups and will be directed to poverty alleviation.

"Context" in the transfer of technical knowledge

Current Canadian international development assistance occurs in a context of mixed values, objectives and expectations, some of which are based on the concept of development through growth, others of which are based on sustainable development. In fact, the ambiguity of the context is an indicator of a flux in thinking. The objective

of rapid economic growth can no longer be assumed, but the language of sustainable development is used without yet understanding its meaning and implications.

This case study of technology transfer for resource management will demonstrate that when the context of a project is not defined, by donor or recipient, the transferred technology will be applied in a variety of ways, some of which conflict. Those who participated in two technology transfer projects in remote sensing are the subjects of this study: it considers the process of gaining technical knowledge, the participants' views of its role in national development planning, and how some apply the knowledge to resource management policy formation.

Methodology for the study

Canada has been the source of much of the remote sensing technology received by Thailand. This study focuses on the transfer of technical knowledge in two projects, one a CIDA project, the other a project funded by the International Development Research Centre (IDRC). Remote sensing usually is housed in governmental institutions, in resource management or research agencies, or in universities. This is the case in Thailand, and the study took place in the National Research Council of Thailand (NRCT), Remote Sensing Division, and in two departments of the Ministry of Agriculture. Although the

technology has diffused to some provincial centres, major institutions involved in this study are located in Bangkok.

All of those chosen as informants had been involved in the CIDA or IDRC projects. The roles of those involved in the CIDA project varied; some were trainees, others were instructors. All who were involved in the IDRC project were instructors in the transfer of technical knowledge to Thais in other government agencies. Originally, I intended to interview all those who had been involved in the IDRC project (16 people) and all those involved in the CIDA project who had participated in a subgroup working on water resources (three people). Perhaps as was to be expected not all of these people were available: six had been transferred to other work, two had returned to university or were taking a course elsewhere, one had left the workforce. All the available participants who met the criteria were interviewed. Two people had participated only in the IDRC project, three had participated only in the CIDA project, and five had participated in both projects. Of the eight in the CIDA project two (neither of whom were involved in the IDRC project) had been in the water resources workgroup. In all, ten informants were interviewed.

The first contact I made with those I intended to interview was to write to two at the NRCT and one each at the Departments of Forests and Fisheries in the Ministry of Agriculture. The reply received from the NRCT was favourable and indicated that my inquiries there would be welcome. I

arrived in Bangkok just before the Twenty-Third International Symposium of Remote Sensing for Environment began. At the Symposium I met the IDRC project co-director. Soon after the Symposium ended, I conducted my first interview for this study with her and she put me in touch with the six others at the NRCT who had participated in the two projects. She also helped me to contact three others, two in the Royal Thai Forestry Department and one in the Department of Fisheries, who had participated in the projects. Over the next two months I was able to interview ten informants.

Another source of valuable information was found in people who had not participated in the projects but who are respected authorities in the field. Five are involved in remote sensing: at the United Nations Economic and Social Commission of Asia and the Pacific (ESCAP), at NRCT, in the Forestry Department, at Kasetsart University and at Khon Kaen University. Another, at the National Economic and Social Development Board (NESDB), was able to discuss government goals and strategies for planning the use of Thailand's resources.

This research was in no way a survey of the state of remote sensing in Thailand, for there are many individuals and institutions involved in the technology whom I never contacted. It is a case study of the background and views of some participants in the technology transfer process, particularly those who have been closely involved in using the

technology for the management of one resource, coastal zone mangrove forests.

Interviews took one to one and one-half hours each, using an interview schedule (Appendix). They allowed me to gather qualitative materials on the transfer process using a small sample of participants. As informants were involved in numerous projects, of which the two Canadian projects were a part, it was difficult to isolate the activities in which they participate. Therefore, in answer to some of the questions, informants referred to their work in a number of different projects. In addition to conducting interviews, I also attended two technical meetings on remote sensing, the symposium in Bangkok and a seminar in Khon Kaen. I wanted to immerse myself in the culture of the remote sensing community, to be a participant observer of the interactions of those who use remote sensing, and to meet those trained in the technology. I also hoped to increase my understanding of the technology in which I have had no formal training.

Language posed some problems because I speak very little Thai. All interviews were conducted in English; a few informants had problems understanding my questions or in forming answers. In these cases the interview could not include in-depth discussion and, occasionally, difficult questions had to be passed over. All of the papers at the symposium in Bangkok were presented in English, and most people conversed in English. At the seminar in Khon Kaen,

most of the papers were presented in Thai and some were completely inaccessible to me. However, most of the participants did speak some English and I could have informal discussions with them.

Other constraints included the lack of a private meeting place for interviews and an inability to have frank discussions of issues that have political content. All interviews of informants were conducted at the NRCT or the Ministry of Agriculture, during working hours. Most interviews were held in private offices, some borrowed for the occasion, with the prospect that someone might come in at any time. From time to time, I met informants in less private situations, with assistants present, or colleagues working within hearing range. In those cases, I felt constrained from asking questions, such as number 42, "Are there others here who would disagree with you about how coastal resources should be used?" In answer to question number 51, "What do you think are some of the major problems facing Thailand now?", only a few informants replied frankly, and one acknowledged he could not reply frankly and that I should discuss such matters with his employer.

I arrived in Thailand during the hot season, in April 1990, which was closely followed by the rainy season, during May and June. I was not able to visit any mangrove areas during that period, as few field trips are scheduled then. It would have been beneficial to see the mangroves, an ecosystem

with which I am not familiar, and the process of "ground truth verification." In December of 1990 I returned to Thailand briefly and was able to attend the seminar in Khon Kaen.

Conclusion

The focus of this study is on the transfer of technology used in natural resource management. More particularly, this thesis considers how remote sensing technical knowledge is used in the management of Thailand's threatened mangrove forests and the part played by Canadian ODA in formulating how this knowledge is employed in Thai resource management policy. Projects originating in an ambiguous context result in conflicting applications and policy orientations; clarifying goals, expectations and values may result in consistent resource management policies for sustained development.

Chapter Two will describe the technology of remote sensing, how it is used in natural resource management, and how it is transferred to Third World countries. After a brief description of the political economy of Thailand Chapter Three considers development planning and resource use, particularly in relation to Thailand's remaining forests and mangrove forests. Chapter Four presents data from the field study of informants who participated in two Canadian projects in the transfer of remote sensing technical knowledge. Chapter Five concludes with recommendations directed to the outcome of technology transfer projects. They should result in

clarification of the context of natural resource management
for sustainable development.

Chapter II. Remote Sensing as a Technology for Resource Management

The idea of resource management, or a coordinated plan to control the use of resources even in marginal lands, is a recent one. It is a function usually taken on by a branch of government, directed by policy for the use of resources and to reduce conflicts between those who want access to them. The management of a country's natural resources requires a broad view, in at least two senses. It requires a time frame for planning how the resources will be harvested and used, whether over a five-year period or for the next fifty years. It also requires a knowledge of what resources there are and how different resources interact in shared or adjacent ecosystems.

Natural resource holdings can be determined and mapped from the ground. This way is reliable but very labour-intensive. Ecological interactions or a count of species over large areas or in inaccessible areas may be difficult to determine. The assessment of the resources of marginal lands calls for a broader, "bird's eye" view. Remote sensing technology supplies such a view. Furthermore, the technology is capable of "seeing" more than we can with our eyes, allowing the remote sensing of such physical characteristics as temperature over vast areas of the earth.

Canadians have taken an active part in the refinement of remote sensing technology for the past thirty years; Canadian expertise in remote sensing analysis and interpretation, and

receiving station instrumentation are among the finest worldwide. With such a reputation it is not surprising that the technology and training has been a part of a number of official development assistance (ODA) packages offered by Canada to Third World countries, including Thailand, the locus of this case study.

In the transfer of remote sensing technical knowledge attitudes toward the use of remote sensing in resource management are also transferred. The context of the values, goals and expectations held by those using remote sensing in Canada becomes a part of the transfer of technical knowledge which takes place. In this chapter I will examine the technology of remote sensing, how it is used as a tool for resource management, and how the technology is transferred to Third World countries.

Remote sensing technology

The term "remote sensing" has a variety of meanings.

Remote sensing describes the range of techniques used to record information about an object from a distance In the narrow sense remote sensing is measurement that makes use of visible, infrared, and microwave radiation in the acquisition of environmental information, which is stored in the form of images or digital tapes.... In a broader sense, remote sensing comprises the collection of data, their display, their analysis or interpretation, and their subsequent use for purposes of inventory, survey, monitoring, planning and management (Cochrane 1986: 18)

A remote sensing system has four major components: a source of energy, a platform which carries sensors, the object

upon which the sensors are fixed, and the resultant data (ibid.) The sun is the major source of energy for remote sensing. All objects on the earth's surface receive solar radiation in a wide range of wavelengths. After striking the surface, the energy is either absorbed or reflected back into the atmosphere. This absorption and reflectance varies, depending upon the specific properties of the object. As the sun's energy is bounced back from the earth's surface, the atmosphere (like the object on the surface) also acts on it, reflecting, scattering and absorbing it. Only certain "windows" in the atmosphere allow energy to be received by remote sensors above the earth. The sensors are tuned to these windows which coincide with certain spectral ranges. "In general, remote sensing with a major interest in terrestrial phenomena avoids those wavebands in which atmospheric absorption is strongly marked and matches the sensor sensitivity with an appropriate window" (ibid.: 19).

Platforms include airplanes (for aerial photography), satellites, and manned spaceflights and shuttles. Aerial photography was developed as an information-gathering tool in the first half of this century, used for strategic military purposes and for land and resource surveys. The use of aerial photography continues today, but other forms of remote sensing have largely supplanted it, for a number of reasons. Aerial photography is expensive, usually requiring the hiring of an airplane specifically for the purpose. Because of the clarity

and detail which is supplied, military restrictions often apply. And the instruments used in aerial photography are limited in spectral range, and cannot penetrate cloud cover.

The transition to other remote sensors started during the Second World War when military analysts discovered that aerial photos which had previously been viewed through 4-power stereoscopes could yield much more information when viewed through stereoscopes of up to 38-power. Stronger sensors, capable of registering a greater spectral range, were called for. During the post-war period, it was recognised that this type of remotely sensed data could be useful for civilian as well as military purposes. Advanced reconnaissance airplanes, such as the U-2 and the SR-71, and then satellites were developed (Brugioni 1989). The earliest satellite with remote sensing equipment, the first of the TIROS meteorological series, was placed in orbit in 1960. The United States National Aeronautics and Space Administration (NASA) orbited the first of the most widely used satellite series, Landsat, in 1972. This was followed by a number of others including four more in the Landsat series, the French *Système pour l'observation de la terre* (SPOT) in 1986, the Soviet Soyuzkarta, the Indian IRS-1, and the Japanese Marine Observation Satellite (MOS). The Indian IRS satellite is fully operational and is designed for agricultural and geological applications. Canada is scheduled to launch Radarsat in 1994; it will be used for sea-ice analysis and

crop forecasting. In tropical areas it will be useful because it can penetrate cloud cover. In addition to these satellites, U.S. space shuttle flights and Soviet manned spaceflights gather remotely sensed data in short-term experiments (Bronstein 1988, Brugioni 1989, Cochrane 1986, Friedman 1990, Haack 1982, Rajan 1986, Szekiolda 1986).

Remote sensing satellites tend to have short working lives and must be replaced frequently. In the U.S., the National Oceanic and Atmospheric Administration (NOAA) has launched at least 29 in its environmental series alone (Rajan 1986: 10). Recently, some western satellites have become commercialized. The Earth Observation Satellite Company (EOSAT) now operates the Landsat satellites and will launch Landsat-6 in 1991 and Landsat-7 later in this decade. SPOT Image operates SPOT, with a series of new satellites being launched in this decade (Friedman 1990). The worry about continuity has been somewhat alleviated by these plans.

Sensors carried aboard satellites have come a long way from the cameras used in the very early days of aerial photography, 100 years ago, when they were carried aloft by balloons and pigeons. Panchromatic (black and white) film, then colour film and infrared film were used, and continue to be used, particularly in aerial photography. Most remote sensors are electronic rather than film-based which allows a greater volume of images and the detection of a greater variety of environmental conditions (Friedman 1990). Present-

day scanning systems have a spectral sensitivity range similar to aerial photography but respond to particular bands within that range of the spectrum. Multispectral scanners (MSS), used on all the Landsat satellites, record in four spectral wavelength bands (Cochrane 1986) which are measured in micrometres, here designated by um. Thematic Mapper (TM) scanners, in use on Landsats -4 and -5 since 1982, have extended the spectral range and greatly improved the detail of information that can be gathered. See Table 1.1 for comparison of spectral bands and principle applications of these two sensors.

Landsat images cover an area 185 x 185 kilometres, or 34,225 square kilometres. At a flight altitude of 905 kilometres above the equator the satellite makes 14 sunsynchronous (maintaining the same position relative to the sun, so that the satellite crosses the equator at the same time on each pass) orbits around the earth every day and returns to the same orbit every 18 days. The ground resolution, or size of objects that can be seen clearly in the images, is 80 metres for the MSS, and 30 metres for six of the seven bands of the TM (band 6 has a ground resolution of 120 metres) (Canada: Energy Mines and Resources 1986; Cochrane 1986; Haack 1982).

SPOT, the French satellite, has a number of features which are improvements on the Landsat. The viewing direction of each of its sensors is controlled from the ground by

Table 1.1 Spectral Ranges: Landsat MSS and TM, and Applications

Multispectral Scanner			
Spectral band	Type of radiation	Wavelength (μm)	Principle applications
1	green	0.5-0.6	Depth and turbidity of standing bodies of water
2	red	0.6-0.7	Topographic and cultural features (drainage patterns, roads and towns)
3	near-infrared	0.7-0.8	Sharp shadows, some land use patterns
4	near-infrared	0.8-1.1	Land-water boundary delineations
Thematic Mapper			
1	blue	0.45-0.52	Coastal water mapping, soil/vegetation differentiation, deciduous/coniferous differentiation
2	green	0.52-0.60	Green reflectance by healthy vegetation
3	red	0.63-0.69	Chlorophyll absorption for plant species differentiation
4	near-infrared	0.76-0.90	Biomass surveys, water body delineation
5	short-wave infrared	1.55-1.75	Vegetation moisture measurement, crop differentiation, snow/cloud differentiation
6	thermal infrared	10.4-12.5	Plant heat stress measurement, soil moisture, thermal mapping
7	short-wave infrared	2.08-2.35	Hydrothermal mapping, lithological studies

Sources: Haack 1982; Cochrane 1986

computers; the angle in which the sensors can be directed correspond to user needs, recording data about particular sites in the orbit swath. The flexibility of the viewing angle allows for stereoscopic pairing of scenes. The sensors have a higher ground resolution than Landsat which makes the images roughly comparable to aerial photography. The

panchromatic mode (with a spectral band of 0.51 - 0.75 um) has a resolution of 10 metres; the multispectral mode (with three spectral bands of 0.5 - 0.59 um (green), 0.61 - 0.68 um (red) and a near infrared band of 0.79 - 0.89 um) has a resolution of 20 metres. SPOT does have some drawbacks in comparison to Landsat. Its operation in only four bands of the spectrum means that the information gathered is more limited than that acquired by the Landsat Thematic Mapper (Friedman 1990). At a flight altitude of 822 kilometres above the equator, SPOT orbits the earth, sunsynchronously, 14 times a day and returns to the same place only every 26 days.

