Making Land Legible

Cadastres for Urban Planning and Development in Latin America

POLICY FOCUS REPORT LINCOLN INSTITUTE OF LAND POLICY
DIEGO ALFONSO ERBA AND MARIO ANDRÉS PIUMETTO

POLICY FOCUS REPORTS

The Policy Focus Report series is published by the Lincoln Institute of Land Policy to address timely public-policy issues relating to land use, land markets, and property taxation. Each report is designed to bridge the gap between theory and practice by combining research findings, case studies, and contributions from scholars in a variety of academic disciplines and from professional practitioners, local officials, and citizens in diverse communities.

ABOUT THIS REPORT

In Latin America, a territorial cadastre is a public registry that manages information relating to parcels of land. In much of the region, cadastres are structured under the orthodox model imported from Europe long ago, which accounts only for economic, physical, and legal characteristics. This model has several limitations: it is typically restricted to private properties; much of the information may be out of date and incomplete; and it does not encompass key parcel-level data needed for urban policy decisions—such as information on transportation, infrastructure, and utility networks—which is scattered among several unconnected institutions and in different formats.

In recent years, an increasing number of jurisdictions in Latin America have begun to adopt the multipurpose cadastre (MPC) model. An MPC is based on a partnership of stakeholders committed to generating extensive, precise, detailed, and up-to-date information about a city. It shares alphanumeric data and maps as well as human and financial resources. Based on voluntary agreements, it can be implemented at the national, regional, or local level at reasonable cost.

While a multipurpose cadastre does not define land policies, it is a key instrument for that purpose. In Latin America, conditions for the implementation of multipurpose cadastres are very favorable due to political support, widespread conceptual and technical knowledge of MPCs, and the availability of low-cost geotechnologies.

This report is about the past, present, and potential future role of cadastres as a land policy tool in Latin America. It describes how a variety of national, regional, and local jurisdictions across Latin America have used updated orthodox and/or multipurpose cadastres to strengthen urban financing and guide planning initiatives. It also includes examples of successful implementation in the region and recommendations for policy makers.

LINCOLN INSTITUTE
OF LAND POLICY

113 Brattle Street, Cambridge, MA
02138-3400, USA
P (617) 661-3016 or (800) 526-3873
F (617) 661-7235 or (800) 526-3944
help@lincolninst.edu
lincolninst.edu

Front Cover

Top: The 3-D cadastre can facilitate territorial management in challenging environments, such as this dense and vertical development of middle-class housing in Ouro Preto, MG, Brazil. © *Diego Erba.*
Bottom: Urban growth gradually takes over open space, demanding more infrastructure and public services. © *Diego Erba.*

Back Cover

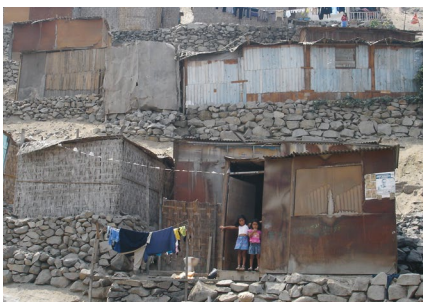
The technique of overlaying photos on 3-D models of buildings provides a compelling perspective of the Potreritos informal settlement in Bogotá, Colombia. © *Elisa Macerattini.*

ISBN 978-1-55844-355-6 (pdf)
ISBN 978-1-55844-352-5 (paper)
Policy Focus Report/
Code PF039

Contents

13

20



25

33

Executive Summary

Upscale buildings stand in stark contrast to precarious wooden houses on stilts *(palafitas)* over the Anil River, São Luis, Maranhão, Brazil. © *Diego Erba.*

Land use in Latin America presents striking contrasts—with vast uninhabited areas and extensive urban sprawl, the Amazon jungle and increasing deforestation, and tremendous wealth and crushing poverty existing side by side. These conditions are a legacy of the exploitation and undocumented, indiscriminate occupation of land that occurred during colonization. The lack of accurate records facilitated illegal land occupations that persist to this day and strongly condition urban policies—particularly those related to tenure security and tax collection practices.

One reason for this scenario is the way that land information is structured and maintained in the region. In Latin America, a territorial cadastre is a public registry that manages information relating to parcels. The majority of cadastres are still structured under the orthodox model imported from Europe, which accounts only for economic, physical, and legal characteristics. The economic cadastre encompasses land and building values; the physical cadastre includes information about the form, size, and location of parcels; and the legal cadastre documents tenure. Much of this information may be out of date and incomplete, particularly because the orthodox cadastre is typically restricted to private properties. Moreover, the orthodox model fails to encompass key parcel-level data needed for urban policy decisions, such as information on transportation, infrastructure, and utility networks, as well as environmental attributes and the socioeconomic profiles of occupants. These data are well structured but dispersed across several different, unconnected institutions.

The claim that Latin America "lacks data" is therefore a fallacy. This argument is sometimes used intentionally to block progress in the region or at other times to hide urban reality, although in most cases it simply reflects neglect or ignorance. In fact, information about urban land does exist, but it's scattered in disparate locations and different formats.

An increasing number of jurisdictions in Latin America, however, are moving toward the multipurpose cadastre (MPC) model. Successful implementations of the MPC in cities in Colombia, Brazil, and other countries have demonstrated its benefits to policy makers.

An MPC is based on a partnership of stakeholders committed to generating extensive, precise, detailed,

The complex urban reality in Zacatecas, Mexico, combines religious, commercial, historical, and residential land uses, all of which must be represented and registered in a territorial cadastre. © *Diego Erba.*

and up-to-date information about a city. It is structured to share alphanumeric data and maps as well as human and financial resources, and it is not very expensive because it is based on voluntary agreements. Like an orthodox cadastre, an MPC can be implemented at the national, regional, or local level, depending on the administrative structure of the country. In the United States, despite the lack of a formal cadastre institution, territorial information is already managed under a multipurpose structure.

Although it does not define land policies, a multipurpose cadastre is a key instrument for that objective. The data integration provided by the MPC model is the most direct way to identify and monitor the economic, physical, legal, environmental, and social characteristics of parcels and their occupants. Planners need this information to manage the growth of cities, define strategies for urban financing, reduce informality, and analyze the impact of government interventions. Moreover, the current environment for progressing toward the MPC model could not be better, given broad conceptual knowledge of its various components—cartography, valuation, legal framework, and so on—combined with strong political support and the availability of free geotechnologies to perform the structuring process.

Orthodox land cadastres are implemented by public agencies using geographic information systems (GIS) and updated with information from periodic surveys. In contrast, an MPC is built within a spatial data infrastructure (SDI) system. Its component parts are updated continuously with data obtained from urban observatories and other sources. Both GIS and SDI systems can be implemented with free software applications—one of the keys to the success of the multipurpose cadastre model.

This report begins with a brief description of the evolution of cadastres in the region and then outlines how adopting the multipurpose model delivers significant benefits that outweigh the challenges to implementation. The following three chapters detail how a variety of national, regional, and local jurisdictions across Latin America have used updated orthodox and/or multipurpose land cadastres to strengthen urban financing and guide several planning initiatives. The final chapter discusses the future evolution of cadastres in the region and provides several recommendations for a gradual transition to the MPC model.

Implementation of a multipurpose cadastre requires a shift that is more philosophical than technological; geotechnologies are not the entire answer. The following best practices can help make cadastres a significantly more useful tool for defining effective urban land policies in the region.

1. **Consolidate the orthodox cadastre before adding components of the multipurpose model.**
2. **For economic data, build land-value observatories that involve the greatest number of partners possible.** In addition, implement assessment methods based on econometric and geostatistical models that can correlate assessment maps with the real estate market.
3. **For physical data, mandate the georeferencing of parcels.** This process is slow because of the lack of trained professionals in the region, so it's essential to start promptly.
4. **For legal data, require updated blueprints on each real estate transaction, or at least blueprints that are no older than a certain age.** This documentation should be a prerequisite to the deed so that physical and legal information on properties remain synchronous.
5. **Incorporate data on public properties and informal settlements in cadastre maps and characterize the parcels in the alphanumeric database.** By recording these data, the map of a city will represent the entire urban reality.
6. **Represent the elements of utilities networks by using the same georeferencing system used for the parcels.**
7. **Implement SDIs through a collaborative process working with partners.**

CHAPTER 1

Evolution of Cadastres in the Region

This wood-based map of the Latin American territory circa 1600 shows the typical east-west deformations that derived from imprecise measurements of longitude. *Anonymous map. Photo © Diego Erba.*

In a territory discovered, occupied, and managed under widely varying conditions, some facts are nonetheless common to the Latin American experience: the presence of cadastres that predate the conquest of the Americas, the importation of European systems that largely inspire today's cadastres, and the declarations of independence and appearances of new states that modified the boundaries and legal frameworks of Latin American countries.

Early Record Keeping

Well before the Spaniards arrived, several types of territorial censuses and agricultural inventories existed in the Americas. In the Northern Hemisphere, after the founding of the city-state Tenochtitlán in 1325, the Aztecs initiated the conquest of territories and imposed taxes. At its peak, the city had an integrated fiscal and administrative body that included an agency similar to a finance ministry, a treasury secretary, and numerous tax collectors. The Aztecs classified and divided their land and dominions for legal, economic, administrative, and fiscal purposes, identifying areas for public use, for temples, for war, and for communal use (Lagarda 2007).

In the territories that now make up South America, the Incas imposed statistical controls and civil procedures for protection and public control since the end of the 14th century. Officials performed functions similar to those of Roman political decurions or curials, recording in detail all demographic movements in their jurisdictions, attending to the needs of the population, and acting as inspectors for tax assessment (Albina 2003).

Following the conquest, the lack of a single and reliable reference system for administrators faced with organizing information about the new lands led to the introduction of the orthodox cadastre model in Latin America. The land cadastre dates back to 1511 with the creation of the Council of the Indies on the island of Hispaniola. The council was a sort of superior court that considered appeals to the royal hearings and decided cases between the conquistadors and natives. The Royal Protection Act of 1578 legalized the tenancy of land, and the Land Composition Act of 1631 ordered viceroys and governors to recognize a portion of the land occupied by settlers.

In the territory conquered by the Spanish in the 15th and 16th centuries, the Castilian monarchy granted lots to certain people as an incentive for colonization. This was a legal institution, known as the *Merced de Tierra*, that originated in medieval times. Each settler received an urban lot and a piece of land outside of the town or village—usually in an irrigable or agricultural region. In some cases, much larger land extensions were granted for cattle raising or for cereal cultivation. The councils or municipalities also received some common land for cultivation.

In Brazil, the Portuguese government granted land to promote agriculture and cattle raising, as well as to populate the territory. The land was provided as compensation to nobles, sailors, and members of the military for services rendered to the Portuguese crown. The system of grants in Brazil was an extension of the Portuguese legal system established in 1375. From that time on, there was a proliferation of small pieces of land used by families for their sustenance, along with the nontenant rural producers. The lack of clear records and conflicting interests in the land gave rise to the *grileros*, people who used falsified titles to claim rights, often in an effort to form large estates (box 1). In this context, and with the goal of regulating

Box 1

Grilagem in Brazil

In Brazil, the term *grilagem* derives from an old technique used by defrauders of real estate titles, or *grileros*, whose goal was to make falsified documents look old. They would place the freshly drawn documents in closed boxes along with several crickets (*grilos* in Portuguese). Weeks later, the false documents would become yellowed with rust spots from the insect feces, and would develop small holes on the surface and corroded edges. This gave the appearance of the passage of time (adapted from the Ministry of Agrarian Development, Brazil, 2002).

this situation, the country created the General Division of Public Land in 1850 (adapted from the Ministry of Agrarian Development, Brazil 2002).

In the early 19th century, as Latin American countries were gradually becoming independent from Europe, the first land cadastres and property registries emerged in the region. The countries bordering the La Plata River basin pioneered the development of cadastre systems. Indeed, in 1826—only ten years after its independence—Argentina created the first land cadastre with legal force in the region, and arguably one of the first in the world.

The Orthodox Model

Most of the governments in Latin America, to dif-fer-ent degrees, continue to structure and manage their cadastres according to the model imported from Europe almost two centuries ago. This is referred to as the orthodox cadastre because of its long tradition and remote origins. The data administered by the or-thodox cadastre—a parcel's land value, dimensions, location, and owner or tenant—were essential for the new countries of the Americas to organize their terri-tories (figure 1).

The **economic cadastre** contains information for determining real property values. The most common method for calculating land values in the region is based on indexes: the value per square meter is based on "homogeneous zones" defined by the urban plan (when it exists) and building types. The land value is complemented by the value of the buildings, defined by a list of categories. Property values thus reflect the location, form, and size of the parcel, as well as the characteristics and size of the buildings.

The **physical cadastre**, also known as the **geometric cadastre**, contains cartographic documents and alphanumeric data characterizing each parcel and the buildings on it (box 2). Over time, administrators

Box 2

The Cadastral Unit

The land unit recorded in orthodox cadastres was identified in different legislation with various names, although they all referred to the same object. The international literature suggests that there was a strong convergence on the Spanish term *parcela*, which is also used in other Latin and Anglo-Saxon languages: *parcelle* (French), *particella* (Italian), and parcel (English).

Figure 1

Aspects of the Orthodox Cadastre and Processes Associated with Data Management

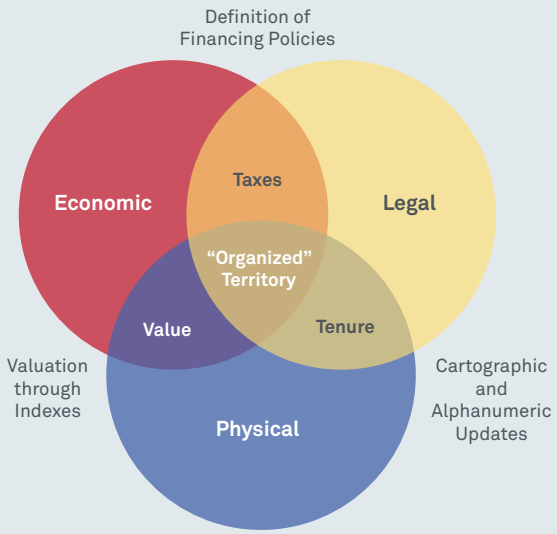


Figure 2

Boundary Confusion Resulting from the Conflict between Situations of Fact and Situations of Law

around the world realized that the cadastral data supplemented information in the registries of deeds.

