

Remote Sensing Applications to Perform Massive Rural Valuations in the Argentine Northwest

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SUMMARY

According to the economical cadastral scope, the objective and simultaneous determination of the real property value placed in different jurisdictions poses the need to establish basic unitary values at a zonal level as a previous stage to obtaining the valuation at the parceling level. The unitary value of the rural area without improvements depends on a set of interrelated features or attributes, such as natural, economic and social characteristics, the territorial structure or degree of ground parceling, and the leading agricultural use.

The systematic information provided by Cadastre about wealth of land to each of the administrative jurisdictions includes quantitative and qualitative aspects as a basis for the decision-making process, mainly for the public service on development planning and on tax-system.

As there are no strictly uniform value zones, in the same way the landscape is not strictly homogeneous. Therefore, every zone definition and classification varies according to the detailed observation and description of the land. So the consideration of every territorial zone with equal unitary value involves two problematic axis. On the one hand, the process of setting-up zoning boundaries may involve different scopes of space differentiation, and on the other, it is possible to apply different procedures to obtain the unitary values for each zone.

The paradigm of zoning is solved at present by remote sensing applications because digital satellite images constitute powerful instruments for the analysis and classification of different land surface characteristics.

This paper examines the problematic cadastral rural valuations in the Argentinean Northwest and gives some examples of delimitations of rural zones in this area in function of digital treatment of Landsat images.

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1. ECONOMIC ASPECTS OF THE CADASTRE

Territorial cadastre has been widely dealt with in different publications, not only in its definition, but also as regards its functions, taking into account some aspects that have traditionally characterized it such as the physical, juridical and economic ones.

The importance of cadastre from an economic perspective is evident in the different origins that is conferred upon the word "*cadastre*", because, on the one hand, it derives from Latin or Byzantine expressions, always referring to the registration or to the list of the taxable parcels or to the levied tax on each parcel or each person. On the other hand, the evolution of the cadastre, as it is stated by Dobner Eberl (1981), has been closely bound to predominant socio-political structure in different times and to the economic interests of the time.

The economic aspect of the cadastre, from the Argentine viewpoint of the 70's, comes out of the definition proposed by the Federal Council of Investments (Marinelli, Luis; 1977), when sustaining that cadastre "*embraces the group of tasks leading to the performance and to the registration of the rational, objective and simultaneous appraisal of properties located in a given territorial area, in the way and with the consequences prescribed by law*". This appraisal or valuation has distinguished as taxing elements, the specification of basic unitary values at zoning level to obtain later, the valuations at parcel level as a result of the appraisal of those features characteristic of each parcel with their corresponding zoning basic unitary values.

From a restricted perspective, the information of the economic characteristics of the parcels given by the cadastre, has consisted on the land value as well as on the value of the improvements carried out to determine the tax valuation of properties. As it was pointed out, the economic aspect of the cadastre has been historically focused on the real state tax, and although in Argentina cadastres have also been developed mainly with taxation objectives, they were used to answer the need of the real state market by means of the publicity of the legal territorial application whose registration unit and publicity is the parcel in their physical, juridical and economic aspects.

The modern conception of the cadastre goes beyond the taxation purpose to be given a decisive role in the knowledge of the territorial objects and their distribution as the cornerstone for sustainable development strategies.

An efficient cadastral system constitutes the main instrument to enforce national, regional or local policies, always in relation to the territory and to the natural resources. In agreement with what was stated by Commission 7- FIG (1998), it is necessary to transform the Argentine cadastral systems into territorial, interdisciplinary multipurpose systems of information, capable to provide geo-referencing data of different nature and for different

purposes, always relative to cadastre, natural resources and geo-diversities. This progressive conception of cadastre, although it goes beyond tributary purposes, will also allow the application of better procedures in determining the fiscal valuation, cooperating also to taxation purposes on more equal premises.