Landsat and SPOT are the platforms accessed most frequently for remote sensing by receiving stations in the Third World. Coming into some use are the NOAA series for meteorological information, and sidelooking airborne radar (SLAR) and synthetic aperture radar (SAR), which are active microwave sensors not dependent upon daylight or clear weather. These systems are useful alternatives to aerial photography for land-use studies, particularly in the tropics where cloud cover is a problem (Cochrane 1986, Eden 1986).

Another component of a remote sensing system is the object upon which the sensors are fixed. As can be seen by Table 1.1, remote sensing will yield some information about any surface of the earth. With the repeated and frequent coverage given by sensors on satellites, or the made-to-order

coverage of aerial or shuttle craft, data about any object or surface on the earth become accessible, usually within days.

By choosing the appropriate sensors, the range of information that is obtained can be extended to include object size, shape, colour, surface characteristics, chemical composition, thermal properties, mineral properties, and moisture status. Using long wavelength airborne or spacecraft radars, it has been demonstrated that it is possible to penetrate dry surface materials and obtain details of subsurface features (Cochrane 1986: 21).

Handling data derived by remote sensing is the most demanding part of the technology, requiring interpretation and verification. A great variety of detail is yielded but those who work with remote sensing must learn to understand the subtle gradations of colour or value. Data from remote sensing are recorded in two forms: images and digital information, which is read by computers.

Photographic or electronic images are supplied in real or false colour, depending upon the spectral band or bands selected. Manipulation of the colour of remotely sensed images has been found to be helpful. Table 1.2 shows how different colour combinations of the spectral bands can be used in the analysis of forestry resources.

Another form of data derived from remote sensing is digital, in which the image is sampled and produced on tape.

Digital image processing combines computing and image scanning techniques for the purpose of image enhancement, correction of distortion, pattern recognition, and object measurement. This technology avoids many of the inherent problems associated with visual analysis of images and objects (ibid.: 26).

Table 1.2 Some Colour Combinations for Thematic Mapper Images

Band used for each primary colour			Comments on colour composite
1	2	3	This combination approximates natural colour, and has far less forest information than the false colour presentations. However, it is useful for display purposes for audiences unfamiliar with the false-colour presentations.
(natural colour)			
2	3	4	This combination gives the same colour rendition as colour infrared film and the LANDSAT MSS combination of bands 4, 5 and 7. It is good for all-round use by people already familiar with colour infrared and shows conifers vs. deciduous, roads, clearcuts, partial cuts, water bodies, burns, and at least two levels of regeneration: bare slash and overgrown slash.
(colour infrared)			
3	4	5	This combination is called RIS-1 for red-infrared-shortwave-infrared-1. This combination is still in the research stage. It has promise of being more sensitive to small canopy thinning as caused by small rock outcrops, blowdowns and patches of dead conifers (mortality).
(RIS-1)			
3	4	7	This combination is called RIS-2 for red-infrared-shortwave-infrared-2. It is also in the research stage but may be better than RIS-1 for small canopy thinnings and mortality.
(RIS-2)			
2	4	3	This uses the same bands as the colour infrared rendition, but changing the order results in green vegetation appearing green (rather than red) in the image. This combination is used by the B.C. Ministry of Forests for inventory, planning and engineering applications.

Source: Canada: Energy Mines and Resources 1986

Digital image processing offers a number of advantages :

- the data are amenable to manipulation by fast and relatively inexpensive computers;

- digital imaging systems can differentiate among finer gradations of grey. The digital imaging systems available use 512 or even 1024 shades of grey, much more than the capacity of film or the human eye (which can distinguish only 16 shades of grey);

- digital information can be visually displayed easily and effectively;

- digital display allows for a variety of manipulations which cannot be done with visual materials (ibid.).

Whether working with images or digital data, those using remote sensing must always include some who can perform field checks to obtain what is called "the ground truth." Using sampling techniques, the team ascertains whether the land use pattern, or the species distribution, or the geologic structure, or whatever feature is under scrutiny actually does occur to the extent that would appear from interpretation of the remotely sensed data.

Remote sensing data are recorded on board the platform and also, in the case of satellites, transmitted electronically to ground receiving stations. Landsat and SPOT transmit directly to their home bases in the U.S. and France, respectively. In addition, receiving stations are located around the world; each may, by arrangement, receive

transmissions from the various satellites as they pass over the area in the range of the station, usually within a radius of 2780 kilometres (Haack 1982). Presently, 16 ground stations around the world receive Landsat coverage (Friedman 1990).

A factor which enters into the use of remote sensing technology is cost. Image by image, satellite pictures are not nearly as costly as those obtained by aerial photography. However, access to Landsat transmissions and the marketing information used to sell remote sensing products within the country now costs a receiving station \$600,000 U.S. per year, three times the price in 1987. In developing countries the result is restriction of access, as systems must be chosen and others eliminated. Even a relatively prosperous developing country such as Thailand must make such choices. Although the Thai receiving station has the equipment, it has not received SPOT transmissions since the end of 1989 because it could not afford the access fee (Vibulsresth 1990a); however, reception will probably resume during 1991 (Dowreang 1991).

Furthermore, although specific images and computer tapes, among the millions recorded until now, may be ordered from the home base they are very expensive. "Typically, Landsat photos and computer tapes sell for between \$50 and \$3,600 apiece. Images and data from the French Spot satellite are comparably priced" (Friedman 1990: 13). With the increasing privatization of remote sensing satellites has come further

control by those having the most funds: SPOT programming, designed to the needs of its clients (Engel 1990; United Nations 1989), serves its biggest customers first, and Landsat appears to be considering a similar course (ibid.), further restricting access to remote sensing data by the developing world.

Remote sensing technology in resource management

There is a growing awareness in the developing countries that the cost of remote sensing techniques should really be viewed against the cost of not having it. The lack of scientific data has been keenly felt in making choices regarding the utilization of the natural resources, some of which have shown alarming rates of depletion and environmental degradation., The need for updating a national resource management system, in terms of data collection and analysis, is realized. Moreover, if properly applied, the net benefits are invariably higher than the initial costs involved in establishing the data analysis system (Rajan 1986: 2).

Remote sensing technology can be used in resource assessment, monitoring and management, covering large areas repeatedly and, for those countries having ground receiving stations, in real time. It is a quick and objective assessment tool, allowing frequent updating of data bases, and the images and maps derived from remote sensing are useful in education and policy-making (ibid.).

With the development of high resolution sensors, capable of scanning through a broad range of finely defined bands of the spectrum, remote sensing applications have moved from a three-tier model, which included aerial photography of selected sites, to a two-tier one, using satellite data and

field checks of selected areas. This has resulted in "...a trade-off between large-area imagery [from satellites], thus speed, and small-area frame [from aerial photos], thus higher accuracy of the spatial data" (Thung 1985: 79) Satellite images and digital data are no longer supplemented by aerial photography, except in particular applications. "Of course from the point of view of planning the spatial aspect is a major factor, as planning is an action to move things over time (priority) and space (design)" (ibid.).

The application of remote sensing technology can be arranged in a hierarchy, "...based on a system which incorporates more and more directly process-orientated approaches, including their suitability for predicting future change" (Haefner 1989: 70) (See Figure 1.1). The levels go from mapping which requires no analysis or digital manipulation, to forecasting which entails technical knowledge, including interpretation and the use of models for the prediction of resource performance. Mapping on the basis of satellite images is widely used. The methodology consists of two aspects, the mapping of the distribution of features such as forest types, rock formations, land use and the like, and then the addition of boundary lines to make a thematic map.

Inventorying requires the inclusion of quantitative data to create an assessment of resources. This can be done only if the precise location of each object can be determined and

Figure 1.1 Application Levels of Remote Sensing Data

MAPPING	Photographic maps General maps from satellite images Thematic maps
	Only qualitative aspects of visual visual interpretation
INVENTORYING	Thematic maps and statistical data according to political, administrative and physical structure
	Qualitative and quantitative aspects, combined with random samples: visual interpretation and digital classification
MONITORING	Spatio-temporal processes and changes Repeating up to current situation
	Qualitative and quantitative aspects of changes, mainly digital processes - change detection - calculations trends
FORECASTING	Mathematical models Predicting harvests and runoffs
	Quantitative aspects, digital processes and mathematical calculations

Source: Haefner 1989

placed in a geographic matrix of political or administrative units (provinces, city lots, etc.), physical units (river catchment areas, plateaux, etc.), or anthropogenic (the wheat belt, the southern corridor, etc.) units. "In addition to location and distribution, the state of each individual phenomenon at the moment when the picture is actually taken is also of crucial importance" (ibid.: 71). It is necessary to be able to recognize mortality from disease among conifers, or sedimentation in river deltas, temperature or salinity of sea

water which indicates the flow of currents, and levels of regeneration in cleared forests. "For the most part, these biophysical variables can be specified from remote sensing data and, when trying to solve the major environmental questions facing the world today, it is almost obligatory that such information be used" (ibid.: 71-72). Location, distribution and condition of the resources must be verified by field checks.

Once a basic survey has determined an inventory of resources regularly repeated checks should be made to monitor any changes over time. Satellites yield data about the same areas repeatedly, every few weeks, within the limitations posed by cloud cover. Visual and particularly digital data can be scanned to detect changes in value. Analysis of the data yielded, however, is more difficult and is subject to certain technical considerations, such as compensation for atmospheric conditions which distort spectral absorption, or the angle of incidence of the sensors. Until such problems are overcome monitoring of natural resources will come neither cheaply nor quickly.

The use of remote sensing for forecasting relies on advanced techniques for data recording and continuous monitoring. "Only if change is measured precisely in quantitative terms will it be possible to calculate trends" (ibid.: 74). With the inclusion of additional materials from other sources (such as records of harvest yields or rainfall

over the past 50 years) it should be possible to start building predictive models. At this time harvest yields and runoff are two applications of remote sensing for forecasting which are being developed.

As the level of abstraction in the application of remote sensing to resource management increases (i.e., from mapping to forecasting) the content of technical knowledge also increases. Of necessity, forecasting must make assumptions about ecological, economic and political interactions. Haefner's model, though helpful, is incomplete. Qualitative aspects must be included in these activities; they are derived from a broad training, by means which include the transfer of technical knowledge.

There are many specific applications for remote sensing in forestry, urban planning, agriculture, water resources and coastal management, geology, and cartography. Detection, identification and monitoring are the most frequent uses to which remote sensing is put in forestry applications. "Accelerated deforestation in some areas can often not be effectively monitored other than by satellite data" (Haack 1982: 903). Manual interpretation and computer processing of remotely sensed information can locate, identify and keep track of particular types of forests endangered by commercial logging or slash-and-burn activities. With the introduction of higher resolution sensors in the Landsat TM and SPOT, the precision of forestry surveys has improved, as has analysis of

urban and rural land use and agriculture. Particularly in the tropics, where field sizes tend to be small, irregularly shaped and covered with a variety of crops through the year the improvement in remote sensing resolution has been important in facilitating the mapping of land use.

Remote sensing is useful in ascertaining the amount of surface water available during various seasons, determining silt deposit patterns and assessing the amount of damage from floods. Acquiring information about coastal resources is more limited because the technology to study coastal waters is not as advanced. Some experimental work has explored the measurement of ocean colour and temperature to determine chlorophyll as an indicator of fish populations. The development of synthetic aperture radars (SAR) for wave studies, and various radiometers to measure salinity and surface temperatures will be useful in coastal studies and conservation (Rajan 1986, Specter and Gayle 1988).

Geological applications, including the use of microwave technology promote the identification of geomorphological features related to mineralization, lessening the area which needs to be searched on the ground. Remote sensing contributes to the updating of maps and provides a "...synoptic overview of features that cannot otherwise be discerned on large-scale maps...." (Rajan 1986.: 35). Satellite images are also useful in cartography. They increase the accuracy of topographic maps and provide updating

to reflect changes in land use, urban growth and the presence of natural resources in thematic maps (ibid.).

The transfer of remote sensing technology to Third World countries

... One may question the benefit of remote sensing inventories, which enlarge the volume of information once more, without contributing to the effectiveness of planning and decision making directly. This criticism should not be a blame to modern technology as such, but to the way in which modern technology can be adapted to processes that involve human society (Van der Broek 1985: 123).

While the technical development of remote sensing has involved the straightforward, though challenging, evolution of sensors, platforms and receiving equipment, the transfer of the technology to the developing countries, those which are in most need of it, has been slow. Extensive use of aerial photography in the tropics during this century has not necessarily resulted in an easy transition to the use of satellite imagery and computer data, requiring as it does skills beyond visual interpretation and mere access to computers. The development of geographic information systems (GIS), which integrate remotely-sensed data and data from other sources, and global environmental databases have advanced integrated data gathering and dispersal tremendously. But ultimately, "... the positive impact of remote sensing technology ... depends upon the creation of a reservoir of human skills and knowledge...." (ibid.).

The transfer of the technology occurs in a cultural and political climate. Training, availability of equipment, and habits held over from the days when aerial surveys were used, may result in a milieu in which it is "... preferable, and at times more effective, to persist with traditional types of imagery and manual modes of analysis" (Eden 1986: 8). Full exploitation of remote sensing tapes and images comes slowly, or may never be achieved. Training may not match the equipment available or may result in an overdependence upon foreign expertise; field checks can be difficult and hazardous for geographical or political reasons and, therefore, haphazard. In these circumstances, the transfer of technology will be slow and incomplete.

The "user gap" between those countries in which the technology is developed and those where it is being transferred can be all but unbridgeable. At the application level, even in North America, there is a difference in how remote sensing is used by those at the leading edge of the technology, and the resource manager; the gap exists also in Third World countries, between those who have been trained in First World universities at the graduate level and planners who have other concerns and little scientific training. Assimilating remotely-sensed information also is slowed by government departments or ministries which have always limited access to their resource and environmental information files. Overcoming the user gap requires "... the infrastructure for a

comprehensive analysis of the resource base and its incorporation into national planning...." (Parry 1986: 354). Even if a GIS is in place, or access to an environmental database is available, there may be a "... lack of coordination between the physical planners, whose concern is the location and suitability of resources, and the economic planners, who are concerned with fiscal resources and revenue generation" (ibid.).

If the planning system does not use the information made available through remote sensing technology there will be little incentive on the part of the sectorial ministries to make use of integrated resource information. A vicious circle results, in which public administrations need better information but are unwilling to increase their capability to make use of it. It is not a matter of a growing appreciation of the possibilities posed by the new technology: it becomes necessary to make some choices, the choice to acquire the infrastructure and local expertise, and the choice to incorporate it into planning. "The utilization of remote sensing for development planning, for example, is barely in the initial phase. Its application to the decision-making process is not merely a technological matter, but a political choice" (Van der Broek and Nossin 1987: 164). The choice to acquire a capability in remote sensing includes the decision to undergo the training, to assimilate the information that then becomes available, and to utilize that information

effectively in the quest for that country's development (Parry 1986). This training constitutes transfer of technical knowledge.

The technology can be used in different ways by various sectors of a society. Transfer and diffusion are well along when a number of uses can occur in different situations. Remote sensing at its most sophisticated level is used for inputting into a GIS for planning; on the other hand, satellite images can be used to elicit information about resource usage and to promote understanding of national resource management planning at the village level (Chen 1987). Thus, remote sensing is employed in upward linkages for resource planning, and for downward linkages for the education of resource users.

A model of the operationalization of remote sensing technology has been proposed by Van der Broek (1985; Van der Broek and Nossin 1986). This model traces the development of the technology from its first inception to the transfer and use of the technology by its potential users. The first stage is the technical one of satellite system development, involving technology research and development, and data acquisition and processing techniques. The second stage is that of application development, which includes learning how to use the technology and understanding the range of uses for which it can be applied. The third is that of market development, adapting it to promote:

- acceptance of the technology and its applications in society;
- use of acquired remote sensing information in planning and policy making;
- adaptation of management structures.