The term ***legal cadastre*** has led to the misconception that a land cadastre must also record title deeds, which would be a senseless duplication. It should also be noted that a land cadastre deals with objects subject to laws (i.e., properties), not with the laws themselves.

Boundaries are the basis for determining the beginning and end of a given property right, a jurisdiction, a political or administrative division, or a nation's sovereignty (Bianco et al. 1983). Cadastres include two types of limits. The first is established by the possession of a piece of land, determined by how the property is used and demarcated by natural or man-made boundaries. The second is a legal limit determined by an imaginary line traced over the land. To set the legal boundary, it is necessary to study the title deed of the parcel as well as the titles of neighboring parcels.

Surveying defines the boundaries, an essential step in integrating the parcel into the jigsaw puzzle represented by cartography. Depending on a parcel's location, its positioning may be absolute (georeferenced) or relative. Figure 2 shows the relative positioning of a parcel where the physical dimensions (sometimes known as situation of fact, or de facto) do not match the legal dimensions described in the title deed (situation of law, or de jure).

The purpose of the orthodox cadastre was therefore to structure parcel-related economic, physical, and legal data. The concept of a land cadastre as a depository of plans to safeguard property rights or as a "mass of data" on which to base real estate tax assessments therefore gradually evolved into a broader vision. This new cadastre model, comprising data from several sources correlated in order to generate information for multiple users, would help planners and economists to better understand the land-market dynamics that fueled the challenging conditions that exist in many Latin American cities.

The Multipurpose Model

By the end of the 20th century, Latin America's poor were increasingly concentrated in marginal neighborhoods and informal settlements were expanding throughout the region's cities. Uncertainty about land tenure prevented investments in rural and urban areas. Good governance and coordinated development were impeded by poor land planning, management, and use; the increasing vulnerability of populations faced with natural disasters; and environmental degradation. The need to reduce poverty, encourage economic growth, and support sustainable development thus resulted in the gradual restructuring of land management systems in the region.

In Latin America today, there is general agreement about the need for multipurpose land information systems as tools for comprehensive planning at the local, regional, and federal levels (box 3, p. 10). The

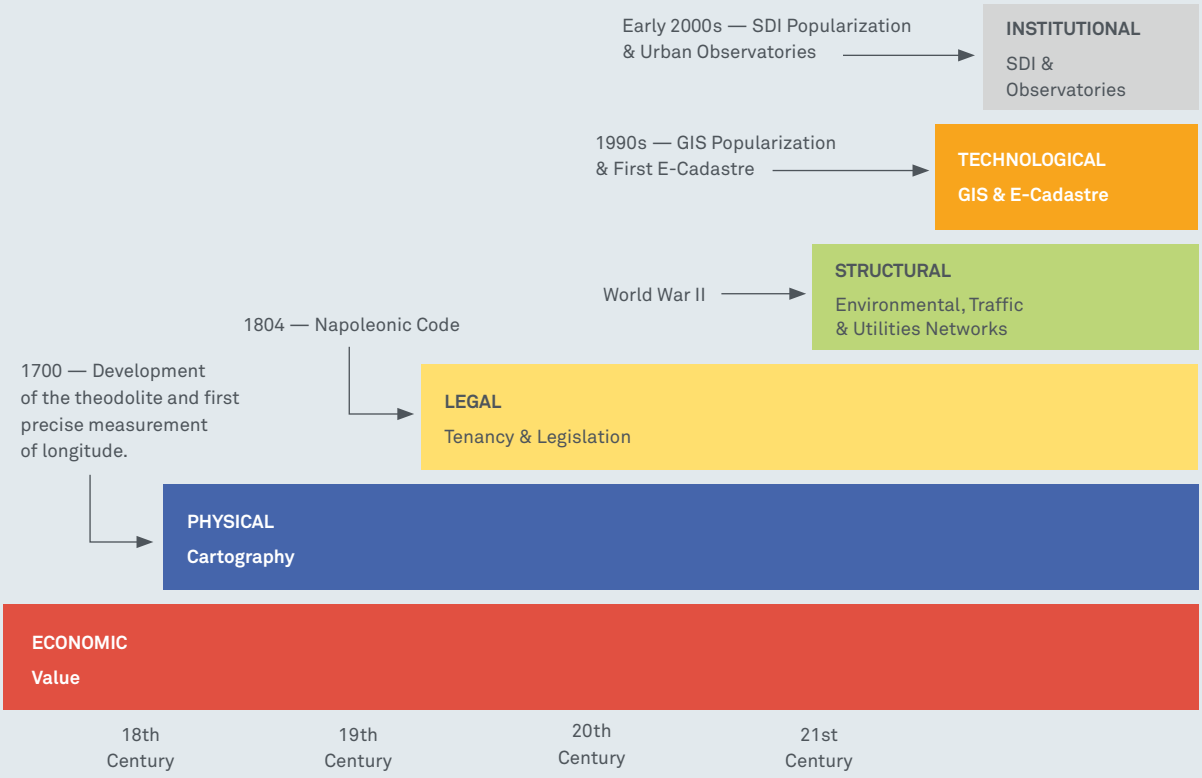
modular structure of such systems interconnects orthodox cadastres with thematic cadastres—parcel-based systems that include data related to the environment, infrastructure, equipment, facilities, and socioeconomics—maintained by different public agencies or private firms (figure 3).

In Latin America today, there is general agreement about the need for multipurpose land information systems as tools for comprehensive planning at the local, regional, and federal levels.

A multipurpose cadastre is built through a partnership among many stakeholders committed to generating large, precise, detailed, and updated data about a city. It is structured to share human and financial rsources as well as alphanumeric data and maps, and it is low cost because it is based on voluntary agreements. While an MPC does not define land policies, it is a key instrument for this purpose. The data it manages are essential for monitoring the growth of cities, defining strategies for urban financing, and analyzing the impact of government interventions before or after they happen.

Figure 3

Evolution of the Multipurpose Cadastre over Time



Box 3

Redefining Requirements for Master Planning

From 1985 to the beginning of the 21st century, different institutions—led by the International Federation of Surveyors (FIG)—continued to develop the concept of a territorial cadastre in response to the needs of technicians, administrators, and academics. In 2004, FIG, the United Nations, and the Permanent Committee for Geospatial Data Infrastructure for the Americas organized a special interregional forum in Aguascalientes, Mexico, to discuss the main challenges of creating and maintaining master plan infrastructure in Latin America and the Caribbean.

Despite their diversity, most countries in the region had identical requirements for the education and institutional capacity building necessary to support master planning. The Aguascalientes Statement that emerged from that meeting highlighted the need to involve political leaders in the technological and administrative changes required to integrate master planning, land cadastres, and property registries, all based on the same maps, as part of a broad national strategy for establishing a spatial data infrastructure (SDI).

STRUCTURAL ASPECTS

In addition to incorporating the components of the orthodox model, the multipurpose cadastre also comprises thematic cadastres organized by different public agencies as well as private companies. These databases typically provide information on the environment, transportation networks, and urban services.

The **environmental cadastre** normally consists of data identifying the environmental features and natural resources found in each parcel. In certain jurisdictions, this type of cadastre also contains information about things such as soil type, geological deposits, hydrographic elements, and ground cover. Indeed, urban cadastres often contain data corresponding to green areas and historically wooded areas.

The lack of well-established property rights over such resources makes it impossible to adequately determine values (box 4). However, the social benefits rendered by natural resources can be valued as ecosystem services, defined as the tangible and intangible benefits derived from wildlife or man-made ecosystems that improve quality of life (Gómez and de Groot 2007). The real estate market directly assesses many of these services, although it does not account for others that are known to be vital to the operation of the ecosystem and the economy.

The economic valuation of ecosystem services provides information about the social benefits of urban improvements, protection measures, and the preservation of natural capital. It also makes it possible to quantify the costs of such processes and assess the amount of remediation work needed for development projects, improve the planning and use of natural resources, help design environmental management policies, estimate the economic impacts of pollution, foster the rational use of natural resources, and, finally, estimate an ecosystem's productivity (Randall 1985).

In addition to its obvious relationship to the economic cadastre, the environmental cadastre relates to the physical aspects of land through the location of preservation areas. The government sets aside such spaces for conservation, and the real estate market depreciates their value because they are unfit for development. Unfortunately, the lack of controls and cartographic identification of protected land often allows these areas to enter the informal real estate market. These illegal lots are not identified on cadastral maps until they are either no longer occupied or are regularized.

The economic valuation of ecosystem services provides information about the social benefits of urban improvements, protection measures, and the preservation of natural capital.

At the same time, the **transportation network cadastre** records systems on land, sea, water, and even in space. National, regional, and local jurisdictions generally have cartography for these networks and include their features in geographic information systems (GIS). These databases make it possible to carry out spatial connectivity analyses of cities and relate to what is known as a **street cadastre**. Normally structured on the same cartographic basis as the orthodox cadastre, the street cadastre includes information such as surface type and street names, as well as useful data for transportation planning and services such as garbage collection. For example, coordination of the transportation network and street cadastres helps to determine the accessibility of a parcel.

The information contained in these databases influences the **utility network cadastre**, which provides details about the characteristics and location of aerial and underground pipes and cables, as well as supporting structures including posts, towers, antennas, platforms, connectors, faucets, and valves. This cadastre covers water and sewer, electrical, gas, and telephone systems, along with any other networked service or utility available in the city.

In many Latin American jurisdictions, utility companies are privatized. Regardless of legal status, however, the cadastres related to utility networks and to their users are highly sophisticated information systems. The data contained in the GIS managed by utility companies are highly relevant to parcel value, making their connection with the orthodox aspects of the land cadastre essential.

Box 4

Assessing At-Risk Areas

In November 2010, the community of Calle Lajas in San Antonio de Escazú, Costa Rica, suffered a mudslide following the heavy rains created by Hurricane Thomas. Twenty-three people died, and a great number of houses and properties were destroyed. A study carried out by Morales et al. (2011) to determine the level of economic losses from the mudslide, primarily for tax purposes, applied the hedonic model, accounting for basic features such as location, size, slopes, and access. The researchers then compared the effects perceived as a result of the event and its potential location in a high-risk zone. The results, shown in the table below, led to prohibitions on building houses in the red areas and on rebuilding houses in the yellow areas.

Zone	Value (US$/square meter)	
	Before the Hurricane	After the Hurricane
Red	65	0
Yellow	65	10
Green	75	30

Source: Julián Morales, Director of Cadastre, Escazú, Costa Rica.

Box 5

Drones: Efficient Geodata for Dynamic and Resilient Cities

Unmanned aerial vehicles (UAVs), commonly known as drones, are revolutionizing data collection and mapping. In Latin America, many local governments have begun enlisting drones equipped with small-format aerial cameras to identify buildings and the physical limits of unregistered properties in order to update multipurpose cadastres.

Drone photography is an agile and relatively inexpensive complement to traditional aerial photos and high-resolution satellite images. The versatility of drones, in terms of flying altitude and spatial and spectral resolution, allows them to produce a wide variety of images and maps, making them a resource well suited for the multipurpose cadastre. With resolutions up to one centimeter, they facilitate the generation of digital models and 3-D representations of parcels. Drones can also use multispectral cameras, which operate on a wide range of frequencies, from visible to infrared. Drones are particularly useful for data collection in areas no larger than 25 km^2, beyond which the use of stock satellite images becomes more competitive.

Drones also have great potential for several urban management purposes beyond the cadastre, such as monitoring nature reserves and surveying informal settlements, areas of high-density construction, or historic centers. Some cities acquire their own drones, while others purchase data collected by UAVs from private mapping companies.

TECHNOLOGICAL AND INSTITUTIONAL ASPECTS

Advances in information technology and the availability of open-source GIS, as well as increasingly affordable commercial applications and the availability of sophisticated tools such as unmanned aerial vehicles (UAVs), or drones, for data collection (box 5), have paved the way for modernizing orthodox cadastres and for developing the thematic cadastres that make up the MPC model. In particular, an MPC replaces the **e-cadastre** (online cadastre) as a single-institution public information system, requiring the incorporation of cadastre data into a local, regional, or national spatial data infrastructure (SDI). An SDI integrates geographic information that is structured and maintained by different institutions, enabling stakeholders to exchange and use the information for their individual purposes.

This interoperability implies the need for strategic alliances and formal associations that might include cooperation agreements, contracts, or joint efforts to share data, information, staff, equipment, work methods, and anything else administrators consider useful. SDIs do not replace GIS at each partner institution, but rather establish relationships among different GIS in order to generate more complete, updated, and detailed information on a city. By setting standard definitions for all these data, SDIs allow stakeholders to work independently and simultaneously in their own fields, using their own systems.

Finally, an **urban observatory** is an administrative and technical structure that monitors a city through images and censuses. The observatory can be created through partnerships with public or private academic institutions that share a common interest in certain spaces. While territorial observatories are created for the purpose of defining public policies in general, land value observatories are designed to support specific urban financing policies such as the property tax, value capture, and betterment levies.

CHAPTER 2

Why Transition to the Multipurpose Model?

Environmentally vulnerable areas in the city of Ouro Preto, Minas Gerais, Brazil, are occupied by a diversity of buildings—new, old, private, public, and informal—and many are not registered in the cadastral databases. © *Diego Erba.*

A growing number of jurisdictions in Latin America are adopting multipurpose cadastres. Successful implementations, such as those in Bogotá and Medellín, Colombia, clearly demonstrate their benefits, requiring minimal investment while efficiently supporting policies related to urban financing. Several factors make the current environment optimal for application of the MPC, from the existence of broad conceptual knowledge and technical skills among administrators and political will throughout the region to the availability of free geotechnologies to support the structuring process.

Benefits of MPC Implementation

Evidence suggests that multipurpose cadastres are facilitating urban planning and development in some Latin American jurisdictions and improving the prospects that land policies will better meet the needs of residents. The reality modeled by the MPC correlates land information, supports more effective urban planning, broadens urban financing alternatives, makes the real estate market more responsive, and optimizes the use of technical and human resources.