2. REAL STATE TAX AND ARGENTINE LEGISLATION

The tax that burdens the real property, denominated real state tax, real property tax or property tax, is charged in most of the countries, and although it is complex to compare the jurisdiction mechanisms operating in connection with the tributary power in relation to the current dispositions either national, local or municipal, the point of contact can be established in the base of the calculation of this tax that is found in the property values.

Taxes constitute "contributions in money or in species, demanded by the State by virtue of the faculties vested on it, to those who are in situations which the law considers as taxable facts" (Giuliani Fonrouge, Carlos; 1993). Consequently, a tax becomes a *facere* -obligation to give– duly established by law, on the part of those people that may come across in different situations that are likely to happen.

The expressions *contributing empowerment* or *imposition empowerment* highlights the faculty of the State to demand within its jurisdiction, the payment of taxes, rates and special contributions.

In Argentina, it is the National Constitution the legislation that determines the contributing power. As a result, there is a State with limited powers and provinces with wide contributing powers, only limited by delegated powers (Sections 121 and 126). In this way, in accordance with the Constitution, provinces- inside its jurisdiction- should be demand direct taxes, meanwhile the indirect taxes are to be received by the State of the nation.

Direct taxes, are the ones falling of in the taxpayer defined by law, taxpayers in general, they cannot transfer the tax. For example, in the national scope, the income tax can be mentioned. Actually, this tax corresponds to the provinces, but by means of the national emergency act its scope is settled in the nation. The same act established as provincial taxation car taxes, real state taxes as well as direct ones. The indirect taxes on the other hand, are those that can move through the prices of the goods or services and they fall of in final consumers, as the Added Valued Tax (IVA) and the internal revenues.

Direct taxes are divided into personal and real ones. While the first ones are subjective, that is to say, they keep in mind the taxpayer's person, as it is the case of the income tax , the real direct taxes, on the other hand, are considered objectives because they keep in mind the wealth in itself, without taking into account the taxpayer, as in the property tax. However this distinction should be clear enough not to be confounded with the compulsory legal and financial nature of taxes.

Section 16 of the National Constitution sets the principle of equality before the law and of equality as the base for taxes and of public charges. As a consequence, the contributing legislation and the taxation in itself are dealt with the same degree of importance.

The concept of equality has been related - by doctrine and jurisprudence- with the rating principle and with another economic principle that is not declared by the Constitution, but that it is in its basement: the contributing ability (CORTI, Arístides H., 1994). That is to say, it includes the horizontal equity -to burden in the same way to those that are equal, without privileges- and the vertical equity or contributing ability -to burden differently to those that are not equal-.

Giuliani Fonrouge (1993), states that the equality principle does not refer to the numeric equality, but to the necessity of assuring the same treatment to those who are under similar conditions, highlighting that the Supreme Court has declared valid, among others, the organization of taxpayers into categories subject to different rates, as differentiating urban and rural properties; or the application of real state obligations to the landlords big extensions -known as “*latifundios*”-, and on the other hand, the tribunal voided in many sentences the real state tax upon co-ownership according to the total value of the property, without keeping in mind the portion of each co-owner, thus , showing acceptance of the principle that every charge having as its aim the possession, should be burden in accordance with the taxpayer’s personal condition.

From a quantitative viewpoint, the concept of real state tax involves two aspects: determination of the taxable base and determination of the rate that should be charged.

The taxable base, or calculation base, constitutes an assessment criterion of the taxpayer economic capacity and it consists on the total or partial value of the properties, while the rate is the percentage -proportional or progressive percentage- that is applied to the taxable base.

It should be kept in mind, also that the National Constitution highlights the inviolability of the private property while prohibits its confiscation (section 17) that is why, public contributions cannot be requested.

Consequently, the real state tax is a direct tax with competence on Argentine provinces, which through the Legislative Power passed their own laws on taxation to create their provincial treasure. These taxes on the other hand, are ruled by the dispositions of the Contributing Codes. It is only the law which can define, among others, the taxable fact and the taxable base, as well as the rate determination or the contributing amounts, always considering the principles of equity and non confiscation.

