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AGENCY FOR INTERNATIONAL DEVELOPMENT

SPRING REVIEW OF LAND REFORM

THE CADASTER

by

Wolfram U. Drewes
OAS/Washington

June, 1970

(Abbreviated version, lacking photos for technical purposes)

SR/LR/A-12

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C O N T E N T S

I. INTRODUCTION.

In agrarian nations throughout the world, the agrarian reform movement has blossomed within the last decade. In Latin America particularly, it is closely related and is almost inseparable from the rural development process. Although initiated more than half a century ago in Mexico, the agrarian movement has spread to include the majority of Latin American nations today. Agrarian reform as we know it today has been systematized and organized whereby it can no longer be looked upon as the taking of land from the rich and giving it to the poor. Specifically the purpose of having an agrarian reform is to increase the productivity of the land, establish a more justified method of taxation, and permit those persons actually engaged in the use of the land to reap the benefits of their labor.

Without attempting to define agrarian reform, its success in some countries, or lack of success in other countries (topics which are to be discussed by others), the close relationship of a sound agrarian reform program to the cadaster should be stressed. A cadaster is the public record, survey or map of the value, extent and ownership of land which is used as a basis for taxation. Consequently, an orderly agrarian reform which would reimburse owners of confiscated lands would rely heavily on the existing cadaster and tax assessment.

II. THE RELATIONSHIP OF THE CADASTER TO AGRARIAN REFORM.

An agrarian reform program without a cadaster would be of extremely limited value. The agrarian program, to have much meaning, should include various cadastral facets: 1) property identification; 2) property titling;

3) resource inventory; and 4) tax reassessment. To omit any one of these component stages would seriously limit the chances of success of an agrarian reform project. And, only upon the completion of these facets can a sound administrative program be established that may lead to positive fiscal results and hopefully to local political stability as well.

Since agrarian reform activities usually pertain to rural area, the cadastral surveys considered in this paper will be rural cadasters. While urban cadasters are also urgently needed in Latin America, they are easier to handle in that ubran properties are more accessible, are smaller in size, can readily be measured, and are usually better recorded. In rural areas property ownership is frequently hard to establish. Absentee landowners frequently live in the towns or the nation's capital. Mapping or aerial photo coverage of rural areas is frequently nonexistant or has been done at inadequate scales. Land values of rural areas are also more difficult to establish since actual production yields should be distinguished from potential production. Consequently, urban cadasters, which require the demarcation of major tracts of land, which require no inventory of natural resources, and which frequently have better title records, will not be related to the agrarian reform movement in this paper.

In many rural areas in Latin America, simple property surveys also do not exist. In others, they may exist but ownership data are lacking or are in conflict with tax assessment authorities. In other countries, such as Honduras, select areas are taxed, usually the more accessible provinces with urban centers, while other less accessible portions of the country are not. Both of the most recent cadastral programs, one in Panama and the other in Chile, have illustrated the fact that many properties were not registered at all, and that other properties were much larger than the size for which

They were assessed. It might also be added that many others were smaller than their assessed size.

To illustrate the dramatic differences in size and shape between the same property taxed before and after the completion of a cadaster the two following maps may be reviewed. Map sheet (Lamina) I demarcates properties inaccurately based on local property sketch maps. Map (Lamina) II shows property boundaries as they actually are, utilizing the aerial photo base with field survey property checks made by experienced photo interpreter technicians checking the actual property on the ground with the owner. Some lots have been shaded for identification purposes.

The governments, over the course of decades, have in general been denied revenue from the taxes of thousands of hectares of privately owned property. Furthermore, it has been reported that Chile had recouped within a period of four years the funds it had expended in carrying out the cadastral survey by collecting additional revenues of assessed land. Preliminary indications are that Panama will experience a similar situation, although their survey has only beencompleted recently.

