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Thesis title: Financing post-disaster recovery through land-based finance. The case of Mexico City after the 2017 earthquakes using density bonuses and land use changes

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Summary

In the aftermath of the earthquake on September 19, 2017, in Mexico City, 137 apartment buildings with 2,991 homes collapsed or were demolished. Given the impossibility of public or private financing for its reconstruction, an innovative mechanism was developed based on granting density bonuses and land use change (DB&LUC) to those affected properties.

This study aims to identify to what extent the use of DB&LUC enables the finance of post-disaster recovery of condominium dwelling buildings in Mexico City after the September 2017 earthquake.

This research was designed from a qualitative approach using secondary data. It is developed through 6 steps: 1) sample selection, 2) data collection, 3) financial model construction, 4) running the model through the dataset, 5) selection of outstanding analysis cases, and 6) in-depth case analysis.

Maximizing the ability to generate revenue from selling additional units is critical to defining the share of the recovery costs covered. These are achieved through three main variables: a) location close to the areas of the city with the highest housing prices, b) extension of the application of the DB. and c) the combination with LUC.

The results analyzed in this research provide solid evidence to state that the financing of the reconstruction of the condominium house affected by the September 19, 2017, earthquake in Mexico City through DB&LUC is a program with variable positive results, between 32% and 133% of the recovery costs, depending on specific conditions.

The theoretical principles of land rent theory, urban land rent theory, and monocentric and polycentric urban models lay the foundations to propose this financing model based on LVC instruments, DB&LUC—the evidence from the sample analysis and in-depth case analysis support that the theoretical principles hold.

This research and others referred to in the literature review represent the first steps in collecting and analyzing evidence on LVC for post-disaster recovery. Further research is required to analyze the program once completed and understand the accompanying mechanisms: a. technical, b. legal and institutional, c. governance and social participation. The results will be vital to transcend from a recovery mechanism to an extended prevention mechanism and to contribute to research on financing for adaptation to the climate crisis with an innovative financing alternative.

Keywords

Urban land rent, land value capture, post-disaster recovery finance, land use change, and density bonus.

Acknowledgments

To Diego, thank you for unconditionally accompanying me on this fantastic journey. Your encouragement during long winter days, your guidance based on experience, and your role as my sounding board during my mental blockages have been invaluable. I love you.

To my family—Doris, Eduardo, Hilda, Martha, Meli, and all the Bibis—your unwavering support throughout this endeavor has been truly remarkable. You've been my safety net, always ready to catch me and propel me higher, making me feel as if I could fly.

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My deepest gratitude is reserved for those individuals I love to call friends who lost their homes on September 19, 2017. I am privileged for meeting them personally, learning from their stories and motivations, and working alongside them for months. Even almost six years later, their unyielding determination to recover their homes continues to burn as brightly as it did on day one. They are a constant source of inspiration for me to share this piece of history with the world—a history rich with untold stories waiting to be heard.

Foreword

This thesis is written as a consummation to the Master's in Science in Urban Management Development with specialization in Land Management: Law, Finance, Real Estate & Natural Resources at The Institute for Housing and Urban Development Studies of the Erasmus University Rotterdam. The master program focuses on understanding the core elements determining how land contributes to resource equity, economic growth, and sustainable management of natural resources and resilience.

Hence, this work focuses on understanding how land value capture instruments, typically used for financing infrastructure and housing, can be transformed into innovative instruments for financing post-disaster recovery and risk prevention. Such is the case of Mexico City after the September 19, 2017 earthquake. Due to the lack of public and private resources for the reconstruction of housing, an innovative instrument was created based on DB&LUC. Faced with a prolonged paralysis in the development and use of land value capture instruments in Mexico, it is necessary to demonstrate and showcase the financial benefits these tools can represent for society, particularly for local public finances.

This thesis attempts to reactivate the evidence-based conversation about land value capture instruments and their practical application. Furthermore, I hope to reach the community interested in continuing innovation in these mechanisms that I am convinced play a crucial role in achieving economic development, equity, social justice, and environmental sustainability.

Table of Contents

List of Figures

List of Tables

List of Photographs

Abbreviations

CBD	Central business district
CDR	Charges for development rights
DB	Density bonus
DRM	Disaster Risk Management
IHS	Institute for Housing and Urban Development Studies
LILP	Lincoln Institute for Land Policy
LR	Land readjustment
LUC	Land use change
LVC	Land value capture
MXN	Mexican peso
RLV	Residual land value
RLVI	Residual land value increment
SEDUVI	Secretaría de Desarrollo Urbano y Vivienda Mexico City
Servimet	Servicios Metropolitanos S.A. de C.V.
SRCC	Share of recovery costs covered
TDR	Transfer of development rights

Chapter 1: Introduction

This chapter provides an introduction to the research topic. It examines Mexico City's operational landscape, particularly the regulatory framework governing land value capture (LVC) tools. A historical comparison explores the use of these instruments and their connection to rising residential property values. The chapter also briefly evaluates the aftermath of the September 19, 2017, earthquake, estimating recovery costs and addressing the pertinent regulatory response.

Furthermore, the research approach is outlined, emphasizing the problem statement, academic relevance, and overarching goal. Research questions and sub-questions guiding the investigation are also presented.

1.1 Background

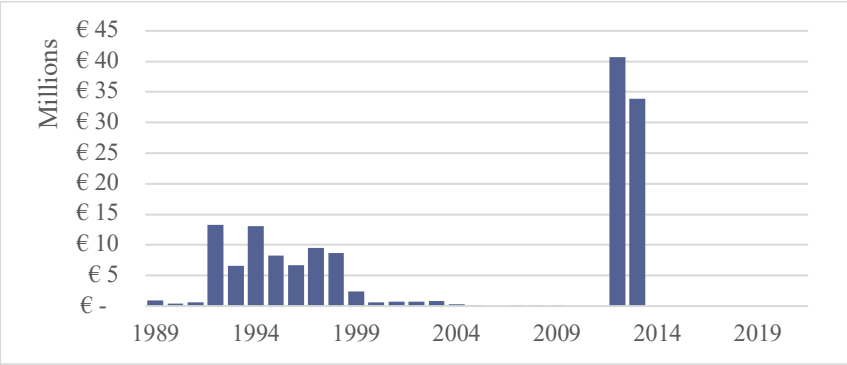
With a Constitutional foundation, Mexico City has had a legal structure since the 20th century, allowing LVC primarily for public infrastructure financing. This study's objective is to describe and analyze the innovative use of LVC in funding the recovery of collapsed housing following the September 2017 earthquakes.

Despite an enabling legal framework at national and local levels, LVC is predominantly employed in developer obligations. The OECD and Lincoln Institute for Land Policy (LILP) pinpoint two main obstacles to broader LVC adoption: a) resistance is reinforced by the idea that property rights are untouchable whose changes entail high political costs, and b) fiscal regulations and weak legal frameworks obstruct its implementation at the local level (OECD & LLIP, 2022). In addition, taxing value increments is considered a complex tax given its linkages with the cadastre and its ability to document and determine value increments derived from actions (Zarzosa Escobedo, 1997).

The Political Constitution of the Mexican United States (CPEUM) establishes the nation's authority to define modalities of private property, including levies for urban projects, Art. 27th. Article 115th grants municipalities the competence to manage their finances, encompassing real-estate-related contributions, value-based taxes, and those based on value increments. The recently published Constitution of Mexico City (CPMC) empowers the city government in land management for equitable distribution. Hence, based on these constitutional grounds, Mexico City possesses a comprehensive regulatory framework on both national and state levels, enabling cost recovery for public interest projects through land management and associated values.

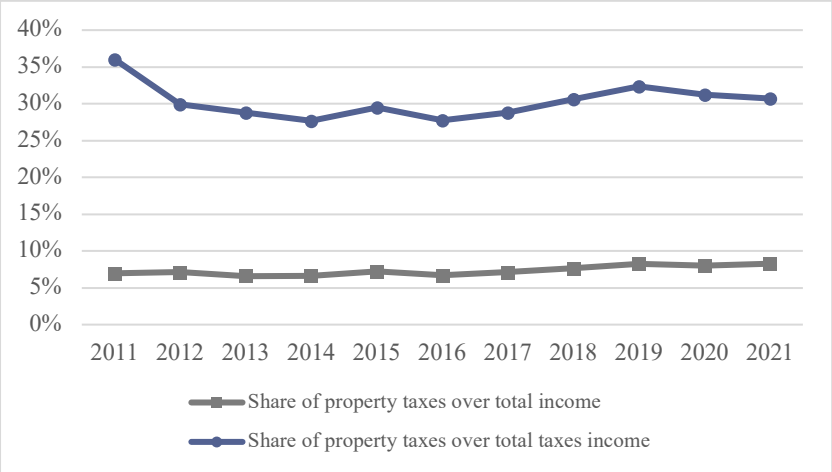
While land taxation is utilized during property transfers, it is rarely applied to value increments in Mexico City (Perló Cohen, 1999). Property taxes consistently contributed around 30.31% to the city's tax collection and averaged 7.32% of total income between 2011 and 2021 (Figure 1). However, the betterment contribution varied between 1989 and 2021 (Figure 2). It was consistently applied from 1989 to 2009, with notable collections exceeding €5 million equivalent in Mexican pesos only from 1992 to 1998. While no income was recorded under this category in 2010 and 2011, 2012 and 2013 saw substantial peaks (€40,752,726 and €33,931,786, respectively). No public income has been registered under this category since 2014 until 2021 (INEGI, 2023a).

Figure 1 Resources collected by the Mexico City government through betterment contributions 1989-2021



Source: Author with information provided by INEGI (INEGI, 2023a) Exchange rate 19.99 MXN per EUR, as of April 26th, 2023.

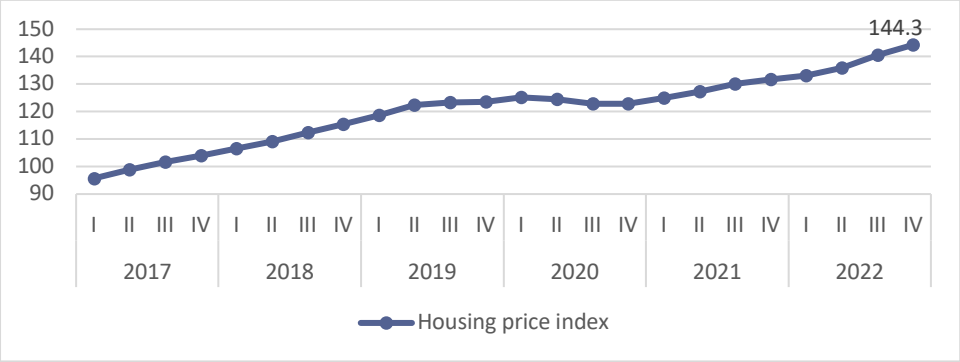
Figure 2 Share of total income and taxes income represented by property taxes in Mexico City 2011-2021



Source: Author with the information provided by INEGI (INEGI, 2023b)

On the other hand, there has been a significant increase in housing selling values between 2017 and 2022 (Figure 3). According to the Federal Mortgage Society (Sociedad Hipotecaria Federal in Spanish), responsible for supporting the finance component of the National Housing Policy, housing prices by the end of 2022 were 44.3% higher than those by mid-2017 (Sociedad Hipotecaria Federal, 2023).

Figure 3 Housing prices index in Mexico City 2017-2022



Source: Author with the information provided by SHF (Sociedad Hipotecaria Federal, 2023)

On September 19, 2017, a 7.1-magnitude earthquake struck (SSN, 2017), leading to 369 fatalities across seven affected states, with 228 deaths occurring in Mexico City (Notimex, 2017). The earthquake caused 20 buildings to collapse. Following structural assessments, 137

housing buildings with 2,991 homes were deemed irreparably damaged and subsequently demolished, henceforth the *damaged buildings* (Comisión para la Reconstrucción. Gobierno de la Ciudad de México, 2023).

