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IMPLEMENTATION OF SPACE SATELLITE REMOTE SENSING PROGRAMS  
IN DEVELOPING COUNTRIES (ECUADOR)

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16. Abstract  The current state of space satellite remote sensing programs in developing countries is discussed. Sensors being utilized and results obtained are described. Requirements are presented for the research of resources in developing countries. It is recommended that a work procedure be developed for the use of satellite remote sensing data tailored to the necessities of the different countries.			
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IMPLEMENTATION OF SPACE SATELLITE REMOTE  
SENSING PROGRAMS IN DEVELOPING COUNTRIES  
(ECUADOR)

\* / 1

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Center for the Combined Surveying of Natural Resources  
by Remote Sensors (CLIRSEN)\*\*

1. SUMMARY

Remote sensing is being widely used in developing countries. These vary from the use of aerial photography with visual interpretation to the use of all types of processed information employing the most sophisticated methods of space satellite remote sensing.

This results in that the problems of these countries are all different to date and at the same time requiring different analysis for devising possible solutions.

The study of these problems are facilitated by receiving the process that inevitably must be followed in the implementation of the national programs of remote sensing and noting at what stage of this process each country finds itself in order to establish the corresponding solution. This methodology of analysis also permits the determination which groups of countries have common problems, thus facilitating the effective application of regional programs.

2. INTRODUCTION

Since the launching of the first technology satellite for detecting Earth resources in 1972, known as LANDSAT-1, some developing nations started to implement centers of study for satellite generated information, to study the advantages and limitations and their correlation with the information obtained by traditional methods of

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\* Numbers in margin indicate pagination of foreign text.

\*\* Spanish Title: Centro de Levantamientos Integrados de Recursos Naturales por Sensores Remotos (CLIRSEN), Quito, Ecuador

remote sensing.

Once its usefulness had been demonstrated several countries installed receiving stations in order to obtain information on a regular and timely basis. The development of modern techniques in the interpretation of satellite remote sensing data has made the use of digital analysis of images common and increasing the advantages in the study of natural resources.

Where the technology has been evolved, this was used at the Center of Remote Sensing already in existence, but where these centers have not been developed, the distribution and actual use of the technology has been rare. /2

This circumstance has caused a wide variation in the availability of satellite remote sensing in developing countries.

The purpose of this study is to prepare a critical analysis of this situation and present the best alternatives to cover the requirements in this field.

### 3. THE CURRENT STATE OF SPACE SATELLITE REMOTE SENSING IN DEVELOPING COUNTRIES

#### 3.1 Sensors being utilized

The large majority of developing countries have been using aerial photography for many years as the most practical sensor to study natural resources and preparation of basic cartography.

In many countries, airborne magnetometers, gravimeters and radiometers have been used sporadically for the purpose of exploring for hydrocarbons and minerals, even before remote sensing was defined and applied as a specific discipline. In recent years certain countries have performed partial or total surveying of their territory

using radar and also other sensors, such as multispectral cameras and different types of scanners.

As for the products of satellite-borne sensors, these are not utilized much in certain countries. In some countries a great deal of use has been made and great benefit has been obtained.

### 3.2 The use of the information

In the developing countries there exists a great variety and wide range of use of the information generated by the remote sensors. In summary the following classification can be made:

- a. Countries that principally utilize aerial photography and traditional methods of photointerpretation.
- b. Countries that use aerial photography, radar images and LANDSAT images, utilizing traditional methods of interpretation and for general studies. 13
- c. Countries that utilize the same information as indicated in b. but with advanced methods of interpretation and digital analysis.
- d. Countries that are developing methodologies using different types of information provided by a variety of image sensors and recorders that detect information on natural resources and geological, geographic and environmental conditions.