CORRELATED TERRITORIAL DATA

In the economic realm, an MPC relates property values to the real estate market rather than to theoretical economic attributes. This correlation averts problems that can arise when contiguous jurisdictions have different assessment systems. If a monitoring system is created through land-value observatories, the relationship between cadastral assessments and market values is even closer.

In the physical realm, all geographical data—related to both the formal and informal city, the exposed and the underground city, the city with and without infrastructure, and the city subject to environmental pollution and social challenges—are integrated by using a single reference system, which could be materialized by permanent GPS stations. These networks already exist in most Latin American countries.

In the legal realm, the MPC integrates information from property records, land tenure regularization institutions, and environmental organizations, using the cadastral map as a reference. This consolidation allows the correlation of facts, legal rights, and restrictions.

MORE EFFECTIVE URBAN PLANNING

Urban policy making is a complex process that requires clear representation of land uses. By implementing an MPC, administrators no longer need to acquire basic data or rely on incomplete information. As part of a spatial data infrastructure system, the multipurpose cadastre makes data available in a transparent and open way (figure 4). Cartographic representation of land by its uses, utility networks, and public and private properties provides a single reference system for identifying areas that are vacant, informal, protected, or lacking transportation services or health and education facilities.

The structuring of SDIs in the land cadastre also facilitates participatory processes such as self-registration, allowing residents to view the current reality as well as future projections. The public is thus able to make observations and contribute to the planning of service networks or zoning changes related to usage and/or density.

EXPANDED URBAN FINANCING ALTERNATIVES

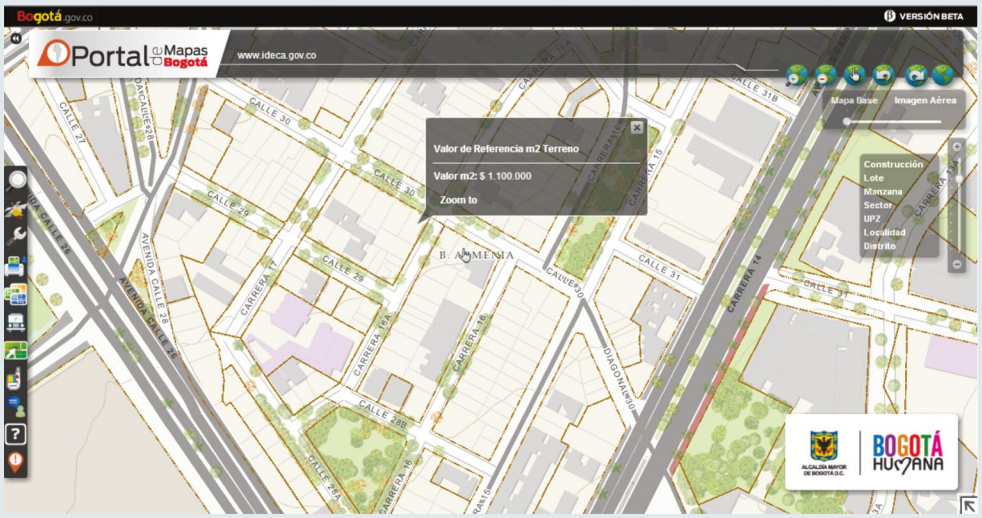
While an updated orthodox cadastre is essential to property taxation, correlating cadastral data with other information in an MPC makes the process even more equitable and efficient. In fact, implementing an MPC can increase revenues in both horizontal terms (by incorporating more taxpayers) and vertical terms (by incorporating more financing instruments).

One of the key features of the MPC model is the incorporation of informal areas into the cadastre database. Acknowledging such areas improves their integration into the city and enables residents to pay for taxes and utility services that they already receive. Another benefit of the MPC is that it can incorporate thematic cadastral data that are crucial to representing urban reality.

In addition, the MPC model makes it possible to implement a variety of municipal financing alternatives ranging from orthodox instruments (such as the property tax) to more heterodox and innovative tools (such as value capture, exactions, betterment levies, and

Figure 4

Maps Portal of Bogotá, Colombia



An online cadastral map shows an overview of parcels and land values in a neighborhood of Bogotá, Colombia.

Source: www.mapas.bogota.gov.co/portalmapas.

charges for building rights). The MPC correlates land values with the socioeconomic characteristics of owners and tenants, thus simplifying the definition of tax policies. Moreover, storing environmental data in a single database allows for making adjustments when public policies become more socially and/or conservation oriented.

IMPROVED MARKET TRANSPARENCY AND AGILITY

Urban dynamics depend on both planning decisions and market preferences. An MPC reveals urban development trends and correlates them into a single time and geographic space. MPC partners help to keep cartographic and tenure-related information updated, which permits measurement of how quickly real property is transferred.

In Latin American jurisdictions, the bureaucracy involved in the real estate market is often considerable, forcing applicants to go from one agency to another to obtain licenses and notifications of transaction approvals. The MPC model reduces the distance between government bureaucracies and real estate agents, thereby expediting approvals for parcel divisions and land subdivisions, cadastre certifications, and deeds and registrations. Data integration thus provides transparency and, most importantly, objectivity—one of the most critical elements of any public policy.

OPTIMIZED TECHNICAL AND HUMAN RESOURCES

Implementing an urban observatory and an SDI-based multipurpose cadastre further reduces costs and shortens update times, and makes it possible to generate more complete information by matching data from different sources quickly and reliably. The institutional integration required by the MPC also makes the most of partner resources through the transfer of knowledge and the sharing of talent.

Source: Aeroimagem S/A (www.aeroimagem.com); *prepared by Everton da Silva and João Norberto Destro.*

In this three-dimensional illustration, the relief and colors represent the variation in land values in Várzea Grande, Mato Grosso, Brazil. The high/red areas signify high land values, descending down to green/flat areas with low values.

Implementation Challenges

Evolving from the orthodox to the multipurpose model of territorial cadastres requires more of a conceptual and philosophical shift than a technological one. The notion persists that implementing an MPC requires the addition of environmental, infrastructure, and socioeconomic data to existing economic, physical, and legal information for each registered parcel. This misconception, along with the centralized structure of many Latin American agencies, represents one of the primary hurdles to MPC implementation.

While the order and number of steps may differ, administrators in Latin America typically must address the following challenges in structuring a multipurpose cadastre.

CREATING MARKET-BASED VALUE MAPS

Most jurisdictions in Latin America continue to use tabular methods to assess taxes, applying a single value per square meter to all parcels within "homogeneous zones" defined by land use. However, uses within these zones are seldom uniform, and adjustments are applied to each parcel according to its form, location, and topography. At the same time, building values are calculated primarily by using the cost method, also involving many adjustment factors

for age, materials, upkeep,and so on. These technical/administrative decisions require complex databases that are difficult to update, leaving assessed property values far below market prices.

Even in jurisdictions where value maps reference market values and are updated through econometric models and geostatistics (box 6), implementation of an MPC depends on political decisions. By law, value maps used for taxes and other public-policy purposes are subject to legislative approval and are therefore likely to be distorted. Taking the politics out of technical assessments is one of the biggest challenges to MPC implementation in Latin America.

The mapping of informal settlements is a related challenge. Many cities have begun to assess these areas, and the results have significantly facilitated urban financing and social integration. But there is much more to do. A particular challenge is determining the value of newly regularized land, given that new parcels can be included in cadastres only once the assessments are made.

CREATING DUAL-LEVEL CARTOGRAPHY

In Latin America, where the correlation between cadastral data and information in registries of deeds is almost an obsession for administrators, territorial cadastres should work at two levels. The first level should show all parcels, georeferenced and integrated into a single layer of the GIS. This parcel layer is the basic document used to create an MPC and is a common reference for all partners in the SDI environment. The second level should include the representation of precise measurements of each parcel, providing the highly detailed views necessary for real estate transfers and for subsequent updating of the cadastre.

Throughout the region, the level of geographic detail of the parcel layer has improved significantly since the 1990s, with representations increasing from a 1:2,000 scale to 1:1,000 at present. But the improvement made at the parcel layer level has not occurred at the individual parcel level. A precise and detailed map should thus contain both the physical and legal attributes of each parcel (figure 5, page 18).

Box 6

Land-Market Analysis Models

The classic regression model is one of several ways to analyze the behavior of land markets. This technique consists of adjusting hedonic regressions of parcel prices based on their features.

Geostatistics is an alternative spatial analysis technique that uses attributes collected at various points in a region to infer a continuous surface of values. One of the many geostatistical models is Kriging, a method of interpolation, which specifies that the spatial variation of a regionalized variable is expressed by three components: one structural, associated with a constant average value or a constant trend; one random, which is spatially correlated; and one residual or random "noise" component (Portugal et al. 2009).

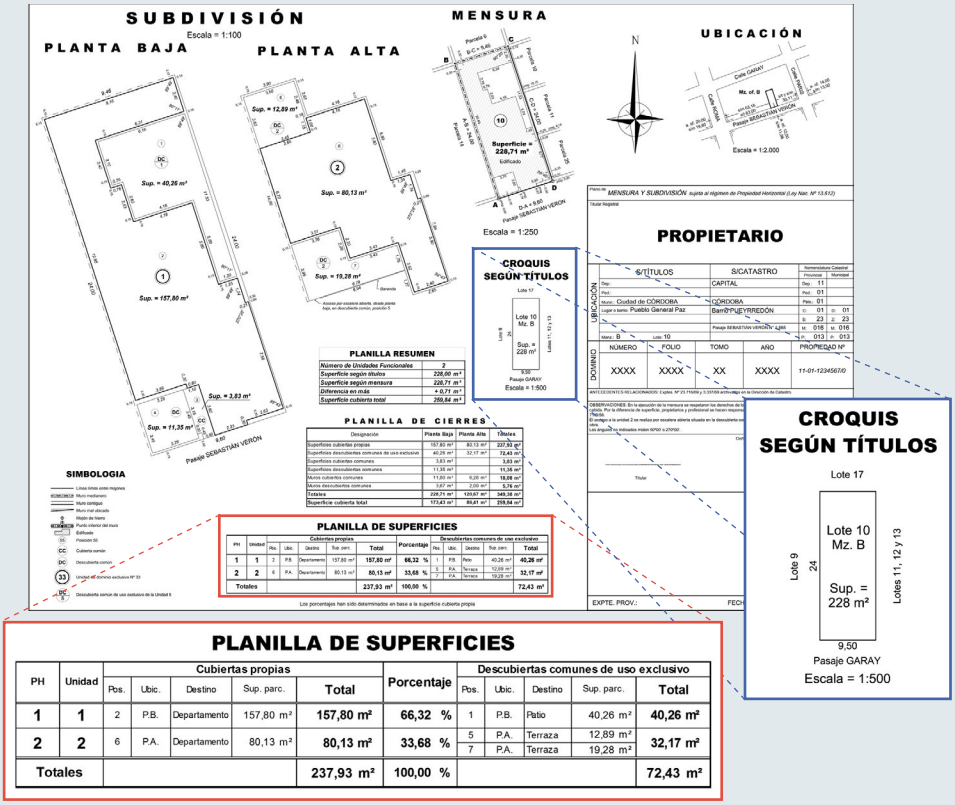
TRAINING CADASTRE PROFESSIONALS

There are 19 national, 400 regional, and almost 16,000 local governments in Latin America. Most of these governments—with the exception of Argentina, Brazil, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, and Uruguay—lack professionals with specialized knowledge of cadastres. Even countries with large land masses and complex legal systems, such as Mexico and Peru, do not offer specific undergraduate programs in cadastre issues. The numbers of professionals relative to the numbers of jurisdictions and their sizes differ widely in the region (table 1, page 19).

To expand the pool of trained professionals, educational institutions across the region must develop comprehensive instruction in several disciplines: economics (assessments, mass valuation); geomatics

Figure 5

Details of a Cadastral Map from Córdoba, Argentina



PLANILLA DE SUPERFICIES

PH	Unidad	Cubiertas propias					Porcentaje	Descubiertas comunes de uso exclusivo				
		Pos.	Ubic.	Destino	Sup. parc.	Total		Pos.	Ubic.	Destino	Sup. parc.	Total
1	1	2	P.B.	Departamento	157,80 m²	157,80 m²	66,32 %	1	P.B.	Patio	40,26 m²	40,26 m²
2	2	6	P.A.	Departamento	80,13 m²	80,13 m²	33,68 %	5	P.A.	Terraza	12,89 m²	32,17 m²
								7	P.A.	Terraza	19,28 m²	
Totales						237,93 m²	100,00 %					72,43 m²

This cadastral map shows the comparison between physical measurements and legal dimensions.

Source: Provincial Department of Cadastre, Córdoba, Argentina.

(geodetics, photogrammetry, topography, remote sensing); law (civil law, urban regulations); infrastructure (implementation and control of networks and environmental restrictions, georeferenced social data management); technology (databases, land information systems); and management of institutions (preferably institutions oriented toward integration through land-value observatories and SDIs).

MANAGING INFORMATION ACROSS INSTITUTIONS

There is a long tradition in Latin American countries of government entities working in isolation, each performing the functions stipulated by law but not coordinating with other agencies. Rapid turnover of managers and public employees is also a challenge because it affects the continuity of agreements and projects.

For a cadastre to be fully multipurpose, it is necessary to integrate information from all institutions working at the parcel level. But not all data has to be stored in the cadastre's information system. Instead, its parcel-related database should be used as a reference to correlate data managed by different institutions that generate or require land information. An MPC achieves this integration by interconnecting all such institutions through a common parcel layer and a single registration code for each parcel.

Table 1

Cadastre Professionals in Latin American Countries

Country	Undergraduate Title	Universities	Students per Institution (Median)[1]	Working Professionals[2]	Jurisdictions[3]	Area (km^2)[3]	Professionals per Municipality	km^2 per Professional
Argentina	Land Surveyor Engineer	14	200	4,800	24 provinces 2,400 municipalities	2,780,400.0	2.0	579.3
Brazil	Land Surveyor Engineer, Cartographer Engineer, and Technicians	22	200	22,000	5,570 municipalities	8,514,900.0	3.9	387.0
Colombia	Cadastral Engineer	1	1,000	900	32 departments 1,120 municipalities	1,141,800.0	0.8	1,268.7
Costa Rica	Topographic Engineer	3	300	1,700	6 provinces 81 cantons	51,100.0	21.0	30.1
Ecuador	Geographer Engineer	2	250	300	210 municipalities	283,600.0	1.4	945.3
Guatemala	Land Administration Engineer	1	250	250	22 deparments 237 municipalities	109,900.0	1.1	439.6
Uruguay	Land Surveyor Engineer	1	150	400	19 departments 89 municipalities	176,200.0	4.5	440.5

Sources:

1 Values obtained from university websites and survey by authors.
2 Approximate values obtained from professional associations.
3 www.wikipedia.org.