By 2019, the National Center for Civil Protection (CENAPRED) estimated that damages in Mexico City amounted to around €2,204 million. In contrast, resources from national and local budgets only reached €813.31 million (Table 1), equivalent to 36.90% of the estimated costs. These funds were primarily directed towards recovering public infrastructure, education, health, cultural facilities, recreational spaces, and impoverished households (Diario Oficial de la Federación, 2011). Concerning private resources for reconstruction, only 16.5% of dwellings were insured against seismic damages by 2017 (Barragán, 2017). While funding allocation profoundly influences the recovery pace, determining the amount needed and strategically allocating it presents a challenge in post-disaster scenarios (Johnson & Hayashi, 2012).

Table 1 Available resources from government sources 2017-2019

Available resources				
Year	**Amount (Million MXN)**	**Origin**	**Yearly total (Million MXN)**	**Yearly total (Million Euros)**
2017	MXN 2,600.00	FONDEN	MXN 2,600.00	€ 130.07
2018	MXN 8,700.00	FONADEN	MXN 9,284.00	€ 464.43
	MXN 584.00	FONDEN		
2019	MXN 4,000.00	Mexico City budget	MXN 4,000.00	€ 200.10
		Total	**MXN 15,884.00**	**€ 794.60**

Sources: (ALDF (Asamblea Legislativa del Distrito Federal), 2017; Esquivel et al., 2018; GOCDMX, 2017b; GOCDMX, 2018a; Instituto de Investigaciones Legislativas, n.d.; SEGOB, 2018). The exchange rate is 19.99 MXN per EUR as of April 26th, 2023.

In December 2017, the Reconstruction Law was enacted, introducing an innovative LVC approach for condominium properties needing reconstruction. Article 38 authorized victims-turned-landowners to receive a no-cost 35% density bonus (DB) beyond initial allowances in units, space, and levels, along with the potential for ground-floor land use change (LUC). The law allowed exemptions and prioritized pathways to enhance financial feasibility and rapid recovery (GOCDMX, 2017c); landowners aimed to fund new building construction by constructing and selling these extra units (apartments, parking, offices, retail, rooftops). Despite modifications under the new 2018 government, Article 26 maintained essential reconstruction financing elements (GOCDMX, 2018b). By 2022, the initial generation of reconstructed buildings under this law was completed and put up for sale.

For almost two years before an earthquake struck, the city administration introduced changes to several key regulations, including the City Housing Law (GOCDMX, 2017d), the City Urban Development Law (GOCDMX, 2017a), and the Norm aimed at promoting accessible housing for eligible workers through national housing organizations (SEDUVI, 2017). These modifications were published within six months, between March and August 2017, shortly before the earthquake occurred.

The Norm encompassed various provisions, such as increased housing density in predefined urban zones and corridors, diversification of housing types within buildings, pricing constraints, incorporation of measures to mitigate environmental impacts, inclusion of retail spaces on the ground floor, and exemptions for parking spaces. The process of instituting these changes was extensive and garnered positive feedback from diverse stakeholders. Due to this favorable reception, especially concerning its financial viability and timely implementation, many of its components were integrated into the Reconstruction Law in December 2017. This

initiative is also in line with an effort by Mexico City to promote mixed land uses. -residential and productive-hoping to have improvements in travel reduction, reduction of transfer times, reduction of polluting emissions, and increase in non-motorized modes of mobility, among others (L. Zamorano, personal communication, June 15, 2023).

1.2 Problem statement

Firstly, although Mexico City has mechanisms earmarked to finance post-disaster recovery, they have limitations. In case of major disasters, they are unable to cover the totality of the damages and are focused on public infrastructure and services. As a private good, housing has few financing options for its recovery. Secondly, there is a continuous increase in the value of private property that is untapped and undistributed back for the public good. Moreover, finally, there is an evidence and operational gap between the traditional use of LVC as an infrastructure financing tool and its use for post-disaster recovery financing.

The reconstruction process, depicted in Figure 4, has been intricate, involving diverse social and governmental entities. This encompasses aspects like strengthened construction codes, establishing regulatory frameworks, creating the Reconstruction Commission and Trust, enhanced co-owner decision-making, grassroots social groups, and innovative financing methods. Due to time constraints and research focus, this document exclusively addresses the financial facet of this multifaceted process.

Figure 4 Different components of the reconstruction process

Source: Author.

1.3 Relevance of the research topic

Despite a broad literature documenting partially similar cases -DB for affordable housing, DB for financing public infrastructure, and land readjustment for post-disaster recovery, no exact matching cases -DB&LUC for financing private housing post-disaster recovery- have been identified.

Hence, this research contributes to bridging the gap between preexisting LVC mechanisms and the innovative approach used in Mexico City by identifying a supporting theoretical framework, providing empirical evidence on land value increments resulting from the use of DB&LUC, their usage to cover recovery costs, and a description of their relation to accessibility variables to potential employment sources and massive transportation nodes. Subsequently, it aims to explain which elements enabled the successful implementation of the mechanism, understood as its financial contribution to recovery cost, as well as those that might compromise this success.

1.4 Research objectives, main research question, and sub-questions

This research aims to examine and explain the use of land-based finance instruments of DB&LUC to finance post-disaster recovery in the case of Mexico City.

Mainly addressing the question, **to what extent the use of DB&LUC enables the finance of post-disaster recovery of condominium dwelling buildings in Mexico City after the September 2017 earthquake?**

The following sub-questions support a coherent response to the central question:

- Which are the key elements that allow for the finance of post-disaster recovery?
    - Development cost determinants, e.g., number and characteristics of recovery and additional units.
    - Development revenue determinants, e.g., number, characteristics, and sales price of additional units.
- Which variables might lead to a difference in this share? Moreover, how can they be explained?

Chapter 2: Literature Review

Chapter 2, the literature review, provides a comprehensive overview of the theoretical underpinnings that explain the origins of Land Value Capture (LVC) instruments. Drawing from the general theory of land rent and the theory of urban land rent, it explores the role of the state and location in determining land values.

Subsequently, the chapter examines the concept of LVC, clarifying its underlying principles, taxonomy, and the intended generation of a virtuous cycle through specific mechanisms. It then explores various case studies that showcase the application of LVC mechanisms for post-disaster recovery and encompassing seismic and environmental events.

The chapter concludes by illustrating how these theoretical foundations and practical applications intertwine, leading to the specific mechanism implemented in Mexico City following the September 2017 earthquake.

2.1 Land Rent Theory

In 1821, David Ricardo analyzed an economic model of how the fertility of the land -what can be obtained from it -determines its price in the market, always depending on the price of the final product -corn in his analysis-, which at the same time was defined by its market. Ricardo introduced the *leftover principle*: "Because of competition among farmers for land, the landowner gets the leftovers, equal to total revenue minus total nonland costs" (O'Sullivan, 2012; Ricardo, 2001). More fertile lands require less investment, thus reducing production costs, and a higher amount leftover is paid to the landowner—the opposite stands for the less fertile lands.

Subsequently, Johann Von Thünen explained how the differential rent derives not only from the demand for land fertility but also from the demand for its location, its accessibility, and its proximity to economic activities. Farmers were willing to pay more to settle on the land closest to the market, thus reducing transportation costs of the final products to their commercialization destination. After subtracting the production and transportation costs from the final product price, what is left could be paid to the landowner as rent (Von Thünen, 2018).

Later, Marx, in the General Theory of Land Rent, explained the role of land in a capitalist economy and how a price is determined even though the land does not have a production cost but through capitalization of rent. Moreover, Marx differentiates three types of rent: differential rent type I, differential rent type II, and total rent. Overall, differential rent refers to the differences among plots of land located in various areas in a market. Type I refers explicitly to the rent from the differential advantage in production; type II from the rent gap between unimproved land and land improved by capital investment; and absolute rent which is rent refers to that which is required from tenants, even for the least productive or lowest-quality land they occupy (Jaramillo González, 2009; Park, 2014).

The concepts mentioned above, derived from the agricultural context of the late 18th and early 19th century: fertility, distance, differential rent, landowner, and capitalist, are reinterpreted for an urban context in the following section.

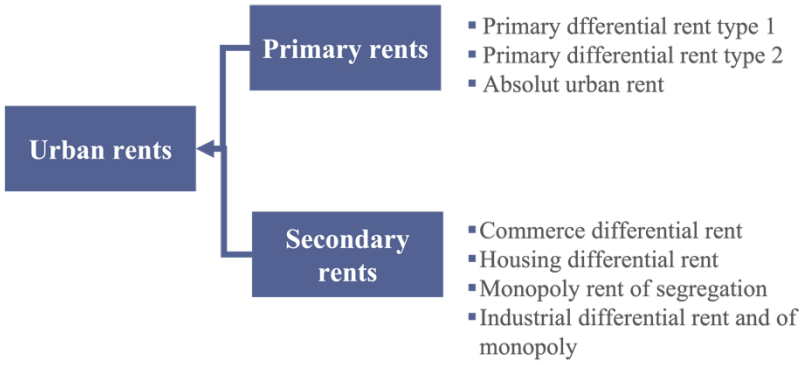
2.2 Urban Land Rent Theory

Samuel Jaramillo's urban land value framework (Figure 5) distinguishes primary and secondary urban rents, where secondary rents replace each other while primary rents accumulate. Primary rents include differential rent type 1, differential rent type 2, and absolute urban rent.

Differential rent type 1 concerns location-specific land characteristics, impacting construction, material, and infrastructure costs[1]. Differential rent type 2 relates to land use intensity and invested capital, yielding diverse products from similar plots. Given two different investments, two similar adjacent plots can produce two different products: a two-story single-family house or a 6 level multi-family apartment building. Absolute urban rent involves peripheral plots with a higher value than rural ones. Differential rent type 2 significantly explains urban land values (Jaramillo González, 2009).

Secondary rents encompass four types: a) differential rents of commerce, b) differential rents of housing, c) monopoly rent of segregation, and d) industrial differential rent and monopoly. Differential commerce rents result from attractive urban areas for trade due to social conventions, yielding higher profits and rents. Thus, commerce is more profitable, sales can be higher, or product rotation can be faster. In these areas, the profit can be higher extraordinary for a similar investment, and a higher rent can be paid to the landowner. Differential housing rents are explained by the distance to working nodes and associated transportation costs. Assuming all the jobs are concentrated in only one central area, all the workers will compete to live closer and avoid paying as much transportation costs as possible. Landowners capture a part of those saving as rent for living in the central areas. Monopoly rent of segregation stems from exclusivity in certain areas, symbolizing social status and resulting in exceptional rents. Industrial differential rent concerns peripheral industrial spaces due to connectivity, scale, and zoning constraints. While these secondary rents are less influential in urban land pricing on a regional scale, they hold significance within their specific contexts (Jaramillo González, 2009).

Figure 5 Urban Rents



Source: Author's adaptation from Samuel Jaramillo (Jaramillo González, 2009)

2.2.1 Urban Regulations and land prices

A critical function of the State is urban planning and the mechanisms for its compliance, thereby directly affecting urban land values. Like many other markets, the State is responsible for amending an imperfect market's failures. In the case of urban land, a free operation of the market would generate undesirable effects such as overcrowding, hyper-densification, socio-spatial segregation, or underutilized properties for speculation purposes. To meet the task, the State has the capacity and responsibility to play different roles: a) as a regulator through statutory regulations, b) as public amenities and infrastructure provider, c) as landowner and

[1] For example, for building the same product, a house, in different locations, the constructor will face a) different construction costs: prepare the land, make it even, drilling and foundation costs; b) materials and workers movement costs; and c) connection to public networks costs: streets, drinking water, sewerage and energy networks. While the differences among locations for a) and b) tend to be negligible in a consolidated urban context, for c) might represent a significative *urbanization* cost.

constructor, and d) as a fiscal agent. Playing these roles, the State becomes a significant player in defining land values (Jaramillo González, 2009).

Property owners aim for maximum short or long-term rent regardless of use or intensity. The State's regulatory role shapes the use and intensity through regulations for socioeconomic optimization. As a provider, it offers amenities and infrastructure, impacting values across scales. Its landownership and construction role, especially in public housing, affect values through landholding and development. As a fiscal agent, the State employs property tax, betterment fees, and development rights sales to steer behaviors and encourage priority land development (Jaramillo González, 2009).