On the average the incorporation of an essentially new technology takes a period of 20 to 30 years until it is optimally used, during which period concepts, values, and norms are modified and new structures in society have been adopted (Van der Broek 1985: 119).

Figure 1.2 illustrates the interaction that occurs in this model, although a time scale is not indicated. Research and development of the technology and its application do pose some constraints, but the main impediment to its operationalization lies in the transfer of the technology to the user community.

The transfer of technical knowledge starts in the second stage, but the "software" aspects become of greatest importance in the third. This stage of the transfer is the

Figure 1.2. Interactive Aspects of the Operationalization of Remote Sensing Technology

Source: Van der Broek 1985

most difficult and slowest. It is necessary to make explicit the "concepts, values and norms" of the society in which the technology has been developed, and the goals and expectations of the society to which it is being transferred.

For the successful transfer of remote sensing technology Forster (1990) has stipulated four necessary conditions aside from basic technical training:

- 1) there is a genuine effort made to adapt the technology to the local conditions;
- 2) the technology will constitute a real contribution to the advancement and development of the country;
- 3) the transfer will be made to the scientists of the country; and
- 4) there will be absorption of the technology into the society, including an awareness by private, government and school sectors of the technology.

The transfer will result in a critical mass of technical, professional, managerial, academic and research staff which will allow for networking and support. Methodologies will be designed to be appropriate for the local environment; there will be access to modern technology, suited to the country's needs; diffusion of the technology within and between academic, government and private sectors will take place; and a national coordinating body will be established.

Educational requirements for the transfer include a range of trained staff, with a broad base of technicians having

vocational schooling, rising up the educational pyramid to include para-professionals having a basic university degree in a science, professionals, having a masters-level degree, who can be coordinators, and at the peak, those with doctoral degrees (usually from overseas) in research positions.

Institutional requirements include the establishment of a national organization which can prepare a national inventory of resources, and which can work with a national planning body to develop a country master plan for resource management.

Financial requirements reflect the high cost of education or training, equipment, data and infrastructure for the installation and use of the technology. In most cases the financial drain necessitates reliance on external sources such as international development assistance for equipment and training, the coordination of which should be linked into the master plan. Finally, the national coordinating body should develop awareness within the government and the public of the potential of remote sensing technology; this can be done through education, training, public relations, and practical applications (ibid.).

As in most technology transfer the transfer process for remote sensing can place the receiving country in a vulnerable position. This is most clearly seen in the financial arrangements, in which the withdrawal of aid or loan funds results in the complete collapse of the transfer. For this reason, Vibulsresth (1990b) of the National Research Council

of Thailand Remote Sensing Centre supports Forster's view that transfer of the technology should be directed through an institution which will arrange for long-term commitments from aid agencies including human resources development, promote a balance of diffusion to government, private sector and scientific institutions, and encourage the private sector to bring up its capacity so it will not be dependent upon aid or government sources. Vibulsresth (1990a) also argues that Third World countries have to be involved in creating the right context for the technology so that it can be implanted into the social and economic background of the country. A part of the transfer process must be the establishment and nurturance of a dialogue between the users, and the suppliers of equipment and donors of funds. When questions arise about the technology, the users must insist that they be answered fully so that they attain full competence and control. By taking charge of the transfer process a less developed country will be able legitimately to say, "one should rely on oneself."

The process of technology transfer results in net benefits for the donor as well. The commercialization of remote sensing technology in the U.S., France and Canada is an example. Landsat is now expected to pay its own way (Friedman 1990) with no government funds directed to the building or deployment of satellites. SPOT Image sells value-added, enhanced images and tapes (Engel 1990). In both the American

and French systems, less developed countries not having their own receiving systems, or desiring remote sensing information not in their files, must purchase this data about the resources of their own country from EOSAT or SPOT Image (Szekielta 1985). MacDonald Dettwiler and Associates, Ltd., the Canadian developer and manufacturer of receiving equipment for the SPOT and Landsat systems, benefits from the CIDA policy of tied aid, as all Canadian ODA projects in remote sensing use equipment from that company. This company holds 50% of the world market share in ground receiving stations (Bronstein 1988). Any human resource development components and value-added products written into Canadian remote sensing transfer projects also derive from Canadian sources. Remote sensing processing including a "complete range of services in this area, from needs analysis to system design and technology transfer" (Computer Technologies 1988) is offered by DIGIM, a division of Lavalin. DIGIM was the first to be awarded a contract in the transfer of remote sensing to Thailand by CIDA. Since then, it has participated in technology transfer to Malaysia and Venezuela. In the business of international development, companies such as DIGIM "are the way of the future because they allow Canada to invest in the management capabilities of a country" (ibid.).

Conclusion

Resource management may have goals of short-term growth and exploitation, or long-term sustainable development. The

technology of remote sensing has the potential to promote the management of natural resources. However, the question of what is the ultimate goal for which it is used, for economic growth or sustainable development, has not yet been resolved.

"Increased acquisition of remotely sensed data will not of itself guarantee any improvement in the quality of land management. Indeed, the acquisition of new imagery may in places encourage or accelerate the over-exploitation of newly sensed resources" (Eden 1986:11-12). This can happen wherever this technology is transferred. "However, in the long term, remote sensing should make the mismanagement of resources more difficult, because of the ability of modern systems to alert the resource planner to many kinds of environmental stress or damage" (ibid.).

After a brief introduction to the technology of remote sensing, this chapter has considered the issue of the use of remote sensing in resource management, and how it is transferred to the Third World. In the next chapter the locus of Thailand for the transfer of remote sensing will be discussed. Thailand's forest resources, and particularly its mangroves, will be considered in light of changing resource management practices and a shifting policy climate.

Chapter III. Thailand's Interest in Remote Sensing Technology

Thailand is a middle income, developing country with a booming economy. Prosperity has been costly, however. There is a wide disparity in the distribution of income, and the environment and resource endowment are badly degraded. Both problems threaten the country's sustained development. It is because of these problems that Thailand's interest in remote sensing technology is pertinent here: the technology can be used to develop policy for informed natural resource management for long-term economic development.

This chapter will briefly describe the economic and political background, and the institutional setting of the transfer of remote sensing. The question of environment issues in development planning in the decades of the 1980s and 1990s will be considered. The discussion will focus on the forests of Thailand, particularly the mangrove forests.

For the inland forests, the transfer of remote sensing has resulted in changes made at the policy and planning level which support sustainable development (Vibulsresth 1990a). However, current use of remote sensing in managing the mangroves indicates that the transfer occurred in an ambiguous context leading to conflicts yet to be resolved. This issue will be explored in Chapter four.

The political economy of Thailand

Contenders for Thai political influence range along the political spectrum from Right to Left with the military on the Right, then the bureaucracy, business interests, the government, workers' and farmers' organizations, and finally radicals on the Left (Girling 1985). For the past decade, until the coup of February 1991, Thailand had a civilian government. The present Prime Minister, Anand Panyarachum, was appointed by the military, but appears to maintain some independence (FEER June 13, 1991). Even during Thailand's democratic periods the military has continued to be a strong political force, generally choosing to exert its influence behind-the-scenes, but letting it be known that it could rule by coup if it so chose. Business and the bureaucracy are, likewise, strong players in the political economy of Thailand. They, as well as the military, are particularly influential on the issues of concern here, income distribution and environmental degradation. While workers' and farmers' organizations, and radicals are vociferous on these issues, their voices are largely dismissed and safely ignored by political decision-makers.

Decision-making is centralized, stemming from traditions of the hierarchy that culminates in the monarchy. The exaltation directed toward the royal family is a reflection of the value placed upon centralized and hierarchical influence

which is built up through the levels of Thai society by a series of patron-client relationships.

Thailand's is an open economy, undergoing a shift of strategies from import substitution industrialization to export promotion. This shift has been the basis for Thailand's recent rapid growth of GDP, which for 1990 reached 9-10 per cent (FEER, January 10, 1991), up from the average of 4 per cent annual growth in GNP during the period 1965-1988 (World Bank 1990). The economy is booming because of exports, tourism and foreign investments, recovery of commodity prices and an expansionary monetary and fiscal policy. Since the early 1980s manufacturing has exceeded agriculture in terms of proportion of the GDP: in 1988 it brought in 24 per cent of GDP while agriculture brought in 17 per cent (*ibid.*). Agriculture continues to be the largest single source of employment. Thailand's primary export, rice, has been meeting some stiff competition recently from Vietnam whose exports to other Asian countries of a lower grade of rice have been very successful in a time of worldwide economic downturn (FEER, January 17, 1991). The domestic natural gas industry, developed in response to the oil shocks of the 1970s, still accounts for only 10 per cent of domestic energy consumption (Pakkasem 1988).

Despite the boom in the economy many Thais remain poor. In 1975-76 the top fifth of the population controlled 49.8 per cent of household income while the lowest fifth controlled

only 5.6 per cent of national income (World Bank 1988: 4.2.). There is no indication that distribution has become more equitable in recent years.

Thailand continues to be primarily a rural country - only 21 per cent of the population lives in cities (World Bank 1990). Reported figures for primary and secondary school enrolment have dropped between 1985 and 1987; whether this is an indication of more accurate reporting or a decline in service is not known. In 1990 the level of compulsory education was raised to grade 9, but particularly in remote areas this level will not be achieved for a number of years.

Population growth from World War II to 1970 was high, at a rate of 3 per cent per year. The realization that such a high rate would be an obstacle to economic growth led to a population policy in the 1970s and decline of the population growth rate to about 1.5 per cent in 1986. The highest rates in the country continue to be in the poorest areas, the North, the Northeast, and the South (Prasith-rathsint 1987).

Institutional setting of remote sensing

Remote sensing is a technology which is controlled to some degree by national governments. It is a high cost information technology; direct reception of images and tapes is accessible only by agreement with the groups owning the transmitting satellites. The primary remote sensing institution in Thailand is the Thailand Remote Sensing Centre

(TRSC) of the National Research Council. It was established in 1972 at the beginning of the Landsat program (Vibulsresth et al. 1988). For the first eight years the Centre purchased remote sensing materials (photographic images), but in 1981 the Thai government bought a ground station, installed in a turn-key project by MacDonald Dettwiler and Associates Limited, of Canada, at a cost of US \$6.3 million. In 1984, and again in 1987, the Canadian International Development Agency (CIDA) upgraded the receiving station, at a total cost of US \$14.8 million. The receiving station is now capable of receiving Landsat Multispectral Scanner (MSS) and Thematic Mapper (TM) data, and SPOT data. It also receives Marine Observation Satellite (MOS-1) data, thanks to a grant of US \$5 million from the National Space Development Agency of Japan (NASDA) (Klankamsorn 1988).

The Thailand Remote Sensing Centre, through its ground receiving station, serves as a data centre supplying panchromatic and colour images, and computer compatible tapes. The largest users are international organizations (almost two-thirds of purchases) and government agencies (almost one-third), while utilization by state enterprises and the private sector are negligible (Vibulsresth 1986). A large proportion of the work done by the Centre is in user application support, at the national and regional (Myanmar, Laos, Cambodia and Vietnam) level. This service allows customers to employ data without having substantial training in remote sensing.

Initial interpretation of the purchased materials is conducted by the Centre and follow-up support is available (Vibulsresth 1990a).

The Centre also finances research to be done by its own staff and at external locations. Since 1975 more than 30 projects have been completed by the TRSC staff, and 24 have been completed by researchers working in government agencies or universities (ESCAP 1989).

In the long-term use of remote sensing technology, training is probably the most important function performed by the Centre and other institutions in Thailand. Training has been ongoing for the past twenty years. When the Thailand Remote Sensing Centre was established, training of its staff was first started by setting up overseas scholarships and fellowships for graduate degrees, a program which continues still in order to maintain the Centre's leadership position in the technology. 1973 was the first year courses were given at the TRSC itself. In the years since over 400 students have been trained in a four-week course in the fundamentals of remote sensing, another 150 have been trained in a three-week course in digital image processing (ESCAP 1989), and recently a three-week advanced course has been added to supplement the introductory one. Trainees come from almost all government agencies, though in recent years it has become clear that some agencies can make more use of it than others. The Departments of Forestry, Agriculture, and Fisheries in the Ministry of

Agriculture are among the primary users. The National Economic and Social Development Board (NESDB), the main development planning body in Thailand, has sent many students to the courses until recently. The Thailand Remote Sensing Centre also supports advanced overseas training for a few selected each year from various government agencies (Vibulsresth 1990a).

Courses and facilities for remote sensing training are available to students at several universities in Thailand. Most of these are basic courses offered in departments of Geography or Soil Sciences. The Faculty of Forestry at Kasetsart University, in Bangkok has a strong program, offering seven courses (ESCAP 1988).

Khon Kaen University offers at least four remote sensing courses in the Faculty of Agriculture and the Faculty of Technology. Under the CIDA Institutional Linkages Programme, six KCU faculty members received training in remote sensing and GIS technology in Canada and a number of resource management activities are underway. As well, CIDA has donated a Meridian Digital Image Processing System and equipment for a GIS to Khon Kaen University (Mongkolsawat and Parry 1990).

The Asian Institute of Technology presently holds a four-month certificate program in Applied Remote Sensing which is open to the public, and will soon be establishing Masters and Ph.D. level programs in remote sensing (North 1990).

Another institution active in the remote sensing technology field in Thailand is the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) located in Bangkok. The Regional Remote Sensing Programme (RRSP) of ESCAP co-ordinates remote sensing activities in the Asia and Pacific region. The RRSP coordinates regional meetings of remote sensing centres, initiates training sessions, and publishes as much as possible to facilitate communications. The training sessions, held throughout the region, use experts in remote sensing for resource management to teach selected employees of government bodies, in about 30 sessions per year. The RRSP also provides funding for pilot projects for member countries, bringing together experts who would not otherwise have the opportunity to work together. The program acts as a catalyst for the training and pilot projects, allowing co-operation across borders in the region (Chaudhury 1990a).

Another institutional setting for the transfer and diffusion of remote sensing in Thailand is that of professional meetings. The primary Thai host for national, regional and international meetings is the Thailand Remote Sensing Centre. The TRSC has hosted, or co-hosted, meetings of the Asian Conference on Remote Sensing, Asian Agricultural Remote Sensing Symposia, and ESCAP meetings and training sessions. In 1990, the TRSC hosted the Twenty-Third International Symposium on Remote Sensing of Environment, which was attended by over one thousand professionals from

most Asian countries, Europe and the Soviet Union, North America, Africa, and Australia and New Zealand.

An important transfer of technical knowledge function is also present in the workshops held by training institutions during the course of project activities. They allow those who have worked on a particular research problem to meet with others in related fields. One such workshop, held in December 1990, with funding from CIDA, took place at Khon Kaen University, bringing together project participants from KKU and many other Thai and foreign researchers.

Official development assistance (ODA) is one source of funding for the transfer of remote sensing technology. Thailand receives such funding from the United States, Japan, New Zealand, Germany, Sweden and Canada. USAID supported a five-year program with the National Remote Sensing Centre of Thailand (TRSC), and a training program at the Asian Institute of Thailand (AIT). This support ended in 1983.

Several Canadian international assistance projects have been important in the transfer of the technology. One is the CIDA upgrade of the Thailand receiving station; a training component was included in that package. The other is a project supporting the use of remote sensing to classify mangrove forests, funded by the International Development Research Centre (IDRC). In Chapter four, these two projects will be examined as loci for the transfer of remote sensing technology. Shortly before the CIDA project considered here,

the Agency supported a training course at the Canada Centre for Remote Sensing (CCRS) in Ottawa, for Thais from the Department of Mineral Resources. In addition, the Satellite Technology Project took place between 1986 and 1988. At the cost of Can. \$13.5 million, it provided further upgrade to the receiving station, and technical assistance (CIDA 1988). Finally, CIDA financed the Khon Kaen University Institutional Linkage.