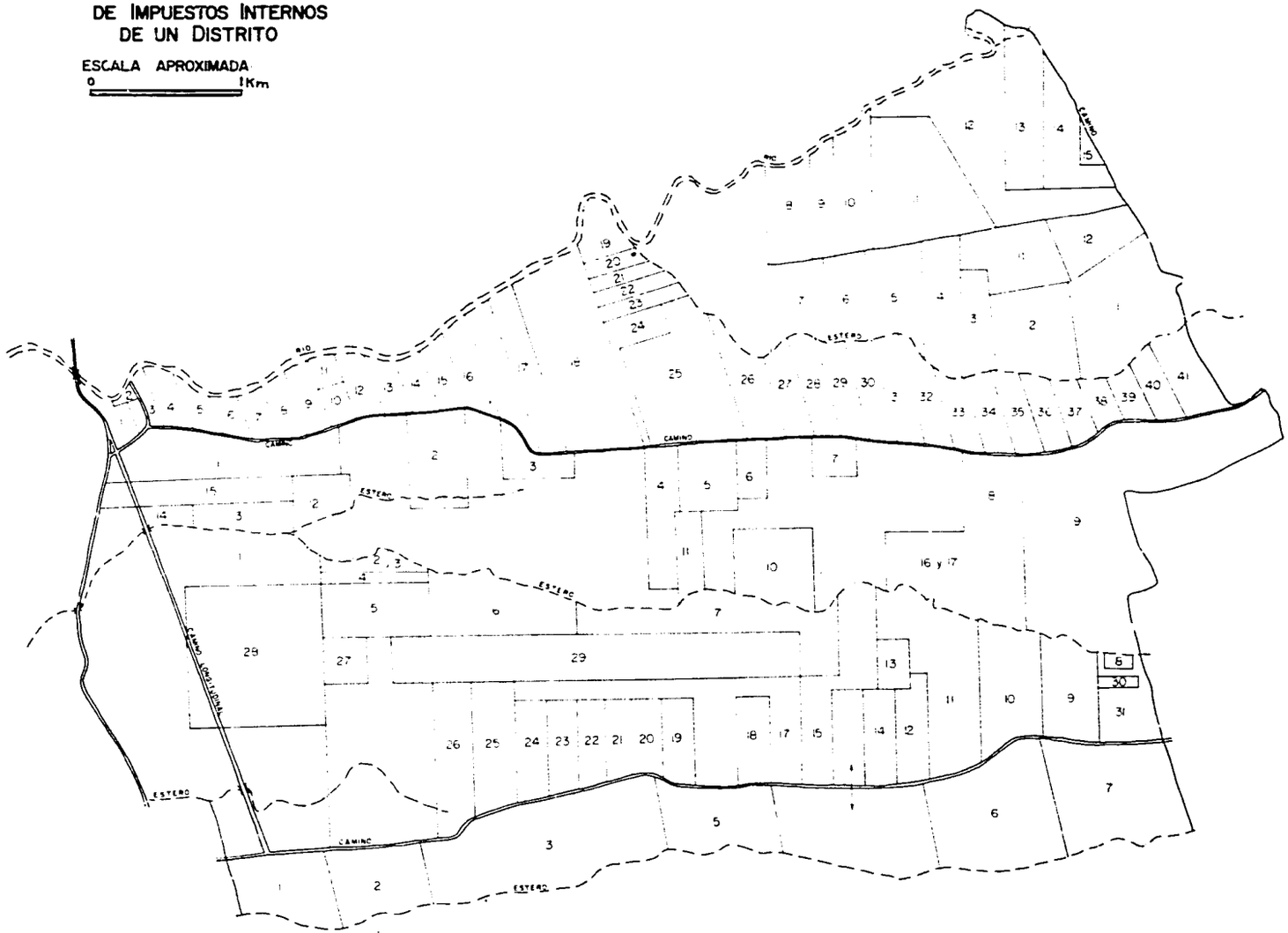
III. WHAT IS A CADASTRAL SURVEY.

A cadastral survey is the investigation and the mechanics carried out for the purpose of making a cadaster. There are basically two kinds of cadasters: the Fiscal Cadaster and the Legal Cadaster. The fiscal cadaster is the inventory of property for tax assessment purposes. The legal cadaster is the inventory of property for land registration purposes and for making legal transactions concerning the land; consequently is is usually more accurate than the fiscal cadaster. The definition as to the use of the land is also a part of the legal cadaster. Surface water as well as subsurface water rights or mineral rights may be excluded or kept separate from the