Sophisticated computer equipment is not essential. Instead, each administrative level must be willing to share data to avoid unnecessary duplication of efforts. In this way, each institution is able to generate the specific information of interest.

Along with the difficulties of forging new relationships among public agencies, there is also the challenge of involving the private sector in updating a cadastre. Overcoming a final administrative hurdle thus involves implementation of a self-declaration capability intended to empower both MPC-related groups and society at large with current information.

CHAPTER 3

Supporting Land Policies

The tremendous concentration of buildings in Punta Pacífica and Punta Paitilla, Panama City, viewed here from the old town, exemplifies the difficulty of developing land policies without a multipurpose cadastre. © *Álvaro Uribe.*

With the development of new and sophisticated land policies in Latin America, the structure of orthodox cadastres has evolved in ways that help support the implementation of diverse programs. For example, databases that once covered only private properties are now being integrated with cadastres of public lands and several other types of information collected by private organizations. The following sections describe some of the successes that jurisdictions have had in combining these data sources in support of major planning initiatives.

Identifying Public Land

A public territorial cadastre is an important complement to the mapping of private properties and is integral to effective policy making. Information about the availability and distribution of public land is essential for defining urban resettlement policies and determining the location of infrastructure, public spaces, and conservation land.

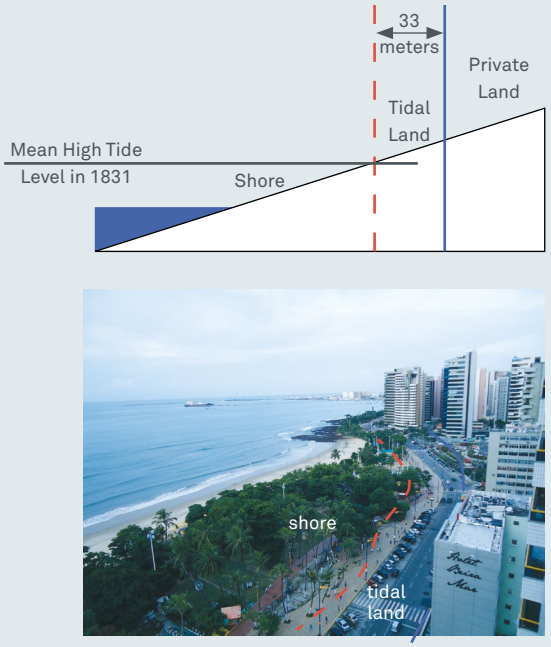
Identifying public land for the cadastre means determining the boundaries that separate it from private properties. This is a particularly challenging technical and legal task in Brazil, where the shoreline extends up to 8,500 miles when considering the detailed contours.

In Latin America, numerous federal, regional, and local agencies are responsible for recording and managing public property, most of them unconnected to the institutions responsible for the territorial cadastre. Chile's Ministry of National Assets *(Ministerio de Bienes Públicos)* is a notable exception. This agency has created one of the most complete and accurate public land cadastres in Latin America. Its mission is to identify and manage public assets, update the physical cadastre of public properties, coordinate land issues with other government agencies, and determine the value of the country's physical and historical assets.

Brazil has also developed an extensive public land cadastre, which is managed by an agency of the Ministry of Planning, Budgeting, and Management. The ministry is responsible for managing, monitoring, and granting use of national properties. In this system, public properties are legally classified as destined for specific uses (for government services) or common uses (such as parks, streets, rivers, and beaches).

Figure 6

Views of High Tide Lines and Public-Private Boundaries in Brazil

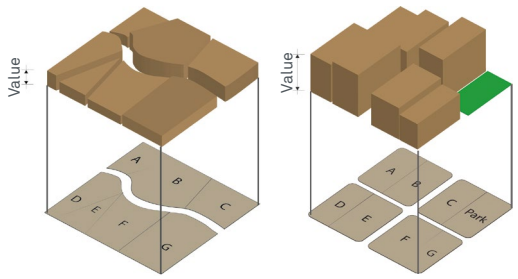


Identifying public land for the cadastre means determining the boundaries that separate it from private properties. This is a particularly challenging technical and legal task in Brazil, where the shoreline extends up to 8,500 miles when considering the detailed contours. Figure 6 shows a strip of tidal land falling between private and public land, the boundaries of which must be determined by measuring horizontally from the mean high-tide level of the year 1831 (red dotted line) and 33 meters inland (blue line).

The ministry also determines the market value of public properties and applies different tax rates in partnership with several federal agencies as well as with coastal municipalities. Management is shared in part with local governments, which can respond

Figure 7

Physical and Economic Cadastral Modification after Land Readjustment



Before Land Readjustment After Land Readjustment

better to changes in demand for land. Government land generates income, which is also shared with the local governments.

Locating Vacant Land

The deep economic and social transformations that characterize Latin America have altered demand for urban land. Vacant lots are no longer viewed as a problem but rather an opportunity for urban development, making it essential for planners and real estate developers to know the distribution, quantity, and size of vacant lots (Clichevsky 2002).

Identification of vacant land begins with analysis of maps, aerial photographs, and/or satellite images, along with fieldwork. The availability of open platforms and products such as Google Earth, Google Maps, and Open Street Maps has facilitated these activities, although different products can also yield widely different results. There are enormous discrepancies among the land information sources available in several web-based applications and official cartography. Estimates of vacant land using each product independently can thus vary dramatically.

Moreover, even if all sources show that a lot is vacant, it is impossible to determine if it is available for development without knowing its tenancy, legal status, condition (i.e., whether it is polluted), and length of vacancy. In Latin America, completing this investigation normally involves visiting several institutions and administrative agencies in search of a variety of physical, social, environmental, and legal data. Even then, integrating the information is neither quick nor efficient.

The relationship between a land cadastre and vacant land has both physical and legal aspects. The former (physical) "sees" the vacancy, and the latter (legal) determines the tenancy. Using historical data, it is possible to determine how long the land has been vacant and if it may be retained for speculative purposes. Using only data from an orthodox cadastre, it is difficult to determine whether a lot that looks like wasteland in a satellite image is actually vacant. Using a multipurpose cadastre through an SDI, however, it is possible to correlate physical, legal, environmental, and socioeconomic data to verify the land's status.

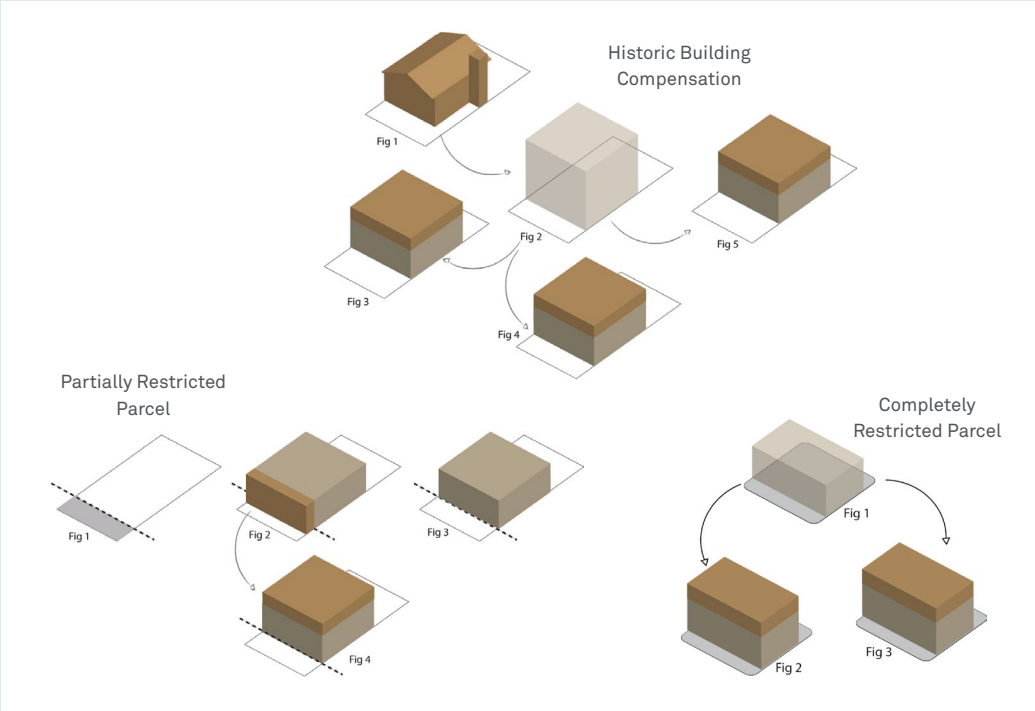
Land Assembly for Redevelopment

Land readjustment is a mechanism for reconfiguring irregularly shaped properties in areas undergoing redevelopment. This process involves aggregating several parcels and then subdividing them in a more standard way in order to provide basic infrastructure such as roads, parks, sewer networks, electricity, and telephone service.

The cadastre plays a highly relevant role in this process. Information about the area in general and about each property owner in particular is essential to ensure an equitable distribution of charges for and benefits from a land readjustment project. The difference between the initial value of the land and buildings (based

Figure 8

Three Types of Transfers of Development Rights



Source: Anamaria Gliesch, adaptation based on Néia Uzón, 2013. "Transferência do direito de construir: a experiência de Porto Alegre, Brasil."

on zoning laws in place before establishment of the plan) and the final value (based on its new uses and densities), shown in figure 7, is then used to prorate restitution for landowners (Rave and Rojas 2014).

Given the complexity of land readjustment, the whole process requires multiple data sources, efficient and standardized assessment methods, accurate cartography, clear definition of boundaries (including legal, physical, and ownership), and information about the land and building markets. Owners can create their own cadastres with these data, which must then be integrated into the official cadastre once agreements are reached (box 7, page 24).

Transfer of Development Rights

Governments use transfers of development rights (TDR) to acquire private property for public works or to establish a protected area without having to disburse any funds. Local laws may allow property owners to build on other lots or even sell the development right when their properties are earmarked for urban infrastructure, conservation, regularization, or low-income housing (Uzon 2014). The TDR is based on the idea that a property right is subject to the limitations imposed by urban legislation and is subordinate to the public interest. The transfer may restrict all or part of the property right, passing it to another area in compliance with planning requirements. There are

Box 7

Land Readjustment in Colombia

In Colombia, a change in land use must comply with the social and environmental function of the property, the preponderance of general interests over private interests, the public function of urban development, and the equitable distribution of charges and benefits. Law No. 388 of 1997, which addresses master planning, identifies joint land management as one of the main drivers of Colombian urban development, enabling real estate integration, cooperation among participants, and land-use changes. These instruments are applied under so-called partial plans or units of urban development. Partial Plan SIMESA, implemented in Medellín, is a good example of how cadastral data can change after land readjustment.

three basic kinds of TDRs: historic building, partial compensation, and total compensation (figure 8, page 23). Implementing a TDR affects the economic cadastre since it alters the value of the parcel. It can also affect data in the physical and legal cadastres.

For example, Porto Alegre, Brazil, developed its Third Perimetral Plan to improve traffic flow across the city. A new agency was created specifically to organize a cadastre of properties affected by the project, set up a computerized system to control purchases, draw up contracts, negotiate the scope of affected areas, and implement the acquisition of properties by eminent domain. A private company was hired to perform the cadastral survey from which the topographical maps were generated (i.e., the physical cadastre). The value of the parcels, initially assessed at US$300 per square meter, increased to US$450 per square meter, as verified by the purchase and sales agreements as well as assessment reports written by legal experts (i.e., the economic cadastre). The exchange of parcels between the municipality and the private parties in charge of construction was done by public deed (i.e., the legal cadastre).

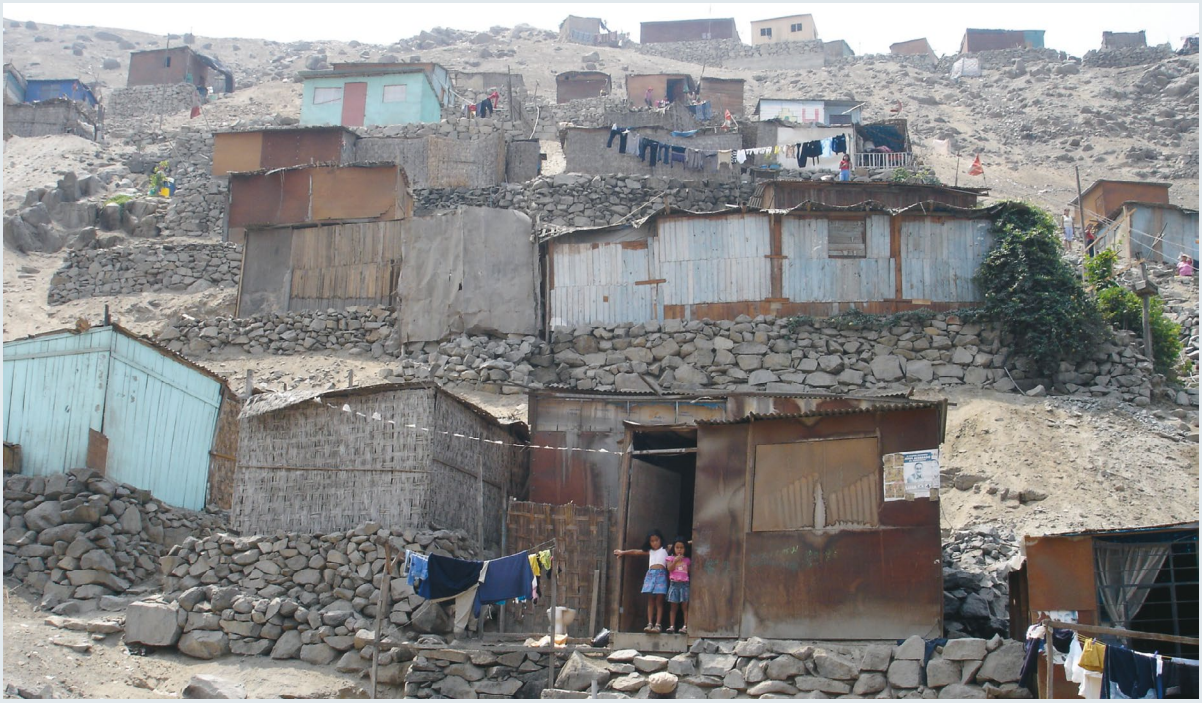
Through amicable expropriations, 131,570 square meters of land were acquired for the execution of public works at a cost of about US$3,249,000. Buildings and construction were likewise expropriated in the amount of US$3,450,000, while spending on escrow deposits (including both land and buildings) reached about US$4,000,000. The total cash disbursement was thus about US$10,700,000.