### 3.3 Results obtained

The results obtained from the use of different sensors and the information they provide are also very diverse and depend principally on the interest and priorities of the developing countries to explore and exploit their natural resources. In general, it can be said that the studies and projects of remote sensing have been oriented as follows:

- Geologic mapping for use in water, hydrocarbon and mineral exploration.
- Identification and use of land capacity for agriculture.
- Forecast of crops, forest inventories and the determination of the growth of deserts.
- Determination of roads and crossing for the construction of railroads, highways, channels and other surface infrastructure complexes.
- Localization of zones for irrigation and flood areas.
- Preparation of basic and specific cartography at different scales.
- Studies of coastal and ocean zones and the localizing of schools of fish and shrimp.

The research done on the resources has only partially been completed in the majority of the countries and at different levels with different limitations on economic and human resources and technical equipment.

#### 4. REQUIREMENTS FOR RESOURCE RESEARCH IN DEVELOPING COUNTRIES

##### 4.1 The importance of natural resources

The progress and economy of the developing countries are sustained principally by the use of their own natural resources. In the industrialized nations on the other hand, these factors are sustained by specialized services, manufacturing, distribution, financing and to a lesser degree, the use of its resources.

Two final points then stand out that our countries should be involved in: First, to provide service and technology for the exploration, operation and marketing of our natural resources and later, with our remaining funds, procure its socio-economic development.

Five large groups of natural resources exist that are within the reach of the developing nations of America:



1. agriculture and forestry
2. hydrocarbons
3. minerals
4. non-conventional energy sources
5. fishing

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These resources have been generally utilized with the technology and capital provided by industrialized countries which in turn were provided in accordance with their own priorities and programs as outlined by these same countries to satisfy the requirements required by the level of development.

Present requirements for the plans outlined by the governments to satisfy these requirements and which require a budget to implement them makes it necessary for the respective priorities and programs to be set up by each individual country. This is possible only if the basic information for the quantification of the natural resources that can generate income is available (for example, the available human element and the means for the utilization of this information).

#### 4.2 Basic information

The factors that govern the basic information that a country should possess concerning its resources are the following:

1. Territorial area and geographic distribution of population.
2. The nature of its resources and complexity of the geography.
3. Immediate and median goals that should be achieved as well as the level of studies to be realized.
4. Objectives and strategies for the development of the country and the priorities for investment.
5. The capacity of the country to assimilate the information on its resources and to put it into operational use.

#### 4.3 The human factor

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The proper use of the basic information requires a competent human factor at three different levels:

a. Technical and scientific, to obtain the maximum use of the basic information by means of adequate interpretation and analysis.

b. Administrator, to properly channel the efforts that the state provides in the research of its resources while rationally operating and/or directing and executing the plans and budgets that are outlined. These are compared with the income they generate.

c. Planners and those in decision making levels of the government who control the proper use of the product obtained from the information processed by the technicians, establish the programs and priorities of the country for use and marketing of its resources to anticipate the income from these resources and assign these funds to those projects that will most benefit in the welfare and development of the nation.

In the developing countries, it has been very difficult up until now to count on a properly trained and indispensable human element for each of these levels. And it is even more difficult to establish a proper understanding of the technology of remote sensing, and its advantages and limitations so that each level may perform its function.

Our countries cannot generally count on the sensors and space platforms required to obtain the information for the same reason that the distribution of this information is not always available, nor can it be interpreted on the national level.

#### 4.4 The means of utilizing the information

Once the basic information has been produced, it should be promptly utilized and more importantly, modern techniques should be used for its interpretation.

Even though good results are obtained by a visual process as by photo interpretation, the principle use of certain images or multispectral information should only be determined using digital analysis.

Nevertheless, if it is difficult to establish and implement a program for acquisition of basic information, contracting or purchasing sensors and space platforms as installing receiver stations and processing satellite images, it is even far more complicated to sell the idea of setting up a complete center of visual interpretation and mechanical analysis for the purpose of space satellite remote sensing.