LAMINA I

MAPA DE LOS CROQUIS DEL SERVICIO DE IMPUESTOS INTERNOS DE UN DISTRITO

ESCALA APROXIMADA
0 1Km

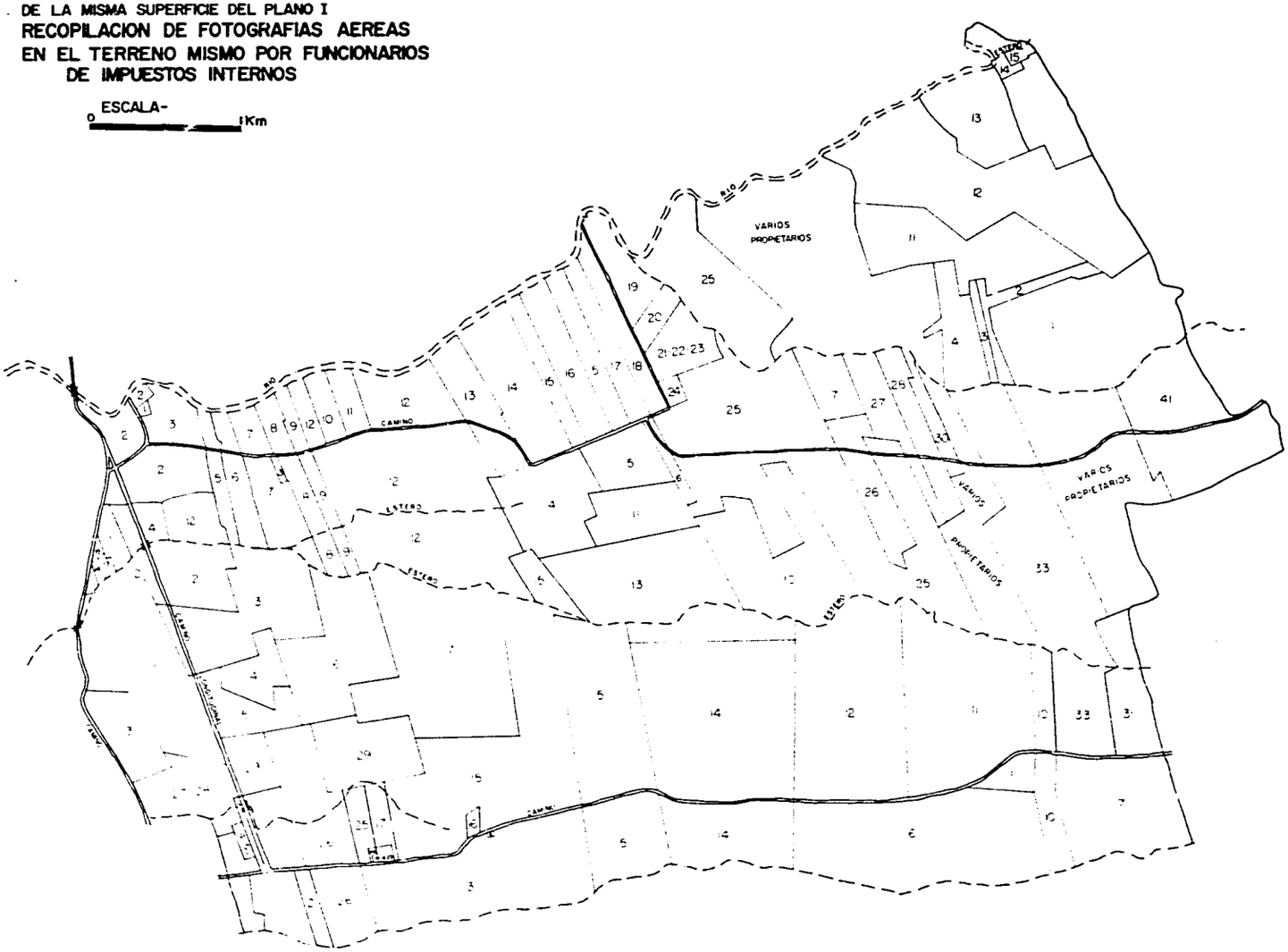


LAMINA II

DE LA MISMA SUPERFICIE DEL PLANO I

RECOPILACION DE FOTOGRAFIAS AEREAS EN EL TERRENO MISMO POR FUNCIONARIOS DE IMPUESTOS INTERNOS

ESCALA- 0 1 Km



rights to utilize the land. Also, access rights are frequently considered in legal cadasters. The legal cadaster* being more accurate, is also more precisely located in that it is tied by latitudinal or longitudinal coordinates to the national geodetic control system. Normally property demarcations for legal cadasters are made on large scale topographic maps. However, it should be recognized that the precision of any cadaster should be closely related to the value of the land. Although the assessment of land may not require establishing exact measurements or locating the exact tract by a coordinant system, it would be highly desirable to carry out a cadaster that could serve the functions of both, the fiscal as well as the legal cadaster. In all probability the criteria to serve both types of cadaster could be justified in areas of dense rural concentrations where taxes are normally higher and where property boundary problems are usually more numerous. But, the superimposition of a new cadastral system or even the modification of an old one that is ingrained in a nation's historical and agricultural development will always be somewhat difficult.

To recommend a standard solution to the cadastral problems of the less developed nations would be impossible. Each case is unique and will have to be treated as such. Also, the methods used depend on the equipment, trained personnel, and base data available prior to the initiation of the survey.

IV. WHAT DOES A CADASTRAL SURVEY COST.

The cost of a cadaster is related directly to the scale of the mapping and the precision of the survey. There are so many variables involved in estimating costs that no unit price figure can be presented. Cost figures of

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* Two different systems, the positive and the negative, are utilized to record rights under the legal cadaster: the positive system establishes clear title to the property, which is guaranteed by the government. The negative system simply records all transactions providing little more than a continuous record of rights held related to a particular piece of property.

various projects such as those mentioned previously for Chile and Panama may be quoted, but no comparison may be made between them because of the differences in criteria between the projects and the differences of existing base data and geodetic control between the respective countries. The Chilean project, however, called the "OAS/Chile Acrophotogrammetric Project," was well publicized and experimental in the sense that it attempted to carry out a fiscal cadaster in a minimum of time due to urgencies related to a national disaster, the Chilean earthquake of 1960. Because several international agencies and many nations were involved in this project, possibly more is known about the funding to sponsor the survey as well as unit price costs than similar operations elsewhere.

To put the cadaster in its proper setting, a brief summary of the project will be presented. In late May, 1960, a number of earthquakes and tidal waves destroyed much of the infrastructure of the southern Central Valley of Chile. Several million people and one-fourth of the nation's area were affected by the seismic disturbances. Reconstruction of the devastated areas was started almost immediately with the assistance of foreign aid and a number of international organizations. Many national Chilean agencies were also involved in rehabilitating the area.

Although the "OAS/Chile Photogra metric Project" initiated its operations to obtain up-to-date aerial photography and ground control, the government requested a cadastral survey and studies of agricultural land use and land capabilities in order to determine real property values for tax assessment purposes. The project was accepted by the OAS in July, 1961, and was completed by December, 1963. More than 12 million hectares of agricultural land were evaluated in less than thirty months, more than 250 Chilean technicians worked with the project as well as sixty persons contracted by

the OAS. A consortium of four commercial firms from the United States and Canada supervised and directed the project.