3. CADASTRAL CLASSIFICATION OF PARCELS

It has been pointed out that the parcel acknowledgment with cadastral purposes implies the delimitation of political-administrative jurisdictions, the delimitation of urban and rural areas, and its corresponding zonings to obtain uniform entities for valuations and for other administrative measures (Dobner Eberl, 1982).

Cadastrés in different countries establish classes or types of parcels in accordance with their location, destination or economic features. The most widely spread is the one distinguishing

urban properties of rural properties, and on each class, generally subclasses are settled down - for example, the distinction between built urban parcels and waste lands-.

In Argentina, these classifications have been included, in some cases, in the provincial acts of cadastre, as it is the case of the provinces of Córdoba, Tucumán, La Rioja and Río Negro, among others.

The Act of Cadastre N° 3585 –passed in the year 1980– belonging to the province of Catamarca, as well as the Act of Cadastre N° 6339 -year 1996- of the province of Santiago del Estero, establish that the cadastral organism should regulate the territorial zoning and the determination of the classes of parcels according to its location and destination, although in those acts there is a general classification of parcels in urban, suburban, rural and subrural, when differentiating the urban and suburban valuations from the rural and subrural appraisals.

4. MASSIVE VALUATIONS

The Cadastre Act of the Province of Catamarca N° 3585 –passed in 1980-, defines “*valuation*” in its section 101 as “*the administrative act of conferring a certain economic value in money to the real state*”, and in general terms, it is affirmed that to value a property consists on determining its most probable economic value for a concrete date and in a free market, without altering factors.

Besides the debate that the meaning of the word “*value*” brings up, and the consideration of a free market, without the influence of some elements which may introduce any distortions, is possible to differentiate the real state valuations in massive valuations and in expert surveys, either if they are carried out on a group of parcels to provide basic values, or individually on certain properties.

Carlos Medeglia de Sierra (1989) has distinguished the massive real state valuations, according to two different purposes. On the one hand, he considers those valuations which aim at elaborating tax bases, and on the other, those aiming at establishing the expropriation value of a group of parcels a priori to estimate the cost of projected works or of space reorganizations for further planning. However, he adds, it should be accepted that the purposes of massive cadastral valuations go beyond the boundaries of taxation basis, constituting an indispensable tool in the decision making process on the part of the State. In this sense, valuations provide the necessary information for planning strategies for social, economic and territorial development, since they are part of referencing base that gathers all aspects characterizing the real state wealth in different administrative jurisdictions.

In Argentina, cadastral legislations belonging to the different provinces, generally establish the specific valuating procedures to be followed in each provincial jurisdiction, in agreement with the classification of parcels in either urban or rural. As it was already analyzed, some provinces also make a difference between the suburban categories and sub rural ones, as it is the case in the province of Catamarca, where the Cadastre Act N° 3585 -year 1980 -, only establishes two procedures: one for urban valuations and another for suburban ones (Chapter

XV). In this way, the key elements for determining the value and the procedure of massive valuation, are not the same in the different jurisdictions, since they are subject to their corresponding norms or legal dispositions, which are prescribed according to their own geographical, economic and social characteristics. In general, the value of parcels is obtained adding the value of the improvements to the land value.

5. AGROGEOGRAPHICAL ZONING FOR CADASTRE

In some Argentine provinces, rural valuations mean -by law- the division in geo-economic areas and subzones of leading agricultural exploitations to assign basic values to those lands without improvements. Thus, from Cadastre it is necessary to determine territorial zonings in order to carry out massive rural valuations, which emerge from a group of features that are related to each other, such as the natural, economic and social characteristics, the territorial structure or the level of parcels, and the predominant agricultural use.