The transfer of development rights can be used only for land. In the Porto Alegre operation, the use of TDRs reduced the cash disbursement by approximately half. Comparing the values of the land acquired with and without transfer of currency, 65 percent of the total value was attributed to the use of TDRs.

This successful value capture experience saved financial resources while also achieving institutional integration and data exchange. However, it should be noted that the data already stored in the municipal cadastre would have been sufficient for accomplishing the stated goals. This example therefore demonstrates that, in some cases, orthodox cadastres contain sufficient and reliable data to support a TDR process.

CHAPTER 4

Cadastres and Urban Informality



Informal settlement on the periphery of Lima, Peru, with precarious living conditions and lack of infrastructure. Areas such as these are often not represented on urban maps or taken into account in public policies, a consequence of the fact that cadastres in Latin America do not register urban informality. *© Diego Erba.*

Informal settlements have been a common form of urban development in Latin America for more than six decades. They reflect the scarcity of affordably priced formal land in suitable locations for low-income residents, as well as the impacts of political patronage and corruption, housing policies, and ever-weaker government interventions to expand the supply of inexpensive land (Jiménez Huerta 2014).

While cadastres frequently record only parcels in the formal market, records about transactions in the informal market often exist as well. For example, neighborhood associations in some communities record buyers, sellers, parcel values, and transaction dates, occasionally resulting in the existence of formal and informal registers in Latin American cities. The problem is therefore not a lack of data on informal settlements, but the fact that the records are created in parallel and have different structures.

Informality and Irregularity

The term *urban informality* conjures up visions of noncompliance with land-use norms and regulations, unregistered property transactions, land invasions, poverty, lack of services, and garbage-strewn neighborhoods. The term *villas miserias* used in some countries aptly conveys this image, which was reinforced by the International Federation of Surveyors (FIG)'s 2008 definition of *urban informality* as "dense settlements comprising communities housed in shelters under informal land tenure. The quality of dwellings in such areas varies from shacks to permanent structures, while access to water and electricity, sanitation, and other basic infrastructure tend to be limited." Moreover, informal settlements do not appear on cadastre maps.

According to Alfonsin (2013), *informality* and *irregularity* are frequently used interchangeably in Latin America, but their meanings are not the same. This distinction is highly relevant for cadastres. When analyzing the impacts of the law and of market forces on land configuration, important semantic differences exist. Irregularity arises from the fact that only some parts of cities are able to comply with strict urban regulations. In other areas—even where parcels are listed in the territorial cadastre and the registry of deeds—people simply build houses without regard to regulations. This duality implies the existence of a formal land market that is controlled by private property rights and urban regulations. Informality is related to land tenure and land markets that develop according to their own rules. However, some experts conceive of the formal and informal markets as existing on a continuum rather than as entirely separate.

Given that informal settlements are present in almost all Latin American jurisdictions, their demarcation is essential for developing effective urban policies. Because territorial cadastres normally do not recognize these areas, it is often up to other public and private entities to create detailed land records.

In any case, most Latin American cadastres either have difficulty identifying irregular areas or simply do not consider the distinction important. When using remote sensing products or aerial photographs to update their cadastres, jurisdictions focus on the size of buildings but do not verify whether any construction meets urban codes. By recording this information, the cadastre helps to turn an irregular area into a "regular" one.

Given that informal settlements are present in almost all Latin American jurisdictions, their demarcation is essential for developing effective urban policies. Because territorial cadastres normally do not recognize these areas, it is often up to other public and private entities to create detailed land records.

Mapping Informal Areas

Chile is an exception to the rule that governments fail to map informal areas in Latin America. In fact, the Executive Secretariat of Informal Settlements, part of Chile's Ministry of Housing and Urban Development, has compiled one of the most complete cadastres of

The Many Faces of Informality

Settlement built on toxic wasteland, Port-au-Prince, Haiti

Spontaneously occupied settlement, Salvador, Brazil

Occupation of an environmentally vulnerable area, Quito, Ecuador

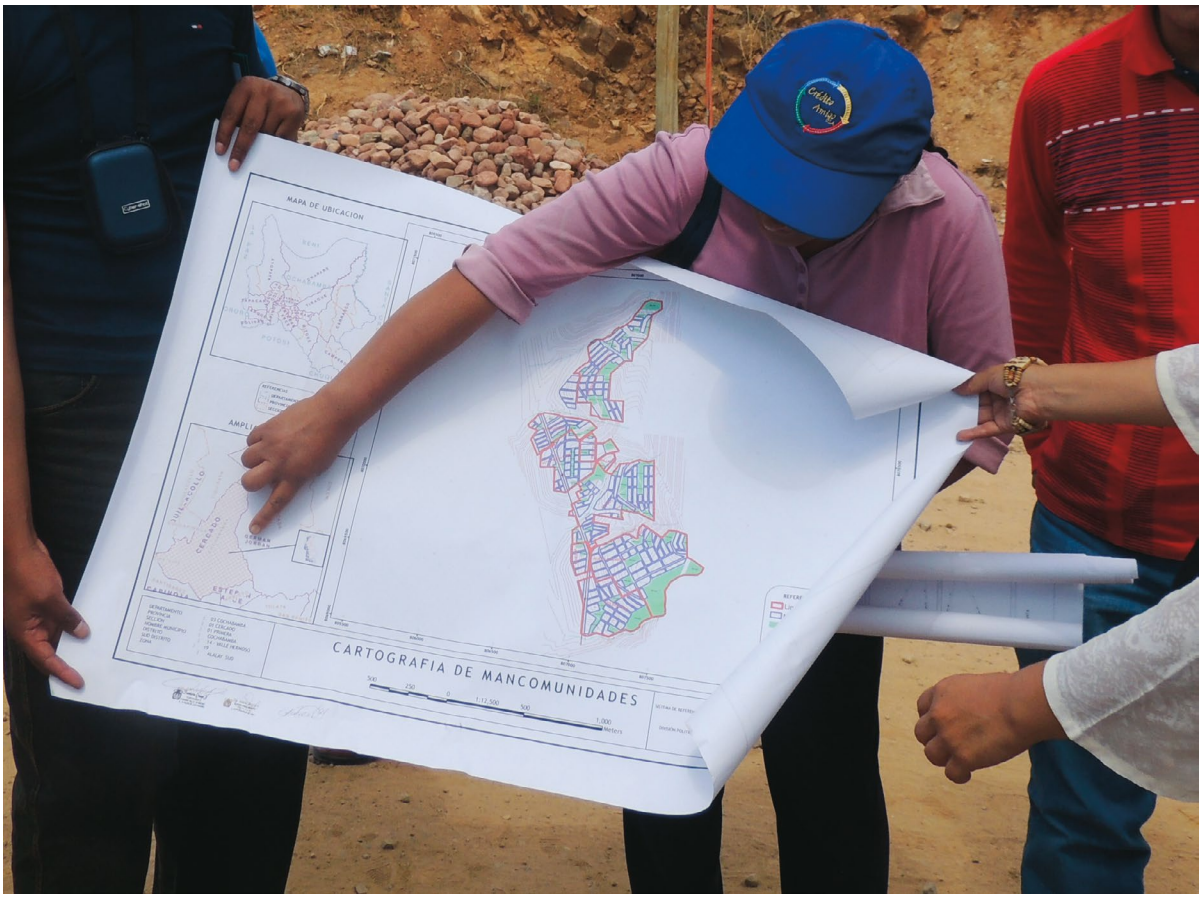
Occupation of buildings in precarious condition, Panama City, Panama

Source: Diego Erba.

informal settlements in Latin America. This extensive cadastre identifies informal areas by region and provides each of the country's 13 administrative regions with its own database.

Unlike this national effort, nongovernmental organizations (NGOs) and communities typically develop cadastres to characterize conditions in a particular area, with the goal of resolving some deficiency in infrastructure, titling, public transit, or other issues.

For example, the nongovernmental organization TECHO has created maps of informal settlements in Argentina, Chile, Nicaragua, and Uruguay in order to help organize their activities. TECHO built the cadastres in stages, first compiling existing information from government agencies, then performing a land survey with fieldwork to establish georeferenced boundaries, and finally identifying infrastructure networks and tenancy status.



A community leader of a settlement located in District 14, Cochabamba, Bolivia, explains the self-funded georeferenced cadastral map created in order to affirm occupants' possession of the land. © *Diego Erba.*

In other cases, occupants of informal settlements may pay to have a cadastral map created in order to affirm current possession of the land. In District 14 of Cochabamba, Bolivia, for example, seven social organizations joined forces in 2008 to develop a rudimentary multipurpose cadastre that they could use to get their settlement recognized and integrated into the urban network. The settlers performed a complete census of the vegetation, infrastructure, socioeconomic profile of residents, and other characteristics and then recorded the information at the local government office. Each family invested the equivalent of US$12 for the preparation of a highly detailed, georeferenced topographical survey of the area.

The settlement in District 14 does not have running water or sewer service, but each household paid about US$4,000 to cover the cost of the electrical network, road construction, and open-space delineation. With these improvements, the average value of the lots rose from US$1,500 in the 1980s to about US$18,000 in 2013.

Interventions to Reduce Informality

Regularization of land tenancy—a legal and administrative procedure intended to promote residents' tenure—is one of the most common policies used

Assessors responsible for building and maintaining assessment maps based on market values have difficulty finding econometric models that fit the reality of informal settlements and the transition areas between the formal and informal markets. Parcel values depend on both tangible and intangible factors, such as the security provided by community organizations.

to address informal settlements in Latin America. Regularization was first implemented in Peru in 1961, in Mexico in 1973, in Chile in the 1980s, and in the rest of Latin America since 1990 (Calderón 2006).

Regularization typically involves setting up an agency—usually independent of the cadastre office—to serve one or more informal settlements. While the ultimate goal may be to correct many social, legal, environmental, and technical problems, most regu-larization programs simply provide property titles. Moreover, implementation sometimes requires concessions that create other urban irregularities. For example, extending the urban grid to an informal settlement such as a consolidated *favela*—where the distribution of buildings is erratic and the lots are irregular in shape—is extremely challenging. A common practice is therefore to consolidate the settlements with minimal removal of buildings, preserving the boundaries established by the settlers and creating cadastre parcels whose footprints do not comply with master plans.

In principle, the process of incorporating parcels created by a regularization program in the cadastre is similar to incorporating parcels that originate in the formal market. However, problems may arise when assigning a cadastral identifier to the new units, particularly in jurisdictions where the numbering scheme follows a city-block designation—often ill-defined in informal settlements. Another limitation is the lack of a street cadastre with official names and addresses.

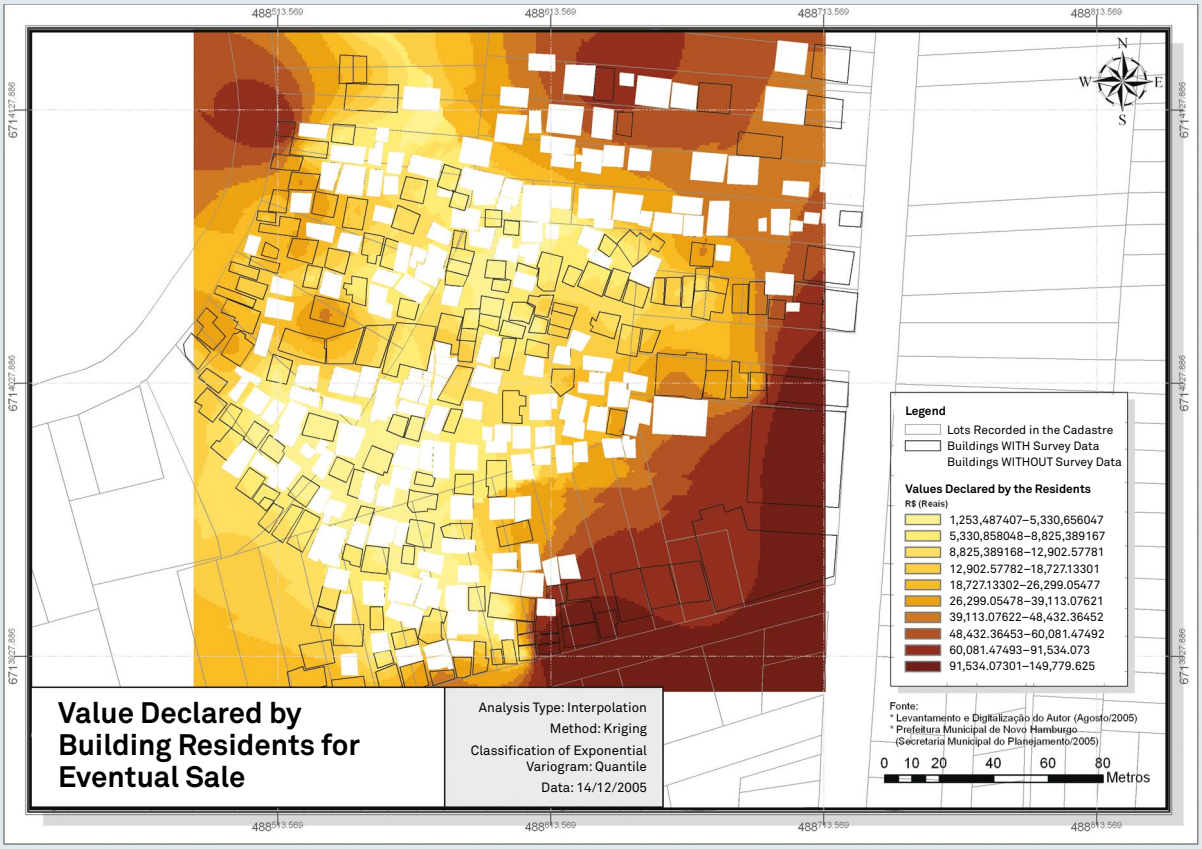
Regularization programs may affect the data stored in physical and legal cadastres, but they particularly affect economic cadastres. Assessors face a big challenge when appraising the value of parcels once a program is completed and the land moves from the informal to the formal market, which is governed by completely different parameters.