2.3 Monocentric and polycentric urban models

Like Von Thünen's model for agricultural land, William Alonso, in 1964, explained in a monocentric model how competing land uses, housing, and productive uses are located in the urban space and contribute to the definition of land prices. In his model, productive uses, commerce, and offices tend to be concentrated in central areas while housing tends to be located around them, and he attributes this phenomenon to transportation costs (Alonso, 1964; Camagni, 2005).

During the 19th and 20th centuries, cities tended to grow due to industrialization processes that required extensive labor force and technological advances in communications and transportation - e.g., telegraph, telephone, train, tram, and automobile. Later, towards the end of the 20th century, this process was characterized by *polycentrism*, associated with the conurbation of preexisting settlements and the creation of new sub-centers in peripheral areas of *edge cities*. However, the creation and incorporation of these sub-centers have yet to supersede the importance of the original historic central business districts (CBD) (Anas et al., 1998). This is reflected in the housing prices and, thus, in the urban land prices. The influence of the sub-centers is limited compared to that of the CBD, possibly because improvements in accessibility are only capitalized on by specific populations (Zubicaray, 2015).

2.4 Land Value Capture

This section delineates the community land value-building principles that underlie LVC and the subsequent generation of a virtuous circle of public wealth generation, accumulation, and recovery. It further illustrates how, given the lack of financing for prevention and scarce insurance coverage, it is through the LVC that it has been possible to finance post-disaster recovery.

2.4.1 LVC principles

Henry George's idea, dating back to 1880, advocates collective ownership of urban land rather than exclusive ownership by individuals or entities. In other words, “increases in the value of land should accrue to society as a whole and not to individual owners since it was the collectivity that created the value arising from the use of land” (Fainstein, 2012). Lefevre's Right to the City principles reaffirm that the city is established as a shared resource. Beyond a condition of equity, the Right to the city encompasses an overall involvement in the authority to shape the city and actively engage in the benefits of urban living (Fainstein, 2012).

The cities play interconnected roles that are crucial to their functioning. They facilitate territorial efficiency for economic activities by providing public goods and externalities, thereby enhancing the competitiveness of these activities. They promote the collective well-being of the communities by offering urban quality and services. Economic prosperity provides

quality amenities, attracts external activities and populations, and increases growth and development (Camagni, 2016).

The city's construction is a long-term process that involves myriad actors, generating an economic value of the individual pieces -private property- that does not depend entirely on individual actions but on collective action. Thus, the values of urban land, as well as the income that is derived, depend on the "overall development of society" and the collective construction of the city and, therefore, can and should be taxed. The fair division between the public and the private of the surplus value generated by the city's transformation is a political principle (Camagni, 2016).

Amid financial crises, securing resources for urban development is vital. Addressing imbalances in gains from transformations favoring the public sector is key. Urban transformations, including rents and capital gains, offer substantial profits; more equitable distribution of these gains is feasible and beneficial (Camagni, 2016).

Legally, land ownership consists of a bundle of rights, multiple and separable. It implies privileges, powers, immunities, and duties. In some legislations, the property rights of the land and the rights of its development have been separated. The Spanish Constitution explicitly states -that the community and the local public administration will participate in the surplus values generated by the planning action of public bodies-. The subsequent Land Act 2007 defines the proportion of the real estate project's profit that must be paid to the municipality. Along the same lines, various Latin American Constitutions -e.g., Colombia, Brazil, and Mexico- include similar principles and are even more associated with equity and wealth redistribution. The unearned income concept stands out; it establishes that no individual should accumulate wealth that does not derive from their effort (Smolka, 2013). In other legislative traditions, such as the North American one, some principles justify the LVC differently through fees to cover the private impacts -traffic or demand for water and drainage- generated in the infrastructure and public services (Camagni, 2016).

Regarding economic justification, urban land rent is the value given to a scarce good through the market or as a *shadow price*. Rent maintains the balance between the supply and demand of land to achieve an allocation of the resources available in the space (Camagni, 2012). However, the remuneration given in land exchange -rent- behaves differently than other production factors: profit to capital or wages to labor. Both classical and neoclassical economists agree that land rent is an unearned income. In urban contexts, the landowners extract the extra profits (Camagni, 2016).

2.4.2 LVC virtuous model and mechanisms

> *"Cities and urban public authorities must increasingly rely on endogenous financial resources, particularly those generated by the constant development and transformation of the cities themselves, continuing urbanization processes, increasing densities and transformation of land uses from less valuable to more valuable ones."* (Camagni, 2016)

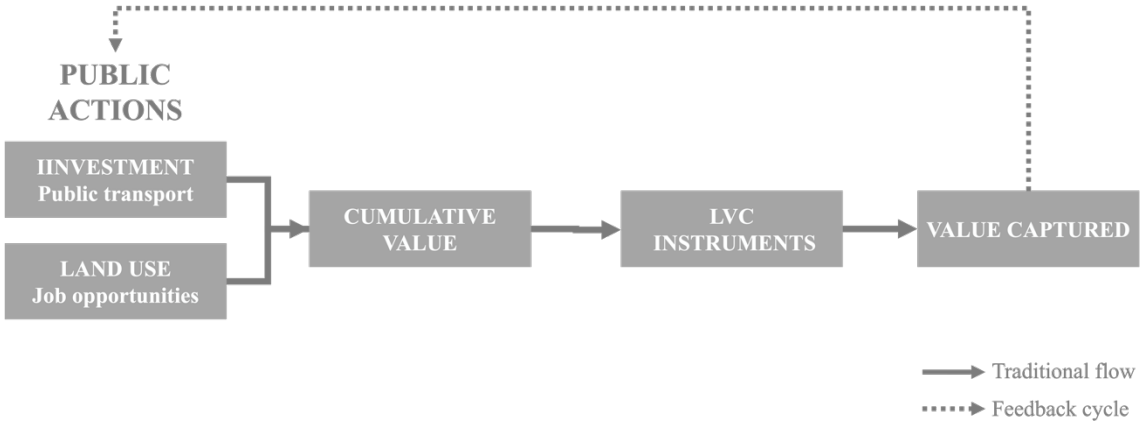
Similarly to Camagni, Smolka defines LVC as the public reclaiming the increase in land value resulting from activities distinct from the landowner's investments. By drawing on the part of these publicly generated land value increments, local administrations can improve the performance of land use and finance the maintenance and expansion of urban infrastructure and service provision. It is crucial that LVC focuses on the increments, the additional value created by public decisions, investments, and administrative actions (Smolka, 2013).

LVC can mobilize community effort through taxes, fees, contributions, or other fiscal means, as well as by providing specific land improvements. Among them are DB, which refers to "applications of zoning whereby builders obtain increased density or floor area in exchange for providing some form of public benefits. "Regulatory decisions such as changes in land use, from rural to urban or from residential to commercial, also impact the land value and may be subject to recovery by the community (Smolka & Amborski, 2000).

For this investigation, the following four-stage cycle diagram is proposed and can be outlined as follows (Figure 6). In the first stage, the government initiates various public actions, including urbanization, infrastructure network construction and expansion, and land use designation for housing or historic preservation, among others. Particular emphasis is placed on public investments in mass transportation networks and land allocation for productive activity development. Subsequently, these public actions lead to the generation of accumulated wealth, manifesting as increased land value.

In the third stage, the government formulates and implements value-capture instruments that enable partial recovery of the value generated through public investments. And lastly, in the fourth stage, the captured value is reinvested through a feedback cycle into new public actions that, in turn, generate additional value.

Figure 6 Simplified LVC cycle



Source: Author

2.4.3 LVC taxonomy

According to the taxonomy developed for the most recent publication by the OECD and LILP (OECD & LILP, 2022), LVC instruments can be classified into two broad categories. On the one hand, those directly generate additional income for public finances; on the other, those indirectly generate various public benefits.

The former includes land and property taxes, which, although not described in this taxonomy, can still be considered LVC mechanisms. However, in practice, they largely depend on the design of specific fiscal structures. Usually, it is difficult to define its role as a separate LVC instrument, as they are typically used in a more general fiscal context. Table 2 briefly describes those that, according to this compendium, can be classified as LVC instruments and are used throughout OECD countries, sometimes with different nomenclature.

Table 2 LVC taxonomy

LVC instrument	Definition
Infrastructure levy	An infrastructure levy is a tax or fee levied on landowners possessing land that has gained in value due to infrastructure investment initiated by the government.
Charges for development rights	Charges for development rights are cash or in-kind contributions payable in exchange for development rights or additional development potential above a set baseline.
Land readjustment	Land readjustment is the practice of pooling fragmented land parcels for joint development, with owners transferring a portion of their land for public use to capture value increments and cover development costs.
Strategic land management	Strategic land management is the practice of governments actively taking part in buying, developing, selling, and leasing land to advance public needs and recoup value increments borne through public action.

Source: Author based on information by (OECD & LILP, 2022).

2.4.4 LVC in post-disaster Recovery and risk prevention finance

This section provides an overview of how post-seismic reconstruction is financed. Later, it exemplifies the application of LVC in post-disaster recovery through various cases. These cases are categorized into two main groups: those utilizing the land readjustment mechanism (such as Japan, India, and Chile) and those leveraging development rights to finance recovery (including the U.S.A. and Brazil). By examining these examples, the section highlights the diverse approaches and strategies employed to implement LVC in the context of natural disaster recovery and risk prevention.

2.4.3.1 Traditional Earthquake post-disaster recovery finance

While the occurrence of earthquakes is relatively stable, the exposure to earthquake risk increased considerably, given the population growth and urbanization of areas in earthquake-prone regions. As for the public interest, critical infrastructure may be damaged, including roads, bridges, dams, and pipelines (OECD, 2018). Between 30-50% of post-disaster resources are allocated to reconstructing dwellings (Freeman, 2004). While a traditional top-down or contractor-driven approach has been primarily implemented, there is also growing evidence that the owner-driven approach results in higher owner satisfaction (Tambe et al., 2018).

It is well-documented how the government uses various tools to manage the financial impacts of earthquakes. Before, governments invested in risk mitigation and public awareness, while after the events, they used risk transfer tools to absorb post-disaster costs. Insurances can effectively spread the risk through existing domestic or international capital markets, thus alleviating the losses of households, businesses, and governments. Nevertheless, low-risk awareness, affordability, and expectations of government compensation have led to meager insurance take-up rates. Despite preventive retrofitting generally having a positive benefit-cost ratio, its cost could reach up to 40% of the cost of a completely new building, leading to an unlikeliness to undertake voluntary prevention measures (OECD, 2018). A broadly extended idea of compensation from the government, both as emergency relief and midterm reconstruction, discourages the voluntary acquisition of insurance schemes (OECD, 2018; Tambe et al., 2018).

2.4.3.2 Land Readjustment for post-disaster recovery

Land readjustment (LR) has been extensively used for converting from rural to urban land use -80% of countries- and for slum or informal settlement upgrading projects. Less than 15% of the countries foresee its use for post-disaster recovery -e.g., Japan, India, Indonesia, Italy, the Netherlands, and Norway- (OECD & LILP, 2022; UN Habitat, 2018)

LR relies on the coordination of landowners to collaborate with a municipality or private entrepreneur by pooling their land resources to a redevelopment project. Beyond the regularization, both as a more efficient spatial distribution of the land and as a tool to solve property conflicts, LR enables the municipality or other development agency to acquire the land required for public infrastructure, networks, and services. In exchange for the contribution of land to the project by the landowners or occupants, they receive a new plot or property of size or value proportional to the original. The parcel or property size may be smaller, but its value is more significant due to the improvements made to the land and the infrastructure (Hong & Brain, 2012)**.**

LR after the 1995 earthquake in Kobe, Japan

Japan's LR *(Kukaku Seiri)* legislation dates back to 1919 and has been primarily used for post-disaster urban infrastructure. After the 1995 earthquake in the Kobe region, LR was used to redevelop affected aging urban neighborhoods (1940s - 1950s) (Dharmavaram, 2013).

In the Misuga Nishi neighborhood, 70% of the wooden houses in two blocks were burnt after the earthquake. The area was mainly inhabited by elderly, low-income families and a high share of tenants, none interested in rebuilding. Thus, the area was included in the Disaster Restoration LR Project, including seismic and fire-resistant high-rise buildings, collective housing, widening streets, and much-needed open space. The project's aftermath highlights the long tradition of community-based planning, the integration of the project in broader city planning tools, the successful cost recovery of private projects, and the integration of risk-preventive technologies. Among the drawbacks, one can find longer implementation times, finance for public projects, some community opposition, and low retention (1/3) of the original residents, probably due to parallel reallocation projects (Dharmavaram, 2013).

