

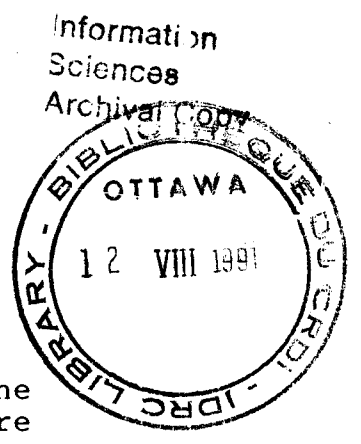
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REMOTE SENSING RESEARCH FOR DEVELOPMENT AT IDRC\*

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ABSTRACT

Within its Information Sciences Division, the International Development Research Centre supports a Cartography and Remote Sensing Program. This paper describes some of the remote sensing projects sponsored by the program in Chile, the Dominican Republic, Mali, Morocco, Nigeria and Thailand.

1. INTRODUCTION

The International Development Research Centre (IDRC) is a public corporation established by the Parliament of Canada in 1970 to stimulate and support scientific and technical research by developing countries for their own benefit. IDRC is somewhat unique among development aid agencies because it has stressed information sciences from the outset, in addition to its support for programs in agriculture, food and nutrition sciences; health sciences; and social sciences (Stone, 1985). Within the Information Sciences Division at IDRC, programs provide support for: information systems and services within various sectors of importance to development, including socio-economic information and scientific and technical information; development and distribution of a database management software package called MINISIS and other computer-based tools; operation of the IDRC Library; and research and experimentation with different information technologies, tools and methods.

The latter Information Sciences Division program, known as Information Tools and Methods (ITM), provides support for research and experimentation covering a variety of technologies and disciplines, including informatics, telematics, cartography and remote sensing, micrographics and other storage technologies, and statistical systems and methods. Activities supported include: information systems, networks, and services on specific technologies and methods; technology assessment, selection, evaluation, and testing; feasibility studies and technology demonstrations; pilot projects and experiments; technology introduction and transfer; technology adaptation and development; education and training; and documentation and exchange of experience (ISD-IDRC, 1987).

The ITM program was established to assist developing countries to acquire, manage, adapt, develop, and test appropriate information-handling tools using a variety of technologies and methods. ITM is especially interested in activities that generalize and package experience with information-handling tools and methods so that developing countries

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themselves can make more informed decisions on the appropriateness of these techniques for their needs and hence make best use of scarce resources (ISD-IDRC, 1988).

## 2. THE CARTOGRAPHY AND REMOTE SENSING PROGRAM

Although only a small fraction of IDRC's budget has been devoted to the field of cartography, the Centre has been involved in this field since the Information Sciences Division began operations in 1971. Some limited resources were made available during the first several years of operation to developing-country institutions involved in the production of thematic maps in support of development programs.

Soon after the launching of the Earth Resources Technology Satellite (ERTS, later renamed LANDSAT-1) by the United States in 1972, IDRC recognized the potential offered by spaceborne remote sensing for meeting the needs of developing countries for mapped information. During the 1970s, projects dealing with the application of remote sensing to provide natural resources maps were funded in five developing countries (Sudan, Bolivia, Tanzania, Bangladesh and Mali). Each of these projects represented a different experience in technology transfer and provided an opportunity to test the feasibility of applying satellite data for the production of thematic maps of importance to development. Although their results were not uniformly successful, they confirmed the hypothesis that remote-sensing techniques are applicable to developing countries and can offer an appropriate alternative to traditional mapping methods in obtaining needed thematic maps (LeBlond, 1982).

In the early 1980s, the Cartography and Remote Sensing program supported a series of 3 projects at the Regional Centre for Services in Surveying, Mapping and Remote Sensing (RCSSMRS) located in Nairobi, Kenya, at the Centre Régional de Télédétection de Ouagadougou (CRTO) in Burkina Faso, and at the Technical and Training Department of the National Remote Sensing Centre of China located at Peking University in Beijing. The former involved the development of a photo-mechanical procedure for producing photomaps based on LANDSAT-MSS data; the two latter were primarily concerned with the strengthening of the institutions' capacity in training in remote-sensing.

With this background of experience, the program recently started concentrating on research projects aimed at adapting, demonstrating, developing, and testing different and novel remote-sensing approaches, procedures, and methods. It also began to give support to activities of the more broader field of geomatics (Computer-assisted mapping, Geographic Information Systems, Facilities Management Systems, etc.) which is gaining in popularity in the developing world. In line with ITM's general philosophy, priorities are given to research activities on information tools and methods which could generate an impact and be beneficial to a broader community, and which are looking for solutions to information problems common to many nations in the Third World. Close links have been established with "applications" programs within IDRC such as Agriculture, Forestry, Fisheries, Earth Sciences, etc. and priority is high for support to projects on the use of geomatics for applications in these fields.