In referring to the state of the public treasury and in particular to the real estate tax on rural property, the President of Chile, in an opening message to Congress, stated:

> The defectiveness of this tax resides in the lack of basic information available for scientifically determining the value of each individual property. In order to resolve this problem, the Government has drafted a work program that includes the following measures:
>
> a) Aerial photography at a scale of 1:20,000* will be taken of all the agricultural land in the country. This will serve as a basis for the preparation of a mosaic in which each square centimenter of photography will equal four hectares of land.
>
> b) With the help of ownership titles, the boundaries of each property will be marked on the mosaic, thus making it possible to know its exact size.
>
> c) Analysis of the photographs and firsthand observations at the site will make it possible to determine the type of agricultural use to which each property is being put and to inventory the areas being used for permanent and shifting cultivation. In addition to providing exact information on types and composition of soils, water, and other resources, these studies will point to better means of utilizing them.
>
> The aim of this program is to complete a rural property cadaster within the present year covering an area of approximately 120,000 square kilometers. During the first quarter of 1962, soil use surveys of the same area will be made, and in the following year the classification of soils according to their type, composition, and productive capability will also be completed.
>
> The data supplied by the foregoing surveys will be used in carrying out a "policy of development and agrarian reform" on an appropriate technical basis, which would include the following activities:
>
> 1) Furnishing to farmers, especially small landholders, all the basic technical information needed on the proper exploitation of their land.
>
> 2) Planning of a policy to encourage subdivision of land into units that would ensure efficient utilization and facilitate colonization programs.
>
> 3) Planning and completion of roads and irrigation works and carrying out of an effective soil conservation policy.
>
> 4) Precise scientific evaluation of properties as a basis for a

*Map scales are presented in proportions. In this case one part on the photograph (or map) represents 20,000 parts on the ground. Aerial photographs and maps used for cadastral purposes normally range from 1:3000 to 1:25,000 in scale with 1:3000 being among the larger scales and employed more frequently

tax that would contribute effectively to better land utilization, providing an incentive to progressive farmers and penalizing those who do not make full use of their land. For this purpose, necessary changes in the laws will be proposed, maintaining the present criterion, however, that taxation of agricultural real estate be based on the real value of unimproved basic property. In addition, income tax incentives will be proposed to induce the farmer to make investments related to better land utilization.

The total cost of project operations amounted to the equivalent of $5,390,000.* Although this sum may appear at first to be high, it is well to point out that if conventional field methods had been used for such an operation it would have been necessary to employ an even larger staff of professional and technical personnel for a period of from 20 to 30 years, which in the end would have resulted in a cost four or five times greater than the actual total for the project. Moreover, the value of the benefits this investment has already provided and of those which will be forthcoming in the future far exceeds the amount in question.

The OAS financed from its Chile Special Aid Fund, for a total of $550,000, the following operations of the project: a) all of the aerial photography taken at 1:50,000 and 1:10,000, and a considerable part of the photography taken at 1:20,000; b) ground control operations; c) topographic mapping of a number of cities; and d) preliminary technical assistance missions, as well as administration and supervision of the project.

From a tax on bottled gas the government collected the equivalent of $600,000 in revenue, with which the following operations were financed: a) preparation of the photomosaics used in the project; b) rural cadaster and property identification; and c) collection of data on present land use. With annual appropriations in the national budget totaling the equivalent of

* This section on project cost figures was taken from the Pan American Union publication Agricultural Land Inventory Techniques by Luis Vera (Washington, D. C., 1964); and unit cost figures were taken from the Pan American Union publication Physical Resource Investigations for Economic Development (Washington, D. C., 1969).

$1,830,000, the government covered the expenses of offices and field stations, as well as the corresponding service costs; the purchase and maintenance of motor vehicles; transportation, per diem, overtime, and social security for Chilean technical and professional personnel; and wages and benefits for craftsmen, drivers, surveyors, and assistants.

When the project was initiated, the Chilean Government planned to finance the total cost from its own resources, with the exception of the OAS contribution. However, because of the domestic economic situation, currency devaluation, and the loss of foreign reserves, the government became short of funds and was faced with the dilemma of either stopping the work of the project until the necessary financing could be obtained or continuing to carry it on while negotiating with an international financing agency for the funds needed to complete it. Due to the urgency of the tax reform, the government chose to continue the work of the project without interruption and obtained a loan of $2,100,000 from the Inter-American Development Bank to finance (a) additional aerial photography of the transverse valleys at 1:30,000; b) additional aerial photography at 1:20,000; and c) the agricultural land capability study.

The oil exploration studies conducted by the OAS project at the request of the National Petroleum Enterprise (ENAP) included: a) a geological survey; b) a geophysical and aeromagnetic survey; and c) tectolinear analysis of the surface for the purpose of locating subsurface anomalies. The cost of these studies totaled $310,000 and was financed entirely by ENAP.

Data processing and analysis operations, as well as some of the economic studies, have not been included in the cost of the project. The United States Agency for International Development (AID) assumed the cost of foreign technical assistance to advise Chilean personnel, and these figures have also been excluded from the total figure.

The project has provided the necessary data to make possible an increase in farm production, as well as improved utilization of natural forests and forest plantations, more transportation facilities, and the establishment of industries directly and indirectly related to the use of these products and services--all of which will result in greater diversification of job opportunities and a reduction in unemployment.