Environmental concerns in Thai development planning

For 100 years before formal economic development planning began, in the 1960s, there had been no increase in agricultural productivity; indeed, there had been a decline in productivity which accompanied an expansion into marginal lands by the peasantry. During this period the government opted for improved security measures to protect uncertain borders, rather than internal development by improved agriculture (Feeny 1982). Over the past 30 years since formal development planning began the objectives have been based upon a neo-classical economic model of industrialization as the engine of development.

The development planning body of the government is the National Economic and Social Development Board (NESDB) located in the Office of the Prime Minister. While each ministry draws up plans and policies of relevance to its jurisdiction, final

incorporation of these is done by the NESDB, which submits the Plan to the National Assembly (Prasith-rathsint 1987).

The First Development Plan of 1961-1966 revolved around the new recognition of the place of industry in development; it emphasized building the country's infrastructure to promote the expansion of agriculture and industry. The Second Plan continued this concern. The Third Plan of 1971-1976 emphasized the need to increase economic stability through production but also recognised a widening income gap. It was during this period that environmental deterioration was first acknowledged. A division, the Environment Board, was added to the NESDB to integrate environmental questions into the planning process (Setamanit 1987). During the Third Plan an aerial photographic survey demonstrated that expansion of agricultural lands was continuing at the expense of the forests. Also at this time, as well as during the Fourth Plan, decreasing hauls indicated that the productivity of another resource extraction industry, fishing, was declining at an alarming rate (Tuntawiroon 1980). By the time of the Fifth Development Plan (1981-1986) an environment plan was included which advocated a balance between development and environmental quality. However, the Environment Board then, as now, had no authority to administer or regulate. It could only make environmental impact assessments of development programs and projects, and voice its concerns (Prasith-rathsint 1987).

The current Sixth Development Plan (1986-1991) renews its commitment to neo-classical laissez-faire development models, in which efficiency, market mechanisms, and a reduction of government involvement are uppermost. The Plan acknowledges that "...the basis and main production input of past development were the abundant natural resources available at that time" and that there "...is less prospect of economic development being based on natural resources than was once the case" (NESDB 1987: 111) due to depletion and environmental deterioration. As a result, the stated aim, in the Programme for the Development of Natural Resources and the Environment is to "...improve efficiency in the use of existing natural resources, to reduce conflicts over the use of natural resources, and to conserve natural resources and the environment" (Prasith-rathsint 1987:184).

The following key principles, therefore, need to be adhered to during the period of the Sixth Plan:

- (1) Basic plans should be formulated to manage each kind of natural resource comprehensively.
- (2) Systematic and integrated planning should be emphasized.
- (3) Plans should be put into practice for the benefit of the local people (NESDB 1987: 135).

Specifically, the Plan proposes improved efficiency of land use by means of planning and information systems, as well as improved land titling programs. These probably could be successfully implemented. But further proposals to speed up

land redistribution, make land taxation and valuation more equitable, and to accelerate the classification of agricultural and forest lands are unlikely to be "...successfully implemented, as they are against the vested interests of the ruling elite" (Prasith-rathsint 1987: 186). The three work plans specified reflect this impasse, proposing primarily that more studies be made during the period of the Plan. The most concrete proposals are in the work plan for natural resource management which calls for the establishment of: (1) information and mapping systems (which would include the use of remote sensing technology), and (2) a legal basis for local participation in resource management (NESDB 1987).

This last proposal gives implicit recognition to one of the reasons why marginal lands and their resources have been over-exploited and why environmental degradation is such a problem. The traditional response of Thai peasants to loss of productivity of their agricultural land has been to move onto marginal lands, namely forest reserves, and to clear them for farming. Presently, it is estimated that "...at least 5 million illegal squatters are farming on forestlands" (Phantumvanit and Sathirathai 1988: 14). As they have no legal claim to the land they farm, management considerations are of little value to them. They hold no long-term interest in maintaining the quality of the land for which they have no security of tenure, and it is difficult to bring them into the formal process of managing forest resources either for

conservation or development. A land titling program for farmers on forest reserve lands would provide them with a legal basis on which to participate in the management of these natural resources.

Another important source of natural resource degradation in the forest reserves is commercial exploitation, for forestry or mining. In 1988 tin was the fifth largest commodity export and furniture, the greatest part of which is made from local woods, was among the top 20 export products (Bangkok Post 1988). Both of these are good sources of foreign exchange, so important to Thailand's economic growth. Further pressure on forest reserves comes from those who clear land, or take over reserve areas already illegally cleared, for rubber and eucalyptus plantations. The government generally turns a blind eye to such abuses until attention is called to them by public outcry (Bangkok Post, May 25, 1990) or by a disaster (which had been predicted but ignored by the government) as will be discussed shortly.

Agriculture, forestry and mining in the forest reserves have been recognised as sources of environmental degradation, but few steps have been taken in the development planning process to deal with these problems. The Environment Board has no authority for action, and the NESDB as a whole is subject to political control by resource extraction business interests which places the NESDB's interest in environmental issues in question (Prasith-rathsint 1987). In fact, the

uncertain commitment of the NESDB to environmental and sustainable development issues is illustrated by two points. The NESDB no longer sends staff members for remote sensing training courses at the NRSC. The importance of technical expertise in understanding the recommendations submitted by such groups as the NRSC and in planning is recognised, yet staff in the Natural Resources Division are described as unwilling to go for special training and apparently are not pressed to do so. Having such a skill is seen as a liability to one's career path which should remain unspecialized (Chancharaswat 1990). The other point is that a continued emphasis upon efficiency, especially as seen in "private enterprise," is forecast for the Seventh Development Plan which is to be approved in 1991 (ibid.). The goal is for natural resource management to be decentralized, taken over by chronically underfunded provincial departments and non-governmental organizations. They are to promote public awareness and popular participation in decision-making. The intention is to devise an efficient style of management which will eliminate conflicts in the use of natural resources. The contradictions involved seem insurmountable.

However, the first proposal in the natural resources management work plan of the current, Sixth Development Plan, the installation of information and mapping systems, is one which is both feasible, and currently being implemented. There has always been support for remote sensing and

negotiations for a Geographic Information System for centralized natural resources management occurred during 1990. The ongoing process of the transfer of remote sensing technology is one means by which the country can take control of the development process for the management and sustainable development - or the short-term exploitation - of its natural resources. This can be seen particularly in relation to the forests of Thailand.

Deforestation and disaster

At the time of the founding of Bangkok, two hundred years ago, most of Thailand was covered by forests. Teak was so abundant and so valued by the Chinese that whole ships were built of it and exported to China (Sukwong 1989). By 1936 the forests had been reduced to 70 per cent of the land area; in 1987 only 25 per cent of the land area remained in forests (Ramitanondh 1989). The ultimate causes of deforestation are many and very complex (see e.g., *ibid.*) but two immediate causes are readily defined: lumbering and farming. Of these two, lumbering started earlier. At the turn of the century, all forests for which titles were not held reverted to the King, and became forest reserves (Brockelman 1989). A centralized system of concessions continued the practice from feudal times, but concessionaires now were British, French and Danish logging companies, harvesting teak for the lucrative export market. By the mid 1970s the total area suitable for

commercial logging was decreasing at a rate of 10 per cent per year (Scott 1981: 18). Logging continued until 1988, while supplies diminished. The demand for teak for the export furniture industry prompted the price to more than double between 1976 and 1986, even while the quality declined from large logs, to wood of any size. At the same time, another tropical hardwood, yang, increased in price by six times. Yet, during this same period, "...the volume of teak cut fell from 263,700 cubic metres in 1976 to 39,166 in 1985 (Tingsabadh 1989: 453). The industry had extracted virtually all that was available.

Deforestation due to expansion of farming has mushroomed during the period of modern economic development as Thailand has become active in the global economy. After 1855, when the Bowring Treaty with Britain was signed, the area under rice cultivation increased six times, with the impetus of supplying neighbouring countries whose colonial governments were directing agriculture into export crops. Then, in 1960 a remarkable expansion of other agricultural commodities started in Thailand, including rubber, corn, cassava and kenaf. By 1968, these crops surpassed rice in export value. "Vast jungle areas were cleared by Thai peasants for the cultivation of these crops, bringing the estimated rate of deforestation up to 4% per annum ..." (Sukwong 1989: 63-64) during the early 1970s. Whereas teak logging had concentrated in the North, clearing of forest areas for export crops occurs in all areas

except the Central plains in which essentially no forests remain. Clearing is usually done "...by nearby farmers in search of more land to farm and to give to family members, and then forest land is converted on a large scale into fields for cash crops when the prices are right" (Tingsabadh 1989: 452). Recently, large areas of forest reserves have been cleared for unlicensed commercial operations, such as eucalyptus and rubber plantations. This illegal clearing has largely been ignored by the government, but not by neighbouring farmers who resent encroachments upon areas viewed as common property to be used for gathering of fruits and fuelwood (Bangkok Post April 1, 1990 and June 5, 1990) and for their own future agricultural expansion.

Environmental problems resulting from deforestation include the heavy loss of topsoil in the North and West where steep hillsides cannot withstand clear-cut logging, or permanent farming on soils more suited to the previous practice of slash-and-burn agriculture (Phantumvanit and Sathirathai 1988). In the Northeast, deforestation due to expansion of farmlands is related to an increasing frequency of drought, as well as salination of the soil where runoff, no longer held on hillsides by trees, has raised the water table near to the surface in the flat paddy areas (Sukwong 1989). The Northeast, with the lowest per capita income, is also most in need of fuelwood for home energy consumption, resulting in further deforestation (Phantumvanit and Sathirathai 1988). In

the South, numerous areas have suffered from flooding and land-slides. These are worst in areas where forests have been cleared by lumbering and then left denuded or planted in rubber. With their shallow root systems and cleared alleys, rubber plantations can neither absorb large amounts of monsoon rains, nor can they provide stability when saturated soils on steep hillsides start to slide (Murai et.al.1990, World Resources Institute 1990).

It was in the South where the effects of deforestation finally were felt so dramatically that action had to be taken. In November 1988, at the end of the rainy season, more than 350 people were killed when slides buried whole villages. In January of the following year, the Thai government placed a ban on all commercial logging, and all logging concessions were withdrawn. Having foreseen the end of lumbering as supplies dwindled logging companies quickly moved their operations to neighbouring countries, particularly to Myanmar which welcomed this new source of foreign exchange.

Leonard (1989) lists the economic and demographic factors most frequently acting against the poor: population growth, land consolidation and modernization, and land tenure inequality. These factors are seen in the push of Thai peasants onto marginal lands. The effective end of commercial lumbering has not eliminated the pressure for land on which to grow cash crops, or for fuelwood needs. In addition, public demands to preserve forest reserves from encroachment mean

that other locations are looked to for raising cash and obtaining fuelwood. Mangrove forests are essentially the only alternative marginal lands available for expansion, and the pressure to use them increases as agricultural lands are degraded and with the growing income gap.

Thailand's mangroves

In comparison to the extent of Thailand's depleted hardwood forests, the mangroves are small. A 1961 survey, using aerial photography, indicated that mangroves covered 3,679 square kilometres. In 1986, Landsat imagery indicated that mangroves covered 1,964.29 square kilometres or 1.32 per cent of the total of 149,053 square kilometres of forest area of the country at that time (RSD-NRCT nd.). In a 25-year period they had declined by 47 per cent. Mangroves are located at the northern end of the Gulf of Thailand, the Eastern Seaboard region of the Gulf, the Southern Seaboard region of the western side of the Gulf, and the Andaman seacoast region. The latter part has 75 per cent of the mangrove forests of Thailand and the only mangroves that have not been cut repeatedly.

The term mangroves refers to both a group of evergreen plant species associated with a particular habitat, and also to a tropical coastal ecosystem. "Physically, the mangrove ecosystem straddles marine and terrestrial environments. The extent and distribution of mangroves depend on environmental

factors, the most important of which are climate, soils and water" (Aksornkoae 1987a: 146). Mangroves grow optimally in climates of high rainfall and humidity with a temperature range of 25-30 degrees C. Periodic flooding with seawater is needed for most mangrove species, and a constant supply of fresh water must bring in nutrients and silt. This ecosystem displays a great diversity of life: 74 species of plants are known in Thailand's mangroves; 72 species of fish and over 30 species of shrimp live there at some time in their life cycle. The ecological significance of the mangrove forest lies not only in its diversity of life forms and productivity; it also functions as a coastline stabilizer, in erosion control, and as a pollutant trap (Gomez 1980). The mangrove protects inner lands from the destructive force of typhoon winds and waves, it allows river-borne silt and silt from off-shore mining operations to settle, and provides a place for water pollution to settle out or be diluted. The mangrove occupies an important position as a physical stabilizer for soil, and as a medium for the interaction of flora and fauna between salt and fresh water. It is "... a highly symbolic resource, straddling the interface between the terrestrial and marine environments" (TDRI 1986a: 119).

The mangrove also has considerable economic significance, and it is in this regard that it is most threatened in the near future. The chief economic activities which occur in Thai mangroves are the production of charcoal and the harvest

of aquacultural products. Ninety per cent of the wood harvested from mangroves is used for charcoal production. The wood of several species of Rhizophoraceae makes excellent charcoal because it is "... heavy, dense and hard, with a high calorific value. When burned, it creates little smoke" (Aksornkoae 1987a: 150). Over a 15 year period, from 1970 to 1984, annual charcoal production in mangrove plantations rose from 196,600 tons to 282,459 tons, valued at 5.64 million baht (ibid.) or US \$225,600. A total of 309 clear-felling concessions are privately held under the management of the Forest Department. Since the 1,256 licensed charcoal kilns have a capacity considerably larger than the wood which can be derived from these concessions, this indicates that "... poaching is rampant to meet the demand of the existing kilns" (TDRI 1986b: 20).

Although the value of charcoal production in mangrove plantations is not large it is important in the national energy inventory; traditional energy sources - charcoal and fuelwood - continue to account for one-third of the total national energy consumption (Pakkasem 1988). With the 1989 ban on commercial logging in Thailand's forests, which included some harvesting for fuelwood and charcoal, coupled with decreasing access by farmers to forest reserves for the gathering of deadfall for fuelwood, the harvest of wood and production of charcoal from the mangroves remains important, particularly in low income, rural areas. Mangrove charcoal is

also exported to Malaysia, Singapore and Hong Kong (Aksornkoae 1987b). Other uses of mangrove woods and plants are for construction materials, wood distillation, tannin extraction and medicines.

Aquaculture is of much greater economic significance to Thailand, and most of this takes place in the mangroves or areas converted from mangrove forest. Shrimp culture has been practised for years, but during the 1980s it expanded dramatically, particularly with the growing market for black tiger shrimp. Thailand is currently the world's second largest exporter of frozen shrimp after China, and these are sent to Japan, South Korea, Taiwan, Singapore and Hong Kong, North America, Europe and Australia. In 1981, 18,700 metric tons were exported; in 1989, 75,000 metric tons were exported at a value of 17,000 million baht (Bangkok Post 1989) or US \$680 million. To accommodate this increase in shrimp farming the area of mangrove used has increased from 242 square kilometres in 1981 to 800 square kilometres in 1989 (ibid.). Other aquaculture crops include several varieties of fish, oysters, mussels and cockerels. Each requires slightly different ecological conditions of water depth and salinity and does not compete with others (Mongkulmann 1990). The crops are all increasing in size and popularity, but the tremendous expansion of shrimp farms has slowed in the past year as prices have declined. Nevertheless, entering the shrimp farming business is very attractive to Thailand's new middle

class: concession licenses cost only 5000 baht, or US \$250, and public classes given by the Fisheries Department in aquaculture cannot keep up with demand (ibid.).