## 3. SELECTED HIGHLIGHTS OF THE PROGRAM

The following provides the reader with a brief description of the key elements of recent projects supported by the program. It is meant to

illustrate the variety of activities being sponsored by IDRC, as well as to highlight the specific types of projects in which the program is currently involved. Some of these projects are executed in cooperation with a Canadian research institution; others are entirely executed by developing-country institutions. Both avenues are eligible for IDRC support. In addition, IDRC promotes the execution of research projects by institutions of different Third-World countries joining their efforts and exchanging their expertise amongst themselves.

### 3.1 Remote Sensing for Artisanal Fishing of Tuna and Swordfish (Chile)

One of the key factors in the distribution of tuna and swordfish relates to the presence and stability of particular oceanic thermal fronts. In their search for tuna and swordfish, artisanal fishermen in Chile traditionally prospect the sea by measuring its temperature with thermometers. However, this prospecting strategy is not very efficient, since it only provides information on the point locations actually covered, and can only be carried out when sea conditions are appropriate. For these reasons, although the search time varies, it may be several days before fish are located. The longer the searching time, the higher the operating costs of artisanal fishermen's boats.

During the tuna and swordfish seasons of 1986 and 1987, remote-sensing and fisheries scientists from the School of Marine Sciences, Catholic University of Valparaiso (ECM-UCV), the Chilean Centre for Space Studies (CEE) and a limited group of experienced artisanal fishermen carried out a research activity aimed at improving the prospecting strategy of the fishermen. The method developed during these experiments introduced in Chile the use of the thermal bands of the Advanced Very High Resolution Radiometer (AVHRR), mounted on the NOAA series of remote-sensing satellites, as a tool to generate sea surface temperature (SST) charts. Although a number of problems were encountered, the preliminary results looked very promising.

IDRC is sponsoring a research project which addresses the main problems identified during these experiments. In essence, this project is aimed at reducing the delay in delivering SST charts to artisanal fishermen through the implementation of an electronic data transmission system between the NOAA ground-receiving station at CEE and the ECM-UCV; at enabling the researchers to further investigate the relationship between fisheries-related oceanographic conditions and sea surface temperature for tuna and swordfish potential site location; at designing and producing improved map products; at training artisanal fishermen in the use of these maps; and at providing complementary computer-based tools to improve the research capacity of ECM-UCV and CEE in remote-sensing technology applied to the artisanal fisheries sector.

This project offers the advantages of being executed with the entire participation of artisanal fishermen - who are a target group and ultimate beneficiaries of IDRC's support - and of being of direct relevance to them. In addition, the full use of local competence and expertise is promoted and links between two Chilean institutions are strengthened through our support. It is also foreseen that the results of this project may have a multiplier effect in other countries for artisanal fishing of tuna and swordfish and, potentially, for other fish species.

### 3.2 Remote Sensing and Land Use, Dominican Republic

For many developing countries, the lack of comprehensive information on their environment constitutes a major obstacle to sound national and sub-national planning. Access to land-cover/land-use information, and to information on the social parameters affecting them, represents a key

element in the planning process. In the Dominican Republic where the country's natural resources are intuitively felt to be depleting rapidly, very few studies have been conducted to quantify the rate of land degradation and the corresponding changing social environment.

A multidisciplinary team of researchers from the Centre for Urban and Regional Studies (CEUR) at the Universidad Catolica Madre y Maestra in Santiago (Dominican Republic), concerned with the lack of awareness and misconceptions on the causes of the country's land degradation, were supported by IDRC to carry out a study on the land-use changes over time. With the partnership of the Centre for Applications and Research in Remote Sensing (CARTEL) at the Université de Sherbrooke (Canada), land-cover and change-detection mapping were made based on LANDSAT-MSS data of 1973, 1979 and 1985 for the Western part of the Dominican Republic.

Statistics on the rates of land-cover changes were generated by comparing supervised classifications of pre-processed (for radiometric and geometric corrections) time series of LANDSAT-MSS data covering a period of 12 years. A ground-truthing campaign was performed to validate the results and to gather socio-economic data as well as information on the environmental changes as perceived by local populations.