As information was produced by the project it was used by the Ten-year Economic and Social Development Plan in the formulation of policies for various branches of the economy and in the preparation of specific projects within the framework of its sectoral programs. Preparation of the master plans for the cities and for the area affected by the earthquake was carried out on the basis of maps produced by the project. Reconstruction of the sewerage systems and the laying out of streets required the use of topographical information derived from the work of the project. In like manner, use has been made of the collected data in the preparation of projects for roads and highways, ports, railroads, irrigation works, and other public sector enterprises.

In estimating the direct contribution of the project to the economic and social development of Chile, it is suggested that this will depend on the use that is made of the information gathered. The results of the application of project data to agrarian and tax reforms have indicated that the total cost of the project was repaid in a period of four years.

As complex as was the overall funding of the Chilean project, so too were the unit costs. Each phase of the study had different unit costs. Property boundaries were located on rectified 1:20,000 photographs. Rectification can as much as double the cost of a photograph, but in the case of Chile, much of t is cost could be discounted because the photographs

had to be rectified to produce the controlled mosaic which served as the new base map of the area which was changed due to the seismic movement. The 1:20,000 scale permitted plotting of parcels of one hectare or larger. In minifundia areas, a boundary was drawn around adjacent properties smaller than one hectare and the area was labelled accordingly. The maximum error permissible was 0.1 inch, and errors in areas of measured property ranged from 1 to 9 per cent. (The maximum error--50 meters on the ground--would only be approached in areas of steep featureless topography, while hedgerows and fences made the identification of properties of inhabited farmland easy and extremely accurate.

Cost of the 1:20,000 photography for the project was $4.10 per square kilometer. Mosaics were prepared at scales of 1:100,000, 1:50,000, and 1:20,000 at a total cost slightly over $1,00 per square kilometer. The cost of mapping and valuation of the 170,000 properties was not kept on a detailed basis due to the variety of agencies that supplied the project personnel.

In the Panama project, the properties were located on proportional enlargements of the new photography at a scale of 1:10,000, permitting the plotting of all rural properties, the use of rectified enlargements being required for only 7 per cent of the photographs. Maximum allowable error in flat ground was 0,16 inch, and errors in areas of properties measured in flat ground averaged 6 per cent. The accuracy is reported to be comparable to that of the Chile project. The photography cost about $3.75 per square kilometer, and the enlargements cost an additional $1.00 per square kilometer.

Of course, it is impossible to make a direct comparison of the two studies since so many factors differed. In the Panama study ground control already existed, while it had to be established in Chile as part of the project. On the other hand, much more detailed property evaluation was made in Panama

than in Chile. Differences in the size distribution of the properties and ease of access, among other factors, also influence the overall cost. As a result of these variables, cost of mapping and valuation, excluding the cost of the natural resource inventory, will range between $6 and $13 per parcel.

V. HOW IS A CADASTRAL SURVEY MADE.

After the basic decision has been made to make a fiscal or legal cadaster, or a combination of the two, the respective agencies of the government who will be working in various phases of cadaster should be contacted. A general agreement should be reached as regards the objective of the cadaster, the input of the different agencies, the criteria to be followed in project execution, the precision required should be clearly established and a review of existing tax laws, land laws and natural resource data should be made as well as checking local boundaries. All too often the administrative boundaries at the second and especially the third order level (equivalent to out county or township boundaries) have not been demarcated with precision, which has led to many boundary and taxation problems in Latin America in the past decade. Such boundaries should all be transferred over from local district surveys to aerial photographs or mosaics where features visible on the photos can be recognized on the land.

Following the preliminary review of data and agency participation, and recognizing the fact that each project varies from the next, the following procedures are most commonly carried out:

a) Aerial photography at required scales is taken (to serve as the basis for making a map) if none is available that is adequate.

b) Photogrammetry and ground control, the mechanics of rectifying and locating the aerial photography must be undertaken.

c) Photo mosaics should be made and controlled upon which field data are plotted, observations are made, and eventually field checked and coordinated.

d) Photo interpretation is done by stereoscopic means to obtain natural resource data, including information on geology, hydrology, geomorphology, soils, land use, and forestry.

e) Data analysis may be done by a variety of means: by map superimposition, by statistical analysis, or by mechanical or electronic data processing means. The end result should be the same. Utilizing the basic natural resource data, both quantitative and qualitative, a land capability map should be made. This should then be compared to a map of the existing land use. Differences between the two maps should indicate the value of the land for agriculture or other uses, especially when relating data to other facets of the broad natural resource field (hydrology or forestry for example). It is on this basis that tax assessment should be made.

f) Economic data such as the existing land tenure system, the local infrastructure, bridges, roads, silos, distance to markets, and existing production yields, etc., may be mapped and taken into consideration.

g) Property boundaries should be plotted on the mosaics in the field. This can best be done by the stereophotographic interpreter assisting the farmer in locating his property on the mosaic. Training local technicians to interpret aerial photographs is not difficult, and use of local inhabitants may give confidence to the area's residents and facilitate operations.

In summary form the execution of the former steps will provide much of the technical and resource data. In addition to the different types of rural cadasters there are also many related investigations that may be carried out at the same time. An inventory of industries, urban centers, engineering works, transport facilities, and investigations of population distribution

and migration rates are all closely related to the rural cadaster and may be carried out in a following stage.