The delimitation of geographical areas confined to agricultural purposes is established in the legislation of different Argentine provinces, as it is the case of the Cadastre Act of the Province of Catamarca N° 3585 –year 1980-, in its section 113. It is also set in the text of Act N° 3778 - which dates from 1978- , belonging to the Territorial Cadastre of La Rioja, in its section 80; the Act of Valuations of the Province of Tucumán N° 5522 (1983) in its section 6; and the Act of Territorial Cadastre of the Province of Santiago del Estero, Act N° 6339 passed in 1996, in its section 78. Such zonings do not only have taxation purposes, but also, they provide the information required in decision making processes as well as they constitute important elements for the design and implementation of policies related to territory and natural resources.

In practice, landscape is not strictly homogeneous. Therefore, the determination of boundaries of agro-geographical zones involves conceptual generalization processes through complex mechanisms of spatial differentiation.

Geographical regions can be formal or functional, according to whether they are linked to with the existing conformity in the landscape (appearance or physiognomy), or they are considered as nodal centers or cores (function of each element inside the group).

In order to classify reality and to differentiate spaces according to their characteristic elements -delimitation of formal regions-, geography has proposed a procedure grouping in two methods: by means of coincidence of generic regions and by site association.

In the first method, each region is characterized as intersectional surfaces of generic regions, which denotes spatial coincidences of the distribution of each element or attribute independently considered through the synthesis of its scientific fragmentation. Transitional zones correspond to land surfaces where no coincidences of the different boundaries of each generic region that has been considered are found.

It has been pointed out as a major inconvenience the difficulty of establishing the number of elements to be considered, because when the analysis parameters increase, the conformity

land surfaces inevitably decrease; that is, the more accuracy, the more inconveniences in the synthesis operation.

The method of site association, instead, answers to the premise that every site is different from the neighboring one because that difference is what has established the border among them, considering site as any homogeneous parcel on the land surface.

According to the homogeneity criterion, the delimitation of land surface will be more or less extended, since the homogeneous character does not mean equality in the strict sense. Due to that, it is maintained that the site association is performed by means of the application of generalization criteria to the land surface, on the basis that there must be more disparities than similarities. Criticism has been centered on the conceptual difficulty presented by the terms “site” and “association”, and on the need stated by geography about carefully observing and understanding the complete territory to be divided into regions. However, the evolution of information systems and remote sensing instruments nowadays facilitate the application of the method of association of sites for the delimitation of homogeneous zones on the land surface. Here their statistics are complex functions of the spatial variation of their attributes, the chosen scale and the representation method.

The main difficulty in the application of geographical methods to divide a territory into regions or zones, consisted in the necessity of detailed observations of large areas. The development of indirect observation instruments, specially the digital satellite images and the image treatment softwares, allow us today to consider the statistical nature of the zone boundaries in relation to the spatial variation of land characteristics. This is a very important aspect, particularly when zones can not be associated to abrupt changes in the land surface.

The application of the geographical method of site association, from images taken by Landsat TM and ETM+, to determine zonings over the territory of the Departments El Alto and Santa María of the Province of Catamarca, ensures the comparative advantages offered by the classification of geo-referenced information provided by satellite images, since the zoning boundaries are better defined. On the other hand, digital information will facilitate the feedback of the systems for land information when the Argentine cadastre evolve toward multipurpose systems.

6. APPLICATION OF SATELLITE IMAGES IN AGRO-GEOGRAPHICAL ZONINGS

The practical application of agro-geographical zoning has been developed, on the one hand, in lands belonging to the Department El Alto, Province of Catamarca, with the aim of contributing to the knowledge and recognizing of an area that has not been surveyed yet. (Argerich, 2001). On the other hand, the agro-geographical zoning of Department Santa María is also introduced, these images were obtained from Landsat ETM+. As this Department has a cadastral report made in the decade of the ‘70, it will be possible to compare the current zoning -based on satellite images- with the results obtained from the traditional methods used when the cadastral report was carried out.