It then becomes necessary that the technical and scientific levels of administration, planning and decision making, understand that the ideal research project using remote sensors should incorporate necessary means for proper and complete analysis of all basic information obtained.

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## 5. IMPLEMENTATION OF NATIONAL PROGRAMS OF SPACE SATELLITE REMOTE SENSING

### 5.1 Aspects that should be considered

The situations brought out in the previous chapter require possible solutions to the problems that confront developing nations in the area of space satellite remote sensing. When it is desirable to implement a program of remote sensing, all the processes leading to satisfactory results should consider the following aspects:

1. Creation and structuring of a national center for remote sensing
2. dissemination of technology and the instruction of personnel on the national level
3. establishing of studies and projects in coordination with other institutions

4. implementation of programs for the acquisition of basic information and its distribution
5. installation of facilities for mechanically processing information
6. permanent and coordinated action by the center of remote sensing in its national activities relating to natural resources in the different levels of technology, administration, planning and decision making.

## 5.2 The national program of remote sensing in Ecuador

In order to better appreciate the previously described material, the implementation of any national program on remote sensing, the Latin American countries can be used as an example. Within these, the case of Ecuador can serve as an illustration.

### 5.2.1 The creation of CLIRSEN

On December 7, 1977, the Center for Combined Survey of the Natural Resources using Remote Sensors (CLIRSEN) was created by decree No. 2027. Its functions were:

- a. prepare a list of natural renewable and non-renewable resources
- b. to plan, organize, direct, coordinate, execute and control the activities concerning remote sensor technology
- c. contribute to the cartographic surveying of Ecuador and the preparation of up to date maps, and
- d. provide a consulting service to the public and private institutions on subjects related to this activity.

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These functions are implemented by the following organizations:

- A directorate composed of six representatives from different institutions relating to natural resources and who design the politics of the center and approve and control the budgets and annual programs.

- The executive staff that plans, directs, administers, participates in and supervises the programs of the center that have been formulated by the directorate.

- The technical administrative management that covers the activities of financial administration, industrial relations and general services.

- The operation management that executes the technical operational work in the applied fields of geology, hydrology, agriculture, forestry, oceanography and geography.

We have attempted to ensure that personnel occupying the different positions in the institution be selected from the best persons qualified in the country within his respective specialty. Actually,

<u>Specialty</u>	<u>Number</u>
geological engineer or geologist	7
agricultural and forestry engineer	6
petroleum engineer	4
geographical engineer	3
industrial engineer	3
hydrologist civil engineer	3
electronic engineer	2
marine biologist	<u>1</u>
total	29

#### 5.2.2 Programs for dissemination and instruction

Since the initiation of activities CLIRSEN has tried to place within the reach of institutions and technicians concerned with natural resources the information on advantages and limitations of satellite remote sensor data. With this in mind, it has edited different publications, organized conferences and expositions with national and foreign technicians and prepared courses, seminars and

technical meetings on the national and regional level, of which the following meetings should be noted:

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<u>course, seminar or meeting</u>	<u>date</u>	<u>number of participants</u>
first national seminars on the use of remote sensors in the inventory of natural resources	July 9-12, 1979	89
training seminar on the automated interpretation of images	April 14-18, 1980	25
first reunion of the professional Latin American specialists in remote sensing (co-sponsored by AID)	Nov. 24-27, 1980	64
Introductory seminars course on remote sensing	Nov. 9-20, 1980	56
Introductory seminar course in remote sensing applied to the field of agriculture	March 6-20, 1982	60
Seminar on the technology of the satellite SPOT and its application in the research of natural resources (cosponsored by SELPER and CNES)	April 12-16, 1982	80

5.2.3 Carrying out of studies and projects in coordination with other institutions

The ample dissemination of technology, instructions for scientists from different institutions and research on basic information requirements of space satellite remote sensing has made possible a coordinated effort on applications of satellite remote sensor data on a broad scale in Ecuador.