Aquaculture and plantations are the primary economic uses made of mangroves. During the period 1980-1986 38 per cent of mangrove conversion was directed to aquaculture alone. Expansion of industry and urban areas also places tremendous stress on mangroves of the upper Gulf region (TDRI 1986b). Salt ponds have been placed in 10 per cent of the cleared mangrove areas since 1980. Tourism and mining result in mangrove conversion around Phuket, on the Andaman coast and in the Songkhla-Pattani area on the western coast of the Gulf. Industry, the growth of cities, tourism and mining also have an indirect influence on coastal resources. The resultant pollution or siltation is a threat to both the health of the mangroves themselves, and to the health of shrimp farms which rely on a steady supply of sea water and are vulnerable to slight chemical and biological changes in the water (Gomez 1980).

Like other government-controlled forest reserves, mangroves are occupied by people having no title to the land. Mangrove dwellers are estimated to number about 98,000 and most have come into the area since 1950, as a result of increasing population pressure on nearby farmlands.

Most mangrove dwellers live in clustered houses in small village communities at the edge of the forest or along channels within an estuary. Most of the villagers

are of Thai origin: other ethnic groups include Muslims speaking a Malay dialect, and Chinese.

The villages can be classified into three main types: island villages, shrimp-pond villages, and coastal-land villages (Aksornkoae et al. 1986: 13).

Less than 10 per cent of mangrove dwellers are employed in the shrimp farm or charcoal concession areas. Most make their living by fishing and gathering materials from the mangrove forest. Sun-dried and salted fish, as well as shrimp paste, are sold to local merchants or merchants in the nearest town, bringing in an average annual household income of 54,743 baht (US \$2190), only about 39 per cent of the national average. A few have cleared mangrove forest for paddy fields, which have low yields, or for salt pans. Mangrove dwellers are not able to muster the capital needed to apply for concessions. Their economic conditions are declining "... because of the decline in populations of mature sea animals and the deterioration of the mangrove forests around the islands" (ibid.: 42).

A management plan for the mangroves

Until 1977 (i.e., prior to the aquaculture boom), the mangroves were used for charcoal production and small-scale shrimp and fish farming, but no natural resource plan was in effect. Then, as a result of pressure from Thai and international scientists alarmed about the ecosystem, the need for a management plan was acknowledged and the National Committee on Mangrove Resources was established as a part of the National Research Council. Representatives on the

committee came from the various government departments concerned with resources (Forests, Fisheries, Hydrography, Mineral Resources, Land Development, Meteorology, and Army Survey), several universities (Prince of Songkhla, Mahidol, Kasetsart and Chulalongkorn), and UNESCO. The committee developed a national mangrove management plan which recognised three classifications of mangrove forests: conservation areas, preservation areas and denuded/degraded areas. The plan for all three zones would emphasize rational, sustainable management "... giving priority to those activities with minimum impact upon the mangrove environment" and ".... multiple sustained use rather than conversion for single exclusive use" (Aksornkoae 1987b: 256). A remote sensing survey, a ground survey, environmental impact assessment reports and ecological studies would all contribute to the data collecting and processing necessary to determine the location of the zones.

Ten years later, in December 1987, a plan for mangrove land-use zones, to be administered by the Forest Department, was approved by Cabinet. There are three zones, now called the preservation zone and economic zones A and B (Table 3.1). These are "... based on the association of physical and human environments" (RSD-NRCT nd.: 150). The zones "... include the existing mangroves as well as designated areas to be protected and/or developed which are currently ... shrimp farms, paddy, etc." (Dowreang 1991). The preservation zone is "strongly

Table 3.1. Definition of Mangrove Forest Land Use Zoning Designated by the National Committee on Mangrove Resources

Preservation Zone	Economic Zone A	Economic Zone B
This area is strongly protected against any impact on its natural ecosystem.	Area for forest utilization on a sustained yield basis.	The mangrove area allowed for other development with consideration for the environment.
1) The area for economic flora and fauna preservation 2) The area for economic flora reproduction and fauna breeding 3) The area subject to erosion: - beach and sand bar - mud flat - islet, cave and coral reef 4) Historical and archaeological areas 5) Area for preservation of local symbols 6) National park, wild life sanctuaries 7) Wind protection area 8) Area for research and study 9) Area for environmental and ecosystem preservation 10) The area within 20 m. of natural riversides, within 75 m. of coast	1) Concession forest area 2) Public forest and area other than concessions for local use 3) Public economic forest plantation	1) Agricultural - agriculture - animal farms - fishery - salt ponds 2) Industrial - mining - industrial - urban and residential - commercial area - seaboard area - others
Totals (square kilometres)		
426.78	1,996.89	1,300.81
Total zoned area: 3,724.48 sq.km.		

 Adapted from Remote Sensing Division, NRCT 1991: 163.

protected" (to quote from the National Committee on Mangrove Resources) from economic use to prevent any impact on its ecosystem. Composed of the narrow strip of land within 20 metres from all estuaries and rivers and 75 metres from the coastline, preservation areas are meant to protect local flora and fauna and their breeding grounds, to prevent the erosion of beaches, mudflats and other coastal features, and to allow limited human activity. The ultimate goal of the zoning system is to preserve 25 per cent of the total zoned area, but "existing resources and the designed zoning criteria" (ibid.) make this goal unattainable. Dowreang continues, "... this might be achieved in the future through the implementation of the plan."

Economic zone A is for sustainable forest use, primarily plantations for charcoal production. This zone is divided into charcoal concession areas and public forest for mangrove dwellers. Economic zone B includes denuded and degraded areas which can be used for fish or shrimp farming and agriculture, or industrial and urban uses. Little or none of this area will be ever converted back to mangrove (RSD-NRCT 1991).

The zone system leaves the mangroves open for use in many different ways, ranging from their preservation in pristine condition, to their permanent conversion to urban and industrial development. As sustainability is an objective of the management plan factors which place it at risk should be recognised. It is instructive to note that the total area in

economic zone B is almost as large as that in economic zone A, and that each of the economic zones is three-to-four times larger than the areas included in the preservation zone. It seems highly unlikely the preservation zone can ever attain 25 per cent of the total area.

The ecosystem preservation capacity of the "preservation zone" seems dubious when the zone is limited to narrow strips adjacent to waterways. It is questionable whether this zone can maintain species diversity and the dynamic growth necessary to counteract the effects of wind and water erosion, water-borne pollution and siltation, and human economic activity in adjacent areas. In addition, unless zones are periodically upgraded and redrawn, the succession dynamics of mangroves will invalidate the zone system. The preservation zone will experience accretion and depletion from the action of wind, water and biomass. These processes require the adaptation of the zones to reflect the reality of what is occurring on the ground. Furthermore, the riverside strips will not be discernible by Landsat TM (having a resolution of 30 meters). Even with SPOT data it would be difficult to assess whether these coastal and riverside strips are being preserved.

Conflicts in the use of economic zone A also appear to threaten the sustainability of this zone: 1) it is being used for single-purpose activities, and 2) blatant abuses of the zoning system occur. Although the sustainable use of economic

zone A is meant to be multi-purpose, in effect concessions are granted only for mangrove plantations, at the expense of public forest lands which should be made available to mangrove forest dwellers (Kongsangchai 1990). Repeated cutting results in lowered productivity for the plantation, increased pressure to convert other mangrove areas to maintain charcoal production, and the danger that the concession will become so degraded it will have to be abandoned. Shrimp farming, which allows the most rapid return of capital, is often discovered in sections of economic zone A. Once areas have been cleared for shrimp farms it is difficult to eliminate them and in effect the area becomes part of economic zone B.

The use of economic zone B, as it is defined now, cannot be done on a sustainable basis. Obviously, the conversion of mangrove areas for industrial, urban or agricultural use will not result in the maintenance of mangroves. Aquaculture is also seen as a practice which endangers the mangrove, and in most cases, leads to its permanent conversion. In the traditional, "natural" method of shrimp culture the mangrove forest is completely removed, creating a pond surrounded by embankments. By means of small creeks and canals, the ponds are linked to coastal waters, which flow in during high tide, or with the help of a pump. Shrimp larvae and other aquatic organisms flow in with the water, but are prevented from leaving by gates. Harvesting is done after about 30 to 45 days (Aksornkoae 1987b). Modern, intensive aquaculture uses

the same type of ponds. Fertilizers are added to the water and the chemical composition of the water is closely monitored. This method gives greater yields but is more costly than the traditional method. Shrimp ponds using either method must be abandoned after about 5 years (Klankamsorn 1990). A further effect of widespread aquaculture in the mangroves is the decline of deep-water fish which spawn in the shallow, nutrient-rich waters of undisturbed mangroves.

Recovery from aquaculture can occur. As long as embankments are broken down so that seawater and freshwater can flow into abandoned ponds, the mangrove will grow back within about 15 years. However, clearing of mangrove by earthmoving equipment, for industrial conversion or large-scale shrimp farms, will not allow the revival of the mangrove when the land is no longer needed for those purposes, because of soil compacting (Kongsangchai 1990).

Shrimp farming can be done on a sustained basis, using the "Tlumpang Sari" or sylvo-fishery system which combines mangrove plantations with canals for aquaculture (Aksornkoae 1986). However, officials in the Forestry Department see the wholesale encouragement of single-use shrimp farming by the Department of Fisheries as an exploitative use of the mangroves, rather than a long-term sustainable one. Fisheries encourages the establishment of shrimp farms in the mangroves, but does not follow up on their long-term effects. There is no education program to promote sylvo-fishery systems.

Holders of shrimp farming concessions are not required to open abandoned areas to the free flow of water, and are not restricted from obtaining further concessions.

The use of remote sensing in the management of mangroves

Remote sensing has been applied to the management of mangrove forests for a number of years, first using aerial photography and then satellite technology. Aerial photography continues to be the preferred technology, used when a one-time intensive study of a very limited area is needed, and when funds are available. Usually, these conditions cannot be met and satellite remote sensing is employed. Early applications were for mapping and inventories of mangrove forests. Researchers have found that remote sensing for management is much more difficult.

With the introduction of regular scanning by satellite the cost per geographic area covered is reduced, repeated scanning of areas of particular interest is facilitated, and the information value of data is enhanced by computer processing.

These advantages have made remote sensing highly appropriate to coastal studies where the land area to survey can be extremely large and where rapid changes in ecosystem structures are characteristic. This technology has thus become quite widely used in a very short time in mangrove ecosystem studies (Chaudhury 1983: 57).

Chaudhury predicts that remote sensing can be helpful in a number of ways in mangrove studies. It can be used to:

1. Identify and quantify mangrove forests;
2. Identify zonal features (vegetation types) in mangrove;
3. Identify extent and profile of mudflats and near subtidal zones;
4. Monitor dynamic processes (progression, erosion) in mangrove environments;
5. Monitor offshore sedimentation, organic export and current systems;
6. Identify soil types;
7. Monitor water characteristics (e.g. salinity, turbidity) in mangroves;
8. Monitor mangrove land use patterns (e.g. aquaculture, forestry);
9. Monitor changes in land use activities in mangroves (ibid.).

These functions mostly require high resolution data, which have become available only recently and are used in such projects as the ones which will be described in Chapter four.

Early Southeast Asian remote sensing mangrove studies in the 1970s started with basic mapping. In a Thai study, Landsat data were used to delineate mangrove areas and tidal flooding boundaries, which were confirmed by ground truth missions. The detected decreases in mangrove area between 1961, when an aerial survey was made, and 1979, the date of the Landsat images used in the study, were due to changes in land use, primarily agriculture, though charcoal and timber production, settlements, urban and industrial growth, mining, shrimp farms, salt ponds, and rubber plantations were beginning to dominate in some areas. Digital analysis and various enhancing procedures allowed the classification of mangroves into two groups, one with dense vegetation cover and the other without (ibid.).

Thai remote sensing studies of mangroves parallel studies of mangroves throughout the Southeast Asian region. Early studies in Pakistan, the Philippines and Bangladesh were used to inventory mangroves, particularly in homogeneous areas (ibid.). More recent studies have documented 1) changes in dense, normal and sparse mangrove vegetation in Pakistan (Siddiqui and Shakeel 1989); 2) denuded mangroves due to shrimp farming in Bangladesh (Chaudhury 1990b); and 3) long-term deterioration of mangroves in Vietnam due to warfare and economic exploitation (Bong 1990).

The recent use of remote sensing for mangrove studies in Southeast Asia has been successful in some aspects of the functions listed by Chaudhury. Considerably more experience with the technology is needed to advance the use of remote sensing in the management of mangroves.

This chapter has described rapidly growing economic pressures placed on Thailand's forests amid severe environmental degradation. These are related to the country's interest in remote sensing, particularly for the management of its mangrove resources. In the next chapter, two projects for the transfer of remote sensing technology in Thailand will be examined. We will see that the transfer of the technology from Canada to Thailand has included the transfer of technical knowledge. The context of the transfer has determined how the technology is applied and for what ends, thus affecting its use in making policy decisions in the management of resources.

1. Introduction

2

Resolution Test Chart Labels:

- 1.0
- 1.1
- 1.25
- 1.4
- 1.6
- 1.8
- 2.0
- 2.2
- 2.5
- 2.8
- 3.2
- 3.6
- 4.0

PIONEERS IN METHYLENE BLUE TESTING SINCE 1974

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Chapter IV. Two Canadian Remote Sensing Projects in Thailand

Much of the transfer of Canadian remote sensing technology in Thailand has occurred through two projects, one sponsored by the Canadian International Development Agency (CIDA) and the other by the International Development Research Centre (IDRC). These projects, which included equipment and training components, were directed to the application of the technology in the management of natural resources and land use planning. The training done in these projects constitute a type of transfer of technical knowledge (Girvan 1983). Another means of transfer of technical knowledge is through technical meetings. Two such meetings took place in 1990.

In addition to the installation of costly new receiving and analytical equipment remote sensing technology transfer involves a learning process. It is this learning process, or the acquisition and application of expertise in a technology, that is of interest in this study. Remote sensing expertise is not applied neutrally. When remote sensing is applied to natural resource management, in the framework of a national development plan, certain assumptions are made about the direction of development. These assumptions relate to four issues: who becomes an expert in remote sensing; how remote sensing data are interpreted and verified; how remote sensing information can be used in the course of national development; and whether remote sensing contributes to policy formation in a national resource management strategy.

This chapter will describe the two remote sensing transfer projects, their objectives and results, and the two technical meetings of people working in remote sensing. The main body of the chapter explores the process of acquiring and applying expertise in remote sensing technology, determined from interviews with informants who had been involved with the two projects.

The CIDA remote sensing project

The CIDA project was designed to upgrade the facilities of the TRSC at the cost of US \$5 million. When the technologically advanced Landsat-4 and -5 satellites were launched, the TRSC purchased a Thematic Mapper and developed appropriate mapping software (Audet 1986, ESCAP 1989). The most costly part of the CIDA project was the installation of digital analysis hardware and computer software. The overall purpose of the project was to "...help Thailand to upgrade, organize and use the LANDSAT data in the development and management of its natural resources" (CIDA 1984: 5).

To ensure that the project would be consistent with the Agency's goals for its program of aiding Thailand in " '... acquiring the technological and managerial expertise necessary to make the best use of capital flows ...' and '... managing its natural resources' " (ibid.: 4), CIDA included an Applications Support Component in the project. It is this transfer of technical knowledge which is of interest here.