LR after the 2001 earthquake in Gujarat, India

LR is known in India as a Town Planning scheme and is used in about 1/3 of urban projects, particularly for reconstructing four damaged urban centers. As in many other schemes, the projects take a long time, must be aligned with major urban plans, and only landowners with proper titles can participate (Dharmavaram, 2013).

Bhuj town was a densely populated area with a narrow and discontinuous road network, obstructing rescue interventions. After the earthquake, residents could relocate to well-serviced and connected peripherical suburbs or participate in the LR projects. Property documentation was a challenge and delayed some transfers. Regarding plot deductions and to contribute to engagement and fairness, the project set specific rules for tiny and large plots. The resulting project ensures minimum plot sizes and access while setting a time record without compromising location. On the downside, the project costs the government a third more than similar projects (Dharmavaram, 2013).

LR after the 2010 earthquake in Talca, Chile.

In February 2010, the central part of Chile was hit by an earthquake. As a response, Chile's national government published the National Reconstruction Plan, aiming to accelerate the recovery. The plan provides four types of monetary relief to the victims: a) to build a new house on the same land, b) to buy a house elsewhere, c) for house reparations, and d) an additional bonus for those properties under heritage protection. However, the plan aimed to support low-income families; thus, more was needed for middle-income families to recover their houses with similar characteristics or locations. Those families had to look for new neighborhoods,

more affordable or safer, with the well-known rupture of social and economic networks that displacement entails (Hong & Brain, 2012).

Amid the recovery, LILP facilitated a recovery plan for Las Heras, addressing those middle-income families with large old houses. Talca had a city master plan, property titles, demographics, land use, and damage assessments to start the project. There was also an active housing market and interest from the private sector to invest in exchange for higher densities. The national and local governments were willing to participate, especially in land acquisition. A survey revealed that 77% of the landowners trusted their neighbors, 65% were willing to remain in the area, and only 12% planned to sell their properties and relocate. The resulting pilot project plans included a whole block (8 to 12 plots) and were financially feasible, including integrating new social housing. However, the project was not implemented since a) existing misinformation among the neighbors regarding LR, b) lack of local government participation, c) some victims were relocated and did not have the incentive to participate, d) there was no incentive for those neighbors that were not directly affected, e) a prevailing belief that the government will support their relocation at no charge (Hong & Brain, 2012).

Out of the three cases, one can identify common conditions. There is a preexisting legal and planning framework upon which some adequations were required, which must be complied with. The recovery works exceeded the planned timing and budget due to unexpected conditions. The projects above were part of more extensive recovery programs that include competing and sometimes more attractive solutions. The programs only benefit the legal landowners with proper legal titling while denying benefits to other stakeholders -tenants and other community members-possibly leading to ruptures and weak or lack of agreements.

2.4.3.3 Development Rights for environmental risk prevention

Charges for development rights (CDR) are defined as cash or in-kind contributions paid in exchange for additional development rights above a set density baseline. They are the least common tools among LVC across countries. CDR is mainly used for areas demarked for heritage and environmental preservation, environmental risk disaster prevention, and less frequently for social housing. They require a precise, predefined land-use regulation that sets baseline and maximum densities. Development rights can be sold or transferred from a sending to a receiving zone -transfer of Development Rights (TDR)- (OECD & LILP, 2022)

TDR in Florida, U.S.A.

Collier County adopted TDR in 1974 initially to preserve coastal islands and later to preserve agricultural land and control development in rural areas. Additional concurrent measures were taken to strengthen the feasibility of the TDR: a) connection to water and sewerage is prohibited in sending zones keeping prices low, b) additional development bonuses were included, c) receiving area must comply with compact mixed-use standards and d) purchasing development rights is the exclusive way of increasing densities (Dharmavaram, 2013)**.**

Collier County has managed to preserve rural areas through its TDR schemes while reducing public expenditure for public amenities. However, implementation risks are related to the fluctuations of the TDR markets, the highly complex definition of sending and receiving areas, and the associated allocation rates (Dharmavaram, 2013)**.**

TDR in Curitiba, Brazil

Since 1969, Brazil has had the most extensive experience with TDR in the Latin-American region, currently accompanied by sophisticated programs -e.g., CEPAC in Sao Paulo- and dedicated institutions such as the Institute for Research and Urban Planning of Curitiba (IPUC).

Curitiba is prone to recurrent flooding in areas occupied by slum dwellers. Through TDR, Curitiba put 140 Ha destined for Barigui Park, including 40 Ha for a flooding mitigation lake, where formerly slum dwellers have settled (Dharmavaram, 2013).

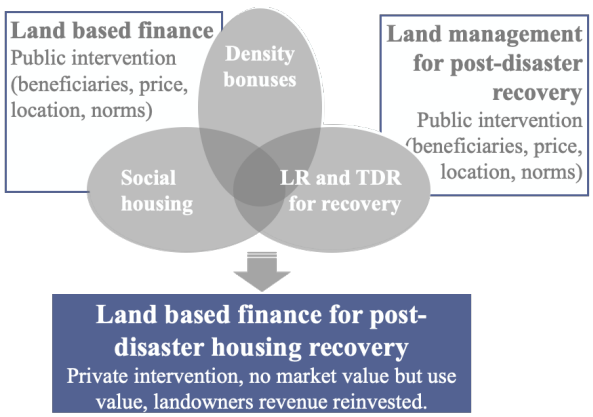
One can observe that both cases heavily rely on an active real estate market, planning enforcement, and mechanisms to keep prices low in sending and high in receiving, thus creating the desired flow. Unlike LR, which has been used for post-disaster recovery cases, CDR and TDR are used more in cases of environmental risk prevention.

2.5 Mexico City's innovative approach

Recalling the situation described in section 1.1 of this document, Mexico City faced a shortage of private and public resources to rebuild the damaged public and private properties after the earthquake. However, a specific mechanism was devised leveraging the existing regulatory framework governing the management of increased land values. This mechanism allowed the earthquake-affected individuals to utilize DB&LUC to finance the reconstruction of their homes.

Despite notable theoretical similarities, none of the approaches in section 2.4.4 precisely matched Mexico City's approach. Land-based finance for post-disaster is an innovative approach that combines elements from previous models. From LR, it incorporates elements of land pooling, whereby the affected landowners, in this case, the earthquake victims who retain a share of ownership of the condominium land after the demolition of their structures, contribute proportionally to the project. Land-based finance incorporates the use of DB in exchange for a social benefit. Traditionally, this benefit is social housing or public infrastructure projects. In this case, the resulting social benefit is private housing provided to individuals who lost their homes due to an external shock, the earthquake (Figure 7).

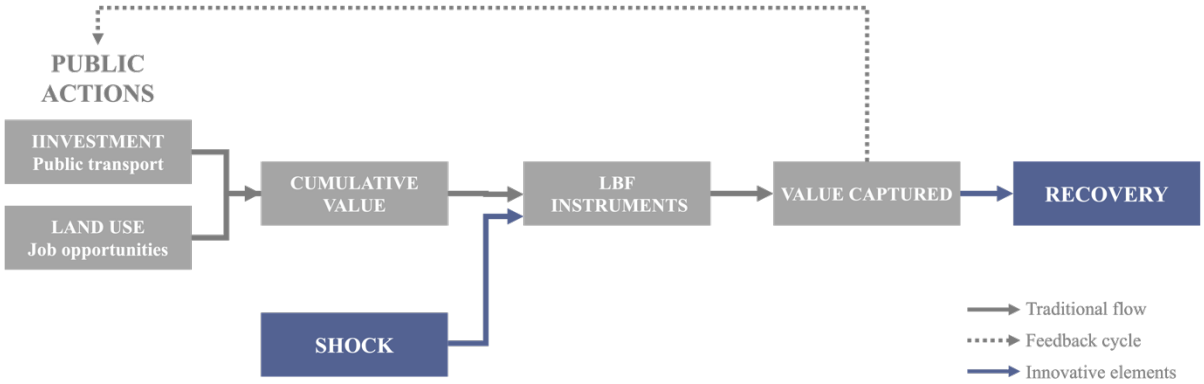
Figure 7 LVC mechanisms behind recovery in Mexico City



Source: Author

Based on Figure 6 the adaptation of LBF for post-disaster scenarios can be elucidated (Figure 8). In this novel model, the impact of an external shock leads to the development of an LBF instrument that facilitates the recovery of a portion of the accumulated value resulting from public initiatives, such as investments in public transportation and the establishment of employment creation zones (land use). This value recovery yields both a direct private benefit—the recovery of private housing—and a social benefit—preventing homelessness among families within the city while fulfilling the government's responsibility to provide adequate housing conditions for all residents.

Figure 8 LVC cycle adapted for Mexico City's case

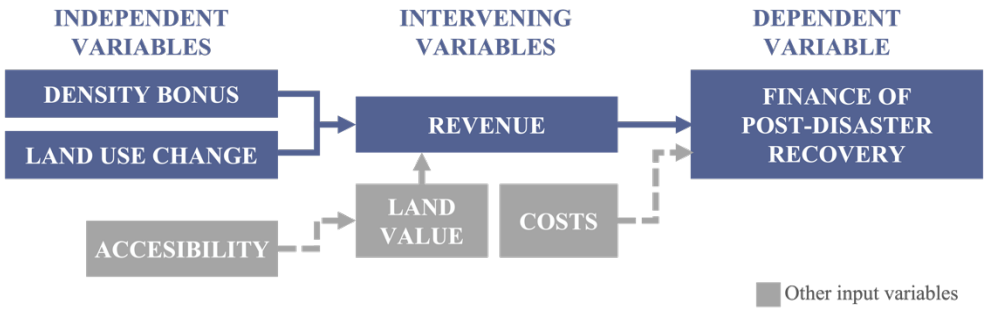


Source: Author

2.6 Conceptual framework

As summarized in Figure 9, in this research, the different variables have been organized in a progressive and linear conceptual framework in which the independent variables determine the dependent variable through intervening variables. DB&LUC, financing mechanisms, determine the share of the recovery costs covered (SRCC). This share is explained as the relationship between the revenue created through the financing mechanisms and the cost of the reconstruction. Complementarily, physical accessibility to a concentration of potential employment sources explains differences in land values and, therefore in the revenue generated.

Figure 9 Conceptual framework



Source: Author

Chapter 3: Research design and methodology

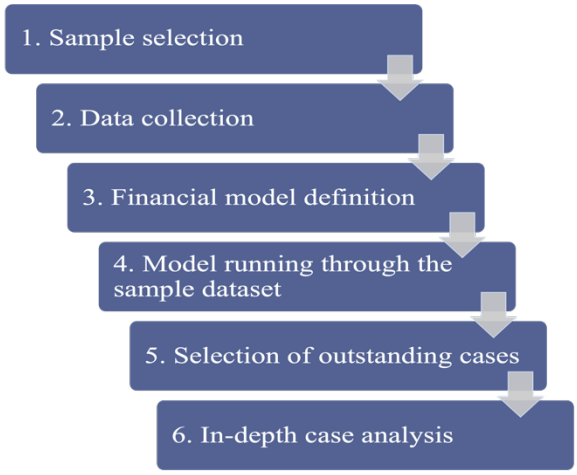
In its first section, this chapter provides an overview of the methodological design that guides this research through 6 steps, namely: 1) sample selection, 2) data collection, 3) financial model construction based on recovery cost, revenue from the sale of additional units, financial balance and share of recovery costs covered by the sale of additional units 4) running the model through the dataset, 5) selection of outstanding analysis cases, 6) in-depth case analysis based on particular characteristics such as location, extend of use of DB and extend of use of LUC.

The second section elaborates on the operationalization of the related variables and indicators. In the last section, this document focuses on the challenges and limitations surrounding this investigation.

3.1 Description of the research design and methods

This research was designed from a qualitative approach using secondary data. It is developed following the steps illustrated in Figure 10.