The province of Catamarca is located in the northwest of the Argentine Republic and it has an area of 102,602 square kilometers. The provincial territory has a total population of 331,635 inhabitants (INDEC [National Institute of Statistics and Censuses], 2001), and it is made up by 16 departments.



Figure 1



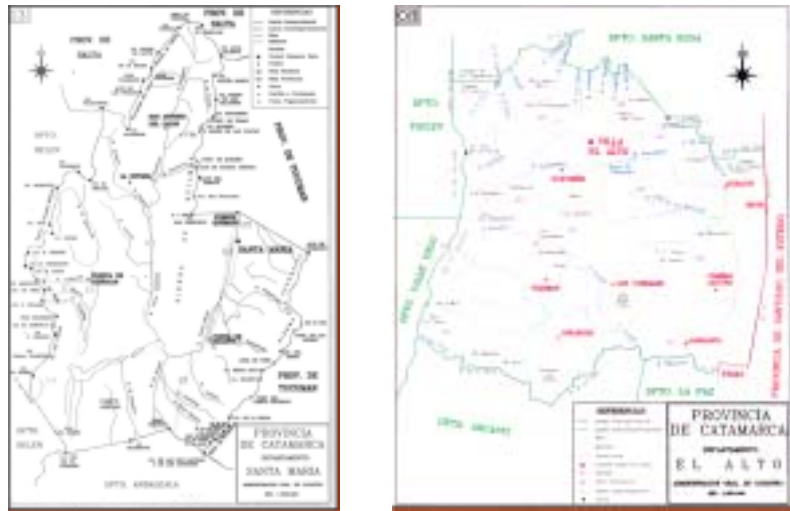
Base Map: Rodríguez, M. I., López, G. del V. (1999)

Like any of the Argentinean provinces, Catamarca has its own Constitution in compliance with the representative republican system, according to the principles, declarations and guarantees of the National Constitution. Cadastral legislation in Catamarca establishes in explicit way the necessity to determine homogeneous rural zones as a previous stage to obtain cadastral valuation at a zonal and parceling level.

The Department El Alto extends approximately between the 28° 10 ' and 28° 40 ' of South latitude and between the 65° 05 ' and 65° 37 ' of West longitude, covering a surface of 2,397 square kilometers and 3,392 inhabitants (I.N.D.E.C., 2001).

The Department Santa María extends approximately between the 26° 10' and 27° 15' of South latitude and between the 65° 45' and 66° 35' of longitude West, covering a surface of 5,740 square kilometers and 22,048 inhabitants (I.N.D.E.C., 2001).

Figure 2: Departments Santa María and El Alto



Font: Cadastral Administration of the Province of Catamarca, Argentina

The digital treatment of the satellite image Landsat TM5 corresponding to path 230, row 80, date 07-16-1997, which was carried out with software Idrisi (Clark University, Massachusetts, USES), allowed to obtain the agro-geographical zoning of the Department El Alto by means of aided classification consisting on the application of maximum probability criterion.

In the false color composition image, between bands 2, 3, 4 in the image sector covering the departmental territory, its most relevant aspects such as vegetation and relief can be recognized (left). In order to establish the most appropriate compositions because of their wider informative content, the index of optimum factor IOF has been calculated (Chuvieco, 1995). The composition among bands 1,4,5, corresponds to the greater IOF, (right).

In the west, the peneplain at the top of the Sierras “Ancasti – El Alto” (more than 1,200 meters over the sea level). Toward the east, the mountains slope down to the eastern plane, at 300 meters over the sea level. In the pendent sector two different environments can be recognized: the high lands where vegetation is more dense, and lower arid lands, in correspondence with rain, which decreases from west to east. The image shows regular shapes of parcels, particularly in the eastern plane, assigned to crops.

Similarly, the digital treatment of satellite image ETM+ of Landsat 7 corresponding to path 231, row 79, date 08-06-1999, carried out with the same software, allowed to obtain the agro-geographical zoning of the Department Santa María by means of aided classification, using criteria of maximum probability.