1. Goals of the CIDA project

Since the establishment of the TRSC, the staff had demonstrated their competence and qualifications in visual interpretation of Landsat imagery in resources studies. The Applications Support Component of the CIDA project was designed to emphasize "... the transfer of state-of-the-art digital image analysis techniques and expertise developed and practised in Canada ..." (Canada n.d.: 3). The emphasis of the component was to transfer techniques for the operation of the digital analysis hardware and software which had been installed by CIDA. The component would also promote "... technology transfer in advanced applications of Landsat data for natural resources management ..." (ibid.) and it would be applied in six priority sectors:

- Agriculture
- Water Resources
- Forestry
- Economic Geology
- Land Use Planning
- Coastal Resources Management.

By increasing Thai government departments' awareness of Landsat capabilities in natural resource management the project would provide the basis on which "... CIDA would contract further Canadian applications services to be provided to Thailand" (CIDA 1984: 14). The transfer would include thirteen person/years of consultancy/training/advisory services over a three-year period, and 63 person/months of short-term technical training for people, chosen with equal regard for men and women, from a variety of government

agencies, plus two or three post-graduate scholarships in Canada. The project advisors would organize and conduct a final regional Landsat Symposium to communicate the results of the applications of the digital analysis. Demonstration projects in land cover/land use, agriculture, forestry, water resources/hydrology, and coastal management would be undertaken with Thai scientists; the projects would cover all major regions of Thailand, and the size of each project would be large enough to necessitate the use of at least two adjacent Landsat frames. The demonstration projects would result in the production of thematic maps and written reports (ibid).

While written in the language of technical assistance the project would go beyond, to the transfer of technical knowledge. "Advanced applications ... for natural resources management," the inclusion of post-graduate scholarships, and the training of two people to be project managers, all indicate a greater complexity of transferred information than is understood by the term technical assistance.

2. The Application Support Component

Most natural resources are within the scope of a single government ministry but data gathering activities pertaining to these resources are often carried out by two or more different agencies within the ministry. "This happens when the same resource is used for different purposes and

accordingly requires mapping with different classes or scales" (Audet 1986: 4). The first task of the Applications Support Component was a survey of ongoing remote sensing applications in Thailand. It indicated the pressing need for coordination of remote sensing activities in government departments and the integration of remote sensing information with other available data to eliminate the overlap of activities. As a result the demonstration projects were expanded to include training in the application of remote sensing in natural resource management. This was a Resources Information Management System (RIMS) demonstration project. Simulations using alternative development models could be run on the RIMS to see the outcomes of various objectives set by resource managers (DIGIM 1988).

Twenty-three trainees from eleven different Thai government agencies participated in the CIDA project. The period of training in Canada was 2-3 months for most, and the longest training courses, in project management and computer systems, were for 6 months. Table 4.1 presents a summary of the training programs, agency affiliations, and field of interest in the program. The trainees presented reports on all the demonstration projects at the final Symposium in 1988.

The IDRC remote sensing project

The project funded by IDRC was smaller than the CIDA project. Funded in 1984, the project cost \$367,900 and was

Table 4.1 Training Programs in the CIDA Project

Training Program	Number of Trainees / Affiliation	Fields of Interest
Forestry	1 / Forest Department	Forest Cover Mapping
Geology	1 / Department of Mineral Resources	Exploration Geology and Mapping
Map Updating	1 / Survey Department	Base Map Revision
Plotter	1 / National Research Council of Thailand (TRSC)	Operation of APPLICON Mapping System
User Services	1 / TRSC	Distribution of Satellite Data
Land Use	1 / TRSC 1 / National Environ. Bd. 1 / Land Development Dept.	Land Use Mapping
Agriculture	1 / Centre of Agric. Econ. 1 / Dept. of Agriculture	Crop Mapping
Water Resources	1 / TRSC 1 / Dept. of Fisheries 1 / Irrigation Dept 1 / Electrical Generating Authority (EGAT)	Aquaculture/Coastal Studies Irrigation Efficiency Reservoir Capacity Evaluation
Photo Reproduction	1 / TRSC	B & W and Colour Film Processing
Project Management	1 / Land Devel. Dept. 1 / TRSC	Project Management
Topographical Mapping	1 / Survey Dept. 1 / Land Devel. Dept. 1 / EGAT	Production of Topographical Maps at 1:50,000
Soils Mapping	1 / Land Devel. Dept.	Production of Soil Erodability Maps
Digital Image Computer Systems	2 / TRSC	Hardware/Software Maintenance

Sources: DIGIM 1988: 7 and Canada n.d.: 10

completed in 1987. The TRSC conducted the study jointly with the Royal Thai Forestry Department. The prime objective of this project was to "... survey and map mangrove forests in Thailand using remote sensing technique" (RSD-NRCT nd.: 5) and to strengthen local research capacity in the area of remote sensing applications to mangroves research. These objectives were to be reached by:

- 1) completing a survey of Thai mangroves using remote sensing technology;
- 2) developing and testing remote sensing data processing, analysis and classification methods, including ground truth surveys;
- 3) strengthening research capacity by training local scientists and encouraging their participation; and
- 4) compiling new information on mangroves and their classification to produce thematic maps at the scale of 1:250,000 and 1:50,000 for certain test sites (ibid.).

Four types of remote sensing data were used: 1) black and white aerial photographs, taken in 1975-1976, 2) colour infrared photographs of eight test site areas, taken during the project in 1986-1987, 3) Landsat MSS images of the mangrove areas of Thailand, and 4) computer compatible tapes of the MSS data.

1. Training and air reconnaissance activities

Project activities consisted of two training courses, a workshop, an air reconnaissance of the selected mangrove test sites and the mangroves survey. The objectives of the training courses were to 1) transfer the technology, 2) train

local scientists in remote sensing for mangroves study, and 3) to increase the numbers of the scientific community versed in remote sensing (ibid.). The courses and workshop succeeded in training more than 50 officials of Thai government agencies in the use of remote sensing. Twelve participants and 10 observers, mostly from the Forestry Department, completed the first two-week course in March 1986. Fundamental and theoretical aspects including principles of remote sensing, mangrove ecology, photo-interpretation and visual-digital analysis, and application of remote sensing to mangrove studies made up the first part of the course. The second part was practical work in photo-interpretation, visual analysis, and digital analysis. Fieldwork was conducted for three days in Chantaburi province on the southeastern Gulf coast, covering a variety of mangrove types, and a profile was derived. The last part of the course consisted of presentation and discussion of results, and final evaluation of the training.

The second training course, held in June 1987, had 23 participants, mostly from the Forestry Department, and 23 lecturers from five agencies. In this three-week course the fieldwork, conducted in Ranong and Phang-Nga provinces on the Andaman Sea, was doubled in length to six days, and a longer period was allowed for writing and presenting results.

The Workshop on Remote Sensing and Mangroves Management took place in October 1987. The objectives were:

- 1) to disseminate ... knowledge on the application on remote sensing to mangroves study and survey,
- 2) to transfer the technology on remote sensing as applied to mangroves and other resources management, and
- 3) to exchange ideas among scientists concerning the application of remote sensing technology to mangroves management in Thailand (ibid.: 11).

There were 40 participants, 17 of whom were from regional offices of the Forestry Department in mangrove areas. The first day was devoted to a seminar on remote sensing and mangroves, and then two days were spent in on-site field observations in Chantaburi province.

The air reconnaissance provided a basis of comparison, at a large scale, to the Landsat MSS materials which were used to determine mangrove zonation. Vertical aerial photography, using colour infrared film, covered the eight test sites at a scale of 1:25,000. Despite technical problems and cloud cover, the photographs illustrated clearly various species of mangrove trees. Oblique aerial photography, using colour infrared and normal colour films, covered four of the test sites.

2. The mangrove survey

The survey of Thai mangrove areas began with the traditional means of forest resource inventory, aerial photography. Panchromatic aerial photographs from the 1975-1976 period provided a basis upon which mangrove land cover/land use was determined, and the newly acquired colour

infrared photography was keyed to the classification of preserved or undisturbed mangrove forest divided into three groups determined by the amount of tidal flooding experienced, as well as economic areas such as mangrove plantations (charcoal cutting areas), orchards, mangroves being cleared, shrimp farms, paddy land and open water. The visual interpretation of Landsat MSS data used panchromatic and false colour imagery. In panchromatic imagery two spectral bands are used complementarily to map the mangrove according to tone and texture. In false colour composite images using three spectral bands, flooding and crown closure of the forest can be detected. Both types of satellite images were used to determine land cover/land use features in the eight test sites.

The next step was to conduct a field study to determine the relationship between the true ground data and the corresponding information derived from remote sensing data. It was important that the ground truth be determined to establish areas representative of their land cover/land use class to be used for comparison in the digital analysis still to come. A correlation of the classes by tone of grey, shade of colour, homogeneity, texture, size and location in the satellite images was confirmed. Zonation of mangrove forest by crown structure, as seen in the oblique aerial photographs, could be checked. The fieldwork also provided information

about the condition and biomass volume of the mangrove forest in the test sites.

The final step in the survey was the digital analysis for the eight test sites. Classification of land cover/land use areas employed three MSS spectral bands and a vegetation index, derived from photo-visual interpretation and the ground truth data. Accuracy of classification was determined to be 72 per cent when three classes of forest were specified, and 85 per cent with one mangrove zone (Ratanasermping 1990).

Results of the survey included thematic maps of the existing mangrove forest areas of Thailand at a scale of 1:250,000. The extent of mangrove forest depletion was derived by comparison with previous mangrove studies in 1975 and 1979 and indicated that 98.73% of the central Gulf mangrove has experienced change during the period. Mangroves of the eastern and southern Gulf and the Andaman sea coast suffered less alarming depletion. Aquaculture, mostly shrimp farming, was the cause of the most depletion, and natural causes had the least impact. Other causes of depletion in the 1980s include (in order of impact): road construction, urban and residential areas, mining, industrial plants, salt production, illegal cutting of trees, and agriculture. Mangrove plantations are not included in this list because the charcoal cutting concessions were in place prior to 1975, and therefore do not represent a change in use of the mangrove.

Large scale maps (1:50,000) of the eight test sites were derived from photo-interpretation of aerial photographs, and from visual interpretation and digital analysis of satellite images. The land cover/land uses of each test site could be placed in nine principle classes: 1-3) mangrove forest classes I-III, 4) mangrove forest plantation, 5) mangrove forest clearing, 6) shrimp farm, 7) paddy field, 8) standing trees and orchard, and 9) resettlement sites. These maps provided the basis for the system of land use zoning for the mangrove management plan for Thailand (RSD-NRCT nd.).

Two remote sensing meetings

Two technical meetings in 1990 were important as loci for the transfer of technology between colleagues, between teachers and students, and between remote sensing experts and attending government officials not having direct contact with the technology. The Twenty-Third International Symposium on Remote Sensing of Environment was attended by people working with remote sensing from all over the world. Thai participants came from the Asian Institute of Technology (AIT) and the National Research Council of Thailand (NRCT), various United Nations organizations, Government of Thailand agencies and Thai universities.

The Seminar on Remote Sensing and GIS for Soil and Water Management was organized by Khon Kaen University and its partner in CIDA's Thailand Institutional Linkages Program,

McGill University. It was attended by those who had worked in remote sensing soil and water management projects in the Northeast of Thailand and others working with remote sensing or GIS in Thailand, in various universities and government agencies (including TRSC), and a few Canadians working in remote sensing and GIS technology.

A study of the transfer of remote sensing technology

The CIDA and IDRC projects, the International Symposium, and the KKU Seminar were loci for the transfer of remote sensing technical knowledge. This study explores how a group of Thais received training in the technology, whether they continue to upgrade their skills in it and how they disseminate the technology to others. It examines their experience of the process of learning the technology, and their views on the applicability of remote sensing to national environmental problems. Finally, the study considers how these people see the technology as being decisive in the formation of government resource management policy.

The transfer of technical knowledge for natural resource management - in training programs and by personal contact - takes place in a context which influences how the technology is used. The context may be directed to development by economic growth, or to sustainable development. More often, as is the case studied here, the context is mixed. In this case, the ambiguous direction given to the technology will

result in conflicting policies for natural resource management.

The argument for this thesis will be explored in several issues: 1) access to the technology, or who becomes an expert in remote sensing technology? 2) technical interpretation and verification, or what is involved in learning to understand and use remote sensing technology? 3) national development or what part does remote sensing play in the recognition of economic opportunity and environmental degradation? and 4) policy, or do those involved in the transfer of remote sensing see the technology as contributing to the formation of resource management policy? In interviews participants in the projects gave their views as to different aspects of these issues, and provided data on the ongoing process of the transfer of technical knowledge.

1. Access to remote sensing technology

Gaining access to remote sensing technology, and becoming competent in remote sensing is determined by education and employment. As the technology diffuses through a society others employ it to a degree: government officials or resource explorers who have taken a course, or school children or shrimp farmers who have been shown satellite images, can make limited use of the technology. Also, at any facility using remote sensing there are technicians, who have received training in the mechanics of the technology and its

application; they are not involved in interpretation, or in communication of results outside the institution. But those trained in the technical knowledge of remote sensing use the technology to provide information to others by inventorying, planning, and monitoring natural resources, providing information for the conservation or exploitation of resources, and providing information and advice to decision-makers in policy formation. The scientific staff of the TRSC and a few employees of government ministries are in this expert group, as are university faculty members engaged in teaching and using remote sensing. It was from this level that participants in the two projects were drawn, and informants for this study chosen.

All of the ten informants in this study had completed university. Of the seven informants at the TRSC, three had graduate degrees and two of these had earned a Ph.D. The other three informants, employed in the Forestry Department and the Department of Fisheries, had Bachelor of Science degrees and one had earned a Masters degree. Half of the informants had their first introduction to remote sensing as a part of their university courses, including all but one of those who had graduate degrees. However, the bulk of remote sensing training took place outside of university. Each of three informants had taken five remote sensing courses and three others had completed three courses. Only one did not have any formal training in the technology; this person had a

graduate degree in mathematics. Geographical origin seems not to influence who has access: informants came from the Central plain, the North, the Northeast and the South of Thailand. All the informants were in the age range of 30 - 50 years old, and the group was evenly divided between women and men.

One-half of the informants could be designated as decision makers in their field. They generated and directed projects, and were able to base decisions on the results of their work and that of their colleagues. This group had more senior positions in their organizations, and therefore, greater access to policy makers in the government. Two worked at the TRSC, and three were at the Forestry and Fisheries Departments.

The decision makers, a group slightly older than the others, were composed of four men and one woman. Three of them came from the Central plains area of Thailand. Three had five non-academic training courses in remote sensing, a fourth had extensive technical training during studies for his Doctorate degree and all but one of the holders of graduate degrees are in this group. A distinctive feature about this group is their dynamic approach to maintaining access to remote sensing technology. Whether having had two technical courses or five, each one exceeds the efforts of those in the non-decision-making group: they read journals, attend national and international meetings, receive visitors and seek out any available knowledge about the technology. Two mentioned

further courses they would like to take, given the opportunity.

The non-decision makers did not display such dynamism. For three in the group, access to the technology was gained by courses suggested by their employer. Although all three had remote sensing skills, none took steps to increase their access to the technology and two of them no longer had an interest in using the technology. Two others displayed expertise in the technology and expressed interest in going further in the field. One of these, however, did not read journals, write papers, or take courses; this person had never had a remote sensing course but picked up knowledge on the job. The other did read journals, presented papers, and had the potential to become a decision-maker in remote sensing; at our last meeting this informant told me she was leaving soon to take a fourth remote sensing course, six-months long, in the Netherlands.