Assessors responsible for building and maintaining assessment maps based on market values have difficulty finding econometric models that fit the reality of informal settlements and the transition areas between the formal and informal markets. Parcel values depend on both tangible and intangible factors,

Extremely dense informal occupation in Osasco, São Paulo, Brazil, led to the development of a new form of regularization of informal settlements by building multistory buildings instead of titling independent pieces of land. © *Municipality of Osasco, São Paulo, Brazil.*

Figure 9

Land-Value Variation Determined by Self-Declaration in an Informal Settlement, Novo Hamburgo, RS, Brazil



Source: Anamaria Gliesch.

such as the security provided by community organizations. These critical features of informal settlements violate many of the premises of a property tax system: the ability to identify taxable parcels and their tax--payers, to describe the physical characteristics of the properties, and to determine their value based on reasonable and predictable market metrics. As Smolka and De Cesare (2006) note, this explains why cadastre databases and tax policies generally exclude informal settlements.

There are, however, some efforts are being made to determine land values in informal settlements. It is well known that land markets exist even in slums where transactions typically go unrecorded. Self-declaration is a technique that has yielded good results in representing the variation in land values in these areas. Residents declare the value at which they are willing to sell their properties. The construction cost is assessed separately and subtracted from the total value, leaving the land value as a residual. Using this approach, it is possible to estimate a proxy land-value map of an informal settlement (figure 9, page 30).

Orthodox cadastres normally omit infrastructure networks and subdivisions in informal settlements,

This blackboard shows a request for payment for water service in an informal settlement on the periphery of Lima, Peru. A commission centralizes payment and service delivery, using a cadastre of settlement occupants. © *Diego Erba.*

even when there are fixed water lines and formal distribution networks. Utility companies, however, maintain good records because residents pay for their services. Connecting these two types of databases therefore helps to create a more complete picture of the settlement.

In cases where service delivery is centralized, a community leader or a neighborhood committee is responsible for paying the bill for the whole settlement. For this purpose, a cadastre of consumers is used to prorate the total value and to track the payment status of each family.

In addition to helping qualified residents obtain legal titles to the land they occupy informally, Terra Nova's work enables the government to implement much-needed infrastructure such as water and sewer systems, electricity, and paved roads.

The regularization program conducted in Osasco in the state of São Paulo, Brazil, is a good example of how a multipurpose cadastre can support efforts to reduce informality. Indeed, its regularization program received an award for Best Practices in the Federal Government in 2008. The northern region of the city was considered the most neglected area, and the western hills the largest slum. The high prices of land in the city forced the poor to build their homes in environmentally fragile areas or on public land.

The Technical Department of the Secretariat of Housing and Urban Development, the government agency responsible for controlling and regulating land use in both formal and informal areas, had three strategic priorities: urbanization of settlements, land titling, and housing provision. The slum-upgrading program

Figure 10

Original Settlement and Urban Guidelines for Regularization, Jardim Primeiro de Maio, São Paulo, Brazil

The top photo shows the original occupation of the neighborhood. The bottom map shows the proposed urbanization with open spaces, streets, parcels, and contours.

Sources: Terra Nova, www.grupoterranova.com.br.

moved numerous settlers out of risk areas for flooding and landslides, restored the areas of environmental risk, and provided housing and public services to the families. Between 2005 and 2008, the government also issued about 7,000 titles. Leveraging federal funds, the government built more than 1,000 housing units, many of which had multiple stories. Although a systematic and complete cadastre for the whole city of Osasco still does not exist, the housing authority organized

The team integrates all of the information from existing maps, topographic and geological surveys, aerial photos, and socioeconomic profiles of the families, as well as the surveys of land value and households' ability to pay.

a specific cadastre and registered all 33 informal settlements where urbanization and regularization occurred.

An alternative to government regularization is an instrument called *regularizador social* (social regularization), developed by Terra Nova, a private for-profit company in Brazil created specifically to promote the regularization of informal urban settlements. Terra Nova mediates disputes between landowners and settlers and manages all activities necessary to stabilize and urbanize the areas. In addition to helping qualified residents obtain legal titles to the land they occupy informally, Terra Nova's work enables the government to implement much-needed infrastructure such as water and sewer systems, electricity, and paved roads.

Terra Nova begins this complex program by identifying and mapping the informal occupations, followed by fieldwork to gather information through a census and photographic records. Back in the office, the team integrates all of the information from existing maps, topographic and geological surveys, aerial photos, and socioeconomic profiles of the families, as well as the surveys of land values and households' ability to pay. The construction of this multipurpose cadastre makes it possible for Terra Nova to perform the financial, social, and legal aspects of the regularization program and to start the participatory planning process (figure 10).

CHAPTER 5

Expanding Urban Financing Options

Medellín, Colombia, is one of the few Latin American jurisdictions that include informal settlements in their cadastral maps and tax systems. © *Diego Erba.*

Urban financing in Latin America is generally linked—and often restricted—to the property tax. Indeed, orthodox cadastres are essentially a means to support this revenue source and are structured by the agencies in charge of tax assessment. Even so, property tax revenues in the region are low relative to their potential. This chapter briefly describes how modernized cadastres have enabled some jurisdictions not only to increase their property tax collection, but also to impose alternative types of levies. The final section explains the innovative use of self-declaration and land-value observatories to update cadastre information.

Table 2

Referential Prices for Cadastral Surveys in Brazil (Estimated by a Private Survey Company)

1. Aerial photography mapping with ground sample distance (GSD) of 10 cm (products compatible with 1:1,000 scale)					
	Levels and Types of Information			Training	Cost in US$/km²
Scenario	Vectorial	Raster	Altimetry		
A	Road network, artificial divisions (fences and walls), and hydrography	Orthophotographic maps	No	Municipal technicians, 40 hours	4,300 to 5,300
B			Contours based on laser profiling		5,300 to 6,000
2. Cadastral survey					
	Actions			Training	US$/parcel
	Identification of parcels			Municipal technicians, 100 hours	22
	Data survey and processing				
	Database creation				
3. Mass assessment of properties					US$/parcel
					22

Source: Author's design based on Everton da Silva, Universidade Federal de Santa Catarina, Brazil.

Improving Property Tax Collections

Even in jurisdictions with well-organized orthodox cadastres, property tax collection rates in Latin America are relatively low largely because of policy choices and outdated information and/or because informal settlements are not covered. But keeping cadastres up to date helps to improve revenues. In addition, cadastral updating has significant nonfinancial benefits that include improved cartography and taxpayer databases, as well as better knowledge of infrastructure, green spaces, and other urban characteristics.

UPDATING WITH GEOTECHNOLOGIES

In 2013, the Metropolitan District of Quito, Ecuador, invested US$11 million to modernize its territorial cadastre. The process included updates to mapping and alphanumeric data, as well as construction of a Metropolitan Information System, an interactive platform that enables government agencies, public companies, and other entities to perform analyses and make decisions on land management and development. Using orthophotographs (aerial photos that are geometrically corrected), the project identified and incorporated 111,504 new parcels into the cadastre. Visits to 688,500 urban parcels helped to identify more than 48 million square meters of undeclared construction. This process, along with other efforts to update land and building values, more than doubled the value of district property, from about US$30 billion in 2010 to about US$63 billion in 2013. Even with these results, the new government decided to reduce the property tax.

The costs of cadastral updating vary throughout Latin America. As a reference, tables 2 and 3 analyze the prices estimated by a one private Brazilian company.

Table 3

Simulation of Costs for a Brazilian City of 20,000 Parcels (80,000 Inhabitants), Occuping an Area of 50 km²

Service	Investment in US$	Urban Property Tax (US$)		
		Per Year / Per Parcel	Taxes Charged	Taxes Collected
Mapping	294,118			
Cadastral Survey	420,168			
Mass Assessment of Properties	420,168			
	1,134,454	240	4,800,000	3,360,000

Source: Data from correspondence with Everton da Silva, Universidade Federal de Santa Catarina, Brazil.

Table 4

High-Resolution Products for Cadastral Updating

Features	Light Detection and Ranging (LiDAR) Scanner + Aerial Photograph	Stereo Satellite Images	Pictometry (Oblique Photograph)
Uses and results	• Orthoimage	• Orthoimage	• Orthoimage
	• Digital Terrain Model (DTM) and Digital Elevation Model (DEM)	• Contours	• Contours
	• Detailed restitution (shapes and areas)	• Detailed restitution (shapes and areas)	• Detailed restitution (shapes and areas)
	• No census	• Expedited census by street	• No census
			• Software for 3-D visualization
Orthoimage restitution	30 cm	50 cm	10 cm
Precision	25 cm planimetry	1 meter planimetry	
	10 cm altimetry	50 cm altimetry	
Approximate costs for 15,000 blocks (before taxes)	US$800,000	US$1,100,000	US$930,000
Unit costs	US$53 / ha	US$73 / ha	US$62 / ha
Term	18 months	16 to 19 months	18 months
Advantages	Quality of the data (definition and precision)	Large numbers of users	• Quality of the data (definition and precision)
			• Less fieldwork
			• Ease of data management
Disadvantages	Few cases of application (less know-how)	Lower quality of data	• Few cases of application (less know-how)
			• Few providers
			• Requires a specific software, incorporated into the GIS

The calculation in table 3 (p. 35) demonstrates that even if property taxes are based on land values before the update, revenues obtained in the first fiscal year after update (assuming a 70 percent collection rate) would cover the cost of the surveys.

Alternative products are being used for urban surveying. Satellite images, oblique photographs, and laser scanners are increasingly popular in Latin America. Table 4 (page 35) describes the high-resolution products that are most commonly used in Latin America.

ASSESSING INFORMAL AREAS

Excluding informal areas from the cadastre reduces the universality of the property tax, with a consequent loss of income. Medellín, Colombia, is one of the few Latin American jurisdictions that include informal settlements in their cadastral maps and tax systems. A land tenant can use proof of payment of the property tax to acquire property rights by statute of limi-tations. In Medellín, there is no distinction between owner and tenant for assessing and collecting the property tax. The rates are established based on the parcel and its use, which can be residential, industrial, commercial, or institutional.

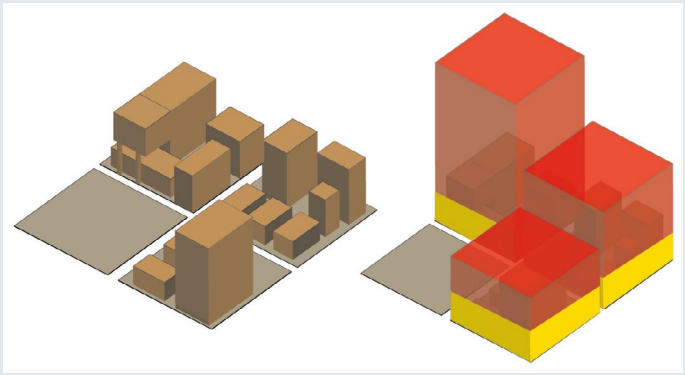
Tax rates for residential areas are progressive, depending on the socioeconomic level of the area. This explains the high degree of compliance of land tenants (informal property owners), particularly with property taxes. Indeed, the city has an excellent taxpaying culture, with a delinquency rate of less than 15 percent. This success can be attributed to the local administration's emphasis on social responsibility. According to the Municipality of Medellín's cadastre unit, more than half of the municipal budget is invested in social programs, public works, and development programs.

Alternative Sources of Financing

Latin America has a long tradition of value-capture policies that are intended to recover some of the costs of public investments in infrastructure and services. In fact, many countries—notably Brazil and Colombia—have passed legislation that explicitly considers value-capture principles. Two of the financing tools related to existing, new, or changing land uses are special betterment contributions and direct charges for building rights.

Figure 11

Physical Interpretation of OODC



SPECIAL BETTERMENT CONTRIBUTIONS

Special betterment contributions are based on the benefits that a property owner receives from a completed public work in the area. The levy focuses primarily on street construction and repaving, although it can also apply to water and sewer networks, parks, and other municipal works. The levy is designed to recover the costs of public works and assumes that the infrastructure benefits are capitalized in property values. This financing tool is most often used in Ecuador and Colombia, although examples exist elsewhere in the region.

The Constitution of Ecuador stipulates that municipal governments must, among other responsibilities, plan

for the development and organization of national territory; build urban roads; provide running water, sewers, garbage collection, and solid waste disposal; and manage public transit and transportation. But the cadastres cover barely 60 percent of urban parcels in the country, and land-assessment values are far below market prices despite a mandate to update assessments every two years. Given this reality, a more ad hoc tool like the special betterment levy appeared to be a good approach for recovering government costs for the projects and returning at least part of the added value to property owners (Aulestia and Rodriguez 2014).

Cadastres provide the economic, physical, and legal data necessary to define the area of influence of the betterment levy. In the case of global public works (such as bridges, tunnels, and connecting roads), the contribution is distributed to all parcels registered in the cadastre. For sector public works (such as squares, plazas, and parks), the levy affects the parcels located within the benefited area. In both cases, the contribution of each parcel is determined according to the cadastral value. In the case of local public works (such as paving, lighting, sidewalks, and curbs), only adjacent parcels are included in the betterment levy, with 40 percent of the cost prorated by the length of frontage and 60 percent based on the cadastral value (figure 12, page 38).

CHARGES FOR BUILDING RIGHTS

Charges for building rights are based on the separation of building rights from land ownership rights, enabling the public to recover the land-value increment resulting from development rights over and above an established baseline (figure 11). In Brazil, the urban policy instrument that regulates charges for additional building rights is the Outorga Onerosa do Direito de Construir, or OODC (Municipal Charge on Building Rights). Regulated at the federal level, the OODC imposes fees for construction permits that exceed a certain density or basic use coefficient (Smolka 2013).