This small project offered the novelty of using satellite remote sensing in support of a social sciences research activity aimed at providing a scientific interpretation of a quantifiable land-degradation process based on socio-economic and demographic parameters, such as changes and trends of the agrarian structure of the country. The results of the study have generated much discussion in the Dominican Republic and have increased the public's and policymakers' awareness. The need for a better understanding of local peasants' agrarian systems and for large-scale resource mapping have been identified as a requirement for potential responsive planning for the country. Consideration is being given by researchers of the Dominican Republic to the potential use of data from the second generation of remote-sensing satellites (LANDSAT-TM and SPOT) to ascertain and refine the results of this IDRC-sponsored project.

### 3.3 Remote Sensing and Agricultural Development Planning, Mali

Considering the persistent drought of the last 15 years and the lack of good rainfall distribution in the Sahel region in general, the Direction nationale du génie rural at the Ministry of Agriculture in Mali, has placed the highest priority on developing irrigation projects through a better understanding of the Niger River waters. The identification of potential sites where new irrigated agricultural development projects could be implemented is a most important step in the planning process. In Mali, such site identification is primarily related to the hydrological behaviour of the Niger River Valley which is traditionally studied by means of air-photos, meteorological data, and ground surveys.

The main factors complicating the identification of potential sites are out-of-date air-photos, the high costs of acquiring new ones, and the difficulty of studying the river valley morphology for a full annual hydrological cycle. In order to remedy this situation, IDRC is sponsoring a research project aimed at comparing the performances of SPOT and LANDSAT-TM data in studying and mapping at a scale of 1:50 000, the hydrological behaviour of the Niger River Valley for the Gao-Bourem region during a one-year period.

This project is being executed jointly by the Direction nationale du génie rural of Mali and the Laboratory for Remote Sensing at the Université Laval, in Canada. Supported by a ground-truthing campaign, the project involves the development of computer-assisted enhanced SPOT and LANDSAT-TM

images for visual interpretation using a PROCOM instrument , which will be transferrèd to Mali. Selected NOAA images will be acquired to complement the work based on SPOT and TM data covering 3 different and relevant times in the hydrological calendar year.

The Direction nationale du génie rural is fortunate to have local scientists who have already been trained abroad in remote sensing. Through support for this project, IDRC is helping these scientists to apply their expertise in remote sensing for the benefit of their country. The Direction is also mandated to apply the project results in agricultural development programs in Mali. The novel methodology developed by this project may offer a response for institutions of neighbouring countries confronted with similar problems.

#### 3.4 Remote-Sensing Contribution to Soil Mapping, Morocco

Medium-scale soil mapping inventories remain a problem for many developing countries. The amount of work and the associated costs represent the main constraints for completing and, in some cases, for starting such inventories using traditional methods. In Morocco, only the irrigated lands have been surveyed for soil resources inventories.

IDRC is sponsoring a project which looks at measuring and defining the potential use of remote-sensing techniques and data as alternative tools to substitute for costly and laborious traditional soil inventory surveys. Remote-sensing and soil scientists from the Institut Agronomique et Vétérinaire Hassan II (IAV) in Rabat, Morocco and CARTEL of the Université de Sherbrooke, Canada, have joined together in assessing the potential of LANDSAT-TM data for mapping the soils of arid and semi-arid Moroccan milieux.

An extensive radiometric measurements campaign is included in the project to construct a databank of spectral signatures of the principal soil and geomorphological units in the Haute Chaouia region of Morocco. An existing soil map at 1:100 000, produced by IAV in 1985, is used as a reference to develop and validate a new method based on supervised classification of calibrated LANDSAT-TM data integrating the spectral signatures' databank. The method developed will be further tested by mapping an area for which no soil map exists.

An important aspect of this project concerns the choice of a microcomputer-based Image Analysis System (IAS) and its installation at IAV. This will strengthen the capacity of IAV's Department of Soil Science to undertake soil mapping inventories using digital processing of remote-sensing data. A comprehensive review of available microcomputer-based IAS is being carried out by the researchers to define criteria for the selection of the most appropriate system for the purpose of the project.

#### 3.5 Resource Mapping - Sokoto-Rima Basin, Nigeria

For Nigeria, as well as for many other countries in Africa, better information on and management of natural resources are essential for improving agricultural production and ensuring food self-sufficiency.

The departments of Geography at the Universities of Lagos (Nigeria) and Waterloo (Canada) have joined their efforts for applying remote-sensing techniques in the field of resource inventory and mapping in the Sokoto Rima Basin in Nigeria. This basin, located mostly in the Sudan Savana vegetation zone in Northwest Nigeria, suffers major environmental problems and is subject to significant land-cover changes due to seasonal climatic

fluctuations as well as man-induced land modifications such as those caused by dam construction and "slash-and-burn" agricultural practices.