To date, the following agreements have been formulated:

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<u>Group</u>	<u>Agreed objective</u>	<u>date</u>
INEC	implementation of a system for statistics on agriculture and cattle	Nov. 1, 1979
IBM	training of CLIRSEN technicians on the digital interpretation of sensor images in Ecuador	April 2, 1980
CEEA	Research on radioactive minerals	May 29, 1980
MAG	inventory of the forestry resources of Ecuador	June 12, 1980
INCRAE	integral diagnosis of the Amazon region of Ecuador	June 27, 1980
NATURE	diagnosis of the environmental situation of Ecuador	Oct. 31, 1980
NATIONAL POLITECHNIC SCHOOL	evaluation of the ichthyological resources of the Amazon region	Jan. 22, 1981
CEPE	surveying by radar and airborne magnetometers	June 5, 1981
BID	preparation and instruction of a master plan for the use of remote sensors in Ecuador	Oct. 8, 1981
INERHI	list of possible dam sites of the basins of the Jubones, Canar and Paute rivers	Feb. 15, 1982

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Implementing the different agreements between institutions has allowed the preparation of studies and projects of this country, utilizing to the best advantage the human and economic resources and the internal organizations of the different entities. The application of satellite remote sensing in this context has made it possible to obtain practical results in a much shorter time and with lower costs.

A typical example has been the evaluation of the natural resources in the central and southern portions of the Amazon in the Amazon region of Ecuador, which utilizes the agreements signed by

the Minister of Agriculture and Cattle (MAG) and INCRAE. The northern portion of the Amazon region will also be studied during the technical training program with BID. Then a complete study of this region would have been made employing inter-institutional coordination (Figure 1).

#### 5.2.4 Implementation of programs for the acquisition of basic information

Another of the benefits of working cooperatively with several institutions has been implementing the CEPE-CLIRSEN agreement during which a radar survey will be performed on a section of the Amazon region as well as an airborne magnetometric survey of the Ecuadorian coast, including the sub-ocean shelf. These projects will be performed during 1982 and 1983. By taking advantage of the fact that sensors are being used in the country itself, CLIRSEN will undertake additional survey projects in other areas, using the funds that the national government has designated for this purpose (Figures 2-3).

In addition, there has been coordination with internal regional institutions, such as CREA, PREDESUR, Provincial Council for Emeralds, etc., to make radar and/or airborne magnetometer surveys in specific sectors which comprise the areas of their respective jurisdictions.

Considering that the costs for obtaining this information will be considerably reduced with this coordinated project and that later this information will be distributed among various institutions associated in the research of natural resources that request it, the value of the Center for Remote Sensing in Ecuador can be appreciated.

In the past, a great deal of similar information has been obtained but it has not been possible to store it, and a great portion of it has not been available. We feel these problems are common to many developing countries and could be solved in the same manner in which they are being solved in Ecuador by an entity that centralizes the remote sensing activities.



Within this project of the acquisition of information, CLIRSEN has proposed the conversion of NASA's tracking station in Cotopoxi into one for receiving and processing satellite information, which would also cover the void that exists in this part of the continent--the northern part of South America and all of Central America, where the receiving stations of Brazil and Argentina cannot receive data signals.

One benefit for the countries involved in this project will be that in the future there will be timely distribution of the satellite data that is required for the study of natural resources. Here we have a clear example of what should be attempted within the developing countries to resolve their common problems.

In Figure 4, one can see that a certain number of countries within the radius of action of an existing receiving and image processing station at Cotopoxi, Ecuador would suffer from the following common problems:

1. Reduced territory (of reception) compared with areas controlled by the larger countries of the continent.
2. Difficulty in timely acquisition of satellite information.
3. Lack of methodology for the interpretation of satellite information, considering the reduced area of their agricultural zones, small areas of mineral and hydrocarbons, etc.
4. Lack of human resources specialized in the methodology of research required by these countries.
5. Lack of research centers that can develop the necessary methodology and teach the candidates once they have been selected.