The Constitution of Ecuador stipulates that municipal governments must, among other responsibilities, plan for the development and organization of national territory; build urban roads; provide running water, sewers, garbage collection, and solid waste disposal; and manage public transit and transportation.

The relationship between the OODC and land is less obvious. According to Maleronka and Furtado (2014), the OODC does not increase the value of a property, nor does it add to the height or density of a city because it respects limits defined by urban laws. As a result, it does not affect the data in the orthodox cadastre, although the cadastre itself contributes to the OODC's implementation through assessors, who work with urban planners to define the final charge. The cadastre of urban service networks is also essential to the implementation of the OODC, given that the capacity of existing or planned infrastructure affects the maximum height and density of structures that can be supported.

Innovative Approaches to Updates

Latin American jurisdictions generally lack the resources to carry out systematic parcel surveys. As a result, some cities have developed alternative strategies for keeping their cadastres updated, such as self-declaration programs and value observatories.

SELF-DECLARATION

Salvador, the capital of the state of Bahia in Brazil, implemented a massive updating process in 2013 in order to improve planning for health, education,

Figure 12

Representation of the Betterment Levy Distribution According to the Public Work Impact

Source: Department of Cadastre, Portoviejo, Ecuador.

welfare, urban sanitation, and public transportation programs. The city required property owners and tenants to register all parcels in the municipality, using a variety of media (including radio, TV, newspapers, and the Internet) to publicize the mandate. Enrollment was conducted in a simple, self-explanatory way through a website.

Administrators estimated that they registered more than 400,000 new parcels over about a month and a half, in addition to reregistering 650,000 existing parcels. With this project, the city was able to georeference most of the parcels, expanding the orthodox cadastre and beginning the development of a multipurpose cadastre that integrated records from the state-owned electricity and water companies. The mayor of Salvador established a formal working group to specify and develop the terms of reference for the city's MPC.

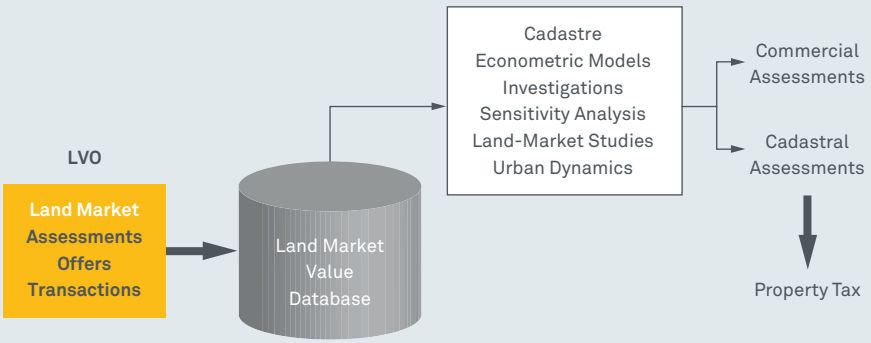
LAND VALUE AND BUILDING OBSERVATORIES

Another low-cost approach to updating cadastres is the use of an observatory, an administrative and technical structure that can monitor land values and/or buildings. Land-value observatories track changes in land values and land use through images and censuses. Building observatories can monitor and identify undeclared construction that has not been included in cadastral maps and databases. Observatories can be created by the administration of an orthodox cadastre itself, or through partnerships with public and private academic institutions with common interests in certain spaces.

For example, the Special Administrative Unit of the District Cadastre of Bogotá, Colombia, established a land-value observatory to analyze the real estate

Figure 13

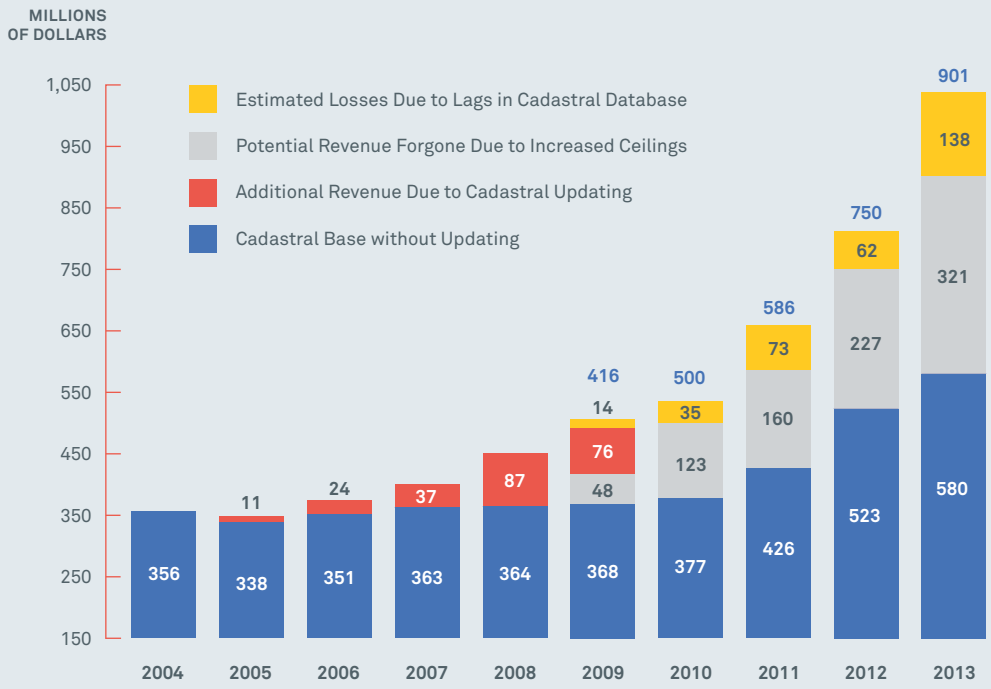
Structure of the Land-Value Observatory (LVO) of the District Cadastre of Bogotá, Colombia



Source: District Cadastre of Bogotá, Colombia.

Figure 14

Impact on Property-Tax Revenues after Implementation of Land-Value Observatory



Source: District Secretariat of Finance—Fiscal Studies, Bogotá, Colombia.

market—in particular, the variation between sales offers and purchase prices, the evolution of prices and their relationship with regularization, and the dynamics of urban economics. The observatory follows day-to-day building activity by monitoring construction permits; provides intelligent (dynamic) information about land development; analyzes physical variations over time; and identifies land uses and built areas, as well as urban and real estate development projects that are underway (figure 13, page 39).

Bogotá's land-value observatory has the capacity to update information on almost all parcels every year. The information it yields can be used to define strategies for the master plan, identify informal occupations at their earliest stages, and provide the data necessary for calculating value capture and assessments. The observatory has also contributed to market transparency and helped to spark a dramatic increase in tax revenues (figure 14, page 39).

Observatories of buildings are extremely relevant in Latin America, where residents routinely construct without permits, despite incentives provided by city administrators for obtaining building permits prior to commencing construction. One of the consequences of this practice is that cadastres become outdated.

This poster explains how to obtain building permits from the Municipality of Pastaza, Ecuador, and defines penalties for building without a permit. © *Diego Erba.*

CHAPTER 6

Future Perspectives and Recommendations

Participatory planning has been a reality for many years in Rosario, Argentina. The need for more data to implement these processes is gradually pushing the city administration to reorganize the cadastre from the orthodox to the multipurpose cadastral model. © *Diego Erba.*

The many technological and conceptual advances that have occurred in recent years have opened the door to new possibilities for the use of cadastres in urban planning and finance. In particular, the use of econometric and geostatistical techniques to perform mass property assessments and create value maps is a key development. This chapter offers speculations about how such changes might support a gradual shift from the orthodox to the multipurpose model in Latin America, and concludes with recommendations for making this transition.

Figure 15

3-D Representation of a Building in Medellín, Colombia

Source: Department of Cadastre, Medellín, Colombia.

Looking Ahead

In the economic realm, cadastres are leading the way toward the use of value observatories to monitor real estate markets. Existing observatories have yielded excellent results, demonstrating the advantages of such systems for tracking transactions, mortgages, and ownership transfers. Public agencies working on land cadastres will gradually develop the capacity to prepare value maps based on observatory data and geostatistically supported econometric techniques.

In terms of cartography, surveys will continue to be carried out by using topographic and photogrammetric methods, and the use of unmanned aerial vehicles (UAVs) and light detection and ranging (LIDAR) systems will generate new and more appropriate products for mapping. In the technical arena, small jurisdictions and those with limited resources will begin to adopt free GIS and online GIS—a priority once the digital cadastre culture is created.

In addition, cadastres may start to represent cities and their structural elements by using virtual three-dimensional (3-D) models. Some jurisdictions are already using GIS tools to do so. For example, the technical team for the City of Medellín, Colombia, is developing a virtual city model by making extrusions of building profiles and their internal subdivisions (figure 15).

With the innovation of 3-D printers, the ability to "create cities" and preview the results of a given land policy—such as the transfer of building rights or redevelopment of an informal settlement—is already a reality. Moreover, the easy-to-understand models can be useful in participatory planning processes. Thus, 3-D spatial representations, whether virtual or physical models, are likely to become part of cadastres in the medium term (box 8.)

Meanwhile, given that informal settlements are present throughout Latin America, cadastres will be forced to

Box 8

Three-Dimensional Models of Major Latin American Cities

Perspective of Mexico City in the Google Earth environment, where most of the buildings can be seen in 3-D. © *Google Earth.*

Google Earth has made a solid contribution to the creation of 3-D city models, enabling users to view a given location with the desired level of detail and within a global environment. This platform also allows movement from a top view showing the city as a flat surface to an oblique view showing the relief and height of buildings, trees, aerial services networks, and other objects in space. All of the capital cities in Latin America have been modeled, at least in part, by using Google Earth. The models of Santiago de Chile and Mexico City are among the most detailed and complete.

represent this reality as well as its associated economy. Current cadastre legislation, however, is based on 2-D representations of the relationships among service networks, public and private properties, environmental reserves, mineral deposits, bodies of water, and other facets of the urban landscape. Connecting the informal city with the rest of the virtual city is an even greater challenge, due to the complexity of dealing with very irregular lots.

In the medium term, there is a real possibility that multipurpose cadastres will be implemented in the region, given the many cadastre laws enacted in recent years, educational events dealing with the topic, and the large number of successful applications that serve as models. By providing systematic information from multiple sources and state-of-the-art financing instruments, MPCs will thus offer additional guidance to planners and to urban economists.

Crowdsourcing in an important concept inherent in the multipurpose model philosophy. Using the Internet and online tools, volunteers can capture and maintain data related to their parcels and their land rights.

Crowdsourcing can help cadastre professionals and citizens form partnerships to solve global challenges. Mobile-phone and personal-positioning technologies, satellite imaging, the use of open-source data, web mapping, and wikis are all converging to provide cadastre professionals with the "perfect change storm" for crowdsourcing to realize its potential (McLaren 2011). This type of public-private collaboration would clearly facilitate better land management, and could help to improve tenure security all over the world.

Finally, the Land Administration Domain Model (LADM) has emerged as a formal language to describe real estate interests. The LADM is an international standard (ISO 19152:2012) for structuring soil, water, and air management at the global level. In principle, the LADM would facilitate the future modeling of informal tenure and customary rights, but the Social Tenure Domain Model would be more appropriate for this.

Honduras based its National System of Property Administration on LADM, implementing it step-by-step on a technological platform. Between 2004 and 2005, the Honduran Unified Registries System was developed by using the Core Domain Model Cadastre, forerunner of LADM. During 2013 and 2014, the technical specifications evolved to the current version that uses open-source technologies and applies the LADM standards established by ISO 19152.

In the longer term, most modern 3-D and crowdsourcing concepts will likely be adapted to the Latin American reality. And, like the LADM, they will be taken into account in cadastre restructuring projects—perhaps encouraging consolidation of spatial land data systems and changing the vision of urban planning and environmental legislation.

Implementing a Multipurpose Cadastre

Orthodox cadastres can be gradually expanded, depending on the financial, human, and technological resources available. In general, the logical sequence for moving toward a multipurpose cadastre is to keep the data from the orthodox model updated, establish interinstitutional alliances to share data, link the cadastre to an SDI, and create territorial and land-value observatories to keep the information up to date. The following recommendations are drawn from the experience of the Latin American jurisdictions described in this report.

POLICY CONSIDERATIONS

These suggestions address some of the specific needs of policy makers.

- **Assess what you already have for data.** The restructuring of a land cadastre does not mean starting from scratch. Thoroughly analyze existing records, and identify those that may be shared with each of your future MPC partners.
- **Use existing technology to the fullest.** Rather than buy new applications or equipment, look to your partners for any additional resources you might need. Alternatively, explore free software alternatives, which are probably adequate to support urban analysis.
- **Build territorial and land-value observatories with the greatest number of partners possible.** This is the best way to monitor the changes that affect the real estate market.
- **Coordinate databases with others.** The vast majority of thematic cadastres have excellent data and information systems, often including coverage of informal areas.
- **Incorporate data on informal settlements in cadastre maps** and characterize the parcels in the alphanumeric database. A cadastre does not grant rights, but its records are strong evidence for obtaining them.

PRACTICAL CONSIDERATIONS FOR JURISDICTIONS

Jurisdictions that are considering a transition to an MPC can benefit from the lessons learned elsewhere in Latin America.

Best Practices

- **Mandate the georeferencing of parcels.** This process is slow due to an insufficient number of trained professionals in the region, so it is best to start immediately.
- **Implement the Cadastre Certificate** as a document that describes the parcel in all its aspects, based on blueprints on each real estate transaction or blueprints that are no older than a certain age (20 years, for example). This should be a prerequisite to a deed, thus keeping physical and legal information in sync.
- **Propose guidelines for implementation of the MPC**. If there is a cadastre law, guidelines can help regulate it. If there is no law, the directives will help you advance in an organized way while the law is being enacted.
- **Use assessment methods based on econometric and geostatistical models** that can correlate assessment maps with the real estate market.
- **Define the essential cadastre variables carefully**. A good cadastre is one that can be continuously and easily updated.
- **Coordinate your actions with strategic partners** that have common interests. This means that you should not update or restructure databases in isolation.
- **Make personnel training a high priority**. Staff members must be theoretically and practically prepared in all aspects of the MPC.
- **Incorporate each aspect of the MPC cautiously**. The multipurpose cadastre is modular, not exclusionary, and it does not have to be structured in a single way. This is one of the main benefits of the MPC model.
- **Form a consortium**, if your municipality is small, to coordinate your actions and share experiences while implementing an MPC. Participating jurisdictions don't have to be neighbors. It is more important that members of your group face similar challenges and therefore may implement similar solutions.
- **Focus on incorporating cadastral data into an SDI**. Even if you have your own e-cadastre, concentrate more on the spatial-data infrastructure. The duplication of data on the Internet creates uncertainty and confusion for users.
- **Incorporate external partners as part of cadastre maintenance**, forcing agents that alter databases to provide updates every time a real estate transaction modifies a parcel.