This IDRC-sponsored project is aimed at responding to the needs of the Sokoto-Rima River Basin Development Authorities for resource information; in particular, for the identification, assessment, and mapping of flood plains, and in the development of a methodology for assessing the amount of land under cultivation during both the dry and wet seasons and mapping and monitoring the extent of annual bush burning and firewood exploitation. Thematic maps at a scale of 1:100 000 are being produced for selected areas of the Basin using both visual and digital processing of spaceborne remote-sensing images. Supervised classifications and multitemporal enhancement techniques, aided by field visits and ground truthing, are used extensively. Recommendations for a practical methodology to obtain basic resource information using remote-sensing data are being developed.

While most of the computer-based image analysis is being performed at the University of Waterloo, the project has provided the Lagos team with a PROCOM instrument for visual interpretation of satellite images and a microcomputer-based MICROPIPS software package to undertake analysis of digital images for small sample areas and to prepare summary maps. The sharing of technical remote-sensing expertise and facilities at the University of Waterloo in the furtherance of the goals of the University of Lagos and the aspirations of the Nigerian Government with respect to transfer of technology is a most important objective for this project.

### 3.6 Remote Sensing and Mangroves, Thailand

In the coastal zones of Southeast Asia, mangroves are becoming depleted at an alarming rate. The magnitude of the problem and its potential danger have led to various research programs concerned with ecology, productivity, and economics of mangroves. In support of these, the need for updated surveys and improved mangrove monitoring techniques prompted IDRC to be responsive to a request from the Thai National Committee on Mangrove Resources, under the auspices of the National Research Council of Thailand (NRCT), to assess the use of remote sensing for developing a comprehensive information base on mangroves in Thailand.

Eight test sites were selected by the project involving those where mangrove environments are competing with human settlements, agricultural development, firewood exploitation, shrimp farming, mining activities, etc. which are, in many instances, detrimental to this fragile ecosystem.

The Remote Sensing Division of NRCT, together with researchers of the Royal Forest Department, has undertaken this research project aimed at comparing the efficiency of photo-interpretation of large-scale air-photos (panchromatic and colour infrared) with digital processing of LANDSAT-MSS data in order to develop and test an acceptable cost-effective method for mangrove inventory and monitoring. The need for periodic mangrove surveys and the difficulty and high cost related to air-photo acquisition have stimulated Thai researchers to look for developing an alternative and reliable procedure based on LANDSAT-MSS data. The presence in Thailand of an operational LANDSAT receiving station and image analysis facilities is certainly a key element for choosing spaceborne data as a potential alternative to air-photos.

In the first place, the results of automated supervised classifications of data consisting of geometrically-corrected LANDSAT-MSS channels 4, 5 and 7 and of a derived vegetation index (NDVI) were compared with those of the visual interpretation of a new series of colour infrared air-photos. The map compilation was made at scales of 1:250 000 and 1:50 000. The need to

discriminate between 3 classes of mangroves, which do not always differentiate spectrally, and the small dimensions of some of the terrain features are the main factors in limiting reliance on the computer-based method thus far used. In the second place, the project is looking at developing customized enhanced LANDSAT-MSS data in printed form for visual interpretation. It is believed that this mixture of computer-based image enhancement and the use of skilled photo-interpreters could resolve some of the problems encountered and increase the accuracy of classification results.

If an efficient satellite remote-sensing procedure for mangrove inventory and monitoring can be defined, many tropical countries may be interested in adapting it to their particular conditions.

#### 4. CONCLUSION

Preliminary inquiries and proposals often reach IDRC through one of its regional offices, which serve as the Centre's link with the researchers and policymakers of the developing countries. IDRC operates offices in Bogota, Cairo, Dakar, Nairobi, New Delhi, and Singapore, in addition to the head office in Ottawa. Normally, only requests submitted by developing-country institutions are considered for funding. Proposals are evaluated against a variety of criteria dealing with the relevance of the proposed project's economic and social development, with the developing country's interest and commitment, with the scientific merit of the proposal, and with the potential for application of the results. Institutions receiving an IDRC grant are themselves expected to make a substantial contribution to the project, proportional to their ability to provide such support.

As described in the various project examples in this paper, IDRC's Cartography and Remote Sensing program provides support to institutions with previous expertise, at different levels, in remote sensing technology. Through support to research projects for specific applications, the program also contributes to the strengthening of the research capacity of institutions having a key role to play in the development of their countries and regions.

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