VI. HOW IS THE CADASTRAL SURVEY USED.

The preceding sections of the paper dealt primarily with the technical aspects of a cadaster: the specific steps from obtaining aerial photographs to the required resource data to be able to make a justifiable tax assessment. The administrative phase which follows the technical phase is more closely related to property mapping and registry. In the case of the fiscal cadaster, it consists of the assessment and collection of taxes and the maintenance of the records concerned with these operations. In the legal cadaster it consists of the registration of the land parcels, the maintenance of the registers and/or the legal transactions concerning the properties. The technical data related to the legal cadaster centers on the location of the property, the boundary and the size rather than the quality of the land.

To describe more specifically how property mapping and the administrative phase of a cadastral survey is developed, a review may be made of the Panama project. While emphasis in the Chilean project centered on resource evaluation, the Panamanian project focused on property assessment.

Panama's development program centered on their agrarian reform. They hoped to improve land use, land distribution, and increase agricultural efficiency. Enforcement of rural land taxation has been one of the most critical problems facing economic development. Few proprietors were paying taxes. Only 10 per cent of the total rural estates, comprising about 500,000 hectares were legally owned at the outset of the present program in 1963. The remaining national territory, about 7 million hectares (excluding urban areas) was government owned. It included patrimonial, squatter, occupied, idle lands, and forests. The exact site and area of almost all the land under

legal ownership title was still unknown in 1963, and no master map or index of properties existed at all.

Several private commercial firms were contracted in August , 1964, by the Government of Panama with the financing of USAID to conduct a property survey and natural rescurces inventory of 39,000 square kilometers of the country. The property survey entailed the mapping and valuation of 90,000 rural properties and classifying them in four categories: 1) private lands (registered), 2) occupied lands (without register), 3) government lands, and 4) forest and other government land encroachments.

The Panama Agrarian Reform Commission was given authority over the cadastral survey and natural rescurces inventory phase of the project. The Ministry of Finance had authority over the tax improvement phase of the project.

Photography flown in 1953 at scales of 1:60,000 and 1:30,000 was available for almost all of the project area, and topographic maps at 1:50,000 compiled by the Inter-American Geodetic Survey were available for much of the area. The photography was completely rectified, and mosaics at a scale of 1:50,000 and 1:20,000 were compiled. Where sufficient ground control or topographic coverage was available, the mosaics were fully controlled; otherwise they were semicontrolled. For plotting the properties 1:10,000 enlargements were made from the new 1:16,000 and 1:20,000 photography. Enlargements and reductions at various scales were made from both the new and old photography for photo interpretation in the other disciplines studied.

Each of the registrars was given an intensive six-week course in photo interpretation, location of properties, use of the compass, interviewing, registration of properties and drafting. The property mapping was conducted by five field parties, each consisting of four or five registrars, including

the party chief. Each man in the party was given 1:10,000 enlargements on which political subdivisions, cities, towns, and caserios had been marked and identified. The registrar visited each property shown in the delineated central part of his photograph and, in the company of the property user, walked out the boundary of the property, marking the corners on the photograph. He also marked rivers, roads, farm buildings, etc., and identified the type of roads for future use in valuation of the property. When there was a doubt about a property boundary, the registrar checked with users of adjacent properties. If some doubts still remained, an investigator made a more detailed study. Farm properties of less than one hectare were treated differently. For large zones of minifundia, the registrar ordered a photo enlargement at a scale of 1:5,000 on which he plotted the properties. For isolated small parcels, the registrar pricked the photograph with a needle at the property corners and drew the property boundaries on the reverse side of the photograph. Each parcel was given a field identification number.

At the same time, the registrar interviewed the property user and filled out two forms: a property identification form and a valuation form. The data on the property identification form included field property number and photo number; location by provincia, distrito and corregimiento; name, cedula, residence, and time of occupancy of the user; identification of each boundary line by adjacent owner of the physical feature to which it corresponded; type of tenure; and the owner's estimate of the area of the parcel. The appraisal form gave information on buildings on the property, provision of water, sanitary facilities, and other characteristics used for valuation of improvements on the land. Each registrar mapped and collected data on eight to ten parcels a day.

After the above data were collected, the photos were returned to the office, parcels were renumbered with a permanent registration identification number,

and the area of each parcel was determined by planimeter. Tracings were made of each photo showing property boundaries and other salient features. The property identification and appraisal forms were coded and sent to a data processing center for recording on punch cards. The tracings showing property locations were reproduced and compiled according to districts (third order political subdivisions), and an index map for each district was made. Finally data on all parcels were recorded in final form in the tax office.

Tax evaluations of property were established in various ways. Selling prices of some properties which had recently been sold were determined, and the owner's estimate of the value of other sample properties was established by interview. Estimates were also made of land value on the basis of sales of farm products and production costs. Having arrived at land values by correlating the results of these methods, a formula was devised for estimating land values on the basis of three parameters: distance from road, quality of that road, and land capability class. Empirical weights were given to each of these parameters so that land value estimates based on them would correspond to the previously determined land values. Once these weights were established and thoroughly field checked, they were used for all land valuation. Standards were also established and field checked for the valuation of farm structures.

The map of a parcel was overlaid on the land capability map, and the area of each capability class included in the parcel was determined. The classification of the nearest road and the distance to it were determined from data collected by the registrar. The value of the parcel was then calculated by the formula.