A difference can also be seen, between the decision makers and those who are not, in terms of providing access to the technology to others. Each one of the total group of ten informants is involved in teaching, to some degree. One person, in user services, attempts to reach the public through educational materials and liaison with researchers. Another teaches his own staff in on-the-job training. All the others teach in formal training settings, and two with graduate degrees taught in the CIDA project. But the decision makers

do more to disseminate their expertise: they write papers for publication and presentation at meetings in Thailand and internationally, they teach a university course as a second job (government employees are limited to three hours/week of outside paid employment) or supervise graduate students, and they maintain contacts with those who have gone through their courses and do follow-up.

One person who was a leader for the IDRC project and an instructor for the CIDA project disseminates his remote sensing expertise in numerous other ways as well. He publishes articles, in Thai and in English, on the use of remote sensing in forestry. He attends international meetings, is engaged in development assistance projects which result in contacts with the international forestry and remote sensing community, and sits on the Board of the Asian Institute of Forest Management. This person teaches remote sensing in the Forestry Department semi-annual training courses; he designs public education courses in forestry, including the use of remote sensing materials, for presentation to mangrove dwellers and to the Hill tribes in northern Thailand, and general courses on remote sensing technology for presentation to high school groups and on television. At the time of our interview, he was conducting a follow-up study with the foresters involved in the IDRC mangroves project, to determine what use they make of remote sensing in their work and what further training is needed.

The CIDA project provided access to new aspects of remote sensing training for six of the informants, and two others were project instructors. Participation in the CIDA project had been requested by one informant working for the Department of Fisheries. For this person gaining access to the technology has been accomplished by his own initiative; he says he is the only one in his department who has any control of the technology, although his requests for training time and for equipment have been supported by his supervisor.

The IDRC project, coming shortly after the CIDA project, allowed three of the CIDA trainees to use their new technical knowledge alongside their former instructors and with other colleagues whose control of aspects of the technology had already been demonstrated. The mangroves project allowed the turnover of remote sensing technical knowledge from newly trained, and seasoned, experts to a large number of forestry officials. Both projects increased Thailand's capacity to use the technology.

2. Interpretation and verification in remote sensing technology

Most remote sensing products, such as false colour satellite images and computer compatible tapes, cannot be understood by using common sense alone. They have to be interpreted, and the interpretation has to be verified. Global remote sensing studies of resources must use very broad

categories (eg., "forested land" and "deforested land").

Local studies of resources, useful for inventorying, monitoring and planning, use finer classifications designed specifically to local conditions.

Even those with years of experience in the remote sensing of a particular resource must learn to interpret remotely sensed products which depict that type of resource in a different location, where species or conditions are different (Prévost 1989). Remote sensing interpretation requires that shades of colour and grey, and different textures be recognised as indicating particular species or conditions of the resource. The classification of a resource built out of this interpretation must be verified by careful ground truth checks, in which small representative plots are painstakingly inventoried for species and condition. Ground truth verification may be required several times in one study.

The CIDA and IDRC projects were designed expressly around the problem of interpretation. The CIDA project aimed to train a broad range of government employees, using workgroups in resources relevant to each trainee. Each workgroup had trainees from different government departments which are concerned with the same resource, so that various aspects of the resource could be explored. The IDRC project was aimed at a basic, and until then, an unmanageable problem in Thailand, an inventory of mangroves. A major part of each project was devoted to verification, checking to make sure that what had

been interpreted coincided with what could be observed in specific areas "on the ground." These exercises in interpretation and verification are basic to learning to apply remote sensing to the management of resources.

The ten informants had different attitudes toward the scope of their work in remote sensing, depending upon their academic background. Those whose background was in geography or in mathematics worked on projects involving a number of different resources. Those whose university training was in the natural sciences worked only with resources directly related to their background and said that the best work was the result of this specialization. One, an oceanographer, who was involved in both projects, felt that it is important to specialize and gain more expertise in working with a particular resource. She lectured on the theory of remote sensing in the IDRC mangroves project courses, but left the interpretation and verification to others with experience in forestry; she does not get involved in the hands-on projects unless they include oceanographic questions.

Visual interpretation in the IDRC mangroves courses was taught by a geographer who had been a trainee in the CIDA project. Another person, a statistician, was involved in teaching digital analysis in both projects. The two had very different approaches to verification; the geographer uses frequent ground checks and becomes thoroughly familiar with the "look" of a resource on the ground before trying to

analyze satellite images; the statistician never does ground checks and leaves verification to others. This person's approach to remote sensing technology was much more detached than the other informants: she denied that she "does" remote sensing, but described her work as statistical interpretation of remotely sensed data.

Those in forestry and fisheries are very much involved in ground truth verification in remote sensing studies. The foresters, particularly, are specialized in this and are the ones who teach ground truth verification in training courses. The two foresters in this study, both admittedly working in a single resource, said they felt comfortable doing remote sensing anywhere as long as they had a chance to get thoroughly acquainted with the ecosystem on the ground. Both had done remote sensing studies of Thailand's forest resources from mangrove forests to the mountainous northern borders.

The biologist working in the Fisheries department had limited experience with remote sensing and felt much more comfortable working in the field, performing ground checks. Trained using traditional biological techniques, this informant had trouble understanding the theory of remote sensing because he did not have a background in physics. He was still trying to ascertain to what extent remote sensing could be of help in managing brackish water fisheries. The technology is vital in monitoring established aquaculture locations, but the limits of brackish waters are defined

biologically - by flora and fauna - rather than by features which can be remotely sensed. Therefore, in searching for new aquaculture sites the technology only can locate those having some probability of being productive. It also locates external threats such as toxic flows, sedimentation and movement of phytoplankton, but ground truth verification by chemical analysis must be done to check the extent of these threats.

The three informants who had been trained as geographers were the most open to "doing" remote sensing with a variety of resources, and this appeared to be related to their view of the interaction of interpretation and verification. The geographer who taught visual analysis in the IDRC project described the process which he goes through with each assignment: first, he gains a firm understanding of the objectives of the project; then, he studies the satellite images of the area to be analyzed. He becomes familiar with the colours, shades, and textures that can be seen in each spectral band and in the combinations of bands that will be used. A preliminary analysis is made, and the unsure areas are marked. He then does a ground check, including the unsure areas, and establishes how they correspond to the satellite images in terms of shades and textures. Further visual analysis is done, and follow-up ground checks are done if necessary. For the IDRC project this man, who had never seen mangroves before, needed "to have some experience with them."

He "went to see what they looked like from the ground, what the land looked like, how it is sloped, and the mixing of sand and mudflats." He "needed to learn the nature of mangroves" before he could work on the project. This person has worked on the visual analysis of many different resources during his career: forests, land use, fresh water resources, and ocean resources.

Another geographer thought the visual analysis of mangroves was easy compared to some problems in agricultural land use she has encountered. Although the accuracy figures for the mangroves project belie this, she asserted that the analysis of mangroves simply entails overlaying the right combination of bands, and the mangrove forests, cut areas and shrimp farms can be seen. When making a study of agricultural lands for cash crops (cassava and sugar cane), and subsistence crops she had to make numerous trips to the area to verify the growing patterns, particularly in areas of intercropping. Once she had visited representative areas, she could perform a visual analysis of land use, using satellite images and topographic maps.

3. Remote sensing in national development

National development depends greatly upon a country's resource endowment. Remote sensing experts hold varying views on the contribution the technology can make to managing natural resources, for rapid exploitation or for sustained

production. This issue has two aspects: one, the use of the technology for natural resource management by a certain segment of the public, and the other, the effectiveness of the technology in the hands of experts, for natural resource management.

Digital remote sensing data and satellite images of an area 185 kilometres long in each direction hold no inherent meaning to a person having no prior introduction to them. But sections of images can be increased in scale comparable to topographic maps, natural colour images are useful for some explanations, and even infra-red images can be made to convey meaning to the uninitiated (false colour images are less accessible). Using movie screens, television and the printed page, some remote sensing products can be useful in educating the public about environmental issues.

One question asked of the informants was whether remote sensing could be used to teach "resource workers" (including mangrove dwellers), those who work with a particular resource, such as charcoal producers in mangrove forest concession areas, or shrimp farm employees. The group who thinks that remote sensing can be of help are those who have a natural sciences background. All of these agreed that satellite images can be understood (given some explanation) on a basic level by anyone. In addition, the person in charge of user services for the TRSC was positive about the effectiveness of remote sensing products for public education.

The two foresters, who are active in public education, have seen remote sensing used to convey the idea of resource management for sustainable use. In explaining the mangrove zone system to resource workers, remote sensing images are used. It is worthless to say, "You are cutting trees in the wrong area," or "You cannot clear for a shrimp farm here." The zones are outlined on the images by forestry officials, and then they "walk the area" with continual reference being made to the images to point out how various species or conditions of trees show up. In doing so, the resource workers can learn why it is important to them to manage the forest. In effect, the foresters conduct a ground truth survey with the resource workers.

On this question, the three geographers and the statistician said that remote sensing products are not accessible to resource workers. The technology could make no contribution to increasing the perception of the environmental problems with which resource workers are directly involved. The images would mean nothing to people who have had no training in remote sensing.

The applicability of remote sensing technology to environmental problems also is pertinent to national development. The three geographers all said that remote sensing could be of little help in alleviating what appear to them as overwhelming national environmental problems. A

general tenor of despair, similar to that seen in the popular press, was expressed by them.

On the other hand, three of the natural scientists had a more positive view of the contribution which can be made by remote sensing in dealing with Thailand's environmental problems. While acknowledging the problems now affecting Thailand, they felt that remote sensing could be useful in the management of resources to prevent further environmental degradation and, eventually, to restore inventories.

Another natural scientist had different views. He saw benefits on both sides of the issue of the use of natural resources to promote rapid economic growth or for a slower process of sustainable development. This informant had a very pragmatic view of the management of mangroves. He reasoned that areas which used to be mangroves are usually excellent sites for aquaculture. It is important that the proportion of fishery production from brackish waters increase and contribute to the Thai economy. Since the mangroves in the coastal waters of the Gulf of Thailand have largely been destroyed by charcoal making, shell-fish farms, salt pans and mining, "there is no reason not to use those areas commercially." With careful, periodic chemical analysis aquaculture areas could be productive indefinitely and the degradation of the mangroves could be put to good commercial use. He did not refer to the Forestry Department's efforts to replant mangroves in destroyed areas, nor their assertion that

the long-term viability of aquaculture and deep-water fish resources depend on the preservation of some of the mangrove ecosystem.

4. Remote sensing and national resource management policy

As a new technology in a new field, the full extent to which remote sensing in natural resource management can be used has yet to be established. The CIDA project demonstrated, in the workgroups on Thai resources, that remote sensing can be effective in assessment; once that is done, periodic checks are required for monitoring (see DIGIM 1988). The IDRC project succeeded in assessing mangrove resources and developing a zoning system for the management of this resource. What is not well established is the part remote sensing plays in determining resource management policy. This issue can be divided into two questions: a) how is remote sensing used in the contest between policies of economic growth and sustainable development? and b) can remote sensing be useful in making major government policy decisions?

a. Remote sensing and sustained development or growth policies

All the informants saw that remote sensing is useful in assessing and monitoring resources; but its utility in planning and policy decisions was recognised only by those in the decision-making group. A problem cited frequently by informants in this group is the conflict between the Forestry

Department's policy of preserving some mangroves and re-establishing new mangrove growth, and the policy of encouraging aquaculture by the Fisheries Department. Different branches of the same government ministry (Agriculture) have different goals. One informant expressed the conflict this way:

The Government encourages the fish farms, but it wants to preserve the forests, too. The regulations are unclear and there is not enough manpower to explain and enforce them. The conflict between the two departments comes down to the goals of making a lot of money, and working for a sustained yield. It is difficult to convince people to work for the long run, because they are anxious to make money and to have the most productive fish farms. All that remote sensing can do is to keep track of where people are making illegal clearings.

Informants in the decision-making group at the TRSC and the Department of Forests hope that remote sensing documentation of continued encroachments on the mangroves eventually will help convince planners to put in place mechanisms to prevent further abuses. Two of them pointed to the installation of a GIS at the national development planning agency, the NESDB, as a means whereby remote sensing and other sources of data will make clear to planners that depletion is continuing and conflicting policies must be eliminated. One of the foresters described how he used remote sensing effectively to inform government planners about forest depletion; he simply explained about the colours on satellite images and the problem became evident to them.

However, one informant had a different view about the ends to which remote sensing can be put. It was his understanding that the remotely sensed documentation of the depletion of mangroves had resulted in a practical arrangement to satisfy those who want to use the mangroves for aquaculture to achieve rapid economic growth. Remote sensing indicates that the mangroves of the Gulf have been largely destroyed but that the depletion of those on the Andaman coast is not so advanced. Therefore, he said, the Fisheries Department and the Forestry Department have agreed that the mangroves of the Gulf, most of which are already developed, could be used for aquaculture and other economic purposes, and those on the Andaman Sea would not. Remote sensing could be used to estimate the potential for growth of the aquaculture industry, by pinpointing areas which might be good sites in the Gulf.

The decision-making group among the informants were aware of the policy conflict between the two departments and saw that remote sensing is a tool used by each department to fulfil its policies.

b. The use of remote sensing in government policy decisions

Only two informants, both in the decision-making group, thought that remote sensing technology can be useful in the formation of new government policy. Two environmental disasters have hit Thailand in recent years: the landslides and flooding of November 1988 in which more than 350 people

died, and Typhoon Gay which devastated the southwest Gulf coast in 1989 and in which over 600 people died. During the rainy season, in the fall of 1988, soil erosion occurred in deforested areas of southern Thailand. Satellite images taken on less cloudy days showed that small slides were blocking river valleys and a dangerous amount of water was building up behind the slides. This eventually resulted in several large, fatal slides which covered whole villages.

When asked what can be done when those using remote sensing see such an environmental problem in the making, all the informants agreed nothing could have been done in the case just described. One informant said, "remote sensing cannot predict the exact places where problems (landslides and floods) will occur as this happens very quickly, and during periods of cloud cover," and therefore nothing could be done. But one other informant, a decision maker at the TRSC, who worked closely with the Director, asserted that the technology was relevant to subsequent policy changes which have prevented recurrence of these slides. Within days of the disaster Suvit Vibulsresth, the Director of the TRSC, appeared before Cabinet to document with satellite images what had happened. He was able to show the sequence leading to the fatal slides. The documentation provided by remote sensing helped to convince the Cabinet of the necessity to radically change government policy, to place a total ban on logging in Thailand (Vibulsresth 1990a). The informant now works with Dr.

Vibulsresth, presenting monthly reports to Cabinet, on various aspects of natural resources in Thailand as revealed by remote sensing.

Another informant, referring to Typhoon Gay, argued that the potential is there for remote sensing to provide a solution to recurrent environmental disasters, but it is not always sufficient to result in strong government policy. It is not possible to predict exactly where typhoons will strike but the government could help coastal dwellers to avoid the terrible devastation suffered in 1989. During the period of recovery after Typhoon Gay, remote sensing was used to locate lands not so vulnerable to storms which would be suitable for farming. The government planned to help those who had been affected by the typhoon to resettle on this land. However, popular resistance caused this resettlement scheme to fail. The geographer who discussed this said that although the technology was there to provide a solution, the political situation was one which the government could not handle, resulting in no resettlement and the probability that disaster will strike again.

Conclusion

Two Canadian aid projects in the transfer of remote sensing technology have resulted in an increased capacity in Thailand to apply technical knowledge to the management of natural resources. Among a group of Thai informants who

participated in these projects experiences were varied in terms of: the access they had to the technology, and the extent to which they used it to inform others; the process of interpretation and verification of remotely sensed data about their country's resources; the extent to which the technology can contribute to the amelioration of environmental problems in the course of Thailand's national development; and the use which can be made of remote sensing technology for resource planning and policy formation. In answering the questions of access, and of planning and policy formation responses varied according to occupational position. In answering the questions about the processes of learning the technology, and its contribution to national development, responses varied along disciplinary lines.