Figure 10 Research methodology

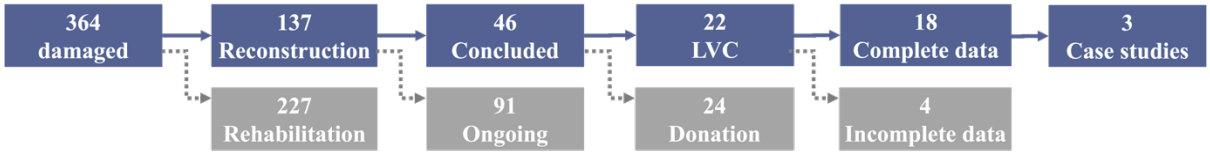


Source: Author

3.1.1 Sample selection

To establish a suitable analysis sample, specific criteria were defined: 1) residential buildings owned as condominium properties pre-earthquake; 2) structures fully or partially collapsed or deemed "high risk of collapse" with no rehab option; 3) buildings in the advanced construction stage with available units for sale; 4) reconstruction via LVC mechanism; and 5) comprehensive pre-earthquake property data, building attributes, and new unit sale prices. Of 364 damaged buildings (Figure 11), 137 met the reconstruction criteria, 46 were well into development, and 22 were selected for LVC-based rebuilding; others relied on private donations. Among these, 18 had complete attribute and sale price data for thorough financial analysis. Six cases were further chosen from the financial assessment based on location, extent of use of DB, and extent of use of LUC, offering insights into the mechanism's financing potential.

Figure 11 Sample selection



Source: Author

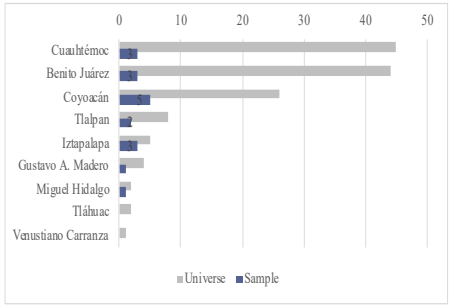
As described in Table 3, the sample of 18 buildings represents 13% of the total of 137 buildings and 10% of the original 2,991 damaged dwellings. The sample covers 7 out of 9 municipalities in Mexico City where reconstruction occurs, indicating territorial representation.
The municipalities with the highest concentration of buildings in the total universe (84%) are Cuauhtémoc (33%), Benito Juárez (32%), and Coyoacan (19%). These municipalities represent 61% of the sample - 17%, 17%, and 28%, respectively. They are centrally located in Mexico City, as illustrated Figure 12.

Municipalities with a moderate concentration of the universe of damaged buildings (14%) are Tlalpan (6%), Iztapalapa (4%), Gustavo A. Madero (3%), and Miguel Hidalgo (1%). Together, they represent 39% of the sample - 11%, 17%, 6%, and 6%, respectively.

Tlahuac and Venustiano Carranza, the two municipalities without sample units, have only 2% of the buildings in the reconstruction process.

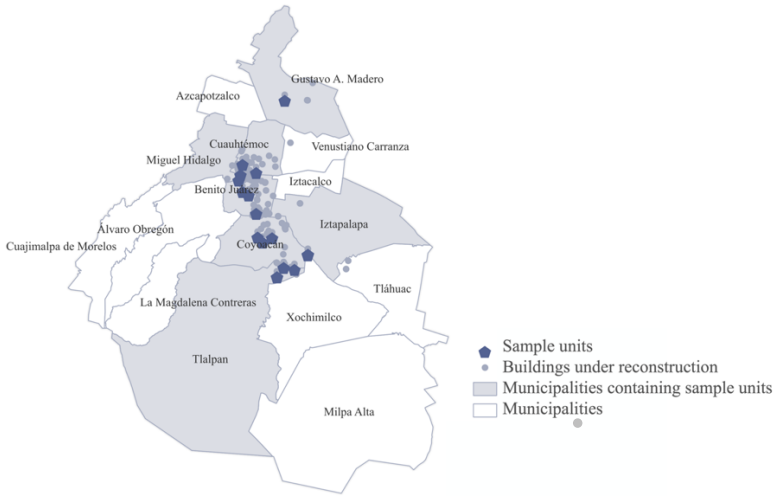
Table 3 Territorial distribution of universe and sample units -buildings and dwellings-.

Municipality	Universe			Sample		
	Buildings	% of total buildings	Original dwellings	Buildings	Original dwellings	Additional dwellings
Cuauhtémoc	45	*33%*	752	3	35	9
Benito Juárez	44	*32%*	886	3	50	22
Coyoacán	26	*19%*	562	5	107	48
Tlalpan	8	*6%*	111	2	20	8
Iztapalapa	5	*4%*	78	3	48	18
Gustavo A. Madero	4	*3%*	45	1	13	10
Miguel Hidalgo	2	*1%*	58	1	20	7
Tláhuac	2	*1%*	490	0	0	0
Venustiano Carranza	1	*1%*	9	0	0	0
	137		2991	18	293	122



Source: Author

Figure 12 Territorial distribution of universe and sample units within the Mexico City's municipalities.



Source: Author

The sample comprises 18 cases of collapsed or damaged buildings that have completed the entire process under the Reconstruction law, including the application, architectural planning, feasibility studies encompassing financial aspects, financialization, reconstruction, and current commercialization stages. These cases were initially evaluated as viable and approved for financing and reconstruction. Buildings not meeting feasibility criteria were disqualified from advancing to subsequent stages and are not subject to analysis using this proposed methodology.

3.1.2 Data collection

Regarding data collection, the information collected is grouped into five categories: a) original and post-reconstruction characteristics of each of the units in the sample; b) the sale prices of each of the units in the sample; c) the commercial prices of similar units in the areas of the sample units and d) the parametric costs of construction of residential buildings.

Each unit's original and post-reconstruction characteristics -size, rooms, parking spaces, and number of units residential, office, or retail- were obtained from three complementary sources. The Real Estate Offer site and the Housing Promotion site are both from Servicios Metropolitanos S.A. de CV (Servimet). Servimet is a company with state participation responsible for the administration and commercialization of real estate owned by the Government of Mexico City, the lease of commercial premises, parking lots, and advertising spaces (Servimet, 2023a; Servimet, 2023b). The third source was the requests for information from the responsible institutions through the National Transparency Platform of the Mexican Government (Plataforma Nacional de Transparencia, 2023).

On the other hand, to obtain the sale prices of the new units, two types of sources were used: public and private. Servimet, the public source (Plataforma Nacional de Transparencia, 2023; Servimet, 2023a), provides information on the prices for which actual transactions were completed and is an essential source for financial models. An open market survey from private sources of commercial real estate buying and selling sites (Inmuebles24, 2023; MetrosCúbicos, 2023) allows for identifying potential sale prices and whether gaps exist between these and the official values.

Regarding construction costs, parametric costs from the BIMSA 2022 Report (BIMSA Report, 2022) were used. Actual construction costs are not available. Therefore, this research makes a standardized informed assumption for all the units of the sample using parametric costs. Costs per square meter or parametric costs serve as valuable indicators for various professionals and stakeholders, including planners, economists, government offices, investors, real estate appraisers, architects, project engineers, contractors, and housing developers. A rough estimate can be derived based on a general understanding of the project, such as the desired surface area (Varela Alonso, 2009).

Finally, this information will be confirmed and triangulated through semi-structured interviews with key stakeholders -former government officers, real estate agents, and landowners-.

3.1.3 Financial model definition

A financial model was designed to capture construction costs, sales revenue, and the residual land value (RLV). In the recovery exercise, as in any other real estate undertaking, it is critical to identify the different elements, stages of the development process, stakeholders, and methods to estimate the financial feasibility (Adams & Tiesdell, 2013).

Moreover, the financial feasibility of the development is critical to following the process. Therefore, the financial model designed for this research has two objectives: 1) estimate the

balance between costs and revenue, and 2) calculate the appreciation of the RLV or residual land value increment (RLVI). The model used a spreadsheet calculator to visualize the input data and corresponding estimations. The model was built following five steps:

a) Identify the original characteristics of the building -number of units, size, and use- the potential characteristics according to the Law and those that were built, the final ones;

b) calculate construction costs from final characteristics and parametric costs,

c) Calculate the revenue for each of the developments based on the market values identified in the survey and the values used by the government;

d) estimate the financial balance between costs and revenue for each project, whether this is positive or negative, and the ratio;

e) calculate the added value of the land from the comparison of the RLV if a building with similar characteristics to the previous one had been built against the RLV considering a DB equivalent to 35% of the original construction and, where appropriate, the LUC (Borrero Ochoa, n.d.; Scarrett, 2008).

To compare the different case studies, the amount of housing was standardized through the price per square meter of housing. The quality of housing is considered a constant given that all the units in the sample were built in compliance with the same structural, safety, and efficiency standards set by current regulations, and the quality of the finishes was defined by the same standard established by the Government of Mexico City.

3.1.4 Model running through the sample dataset

The following step involves applying the financial model to the dataset of the 18 selected sample units. The information collected from the various sources listed in section The sample comprises 18 cases of collapsed or damaged buildings that have completed the entire process under the Reconstruction law, including the application, architectural planning, feasibility studies encompassing financial aspects, financialization, reconstruction, and current commercialization stages. These cases were initially evaluated as viable and approved for financing and reconstruction. Buildings not meeting feasibility criteria were disqualified from advancing to subsequent stages and are not subject to analysis using this proposed methodology.

3.1.2 Data collection was organized in a spreadsheet for each development and later integrated into a dataset. This dataset encompasses textual fields detailing property information, status, address, and municipality; numeric data including unit count, dimensions, costs, and revenue; and georeferenced data indicating location.

Analyzing this dataset enables comparing the 18 sample units, revealing statistical metrics such as maximums, minimums, and averages. Housing prices comprise components intrinsic to the house and those related to the neighborhood (O'Sullivan, 2012). Housing price hinges on individual attributes grouped into four categories: a) housing consumption quantity, b) quality, c) neighborhood traits, including accessibility to services, and d) employment access (Sobrino, 2014). Additional RLV allows deriving land value from housing value (Borrero Ochoa, n.d.; Scarrett, 2008).

This research aims to elucidate variations among case studies based on the employment accessibility component while controlling for housing quantity, quality, and neighborhood attributes. Employment accessibility refers to access beyond residential land uses, primarily concentrated employment areas. This variable significantly affects housing prices within location-based accessibility factors (Zubicaray, 2015).

To facilitate comparison among cases, housing quantities were standardized using price per square meter. Housing quality remains consistent, as all sample units adhere to equivalent structural, safety, and efficiency standards mandated by current regulations. Mexico City Government regulations also standardize fixtures quality. Neighborhood characteristics concerning access to public facilities and services are constant, given the sample's location in established city areas with relatively uniform public service distribution (Brito et al., 2021).

3.1.5 Selection of outstanding cases

Out of the 18 sample units, six outstanding projects were identified and paired with a contrasting project into three cases, to explain three types of effects: the effect of location, the effect of the application of the DB, and the effect of the application of the LUC.

3.1.6 In-depth case analysis

An in-depth analysis of those selected case studies was performed to identify contrasting conditions among the pairs that explain the three selected effects and, thus, the capacity to cover their recovery costs.

However, given the limited number of units in the sample, it is impossible to carry out an econometric analysis that allows isolating the effects. Contrasting comparable projects, in which other things could be held constant, provides insight into the effect of the variable under analysis.

3.2 Operationalization: variables, indicators

The concepts from the previous conceptual framework were operationalized as shown in Table 4.