In the false color composition image, between bands 2, 3, 4, that can be seen to the left, observing the image sector embracing the departmental territory, distinctive characteristics including cultivation areas can be recognized, as well as mountainous regions and desert areas (Campo del Arenal o de Los Pozuelos), while the result of the composition image, between bands 1, 4, 5, can be observed to the right.

Figure 3: Compositions between bands (territory of El Alto)

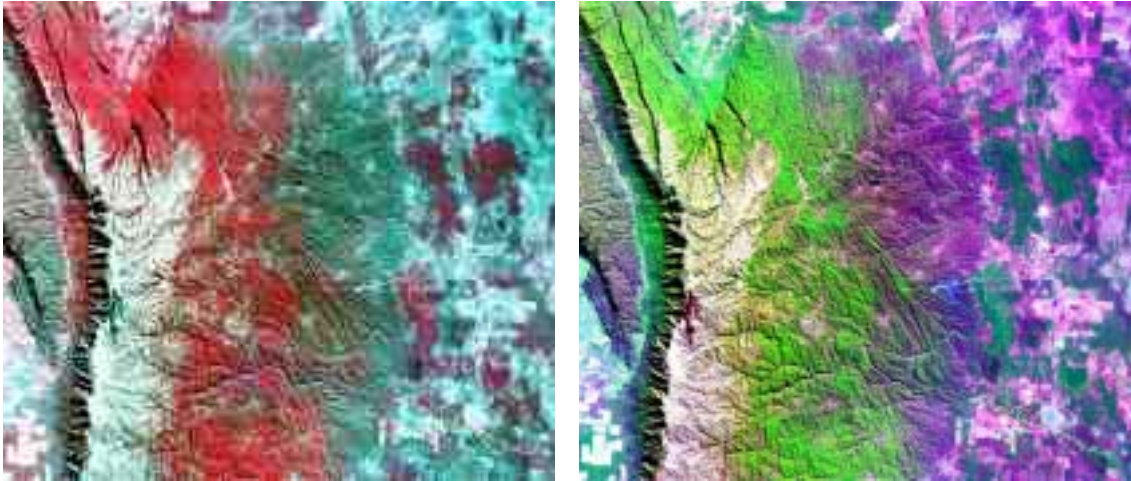


Figure 4: Compositions between bands (territory of Santa María)

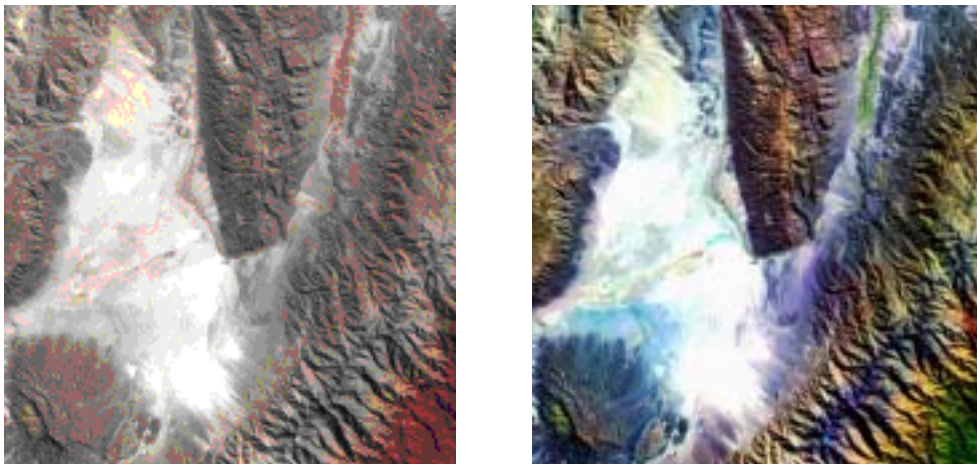
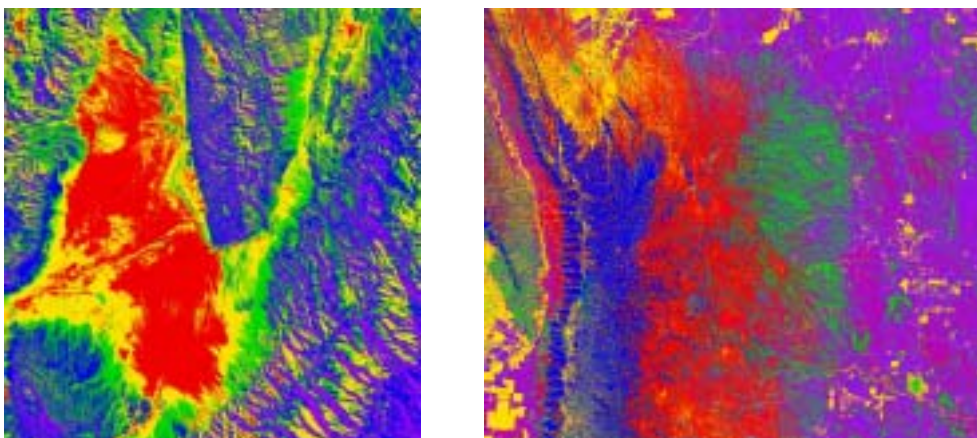


