Remote Sensing in Mexico: An Application in the Agricultural Sector

Guillermo Arita
Juan Manuel Galarza

Centro de Estadística Agropecuaria,
Secretaría de Agricultura, Ganadería y Desarrollo Rural, México

ABSTRACT: In order to improve the quality of Mexico's agricultural statistics, CEA/SAGAR has conducted several projects to explore the feasibility of using remote sensing and geographic information systems. Studies have been conducted in areas with large farms that use modern agricultural production methods, and in areas with very small farms that use more traditional methods of farming. One result has been the proof of the hypothesis that the quality of crop area estimates developed using traditional survey methods has been significantly poorer for areas at some distance from the Ministry of Agriculture field offices.

1. Introduction

In the last twenty years, Mexico has been involved in many recurrent crises that have impacted the agriculture sector. Among the problems were the limitations and poor quality of some of the basic agricultural statistics. In 1995, at the beginning of this Administration, the Minister of Agriculture started an ambitious project called "Sistema Nacional de Información Agropecuaria" with a goal of improving the quality of agricultural statistics and information. The initial diagnosis of the project pointed out three main problems:

- obsolete methodology including field measurements, data collection, data processing and publication of the statistics,
- lack of coordination between producers and users of the information, and
- a very poor infrastructure in telecommunications hardware and software in the agricultural sector.

To increase the quality of the agricultural information, we applied three areas of technology and statistical methodology which were:

- Remote sensing and Geographic Information Systems (GIS),
- Sample Surveys, and
- Information technology.

Each of these efforts required a large investment in training and human capital development, and also a hardware investment.

One hypothesis about data collected under the historic methodology states that quality was significantly poorer in areas distant from Ministry field offices. This paper will concentrate on the application of remote sensing to analyze this hypothesis for crop acreage estimates and discuss how the other technologies also aided this analysis.

2. Remote Sensing Projects in SAGAR, Mexico

In Mexico, the agricultural year is divided into two crop season cycles. The "Autumn/Winter" cycle mainly involves irrigated agriculture for commercial purposes. Irrigated agriculture accounts for approximately one third of our principal grains and oilseed production. The "Spring/Summer" cycle, which is mainly non-irrigated and includes much subsistence farming, accounts for the other two thirds of this production. Agriculture in Mexico may be further characterized by its two types of production technologies, "modern" versus "traditional". Modern production states such as Sinaloa, Tamaulipas and Sonora have yields of 5 tons per acre, while traditional production states such as Oaxaca, Tlaxcala and Chiapas produce 500 kilograms per acre.

Since 1995 we have been working on several projects:

- Spring/Summer crops from the 1995 season in Morelos,
- Autumn/Winter crops from the 1995-1996 season in Tamaulipas,
- Spring/Summer crops from the 1996 season in Guanajuato, and
- Spring/Summer crops from the 1997 season in Zacatecas, Durango, Estado de Mexico, Jalisco, Chiapas and Guanajuato.

2.1 Coverage of Landsat TM Images

During the last three years, we have obtained thirty Landsat Thematic Mapper (TM) images covering nine states across the country during both crop cycles. The TM sensor measures reflected light in seven bands of the electromagnetic spectrum. These measurements are taken from a 30 meter (square) ground area, known as a "pixel". One TM scene covers an area of 185×170 km, approximately 42 million pixels.

We have conducted this work in all types of land areas, including Morelos with very small pieces of land planted with corn, Tamaulipas with 200,000 acres of sorghum in one concentrated area, and Jalisco which combines both sizes of areas planted. The northern states have very large areas of corn and wheat production and use modern technology, while southern states have many small farms and use older, more traditional methods. We have found out that remote sensing is more precise in the north than in the south. This is consistent with the relationship between the average field size in an area and the size of a pixel.

2.2 Resources Used

To conduct these projects, the following resources were utilized:

- four PCs with Windows NT in a LAN environment to manage the geographic information (including data bases of the GPS campaigns and Digital Cartography),
- ERDAS image processing and ArcInfo GIS software,
- one Motorola Global Position System GPS unit and Geolink software,
- a technical staff of four persons, and
- four students of the National University working for free.

2.3 Expected Products

Short Range Product: Once the crop area planted is estimated, we will be able to make an estimate of the production with the yields that were found via sample surveys. This exercise can be done by region, by product and by agricultural cycle.

Long Range Product: With the continued development and expansion of this effort, we expect to have an "Agriculture Resource Inventory and Monitoring System" in Mexico that meets the statistical standards that we now expect.

3. Example of Procedures for Zacatecas and Durango

Zacatecas and Durango are the main producers of beans in the Spring/Summer cycle. This is the reason why they were selected to be part of the estimation of area planted with the use of these new technologies and methodology.

The activities done in this project are digitization and georeferencing, GPS sample survey, image processing, and integration of information.

3.1 Digitization and Georeferencing

The following paper documents were converted to digital form (digitized) and/or registered to a map coordinate base (georeferenced):

- INEGI cartographic maps and CIMA census-type boundaries,
- Ministry of Transport Road Atlas, and
- Regional Rural Development Districts (DDRs) and previous statistics of SAGAR.

3.2 GPS sample survey

A GPS sample survey was done in Zacatecas, collecting information based on 345 randomly selected points. These were divided into classes such as good quality beans, regular quality beans, poor quality beans, corn, etc.

3.3 Landsat Thematic Mapper Image Processing

The Landsat TM images were programmed in the same period of time when we did the GPS survey near the harvest season for identification purposes.

There are two stages in the classification of the images:

- the automatic classification that is done dividing the "pixels" of the image in 60 classes, and
- the information obtained in the GPS survey is introduced in the "training" process of the computer for a supervised classification.

3.4 Integration of Information

The last part of the project is the integration of the information in reports that are sent to the States for verification and discussion. Some results for the project in Morelos are shown in Table 1.

Table 1. Comparison of Information Obtained by the Traditional Method and Remote Sensing in Morelos

Distance from Field Office	No. of counties	Area planted traditional method	Area planted remote sensing	Area planted as % of total	Mean[1] difference
		ha	ha	%	%
Far	10	9,033	19,140	40	173
Intermediate	18	23,336	19,347	40	58
Close	5	8,238	9,296	20	12
	TOTAL	40,607	47,785	100	18

[1] Difference of the absolute value

The first row of the table contains the counties more distant from our offices, and of more difficult access, while the last row contains the counties in which SAGAR has offices. This comparison proved our hypothesis that the farther the county the less precise the information.

After this project in Morelos, we did a new ground-based survey using GPS and found that the largest difference between the survey results and the remote sensing approach was 20 percent in a county with very small farms from 2 to 5 acres and a non-homogeneous kind of cropping pattern. These results have been encouraging and the new ground-based survey with GPS methodology and the remote sensing technology have indeed improved our crop acreage estimation system.

Acknowledgments

We want to point out that this is a joint project with the National Agricultural Statistics Service (NASS), the Foreign Agricultural Service (FAS) and the Economic Research Service (ERS) of the U.S. Department of Agriculture. They have been a great help with technical assistance, images, equipment and provided, more than anything, a lot of moral support.

Last but not least, we have been receiving considerable help from the Mapping Science Laboratory at Texas A&M University. They have been giving us technical assistance related to the new technologies and methodologies as well.