Table 4 Operationalization table

Concepts	Variables	Indicators	Data type (Qualitative, quantitative, mixed)	Data source (primary or secondary)	Data collection method
FINANCE OF POST-DISASTER RECOVERY (dependent)	Share of recovery cost covered by sales income	Balance between cost and revenue	Quantitative	Secondary	Data analysis
		Percentage covered	Quantitative	Secondary	Data analysis
VALUE CREATION INSTRUMENTS (independent)	Use of density bonus	Number of additional units	Quantitative	Secondary	Government public information (Servimet)
		Types of units -type of apartments, office or retail space, parking and or rooftop	Cualitative	Secondary	Government public information (Servimet)
		Percentage used of the DB	Quantitative	Secondary	Data analysis
	Use of land use change	Used of not	Cualitative	Secondary	Government public information (Servimet)
		Percentage of total surface	Quantitative	Secondary	Data analysis
REVENUE (intervening)	Development revenue	Units for sale	Quantitative	Secondary	Government public information (Servimet)
		Total revenue	Quantitative	Secondary	Government public information (Servimet)
		Price per square meter	Quantitative	Secondary	Data analysis
DEVELOPMENT COSTS (input)	Development costs (input variable)	Recovery units	Quantitative	Secondary	Government public information (Servimet)
		Additional units	Quantitative	Secondary	Government public information (Servimet)
		Total construction space	Quantitative	Secondary	Government public information (Servimet)
		Parametric costs	Quantitative	Secondary	Developer inteview & Bimsa manual
LAND VALUE (input)	Land value	Residual price per m2	Quantitative	Secondary	Data analysis

Source: Author

3.3 Challenges and limitations

In this research, four main categories encompass the challenges and limitations faced: a) limited access to costs and sales price information, b) wide variability in parametric costs, c) potential self-selection bias in the sample and d) underestimation of retail space prices.

The first challenge arises from incomplete accessibility to costs and sales price information due to a lack of transparency and the auction-based nature of the sale process. To address this, direct information requests were filed, but the responses provided information of limited use. Therefore, parametric costs and a private market price survey were utilized.

The second challenge pertains to the broad range of parametric costs, making it difficult to identify specific structural variations associated with foundation characteristics, material selection (steel or concrete), and number of levels (e.g., 5 or 12).

The third challenge relates to the potential self-selection bias mentioned in section 3.1.1 Sample selection; only projects initially assessed as viable could progress to the final stage of commercialization. A larger sample, not limited to the 18 projects publicly shared for sale and including those under the latest assessment and construction stages, would provide a deeper understanding of the differences among the independent variables and, therefore, into the dependent variable, finance of post-disaster recovery.

The fourth challenge refers to sales underestimation of the values for retail spaces by Servimet compared to those found in the open market survey. This directly affects the projects' financial balance, SRCC, and indirectly the RLV and, consequently, the RLVI.

Chapter 4: Results, analysis, and discussion

4.1 Description of sample results

This section presents a general description of the physical characteristics of the sample units, including recovery and additional units, their size, and use. It also describes the use of the regulatory changes provided for in the Reconstruction Law on DB&LUC, which and to what extent the available DB was used, and the LUC from residential to retail and offices. Finally, a preliminary grouping of the sample units is presented based on location criteria in the municipalities of Mexico City, and the findings regarding the sale prices of the units are presented descriptively.

It is important to remember that, as mentioned in section 3.1.2, the information presented in sections 4.1.3 onwards refers to the sale prices provided by Servimet. Servimet is the company with state participation responsible for commercializing real estate owned by the Government of Mexico City. Particularly in the case of the Reconstruction program, it is responsible for the sale of the additional units -apartments, retail spaces, offices, parking lots, terraces, and storage spaces, among others-. This includes the auction processes established recently for the marketing phase.

4.1.1 Characteristics of recovery and additional units

Regarding the size of the original apartments, now recovery apartments, three groups were identified. In the first group, small apartments between 75 and 89 m^2, we find five buildings; in the second group, medium-sized apartments between 90 and 110 m^2, we find six buildings; in the third group, large apartments between 111 and 202 m^2, we find seven. Regarding the additional apartments for sale, the analysis found that seven buildings have small apartments for sale, nine have medium-sized apartments, and only two have large apartments.

There is a reduction in the floor area of the apartments that can be attributed to two factors: a) the new construction regulations require more extensive circulation, lighting, and service areas, which in the architectural projects were taken from areas previously considered private, and b) currently, given the current conformation of households, apartments smaller than 90 m^2 tend to be a product that is marketed with greater speed and higher relative price, both critical conditions for the financial feasibility of individual projects. To consult details of each project, see Pre-existing and additional units' size in Appendix 1.

4.1.2 Use of the DB&LUC provided for in the Reconstruction Law

The Reconstruction Law of November 2017 provided those victims, now landowners, an additional DB at no cost, equivalent to 35% of the allowed initially -in terms of units, floor area, and the number of levels- and the possibility of a LUC on the ground floor, from residential to retail or office space. Later, in December 2018, this Law was modified, and although it maintained the essence of DB&LUC, it allowed much more flexibility in its application. While with the first Law, the DB was limited in three dimensions: no more than 35% in units, no more than 35% in levels, and no more than 35% in floor area; the second Law restricted only one variable. In other words, more than 35% of units could be built and distributed in more than 35% of levels, as long as 35% of the floor area was not exceeded or any combinations until financial feasibility is achieved. This modification allowed the generation of better architectural solutions and, above all, an offer of units that were easier to market according to the needs and the current market.

> *"For example, if a 1980s building had 20 200-m^2 apartments, the first Law (2017) allowed it to build 7 additional 200-m^2 units, an unattractive product for today's market. Using the new Law (2018), up to 14 units of 100 m^2 could be built, much more appropriate for the needs of new households. Therefore, they can be sold faster and at higher prices per square meter."* (Realtor A, personal communication, June 13, 2023).

The analysis found that concerning the 35% restriction on floor area, ten projects remained below the restriction while eight projects exceeded it. The cases of Chapultepec 444 (12%), Canal de Miramontes 1868 (15%), and Cafetales 1710 (16%) stand out among the minimum. Among projects that exceeded the area, Prosperidad 4 (57%) and Canal de Miramontes 3004 (87%) stand out.

Regarding the 35% restriction in the number of units, five projects remained below the limit, and thirteen projects exceeded it. Again, Chapultepec 444 (12%), Canal de Miramontes 1868 (22%), and Cafetales 1710 (25%) are among the minimum. While among the three highest, we find Coquimbo 911 (77%), Escocia 10 (71%), Hacienda la Escalera 5 and 11 (both 70%).

Regarding the possibility of the LUC, the analysis found that of the original buildings, 13 were totally residential, and five already had a mixed-use and at least one retail space. Later, 11 reconstruction projects remained exclusively for residential use; 2 projects added retail spaces that did not exist previously, and the five projects that initially had retail spaces added new retail spaces in addition to the recovery ones.

> *"In my condo we decided not to include retail spaces. They bring a lot of trouble. Unknown people can enter, we would not have security control. Or what if they want to open a restaurant and we get smells or insects. But above all, it is already very difficult to park around here, and new customers would use the few remaining places."* (Neighbor A, personal communication, June 10, 2023).

> *We decided to increase the retail spaces. We already had one in the previous building, a pastry shop. We have lived together well for more than 30 years. Several neighbours used to buy our desserts there. I don't think one more will bring us problems."* (Neighbor B, personal communication, June 8, 2023).

For further details about each of the units in the sample, see Pre-existing and additional units' size in Appendix 1.

4.1.3 Territorial distribution of the units and their relationship with housing prices

The sample has been subdivided based on its location and correspondence with one of the municipalities of Mexico City to facilitate the analysis. The seven municipalities containing units from the sample were divided into three zones: 1. Central, which includes Cuauhtemoc, Benito Juarez, and Miguel Hidalgo; 2. Intermediate, including Coyoacan and Tlalpan; and 3. External including Gustavo A. Madero and Iztapalapa. Table 5 shows the distribution of the sample units according to these three zones.

Table 5 Regional distribution of the sample

Zone	Projects	Zone	Projects	Zone	Projects
1. Central	**7**	**2. Intermediate**	**7**	**3. External**	**4**
Benito Juarez	3	Coyoacan	5	Gustavo A. Madero	1
Cuauhtemoc	3	Tlalpan	2	Iztapalapa	3
Miguel Hidalgo	1				

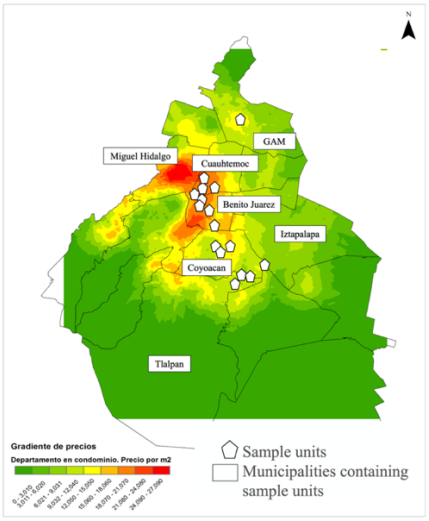
Source: Author

The decision for this regional distribution was based on reference studies. As discussed in section 2.3 of this research, urban models have evolved from monocentric to polycentric over time to explain the complex growth of cities. In Mexico City, there is a significant concentration of jobs in the center, and sub-centers have developed along linear activity corridors (Muñiz et al., 2015). The neighborhood characteristics, such as access to public facilities and services, remain consistent throughout the sample units. These units are situated in well-established city areas where public amenities and services distribution is relatively uniform (Brito et al., 2021).

As a result, the highest housing values in the city are centered in the municipalities of Miguel Hidalgo, Cuauhtemoc, and Benito Juarez. Coyoacan and Tlalpan exhibit areas with a concentration of medium housing values, while Gustavo A. Madero and Iztapalapa display mid-low housing values (See Figure 13). This price distribution is closely tied to accessibility in terms of proximity and access to mass transportation systems, particularly in areas with a high density of employment opportunities. Mexico City can be divided into three tiers based on condominium apartment prices (Zubicaray, 2015).

a. High prices. It considers prices between MXN 18,070 MXN and 27,000 per m^2 and is concentrated in Alvaro Obregon, Benito Juárez, Cuauhtemoc, and Miguel Hidalgo.
b. Medium price. It considers prices between MXN 9,032 and MXN 18,000 per m^2 and is concentrated in the Azcapotzalco, Coyoacan, Cuajimalpa, Magdalena Contreras, and Tlalpan municipalities.
c. Low prices. It considers prices between MXN 0 and MXN 9,031 per m^2 and is concentrated in the municipalities of Gustavo A. Madero, Iztacalco, Iztapalapa, Milpa Alta, Tlahuac, Venustiano Carranza, and Xochimilco.

Figure 13 Housing price gradient (condominium apartments)



Source: (Zubicaray, 2015)

According to the information published by Servimet, the average price per square meter of housing in zone 1. Central is MXN 47,879, in zone 2. Intermediate MXN 39,027; and in zone 3. External MXN 34,192. However, in the open market survey for the same areas of the units in the sample, it was found that the average prices per square meter for zone 1. Central is MXN 70,037 for zone 2. Intermediate MXN 49,312; and for zone 3. External is MXN 44,786. In all three cases, the average prices considered by Servimet are below commercial prices in the current market and represent between 68 and 79% of the latter (See Table 6).

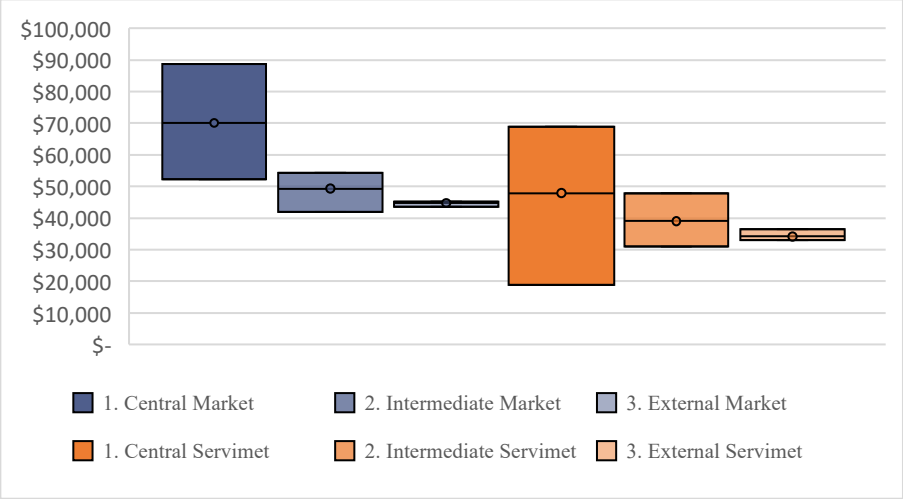
Table 6 Average prices per square meter in three areas -Servimet vs market-

Zone	Market	Servimet	% of market price
1. Central	MXN 70,037	MXN 47,879	68%
2. Intermediate	MXN 49,312	MXN 39,027	79%
3. External	MXN 44,786	MXN 34,192	76%

Source: Author

Delving into greater detail, when the market prices considered by Servimet are compared, even the highest ones are below the average prices of each of the three zones (See Figure 14). This may be due to various causes: a) different specific characteristics of the units, especially the quality of the fixtures, or b) a time lag between the moment in which Servimet determined the sale prices and the moment in which the values of the market. It is possible that in the period between these two moments, there has been an increase in the entire market that was not registered by Servimet's original price determination.