Common Pitfalls

- **Don't wait for a new cadastre law before starting**. If current regulations do not meet some of your needs, you can often find solutions within the current legal framework. You just have to analyze it carefully.
- **Don't place all your hopes for change on geotechnologies**. The implementation of a multipurpose cadastre is more of a philosophical process than a technological process.
- **Don't try to update everything at the same time**. Before starting a project such as this, clearly define whether your MPC priorities are assessments (economic cadastre), cartography (physical cadastre), owners, tenants, and occupants (legal cadastre), infrastructure distribution, conservation, and preservation areas (environmental), or technology (hardware and software).

References

Albina, Lorenzo M. 2003. *Recopilación de antecedentes relativos al inventario de inmuebles e imposición en el Estado Incaico.* Argentina: self-published.

Alfonsin, Betania. 2013. "Definición de políticas de suelo urbano Una mirada dialéctica sobre la informalidad urbana." In *Definición de políticas de suelo urbano en América Latina: Teoría y práctica,* ed. Diego A. Erba. Cambridge, MA: Lincoln Institute of Land Policy.

Aulestia, Diego and Vanessa Rodríguez. 2014. "Incentivos por el cobro de contribución especial de mejoras para el financiamiento de la infraestructura pública." In *Instrumentos notables de políticas de suelo en América Latina: Respuestas locales a problemas regionales,* ed. Martim O. Smolka and Fernanda Furtado. Lincoln Institute of Land Policy (Cambridge, MA) and Banco del Estado de Ecuador (Quito, Ecuador).

Bianco, Carlos, Miguel A. Ciuro Caldani, and Héctor Oddone. 1983. ¿Qué es Agrimensura? Rosario, Argentina: Universidad Nacional de Rosario.

Calderón, Julio. 2006. *Mercado de tierras urbanas, propiedad y pobreza*. Lima, Peru: SINCO Editores.

Clichevsky, Nora. 2002. *Tierra vacante en ciudades latinoamericanas.* Cambridge, MA: Lincoln Institute of Land Policy.

Erba, Diego A. 2007. *Catastro multifinalitario aplicado a la definición de políticas de suelo urbano.* Cambridge, MA: Lincoln Institute of Land Policy.

———. 2008. *El catastro territorial en América Latina y el Caribe.* Cambridge, MA: Lincoln Institute of Land Policy.

Erba, Diego A. and Mario Andrés Piumetto. 2012. "3-D Cadastre in the Federal Countries of Latin America." International Institution of Surveyors Article of the Month. July. *www.fig.net/resources/monthly_articles/2012/july_2012/july_2012_erba_piumetto.pdf*

Gómez-Baggethun, Erik and Rudolf de Groot. 2007. "Capital natural y funciones de los ecosistemas: explorando las bases ecológicas de la economía." *Ecosistemas* 16(3): 4–14.

International Federation of Surveyors (FIG). 2008. *Informal Settlements: The Road Towards More Sustainable Places.* FIG Publication No 42. June. *www.fig.net/resources/publications/figpub/pub42/figpub42_A4_web.pdf*

Jiménez Huerta, Edith R. 2014. "Oferta de suelo servido y vivienda para la población de escasos recursos en Aguascalientes." In *Instrumentos notables de políticas de suelo en América Latina: Respuestas locales a problemas regionales*, ed. Martim O. Smolka and Fernanda Furtado. Lincoln Institute of Land Policy (Cambridge, MA) and Banco del Estado de Ecuador (Quito, Ecuador).

Lagarda Lagarda, Ignacio. 2007. *El catastro.* Hermosillo, Mexico: Ayuntamiento de Hermosillo.

Maleronka, Camila and Fernanda Furtado. 2014. "Concesión onerosa del derecho de construir (OODC por sus siglas en portugués): La experiencia de São Paulo en la gestión pública de las edificabilidades." In *Instrumentos notables de políticas de suelo en América Latina: Respuestas locales a problemas regionales,* ed. Martim O. Smolka and Fernanda Furtado. Lincoln Institute of Land Policy (Cambridge, MA) and Banco del Estado de Ecuador (Quito, Ecuador).

McLaren, Robin. 2011. "Crowdsourcing Support of Land Administration—A Partnership Approach." International Federation of Surveyors Article of the Month. December. *www.fig.net/resources/monthly_articles/2011/mclaren_december_2011.asp*

Ministry of Land Policy and Agrarian Development, Brazil. 2002. *O livro branco da grilagem de terras no Brasil*. Brasilia, Brasil.

Morales Díaz, Julián, Ingrid Carballo Valverde, Zeidy Montero Marín, Carlos Sibaja Solano, and Ricardo Chinchilla Vargas. 2011. "Valoración Económica Ecológica de Calle Lajas, San Antonio de Escazú." Costa Rica: Universidad Estatal a Distancia (UNED).

Piumetto, Mario Andrés and Diego Alfonso Erba. 2012. "El rol del catastro en la nueva administración territorial de América Latina." Paper presented at the 8th FIG Regional Conference "Surveying towards Sustainable Development," Montevideo, Uruguay (November 26–29). *www.fig.net/resources/proceedings/fig_proceedings/uruguay/papers/ts07c/TS07C_piumetto_erba_6415.pdf*

Portugal, José Luiz, Rubens Dantas Alves, Lucilene Antunes Correia Marques de Sá, and João Freire Prado. 2009. "Spatial Inference and Geostatistics as Instruments of Support for Calculation of Betterment Levy in Aracaju, Brazil." Working paper. Cambridge, MA: Lincoln Institute of Land Policy.

Randall, Alan. 1985. *Economía de los recursos naturales y política ambiental.* Distrito Federal, México: Editorial LIMUSA, S.A.

Rave, Beatriz and María Cristina Rojas. 2014. "Reajuste de tierras en planes parciales en Colombia." In *Instrumentos notables de políticas de suelo en América Latina: Respuestas locales a problemas regionales*, ed. Martim O. Smolka and Fernanda Furtado. Lincoln Institute of Land Policy (Cambridge, MA) and Banco del Estado de Ecuador (Quito, Ecuador).

Smolka, Martim O. 2013. *Implementing Value Capture in Latin America, Policies and Tools for Urban Development*. Policy Focus Report. Cambridge, MA: Lincoln Institute of Land Policy.

Smolka, Martim O. and Claudia M. De Cesare. 2006. "Property Taxation and Informality: Challenges for Latin America." *Land Lines* 18(3): 14–19.

Uzon, Néia. 2013. "Transferência do direito de construir: a experiência de Porto Alegre, Brasil." Presentation at Foro Latinoamericano sobre Instrumentos Notables de Intervención Urbana. Quito, Ecuador (May 6–10).

Acknowledgments

The authors are grateful to the following Lincoln Institute of Land Policy staff for very helpful comments on earlier versions: Gregory K. Ingram, former president and CEO; Martim Smolka, director of the Program on Latin America and the Caribbean; Anna Sant'Anna, former senior research associate in the Program on Latin America and the Caribbean; and Maureen Clarke, director of publications. Particular appreciation is given to Marcia Fernald, for her editing work, and to David Gerratt, for his design of this report. Finally, very special thanks to Laura Mullahy, who managed the final stages of production and provided key insights on both form and content. Without her contribution, it would have been impossible to publish this report.

This report also benefited from numerous insights and specific inputs from experts throughout Latin America who are directly involved with cadastral activities. Deep appreciation is extended to all those listed below who provided timely updates on local issues and practices; critical clarifications of how territorial cadastres operate and their impacts in different jurisdictions; and many of the graphic illustrations and photographs. The authors, however, are fully responsible for any remaining misinterpretations, errors, and omissions.

Betânia de Morães Alfonsin, *professor at Pontifical Catholic University of Rio Grande do Sul, Brazil*

Golgi Álvarez, *Land Administration Program of Honduras (PATH), Honduras*

Ana Lucia Alvares de Aragão, *Municipality of Salvador, BA, Brazil*

Juan Pablo Barrero Vélez, *Observatory of the Cadastre of Medellín, Colombia*

Iván Darío Cardona Querubín, *former director of the Cadastre of Medellín, Colombia*

André Luís Cavalcanti de Albuquerque *and* Simone Sumi, *Terra Nova Regularizações Fundiárias, Curitiba, PR, Brazil*

Nora Clichevsky, *former professor and researcher, University of Buenos Aires, Argentina*

Ricardo Raúl Flores, *former director of Cadastre of Puebla, Mexico*

Gustavo García, *director of the Provincial Cadastre of Córdoba, Argentina*

Anamaria Gliesch, *director, designconcept4you, Pittenhart, Germany*

Ignacio Gregorini *and* Esteban Fernández, *Fundacion Techo, Argentina*

Daniel Hidalgo, *former director of the Cadastre of Quito, Ecuador*

Ignacio Lagarda Lagarda, *former director of Cadastre of Hermosillo, Sonora, Mexico*

Viviane Manzione Rubio da Camara, *Municipality of Osasco, SP, Brazil*

Gustavo Adolfo Marulanda Morales, *former director of the Cadastre of Bogotá, Colombia*

Álvaro Medina Aravena, *Division of Cadastre, Ministry of National Assets, Chile*

Julián Morales, *director of Cadastre, Escazú, Costa Rica*

Fricson Moreira, *director of Cadastre, Ambato, Ecuador*

Carlos Orrego, *Internal Revenue Service, Santiago, Chile*

Iliana Sánchez, *sales and marketing director, Merrick & Company, Mexico*

Everton da Silva, *professor at Federal University of Santa Catarina, Brazil*

Tulio Edelberto Ureta Vélez, *director of Cadastre, Portoviejo, Ecuador*

Néia Uzon, *independent consultant, Porto Alegre, RS, Brazil*

ABOUT THE AUTHORS

Diego Alfonso Erba is a land surveyor engineer specializing in cadastres and geographic information systems. As a fellow in the Lincoln Institute of Land Policy's Program on Latin America and the Caribbean (LAC) from 2004 to 2013, he taught and researched on cadastres in Latin America and developed the LAC Program's distance education program. As an independent consultant, he has worked with local, regional, and national governments in several countries in Latin America. He has authored and/or edited several books and papers on multipurpose cadastre, and, more recently, on 3-D cadastres.

Mario Andrés Piumetto is a land surveyor specializing in geographic information systems and cadastres. He is part of the teaching faculty in the Program on Latin America and the Caribbean of the Lincoln Institute of Land Policy and professor at the School of Surveying at the National University of Córdoba, Argentina. He was formerly director of cadastre of the city of Córdoba. Currently, as an independent consultant, he works on cadastres, geotechnologies, and land taxation. He has coauthored several books and papers on cadastres applied to urban land policy.

ABOUT THE LINCOLN INSTITUTE OF LAND POLICY

www.lincolninst.edu

The Lincoln Institute of Land Policy is an independent, nonpartisan organization whose mission is to help solve global economic, social, and environmental challenges to improve the quality of life through creative approaches to the use, taxation, and stewardship of land. As a private operating foundation whose origins date to 1946, the Lincoln Institute seeks to inform public dialogue and decisions about land policy through research, training, and effective communication. By bringing together scholars, practitioners, public officials, policy makers, journalists, and involved citizens, the Lincoln Institute integrates theory and practice and provides a forum for multidisciplinary perspectives on public policy concerning land, both in the United States and internationally.

Ordering Information
To download a free copy of this report or to order copies, visit **www.lincolninst.edu** and search by author or title. For additional information on discounted prices for bookstores, multicopy orders, and shipping and handling costs, send your inquiry to **lincolnorders@pssc.com.**

EDITOR & PROJECT MANAGER
Laura Mullahy

MANUSCRIPT EDITOR
Marcia Fernald

DESIGN
Sarah Rainwater Design

PRODUCTION
David Gerratt/*NonprofitDesign.com*

PRINTING
Recycled Paper Printing, Boston

LINCOLN INSTITUTE
OF LAND POLICY

113 Brattle Street, Cambridge, MA
02138-3400, USA
P (617) 661-3016 or (800) 526-3873
F (617) 661-7235 or (800) 526-3944
help@lincolninst.edu
lincolninst.edu

Making Land Legible

Cadastres for Urban Planning and Development in Latin America

In Latin America, a territorial cadastre is a public registry that manages information relating to parcels of land. As an institution, the cadastre is common in many countries, although it does not exist in the United States. The cadastre plays a key role in urban planning and property valuation in Latin America.

An increasing number of jurisdictions in Latin America have begun to move from the orthodox cadastre model imported from Europe to the multipurpose cadastre (MPC) model. An MPC is based on a partnership of stakeholders committed to generating extensive, detailed, and up-to-date information about a city. In addition to legal, economic, and physical characteristics contained in the orthodox cadastre, an MPC also shares alphanumeric data, maps, and human and financial resources. In recent years, conditions in many countries of Latin America have favored the implementation of MPCs at reasonable cost.

This report describes the past, present, and potential future role of cadastres as a land policy tool in Latin America. It describes how national, regional, and local jurisdictions across Latin America have used updated orthodox and/or multipurpose cadastres to strengthen urban financing and inform planning decisions.

The following set of practices and policies will facilitate the implementation of an MPC.

- **Assess and utilize existing data.**
- **Use existing technology to the fullest and explore free software alternatives.**
- **Coordinate actions and databases with the greatest number of partners possible.**
- **Incorporate data on informal settlements in cadastre maps and characterize the parcels in the alphanumeric database.**

LINCOLN INSTITUTE
OF LAND POLICY

ISBN 978-1-55844-352-5 (paper)
ISBN 978-1-55844-355-6 (pdf)
Policy Focus Report/Code PF039