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This is explainable because the large countries that possess receiving stations probably expend their efforts in obtaining the great volume of information on their territory as regularly as possible. In the same way, they will dedicate the time spent on research to vast agricultural areas as in discovering and developing the large mineral resources and hydrocarbon yields that are of

prime interest, to be explored first; postponing for an indefinite period of time the study of the smaller areas.

If it ever comes to pass, as CLIRSEN anticipates, establishment of the receiving station at Cotopoxi would mean the first step would have been taken in resolving the problems of the countries of that region. Then thought should be given to the implementation of a central region for research and training in satellite remote sensing that will develop and disseminate the techniques and methodology for the tasks that these countries require. This could be one of contributions that the United Nations could provide to the countries of that region.

#### 5.2.5 Installation of digital processing facilities

To date, CLIRSEN counts on sufficient equipment to provide adequate visual interpretation of information originating from their remote sensors. In addition, CLIRSEN works with the computer PRIME 550 at the Military Geographic Institute, which provides calculation services for forestry data.

In spite of this, the major benefits of this satellite information are well known using digital processing. For this reason, a requisition has been initiated for a digital image processor which will include the following:

- 1 centralized processing unit
- 2 disk record units
- 1 tape unit
- 1 video system
- 1 color-graphic reproducer
- 1 printer-graphic reproducer
- 1 screen terminal

This equipment will be utilized and expanded upon once it is found that the BID agreement is active and in this way the consulting service for the interpretation of satellite images, CLIRSEN, will

be sufficiently complete.

It is hoped that the equipment to be acquired and installed /12 will permit the proper implementation of a national system of information on natural resources, that will allow the government planners to provide the basic information for an outline of the national programs and permit exploiting the resources in a reasonable manner as well as enjoying the income generated by the planning and efficient execution of infrastructural tasks within our national capacity.

In this way, CLIRSEN, like other centers for remote sensing, can participate in all the activities that are developed on a national level, that are related to the exploration, exploitation and utilization of the natural resources of Ecuador.

#### 6. Conclusions and recommendations

1. The state of the art of satellite remote sensing in developing countries is very diverse. It varies from the simple use of aerial photography in some cases to the utilization of all types of information on remote sensors and advanced methods of interpretation.

2. This means that the requirements of the developing countries in the area of satellite remote sensing will vary. For the same reason, they require different solutions.

3. The analysis of the requirements and the statement of the solutions are facilitated following the process that results from the implementation of the national program for satellite remote sensing in developing countries (Chapter V). At some date a country could find itself in any of the phases of this process and as such, should then direct its effort to overcome that phase and continue in its progress.

4. For the implementation of regional progress, one has to consider the actual state and common requirements of the different developing countries so that the assistance provided by the international organizations can be mainly channeled to satisfy their requirements and not to establish major differences between countries in the use and handling of the information provided by the remote sensors.

5. It is recommended that a work procedure be permanently developed in the application of satellite remote sensing data tailored to the conditions and necessities of our countries so that no decrease in the interest of satellite information occurs. In addition, the information should be available regularly and promptly and costs should not be increased. The reverse could then occur, of the continued use of traditional methods and techniques, which would delay even more the process of research and utilization of natural resources of developing countries.