Figure 14 Prices per square meter in three areas -average, minimum and maximum-.



Source: Author

In 2023, Servimet implemented an auction mechanism for additional units to overcome this temporary adjustment gap. Servimet publishes a starting price, and potential buyers offer the price they are willing to pay. In principle, this mechanism should incorporate price increases. However, the data collected from this source does not indicate substantive appreciations. Even in some cases, the prices offered with which the sales are closed are below the starting prices publicly requested by Servimet.

For example, in Pacifico 223, the price requested by Servimet for apartment 101 was MXN 3,320,568, and the final sale price after the auction was MXN 3,320,600—an appreciation of only MXN 32. In the case of Escocia 10, the registered starting price was MXN 5,556,233. However, it was sold directly, without an auction, for MXN 4,152,168. That is MXN 1,404,065 below the starting price.

4.1.4 SRCC by the sale of additional units

As stated in the research question, it is essential to find out to what extent the revenue from the sales of the additional units covers the recovery costs of the damaged buildings. What is the difference between costs and revenue, and how much does it represent proportionally? To answer this question, two scenarios are posed. The first is with the official prices Servimet used to commercialize the units, and the second scenario considers the current market values obtained from the open market survey. Next, each of the two scenarios will be analyzed, and a comparison will be made between them. For further detail on each sample balance, see Project financial balance, recovery cost, additional cost, total cost, revenue and SRCC for Servimet and market prices in Appendix 1.

In the first place, for the first scenario (see Table 7), according to the data obtained from Servimet, this research found that there is a wide range between the project that achieved the highest SRCC, Prosperidad 4 (133%), and the one that presented the lowest SRCC, Canal de Miramontes 1868 (with only 32%). On average, the projects managed to achieve a 72% of SRCC. Furthermore, five projects only achieved a SRCC of less than 50%, four more projects achieved a SRCC between 51% and 75%, eight achieved a SRCC between 75% and 100%, and one exceeded 100% of the construction costs.

When considering the regional subdivision proposed in the previous section of this document, we find that in zone 1. Central, the projects covered an average of 88% of the construction costs in zone 2. Intermediate, they reached 67% and were in zone 3. External only 55%.

Table 7 Costs covered considering Servimet prices

SRCC (Range)		Projects
Low	<50%	5
Medium	51-75%	4
High	76-100%	8
Very high	>100%	1
Zone		**Average SRCC**
1. Central		88%
2. Intermediate		67%
3. External		55%

Source: Author

For the second scenario, according to the data obtained from the open market survey (see

Table 8), this research found that the range between the project that achieved the highest SRCC, Prosperidad 4 (273%), and the one that presented the lowest coverage Cafetales 1710 (40%), is even wider, 233 percentage points. On average, the projects managed to cover 96% of the costs. Furthermore, two projects only achieved a ratio of less than 50%, four more projects achieved a ratio between 51% and 75%, five projects achieved a ratio between 75% and 100%, six projects project exceeded 100% of the construction costs, and even one project exceeded 200% of the reconstruction costs.

When considering the regional subdivision, we find that in Zone 1. Central, the projects managed to cover an average of 123% of the construction costs in Zone 2. Intermediate, they reached 84% and were in zone 3. External only 71% on average.

Table 8 Costs covered considering market prices

SRCC (Range)		Projects
Low	<5	2
Medium	51-75%	4
High	76-100%	5
Very high	>100%	6
Outstanding	>200%	1

Zone	Average SRCC
1. Central	123%
2. Intermediate	84%
3. External	71%

Source: Author

The significant differences between the SRCC in the Servimet and open market scenarios are noticeable. These are a direct consequence of using different sales prices already explained in section 4.1.2 Use of the DB&LUC provided for in the Reconstruction Law.

The vast differences between the projects that only reached minimum levels of cost proportion and those that achieved the highest levels are explained since not all projects applied the BD&LUC to the same extent. As for DB (See Table 9), the sample analysis found that concerning the 35% restriction on floor area, the ten projects that remained below the original restriction achieved a SRCC between 32% and 90%, on average 59%. While those eight that exceeded it achieved a SRCC between 89% and 133%, on average 89%—a difference of 30 percentual points between both conditions.

When analyzed as the 35% restriction in the number of units, the five projects that remained below the original restriction achieved a SRCC between 32% and 81%, averaging 52%. While those thirteen that exceeded it achieved a SRCC between 46% and 133%, on average of 80%.

Table 9 SRCC considering the different use of the DB

% Floor area over original	SRCC covered			% Units over original	SRCC covered		
	Ave.	Min.	Max		Ave.	Min.	Max
Below 35%	59%	32%	90%	Below 35%	52%	32%	81%
35% or above	89%	71%	133%	35% or above	80%	46%	133%

Source: Author

Regarding LUC, the sample analysis found that given different usage conditions, the projects achieved different SRCC (See Table 10). On average, the eleven projects that did not use the LUC option achieved 63%; the two projects that used it, going from residential to mixed, achieved 78%; and the remaining five, which not only recovered the preexisting but increased the units, achieved 90%, respectively.

Table 10 SRCC considering the different use of the LUC

LUC	SRCC covered		
	Ave.	Min.	Max
No LUC	63%	32%	96%
LUC	78%	74%	81%

Recovery and more	90%	70%	133%

Source: Author

Section 4.2 In-depth case analysis seeks to explain these differences more precisely from a selection of cases.

4.1.5 RLV and the application of DB&LUC

RLV allows to derive the land value from the housing value (Borrero Ochoa, n.d.; Scarrett, 2008). At the same time, it is a monetization measure of the impacts of public actions that can be recovered from LVC tools. It also serves as a standardized measure that compiles the effects of the analyzed variables: location, use of DB, and use of LUC.
To facilitate the comparability of these results with other projects that use LVC tools - infrastructure construction, urbanization, and zoning changes- an additional analysis was carried out to calculate the RLV under two scenarios. The first, if only the replacement departments and retail premises had been built, and the second, considering the DB&LUC. From the comparison between these two scenarios, it was possible to calculate RLVI (See

Table 11).

On average, the 18 projects achieved an RLVI of 43%, where the maximum was 106% and the minimum was 13%. Fourteen projects reached an RLVI of less than 50%, three were in the 51-75% range, and only one project exceeded 100%.

Prosperidad 4, the project that achieved 106% of RLVI, used all the available tools. Its location is privileged within Zone 1 Central, reaching a value per m2 of MXN 50,824 for residential use, the third highest in the sample. Regarding the use of the DB, in terms of the number of units, it remained at 35%, although in terms of the area, it used 57%. Above all, LUC increased the number of retail spaces from 1 before the earthquake to 4, the highest in the sample.

In contrast, Canal de Miramontes 1868, the project that achieved 12% of RLVI, only used some of the tools at its disposal and in a limited way. Its location is in zone 2. Intermediate gave it a value per m2 of MXN 36,096 for residential use, the eleventh highest in the sample. Concerning the use of the DB, in terms of the number of units, it remained at 22%; in terms of area, it used only 15%, below the original restriction. As for LUC, it did not use the option and was kept as a fully residential project.

When analyzing by zone, the average RLVI in zone 1. Central was 54%; in zone 2. Intermediate was 39% and in zone 3. External only 30%. For further detail in each sample RLV and RLVI, see Residual land value per project and residual land value increment considering the application of DB&LUCProject financial balance, recovery cost, additional cost, total cost, revenue and SRCC for Servimet and market prices in Appendix 1.

Table 11 RLV and RLVI

Scenario Servimet		
RLVI		**Projects**
Low	<50%	14
Medium	51-75%	3
High	76-100%	0
Very high	>100%	1
Zone	**Avergage RLVI**	

1. Central	54%
2. Intermediate	39%
3. External	30%

Source: Author

4.1.6 Discussion

As stated in the conceptual framework of this research, section 3.2, there is a direct relationship between the application of the DB&LUC in recovery projects and the revenue that can be obtained from the sale of additional units, and this, in turn, affects the SRCC. This revenue depends significantly on the location of the projects, which is directly related to access to areas with a high concentration of employment sources.

Regarding the characteristics of the recovery and additional units, it is essential to highlight the flexibility provided by the Second Reconstruction Law (2018). Based on it, the new projects were able to generate new units with different characteristics from the original units, more and smaller units. These are more responsive to the current housing market and allow faster marketing at a higher price.

Regarding the application of LUC, the results show complex results. Despite the theory that commercial uses and offices should present higher sales prices than residential uses, this was only partially captured by the sales prices used by Servimet. However, this condition is met when exploring the open market survey data. It was also found that most of the projects did not use this option and remained with entirely residential use. Those projects that originally included retail spaces increased the units, and only two integrated new retail spaces. These results can be explained by two factors: a) resistance to change and the perception of possible disturbances that a new retail space could bring to the community and b) the limited financial benefit, given the underestimation of Servimet prices, that new retail spaces represent for the balance.

The location of the projects and their relationship with the accessibility to areas concentrating potential employment and, therefore, with high housing values are crucial for the SRCC. Zone 1. Central, which corresponds to the high price range, clearly performed better than zone 3. External, which corresponds to low price ranges. In this sense, it is essential to remember that these conditions, concentration of potential employment sources, and access through public transportation are the product of public actions taken cumulatively by the government. Therefore, it reinforces the LVC virtuous circle principle mentioned in section 2.4.2.

Regarding sales prices, this study found a significant disparity between the official prices determined by Servimet and used in reality and those on the open market. In the balance of the projects, this difference does not alter the trend of the results. Using higher market prices increases revenue, the SRCC, and the gap between sample results.

The differentiated use made of the DB plays a crucial role in the SRCC. In this sense, the evidence analyzed shows that those projects that used less than an additional 35% in floor area had a lower performance -59% on average- than those that exceeded it -89% on average-. A similar effect is observed when the DB is analyzed as additional units. Projects that used more than 35% of additional units showed a higher performance -80% on average- than those that remained below this original restriction -52% on average-.

4.2 In-depth case analysis

This section seeks, beyond describing the general results of the analysis of the use of DB&LUC, the financial results of the model, the SRCC, and RLVI, to explain the combinations of these conditions that allow to a greater or lesser extent to cover the costs of recovery.

For this analysis, it was decided to explain three types of effects of the application of DB&LUC and the location in the city (See Table 12 and Figure 15):

- Case 1. Effect of location
- Case 2. Effect of the application of the DB
- Case 3. Effect of the application of the LUC

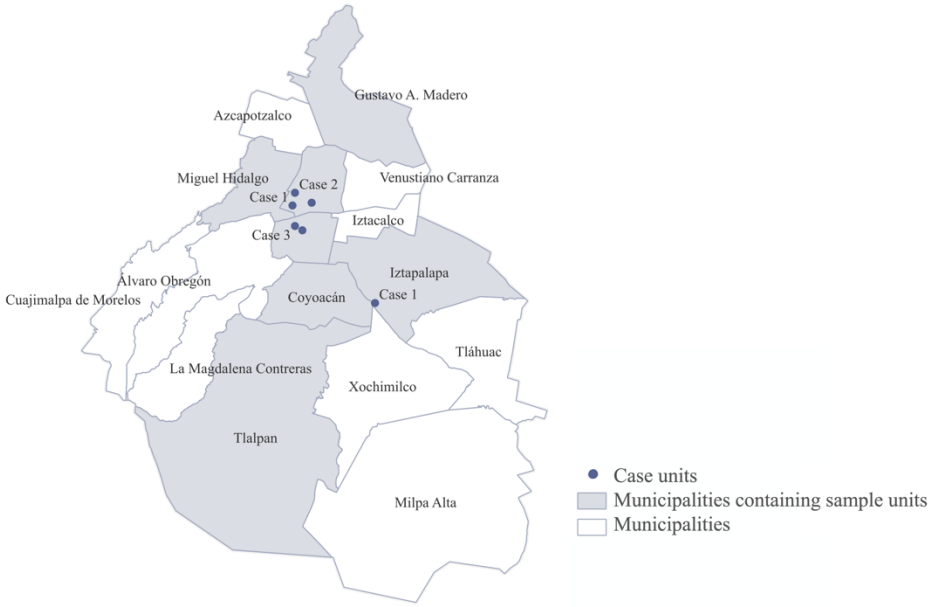
For further detail on each sample unit of the three cases, see the Financial Models in Appendix 1.