In addition to the natural resource inventory, the survey will provide

Panama with a complete record of rural property, including a map of each parcel, a valuation for tax purposes of each parcel and the structures on it, and systematic property registration list. All data will be recorded on IBM punch cards and turned over to the tax office.

Laws now exist by which the system of taxation can be implemented, but some revisions will be necessary. It has not yet been established which agency will be responsible for the implementation, and administrative reorganization is being considered.

As regards the relationship of this fiscal cadaster to titling of landholdings, a law is now before the Parliament which will require the distribution of deeds to the properties before implementing the new taxes. The photograph on which the property is delineated will constitute the property description and will be distributed with the deed. A method for adjucating property disputes is included in the proposed legislation. Without doubt, Panama's cadaster is one of the most comprehensive fiscal cadasters;and when titling is activated, it will also be one of the first countries in the world where the survey accuracy is adequate to serve as the basis of a legal cadaster as well.

VII. NEW METHODS FOR CARRYING OUT CADASTERS

Although cadastral surveys have traditionally been based on terrestrial measurements, aerial photography has been improved so tremendously in the past two decades that it is being relied on very heavily today. However, in selecting the aerial photo base desired for the cadastral survey, many variables are present in relation to the selection of the appropriate combination of aircraft, cameras, lens, films, filter, and processing methods that technical advice regarding the project is desirable. There are no short cuts or other quick solutions by satellite photography or remote

sensors which would produce a cadastral map. The aerial photograph still forms the backbone of mapping activities.

While satellite photography may eventually be used much more commonly to make small scale maps of large areas, serving almost like a mosaic does today; and while certain type of remote sensor information is extremely useful in analysing resource data such as infrared photography or enhanced multiband filter photography, these are related much more directly to the topographic or resource evaluation fields. Probably the biggest advance in recent years has been the development of high resolution film. The centerline of a highway can be recognized from extreme distances by simply enlarging high resolution film. Another advance is the development of the RC9 extreme wide angle camera which will permit taking usable photographs from extremely low altitudes. Other devices such as the Log-E-Tronics also are valuable in the film processing systems.

Probably the newest development that is related most directly to the cadastral survey is that of orthophotographs. Equipment has been developed to produce photographs that are fully corrected for scale, relief and tilt distortions and are of particular value in the preparation of mosaics that may be used as a reliable planimetric base map for the delineation of terrain data and field information. The orthophotoscope was developed by the U. S. Geological Survey. This and the orthoprojector, built by the Zeiss Company, are used to produce orthophotos. The photos are butt matched together (not like making a regular mosaic, which requires overlap) to produce the orthophoto mosaic. At present the cost of the instruments and the methods used to produce the orthophoto appears to be considerably more than that of standard mosaic costs but prices will undoubtedly be reduced in the future, especially on large projects. A comparison of the orthophoto to the regular aerial photo is shown on the following page.

Recently fully rectified aerial photograph composites have been made with contour lines superimposed upon the photographic positive. These are called "photo contour maps" and provide detailed slope and elevation data that could be extremely useful in making property demarcations for a cadaster. Along with some of the more dramatic innovations mentioned above are an ever increasing number of refinements in measuring devices such as the Tellurometer and the Electro-tape which measure distances accurately, up to one inch error per 100,000 inches, by the comparison of phased microwaves reflected back to the measuring device (almost like radar). The Geodimeter also measures distances but does so even more accurately, up to one inch error per million inches, by measuring phased light beams of different frequencies, an application of the laser beam. For shorter distances, up to 500 feet, infrared light is also used for making measurements. Also, almost every year improvements are made in photogrammetric instruments and high speed electronic computers that add to improve the quality and reduce the costs of cadastral surveys.

VII. THE U. S. CADASTRAL SYSTEM RELATED TO THE LESS DEVELOPED COUNTRIES.

Two types of cadastral systems typify U. S. efforts in this field. In the east where settlement normally took place before surveying was carried out, a system of "metes and bounds" prevails. Property boundaries were described as going from hill tops to creeks, or as being on a compass bearing of so many degrees, etc. There are usually no major coordinants to which the property lines could be tied. In the west, however, land was usually in government control before settlement took place. Also, much of the midwest and west includes extensive tracts of flat, almost featureless prairie land or desert to which a system of metes and bounds could not

readily be adapted. This gave birth to the United States Land Survey.

By Congressional authorization in 1785 a survey system was established in which meridians and parallels were laid off in six-mile intervals from a base line to form the boundaries of townships.* Thirty-two principal meridians were established running north and south from carefully selected points whose latitude and longitude were calculated by astronomical means. In a similar fashion base lines were established following selected lines of latitude. Thus, townships were formed with dimensions of six miles on each side. Each township in turn was divided into 36 sections, each one a square mile, numbered continuously from the upper right to the lower right. Each section, containing 640 acres, may in turn be divided up into half sections or quarter sections, etc. This township-range system is practical in that with but little experience one may locate precisely the "north half of the southwest quarter of section 20, township 13 N, Range 6 W of the 5th principle meridian.