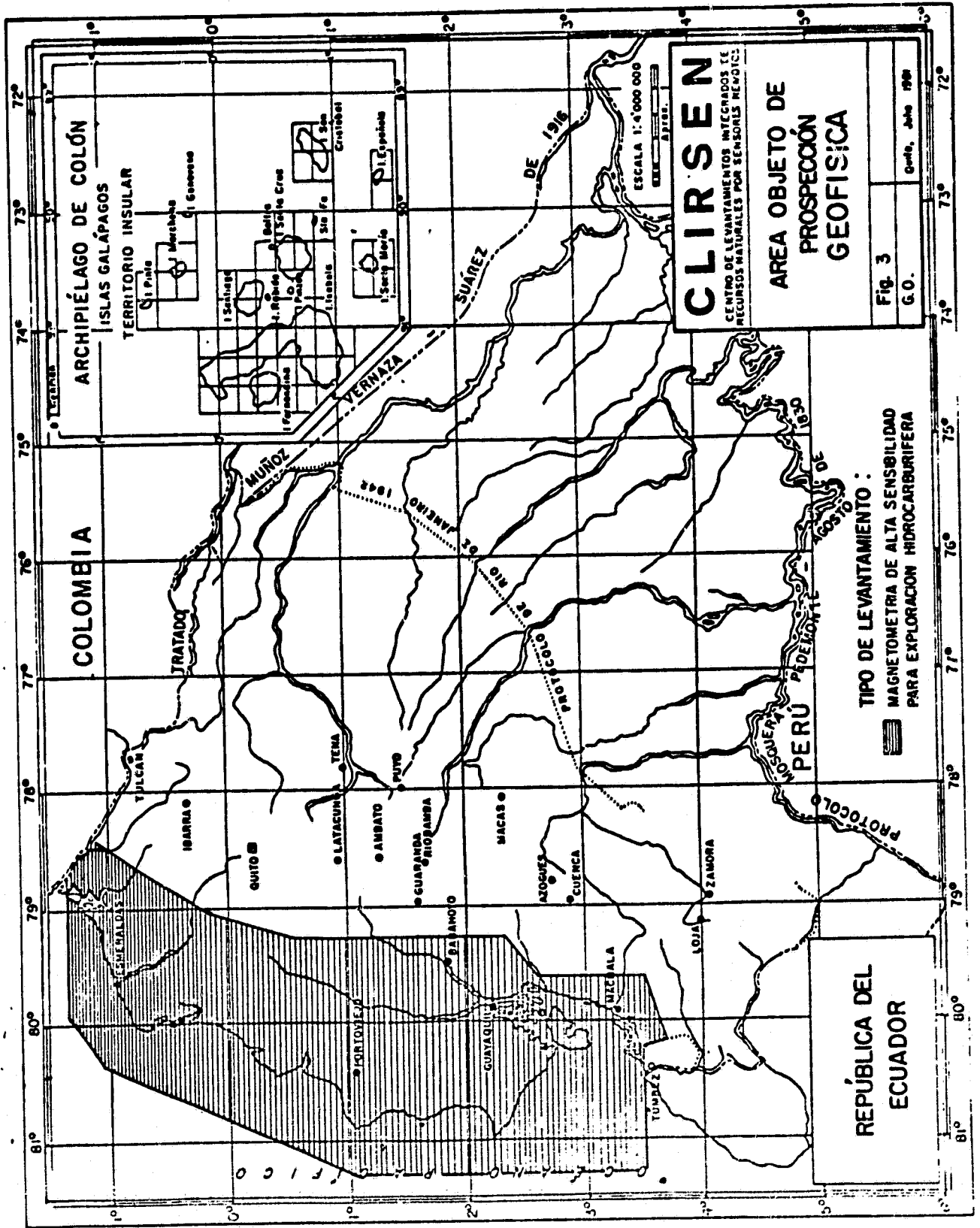
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REPÚBLICA DEL  
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**CLIRSEN**  
CENTRO DE LEVANTAMIENTOS INTEGRADOS DE  
RECURSOS NATURALES POR SENSORES REMOTOS

AREA OBJETO DE  
PROSPECCIÓN  
GEOFISICA

TIPO DE LEVANTAMIENTO :  
MAGNETOMETRIA DE ALTA SENSIBILIDAD  
PARA EXPLORACION HIDROCARBURIFERA

Fig. 3  
G.O.

Quito, Julio 1980

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