Chapter V. Conclusion

During the decade of the 1980s Thailand was becoming a middle income, newly industrialized country (NIC), with a rapidly depleting stock of natural resources. In this same period Canada donated two projects in remote sensing technology intended to further Thailand's capacity to manage its natural resources. One project, sponsored by CIDA, had a costly hardware component, and an application support component, the part of the project under study here. This component would apply the technology in several areas of resource management. The second project, sponsored by IDRC, was directed to surveying and mapping Thailand's mangroves. The CIDA application support component and the IDRC project are examples of the transfer of technical knowledge.

Technical knowledge of remote sensing goes beyond knowing how to receive and analyze data from satellite images and computer compatible tapes; technical knowledge provides the capacity to interpret, forecast and manage resources. Built on the mechanics and theory of the technology, it incorporates also knowledge derived from fields pertinent to the resources to which it is being applied. Thais involved in the transfer of technical knowledge have an academic background, usually in the natural sciences or geography, and use the technology in activities contributing to the management of resources. These also are the people called upon to advise in the formulation of policy for applications of the technology to resource

management. Technical knowledge, including remote sensing technical knowledge, closes the "gap" between the assessment of resources and their management (Thacher 1986).

International assistance programs in the transfer of technology for resource management have the ultimate goal of development. But development is elusive and the paths chosen to reach it must be carefully chosen. When technology transfer programs begin the application intended should be agreed upon by donor and recipient, based upon the donor's experience and the recipient's priorities.

Development can be defined using various concepts. The two most frequently used at this time are economic growth, and sustainable development. Specific ODA projects do not usually address the issue of the concepts of development or their operational objectives. This was so in the case study of the two projects treated in this thesis. But transferred technical knowledge comes in a context of expectations of how it will be used and for what ends as a part of the process of directed change called development. It is not sufficient simply to define sustainable development as growth managed sustainably, as did the World Commission on Environment and Development (1987). If, as Lélé (1991) argues, growth may or may not result in the elimination of poverty, then growth may be a result of sustainable development but cannot be included in its operational definition. Ultimately, ODA projects must be directed to increasing growth or sustaining development.

A strategy of technological control seeks to increase a developing country's knowledge and capability. Experience, and the transfer of technical knowledge needed to apply a technology to the resources available, are vital to the process of transfer of technology. In reference to IDRC's program to transfer information technologies, this has been recognised;

[It] ... is especially interested in activities that generalize and package experience with information-handling tools and methods so that developing countries themselves can make more informed decisions on the appropriateness of these techniques for their needs and hence make best use of scarce resources (Cliche and Valantin 1988: 369-370).

When a technology is transferred, the recipient should understand the context in which it was developed, as well as how previous experience has defined the operation and application of the technology. The recipient also will have expectations as to how the technology will be used, and what benefits it will bring. Thus, at the donor end there will be input, or a context of goals, values and expectations. At the recipient end, output is determined by the input, modified by the context in which it was received. The input and output contexts probably will limit the amount of technological control actually achieved.

This study has considered the output of two projects in the transfer of remote sensing technology. Remotely sensed data and technical knowledge of how to analyse that information resulted in a better-informed policy-making

process which can react with greater speed to a changing economic and physical environment.

However, because expectations as to how the technology would contribute to the management of natural resources were not made explicit in the CIDA project the effectiveness of the technological control achieved by the transfer of knowledge was diminished. A conflict of interest over the management of mangrove resources was neither initiated nor exacerbated by greater technological capacity but policies which reflected input from the new remote sensing capacity were not consistently environmentally sustainable. Future technology transfer projects might explore how remote sensing technology, in concert with geographic information systems for forecasting, can contribute to rational, coordinated national planning for the sustainable development of Thailand's mangroves.

The IDRC project to survey Thailand's mangroves was able to assess their extent, and to document the severe losses which have occurred recently; however, the accuracy figures indicate that further work on classification is needed and that perhaps the technical capacity of remote sensing to monitor violations of the zoning plan is overestimated.

The perception that transferred technical knowledge can contribute to policy and planning may be deterred by cultural factors which should be explored when designing projects. Most of those who participated in the CIDA and IDRC projects did

not make the connection between their technical and resource management expertise, and an advisory role in policy and planning. Role and status, the full dimensions of which have not been explored in this study, may be barriers to a more active participation in management. Recognition that this contribution can be made is seen in plans for the installation of a GIS at the Thai development planning board, and the support for this that comes from the top levels of the Remote Sensing Division of the NRCT.

The present activities of the informants, at the NRCT and the Departments of Forestry and Fisheries, reflect an unsettled period in Thailand's management of its natural resources. This is typical of the bureaucratic response to a changing situation, in which civil servants lack guides to follow. After a radical shift in policy (the logging ban), the Forestry Department now devotes more time to conservation and popular education in the effort to preserve the mangroves. The Fisheries Department promotes use of the mangroves for aquaculture, in conflict with Forestry Department plans, and also to the detriment of Thailand's deep-sea fisheries. The Remote Sensing Division of the NRCT, monitors a zoning plan for mangroves which appears ineffective in preventing further depletion. These government agencies have considerable capacity in both remote sensing and natural resource management which could be effective with a coordinated plan for the ecosystem. The technical knowledge of remote sensing

brought to the plan combined with an academic understanding of the resources of the mangroves are needed for the sustained development of Thailand's coasts.

The mangroves are among Thailand's last frontiers. Marginal lands are sites of endemic poverty and the mangroves are no exception. While some middle-class concession holders are "striking it rich" in short-lived, extensive shrimp farming, the mangrove dwellers are seeing the source of their livelihood constantly reduced. The alternatives available to them need investigation - and action - to prevent them from becoming environmental refugees. The possibilities of making aquacultural activities more intensive and long-lasting should be promoted; the higher input costs would reduce the pressure for more concessions, and intensive production would provide more employment for mangrove dwellers while slowing the depletion of the forests, perhaps putting their yield on a sustainable basis. If the mangrove zoning system is to be successful the monitoring and policing activities of provincial and national forestry departments and the NRCT should be supplemented by intensified public education on the value of the mangroves.

The rush for economic growth and industrialization has not passed by Thailand's mangroves. Even in the back waters the push to convert the resources of the forests into cash endangers them. Frozen aquacultural products bring in badly-needed foreign exchange, and enrich those holding concession

licenses. However, the mangrove dwellers, as well as the ecosystem's flora and fauna, lose the basis of their subsistence with each new shrimp farm. Exploitation of the mangroves presently contributes to Thailand's rate of economic growth, but adds to the increasing disparity of incomes.

Environmental degradation and depletion reduces the options available, particularly to the poor who have already resorted to the last option open to them, settling on marginal lands. The zoning of the mangroves for economic development could keep the options open to mangrove dwellers by limiting any further development to activities which are sustainable. Economic development of the mangroves can be slowed to a pace which will neither endanger the forests, nor continue the current impoverishment of the low-income dwellers. The plan as it now stands provides inadequate protection for conservation areas, and mangrove dwellers are not served by the economic zones which, in practice, are devoted to commercial interests.

Can remote sensing technology, used in management and planning for the mangroves, be used for the long-term economic development of the mangrove dwellers? Or will use of the technology come to epitomize top-down planning for rapid growth which endangers the subsistence base of the dwellers by destroying the ecosystem? Two Canadian projects in the transfer of remote sensing technology have contributed to Thailand's capacity for natural resource planning. However,

the full potential of these projects to increase planning and policy coordination has not been realized.* The ambiguity of the Thai context in which the projects were implemented has resulted in a lessening of their effectiveness. Preservation of a marginal ecosystem competes with rapid economic growth as objectives to which the technology is directed. If depletion continues, the debate as to how the technology can contribute to development planning in the mangroves is likely to be for nothing.

Several lessons can be learned from the two projects. When technical knowledge is transferred, it is the responsibility of the donor to make clear the context in which the technology has been developed. Likewise, the recipient might make explicit the values, goals and expectations which will determine how the technology is to be applied. A part of the transfer could be devoted to exploring how the technology can be used in planning and policy formation. Projects can foster upward linkages, to national development planning agencies; they can include the training of planners in the technology, and demonstrations of the effectiveness of remote sensing in planning, particularly when integrated in a GIS. Projects can support, also, downward linkages to develop

* Some of the reasons for this failure certainly lie in the input of the projects. This would include how the technology is used in the exploitation of Canada's resources, but this issue has not been under study here.

effective public education in the benefits of using the technology; these can be directed at both the general public, and at people who make use of natural resources.

As agencies for international assistance adopt policies of sustainable development, it is necessary that they clarify the meaning of the policy in operational terms, and in terms of the expectations they have as to how the projects will be used. In response to the priorities of recipient developing countries, projects can be designed for the sustained development of their resources. "Sustainability can only mean something useful for policy formulation once a specific context has been identified" (Dovers 1989: 35). In a specific context the means of meeting the needs of a population on a sustained, long-term basis, can be considered.

In order for transfer of technical knowledge projects to be successful in promoting development which will benefit all sectors of society, including the most needy, an understanding of the context of that transfer must be held. Donors must understand the attitude held toward a recipient nation's resources, and the part they play in the socio-economic processes of that society (Miller 1989). Likewise, the recipient country should have an understanding of the context in which the technology was originally developed, how it is currently used, and the successes and failures experienced in applying the technology to planning and policy. A realistic

assessment of both contexts gives greater chance of success
for the project.

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APPENDIX

INTERVIEW SCHEDULE - REMOTE SENSING TECHNOLOGY

Name
Location

Date

Associated with CIDA project? _____ IDRC project? _____

Professional background

1. Employment history

What is your current job title?

How long have you worked at _____?

Where else have you worked in the past ten years?

2. What was your position in this (these) project(s)?

3. What are some other remote sensing projects you been associated with, before or after this (these) project(s)?

4. Could you tell me about your education - where did you go to university?

Do you have any graduate degrees? In what field(s)?

So, would you call yourself a _____?

Where have you received training in remote sensing?

5. Remote sensing is a rapidly changing technology. How do you keep up on the technology? Is it difficult to keep up?

Do you write articles about remote sensing?

Where are these presented/published?

Who do you hope to reach with these?

6. Do you have any interest in taking further courses in remote sensing? Do you plan to take these?

Do you use remote sensing in the projects you are currently working on?

Experience with the project(s)

7. Can you tell me about your involvement with the CIDA/IDRC project(s)?

How did you learn about it (them)? How did you get assigned to it (them)?

8. How many people were in the project(s)?
(CIDA project) How many were in each workgroup?
9. Were these people all in your field?
10. What sort of problems did you experience when it first started?

Was it important to _____ (institution) that you learn more about remote sensing? Why?

11. How long were you involved with the project(s)?
12. Can you give me a short account of the project(s)?

What were the goals and objectives?

Were they achieved? What was your role?

In what ways was (were) the project(s) successful?

Do you keep in touch with other participants?

13. What part did Canadians have in the project(s)?

How was your contact with them helpful to you?

Were there problems associated with this contact?

14. Before the project(s) did you have any international contacts with others involved in remote sensing?

15. Has your experience in the remote sensing project(s) resulted in increased contacts with those using remote sensing, here? ... internationally?

Technology transfer

16. Before this (these) project(s) had you used remote sensing technology in your work?

17. Could you describe the way you learned about remote sensing in this (these) project(s). Did all of the team members learn the same things simultaneously?

Was remote sensing a difficult technology to learn?

Is there more that you want to learn about it?

18. What roles did Canadians play in the transfer of the technology?

19. Have other foreigners (farang) been involved in this (these) remote sensing project(s)?

Have you worked with foreigners in other remote sensing projects?

20. Why were Canadians asked to support this (these) project(s)?

21. Have you had contact with Canadian manufacturers of remote sensing equipment?

In what way have Canadian firms been involved in training in the use of remote sensing?

22. Is this a difficult technology to learn?

23. Is it easy to transfer this technology from Canada to Thailand?

24. Did you benefit from working in a large team?

Do you prefer working in a large team or in a smaller group?

25. Do you have a chance to teach any remote sensing now in your present work? To whom?

26. Do you think this technology can be of use to farmers, fishermen or foresters?

Do you know of anyone who teaches them, using the technology?

What are the basic requirements for being able to use this technology?

27. During your work on the project(s) did you find there were aspects of the technology which had not been covered in the formal training you had?

28. When Canadians work with tapes or images of Thailand, do they encounter problems in the interpretation?

How are such problems of interpretation handled in a training situation?

Technical aspects of the project

29. What form(s) of remotely sensed data did you use in the project(s)?

30. How did you obtain the data?

Did you have any difficulties in obtaining it?

Do you have similar problems in other projects?

31. How much ground truth verification did you take part in?

How was the verification obtained?

Can a person skilled in remote sensing technology dispense with using ground truth verification?

32. What sort of ground experience is necessary to understand the data which are being transmitted by remote sensing?

Is interpretation a difficult skill to learn?

33. Do you think the Canadians involved in the(se) project(s) increased their knowledge about remote sensing from this experience?

34. Once you know how to use the technology, is it easy, or is it difficult to apply it to the assessment of other resources?

Have you used remote sensing for quite different problems?

35. Do you think the project(s) achieved its (their) objectives?

Remote sensing for resource management

36. What role does remote sensing play in the management of natural resources ?

37. Do you think that the use of remote sensing can help with the detection of the abuse of natural resources?

38. Can remote sensing help to spot environmental problems affecting resources which are caused by external factors, such as water pollution and upriver run-off?

39. How are Thailand's coastal resources used at this time?

Are there non-commercial uses that are made of the coastal resources?

Are these as important to Thailand's future as the commercial uses?

40. What do you think is the best use for Thailand's coastal water resources?

41. How is the use of coastal areas subject to government regulation?

What do you think the government is planning to do about developing the resources of the coastal waters?

Does the use of remote sensing technology promote the use of the coastal resources? In what ways?

Can remote sensing help to make these areas more productive?

42. Are there others here at _____ (institution) who would disagree with you about how coastal natural resources should be used?

In their view, how should these resources be used?

43. What types of natural habitats are found on Thai shorelines?

Can you describe any changes you have seen in the mangroves?

44. Can you tell me about the uses people make of Thailand's shorelines?

Can they also be used for other purposes?

45. On shorelines where mangroves have been cut, do you think they should be allowed to grow back, or should they be used repeatedly?

46. Is there a conflict between using remote sensing for assessing aquaculture sites and using it in the maintenance or rebuilding of mangrove forests?

Perception of environmental problems

47. What do you think are the main environmental problems facing Thailand at this time?

Does remote sensing help us to see environmental problems as they are occurring?

48. What should the researcher do if evidence of environmental problems is uncovered by the work of the project?

How does the researcher make this known?

49. Do you think remote sensing data can be made understandable to those who are not trained in the technology?

How can remote sensing images be used to reach commercial users of natural resources? individual users? .. government planners?

50. How can remote sensing contribute to the prevention or correction of environmental problems?

Models of development

51. (Besides environmental problems) What do you think are some of the major problems facing Thailand now?

What causes these problems?

52. Thailand's economy has been growing at a high rate in the past few years; is there any relation between this growth and the problems you describe?

Will the growth of the economy help Thailand to overcome the problems you describe?

53. Do you think individual Thais can help to deal with these problems? Why/why not?

54. Can remote sensing technology contribute to dealing with these problems?

Personal background

55. What year were you born?

56. Place of birth

(57. Sex)

END

2/3/1 2/92

FIN