Now, how relevant is this survey and the U. S. experience to the less developed countries? The eastern U. S. metes and bounds system is probably a cruder form of cadastral measurement than that adopted by the early Spaniard or Portuguese. Certainly the rectangular rural patters and the city squares attest to the use of a system of some sort since early colonial days. Even the vestiges of the circular land patterns, so common in Cuba, attest to a methodology, even if difficult, practiced since the first days of settlement.

The western U. S. cadaster utilizing the township and range system could probably be efficiently utilized in the flat pampas of Argentina or

* A. Strahler: Physical Geography, New York, 1951.

the featureless scrublands of the Gran Chaco, but it would be difficult to utilize in a minifundia situation in the rugged Andes.

To cite a specific case in which I was involved in Colombia a few years ago: A USAID technician working on the colonization of the Ariari area was strongly advocating the use of the township-range system for the heavily forested llanos area. The Colombians living in the area were well acquainted with the value of the river front footage they might have had. Everyone of the settlers preferred living along the river, the natural avenue of communication for the region. They also knew that the open river provided more breeze, less insects, an assured supply of water, and a view of which they were proud. They had no interest in moving inland a "quarter-section" or "half-section" from the river because the survey was to be a more efficient one. They would much prefer to have strip lots, each with footage on the river and a cross section of land running away from the river paralleling the neighbor's property. But for fear of losing an agrarian loan that was tied to "the survey" nobody spoke up in opposition. It was only through the enlightenment by an IAGS long-time resident of the country that the plight of the people was brought to AID attention.

In summary, I do not think that U. S. experience in the cadastral field is particularly outstanding. We have developed a system that was adopted in the east and another well suited to our west. The Latins, too, must adopt the system best suited to their environment. An orderly cadastral system related to the geodetic network of the country and the historical or traditional land ownership patterns of the country will probably be the most effective and sensible for each nation.

What has the U. S. done to foster cadastral projects? Aside from sporadic efforts of AID during the past decade to utilize specialists or

consulting firms, such as the J. L. Jacobs Company, to advise on cadastral projects, only the Inter-American Geodetic Survey has become engaged in such surveys in Latin America. It has been considered a "sensitive area" shunned by most AID missions. International organizations such as the United Nations and the Organization of American States also tended to avoid controversial subjects, and the international lending agencies have found such agrarian reform programs difficult to fund or sponsor. Providing funds to carry out a forestry colonization or road development project is much easier to justify and usually can be done by quantifiable methods.

VIII. THE PRESENT AND FUTURE OF CADASTRAL PROGRAMS.

In a recent discussion of agricultural production in Latin America Dr. Jorgenson stated that Latin America will have an additional million people to feed six weeks from that date. Less than a year from now there would be an additional eight million people. By the end of the century, with the rate increasing in geometrical progression, there would be 756 million, two and three-quarter times the present population.* Many millions will be engaged in agriculture. There will certainly be no reduction in agrarian reform programs in the near future.

Almost concurrent with this trend, the U. S. support to the cadastral program is declining. U. S. support in the past for such projects came primarily from the Inter-American Geodetic Survey. Funded primarily by the U. S. Department of Defense, their major objectives were to establish a high quality geodetic network communal to the hemisphere, and to improve the national topographic mapping operations within each of the nations. After these objectives had largely been accomplished, they assisted the countries

*Harold Jorgenson: "Basic Issues in the Process of Development in Latin America," an unpublished paper presented at Muncie, Indiana, 1970.

in the establishment of cadastral surveys as well as in resource inventory surveys. However, with the recent cut-back in foreign aid spending, the U. S. Defense Department has, for all practical purposes, discontinued support of this program, just when it was beginning to have a major effect on the agrarian reform movement. This can be evidenced by the orderly progress and methodological thoroughness of the recently completed Panama cadastral survey, the first Latin American fiscal cadaster that also qualifies as a legal cadaster. Already Uruguay, Ecuador and other countries are looking toward Panama for advice. Technicians acquainted with resource and cadastral fields have strongly opposed the phasing out of the IAGS programs and its cartographic training center in Panama.*

Although other centers, particularly those sponsored by multinational agencies, may assume some of the cadastral burden, and may even be more in tune with Latin American priorities, such a complex survey and mapping program can not be turned over to the uninitiated overnight. Sophisticated methods, expensive instrumentation and maintenance facilities, and years of trained technicians can be lost if a logical switch over of Canal Zone operations from the Department of Defense to a "Department of Development" is not activated soon.

Many advances have been made in the field of cadastral surveys in the past decade, but many more are foreseen for the future. With the computers and the space age came a vast number of new techniques for mapping and data processing. Remote sensors are coming into use, "ground truth" of much data collected by the various means must still be established, stereophoto analysis of some types of high resolution films is still in the experimental

*A resolution to this effect was passed at a recent Conference of Latin Americanist Geographers (May, 1970) supported unanimously by more than eighty leading U. S. Latin American specialists in the field.

stage and new instruments and their use must be introduced to the Latin American technical agencies. The cadastral survey, the resource inventory and the titling of property for fiscal or legal purposes is just coming into being. The U. S. can play an extremely useful roll in assisting the nations with the establishment of sound technical and administrative methodologies. We have a solid function to perform in resource evaluation, in cartography and photogrammetry, and to introduce the use of the latest methods of land measurement as well as to assist the nations in developing sound loan requests so as to carry out solid development projects in the agrarian field.