Figure 5: Images classification as a base of agro-geographical zoning



Finally, the compositions that have the greater IOF have been taken as the basis for the supervised classification by the maximum likelihood classifier obtaining the results that can be seen on Figure 5 (Santa María to the left and El Alto to the right).

7. ANALYSIS OF RESULTS AND FINAL REMARKS

The agro-geographical areas are defined in relation to the analysis and evaluation of diverse features, such as climate, land, topography, hydrology, main agricultural use, among others, as a consequence of the characterization of formal geographical regions. Thus, these zonal delimitations are either performed by the methods provided by Geography, either because of coincidence of generic regions or due to site association.

The experimental application of the site association method in the territory of the Department El Alto as well as in the Department Santa María, Province of Catamarca (Argentina), allows to sustain that the zoning in relation to the statistical association of homogeneous groups related to similar levels of radiance collects inter-zoning variations that derive in clearly defined limits. Thus, the zoning is carried out on the basis of the classification of information simultaneously obtained and under the same conditions for the whole territory under study (image acquisition date), and it can undergo a checking or control in the periods that are considered convenient, for comparison with new acquired images to detect changes (analysis of dynamic phenomenon).

The satellite images facilitate the global vision of the territory, exceeding in many cases the limits of administrative jurisdictions, what allows to make considerations about agricultural-geographical units beyond the departmental boundaries. On the other hand, the zoning boundaries can be reset easily in the land, since the geo-referencing of satellite images allows to know the coordinates corresponding to each point of the land. Finally, the zoning stored in digital format can be integrated to systems of geographical and territorial information.

In order to determine the agro-geographical areas required in particular for the procedures of massive valuations, according to what is established by cadastral laws of different provinces of the Argentine Northwest, and as they are required in general in the processes of decision making as essential tools for the design and implementation of policies related to the territory and the natural resources, the application of the method of site association from the aided classification of satellite images is highly recommended.

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BIOGRAPHICAL NOTES

Dr. Analía I. Argerich is a Surveyor Engineer graduated in 1986 from the School of Technology and Applied Sciences [*Facultad de Tecnología y Ciencias Aplicadas*], the National University of Catamarca [*Universidad Nacional de Catamarca*], Argentina. She holds a Diploma in University Teaching of Technological Disciplines from the School of Agricultural Sciences [*Facultad de Ciencias Agrarias*] the National University of Catamarca, Argentina, in agreement with the Central University of Las Villas, Cuba [*Universidad Central de Las Villas, Cuba*] (1999). She holds a PhD. degree from the National University of Catamarca, Argentina (2000) with the thesis “*Satellite images application in massive rural valuations*”.

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