Table 12 Case and sample project selection

Case	Street	Num	Neighborhood	Municipality	Zone	% Area over original	% Units over original	LUC	SRCC (%)
Case 1. location	Ozuluama	20	Hipodromo	Cuauhtémoc	1. Central	31%	40%	NO LUC	**90%**
	Paseo de las Galias	31	Lomas Estrella	Iztapalapa	3. External	30%	38%	NO LUC	**49%**
Case 2. application of the DB	Chapultepec	444	Roma Norte	Cuauhtémoc	1. Central	12%	14%	NO LUC	**39%**
	Coahuila	10	Roma Norte	Cuauhtémoc	1. Central	28%	50%	NO LUC	**90%**
Case 3- application of the LUC	Escocia	10	Del Valle Centro	Benito Juárez	1. Central	41%	71%	NO LUC	**91%**
	Patricio Sanz	612	Del Valle Norte	Benito Juárez	1. Central	39%	55%	Recovery +3	**93%**

Source: Author

Figure 15 Sample unit location for case analysis

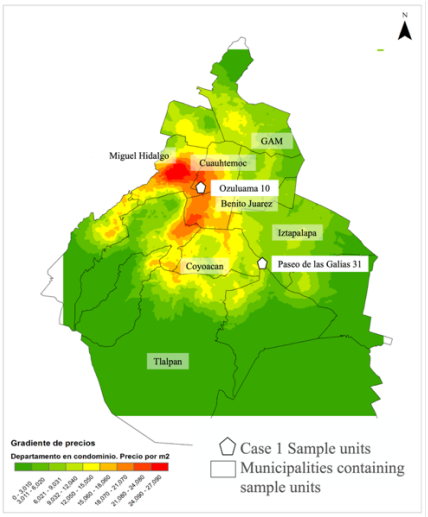


Source: Author

4.2.1 Case 1. Effect of location

This first case compares the effect of a different location between two projects (See Figure 16) with similar characteristics regarding the use of DB&LUC and its effect on the SRCC.

Figure 16 Location of sample units for case 1.



Source: Author based on Zubicaray, 2015.

The first project, Ozuluama 20, is located in Zone 1. Central used only 31% of additional surface area and 40% of additional units, did not use the LUC option, and reached a 90% SRCC (fifth highest in the sample). The original building had ten apartments of 150 m^2. The new project has 14 apartments of 131 m^2, 16 m^2 smaller than the original ones. Regarding the location, it is located in the Cuauhtemoc municipality, in the Hipodromo neighborhood, one of the areas with the highest housing prices in the city. According to the information provided by Servimet, the price per square meter of housing is MXN 59,501 (the second highest in the sample), and according to the open market survey, it is MXN 88,788 (the highest in the sample).

Picture 1 Case 1 projects. Ozuluama 20 before (2017) and after (2023).

Source: Google Street View

The second project, Paseo de las Galias 31, is in Zone 3. External used only 30% of the additional area and 38% of additional units, did not use the LUC option, and reached a 49% SRCC (fourteenth place among the sample). The original building had 16 apartments of 75 m^2. The new project has 16 apartments of 71 m^2, 4 m^2 smaller than the original ones. It is located in the Iztapalapa municipality, in the Lomas Estrella neighborhood, and where housing prices are medium-low. According to the information provided by Servimet, the price per square meter of housing is MXN 32,979, and according to the open market survey, it is MXN 45,208 (position 16 in the sample in both cases).

Picture 2 Case 1 projects. Paseo de las Galias 31 before (2017) and after (2023).

Source: Google Street View

When we compare both cases, it is found that despite having made similar use of DB&LUC, the critical difference between these two cases is the price of housing, where the price is 80% higher at Ozuluama 20 than at Paseo de las Galias 31 a SRCC 51 percentage points higher - 49% vs. 90%- is achieved.

4.2.2 Case 2 Effect of applying the DB

The second case of analysis compares the effect of the application of the DB between two projects with other similar characteristics -location and application of the LUC- and its effect on the SRCC.

The first Chapultepec 444 project is located in Zone 1. Central used only 12% of the additional area and 14% of the additional units, did not use the LUC option, and was able to cover it with sales revenue according to information provided by Servimet 39% of the reconstruction costs and 52% with information from the real estate market survey (position 16 of the sample in both cases). The original building had 21 apartments of 104 m^2. The new project has 24 apartments, with only three additional apartments of similar dimensions to the original ones. The project is located in the Cuauhtemoc municipality in the Roma Norte neighborhood, one of the areas with the highest housing prices in the city.

Picture 3 Case 2 projects. Chapultepec 444 before (2017) and after (2023).

Source: Google Street View

The second Coahuila 10 Project is located in Zone 1. Central used 28% of the additional area and 50% of the additional units, did not use the LUC option, and achieved a 90% SRCC, according to Servimet's prices (the fifth highest among the sample). The original building had four apartments of 90 m^2. The new project has six apartments of similar dimensions to the original ones. The project is located in the Cuauhtemoc municipality in the Roma Norte neighborhood, one of the areas with the highest housing prices in the city.

Picture 4 Case 2 projects. Coahuila 10 before (2017) and after (2023).

Source: Google Street View

When comparing the two cases, this research found that both are in the same neighborhood. Therefore, they share characteristics of accessibility and housing prices, and neither of the two projects used the available LUC option. Although there is a similarity regarding the additional units available, Chapultepec 444 has three additional departments and Coahuila 2; there is a significant difference in what they represent, 14% and 50%, respectively. The construction volume to be replaced and its cost is significantly different. While Chapultepec must rebuild 2,125 m^2 with a total cost of MXN 34,235,753, Coahuila 10 only has to rebuild 685 m^2 with a total cost of MXN 14,419,254. So similar revenues around MXN 13,000,000 represent different SRCCs -39% vs 50%-.

4.2.3 Case 3 Effect of the application of the LUC

In this third case, the effect of the application or not of LUC is compared, going from a residential use to a mixed-use with retail or office spaces, and its effect on the SRCC.

The first project, in this case, Escocia 10, is located in zone 1. Central used 41% additional space and 71% additional units, did not use the available LUC option, and reached 91% SRCC (fourth highest in the sample). The original building had seven apartments of 160 m^2. The new project has 12 apartments, seven for recovery and five additional apartments, 106 m^2. It is located in the Benito Juárez municipality in the Del Valle Centro neighborhood, where average housing prices are estimated at MXN 43,565 per square meter, and the average price of retail spaces is MXN 90,254 (the highest in the sample according to the open market survey).

Picture 5 Case 3 projects. Escocia 10 before (2017) and after (2023).

Source: Google Street View

The second project, in this case, Patricio Sanz 612, is located in Zone 1 Central; it used 39% of the additional area and 55% of the additional units. In addition to replacing its original retail spaces, it added two more spaces and achieved a 93% SRCC (third highest in the sample). The

original building had 11 apartments of 170 m^2 and retail spaces. The new project has 17 apartments, six additional apartments of 124 m^2, and four retail spaces, three additional 28 m^2, 47 m^2, and 55 m^2. It is located in the Benito Juárez municipality in the Del Valle Norte neighborhood, where average housing prices are estimated at MXN 44,399 per square meter (seventh place among the sample). The average price of retail spaces is MXN 42,500 (according to Servimet) and MXN 76,937 (third in the sample according to the open market survey).

Picture 6 Case 3 projects. Patricio Sanz 612 before (2017) and after (2023).

Source: Google Street View

When comparing these two cases, we find that both projects are very similar in location characteristics and, therefore, in housing prices. At the same time, both achieved somewhat similar construction cost coverage ratios -91% and 93%-. However, they achieved it with different strategies. While Escocia 10 used 71% of additional units -16 percentage points more than Patricio Sanz 612- the second project achieved it from the incorporation of three additional retail spaces that represented MXN 14,730,918, equivalent to 24% of the total revenue of MXN 46,672,898.

4.2.4 Discussion

The SRCC confirms that all the projects had positive results. Among them, there is a wide diversity depending on three main conditions: the location, the application of the DB, and the application of the LUC. The projects are located in Zone 1. Central performed better than the projects in Zone 3. External. The projects that used the DB to a greater extent under the flexibility conditions offered by the second Law performed better than those that used it to a lesser extent. Moreover, the projects that used LUC had positive results equivalent to the even more intensive use of DB.

The evidence presented around the two projects in the first case shows that the projects are located in Zone 1. Central performed better than the projects located in Zone 3. External. This is consistent with the theory presented in section In 1821, David Ricardo analyzed an economic model of how the fertility of the land -what can be obtained from it -determines its price in the market, always depending on the price of the final product -corn in his analysis-, which at the same time was defined by its market. Ricardo introduced the *leftover principle*: "Because of competition among farmers for land, the landowner gets the leftovers, equal to total revenue minus total nonland costs" (O'Sullivan, 2012; Ricardo, 2001). More fertile lands require less investment, thus reducing production costs, and a higher amount leftover is paid to the landowner—the opposite stands for the less fertile lands.

Subsequently, Johann Von Thünen explained how the differential rent derives not only from the demand for land fertility but also from the demand for its location, its accessibility, and its

proximity to economic activities. Farmers were willing to pay more to settle on the land closest to the market, thus reducing transportation costs of the final products to their commercialization destination. After subtracting the production and transportation costs from the final product price, what is left could be paid to the landowner as rent (Von Thünen, 2018).

Later, Marx, in the General Theory of Land Rent, explained the role of land in a capitalist economy and how a price is determined even though the land does not have a production cost but through capitalization of rent. Moreover, Marx differentiates three types of rent: differential rent type I, differential rent type II, and total rent. Overall, differential rent refers to the differences among plots of land located in various areas in a market. Type I refers explicitly to the rent from the differential advantage in production; type II from the rent gap between unimproved land and land improved by capital investment; and absolute rent which is rent refers to that which is required from tenants, even for the least productive or lowest-quality land they occupy (Jaramillo González, 2009; Park, 2014).

The concepts mentioned above, derived from the agricultural context of the late 18th and early 19th century: fertility, distance, differential rent, landowner, and capitalist, are reinterpreted for an urban context in the following section.

2.2 Urban Land Rent Theory, particularly the one that refers to differential housing rents. Differential housing rents are explained by the distance to working nodes and the associated transportation costs. It is also consistent with the polycentric urban models described in section 2.3 Monocentric and polycentric urban models and the previous studies mentioned in section 4.1.3 that classify city areas into three levels according to condominium apartment prices -high, medium, and low-.

Regarding the second case, the evidence from the projects analyzed supports that the projects that used the DB to a greater extent performed better than those that used it to a lesser extent. This evidence is consistent with the theory described in section 2.2 Urban Land Rent Theory , particularly with the dimension that refers to primary rents, those characteristics inherent to the land's location, and among them with the differential rent type 2. Recalling that the differential rent type 2 refers to the intensity of land use, usually regulated by the planning and legal framework, and which concludes that the greater the intensity of use, holding other variables constant, the greater the value of the land. The relationship between land value and SRCC is explained in section 4.1.5 RLV and the application of DB&LUC.

Finally, as a result of the analysis of the projects of the third case, the results are diverse. The Urban Land Rent Theory, in its differential rents of commerce, establishes that commercial uses are associated with a higher profit and, therefore, with a higher rent for the landowner. However, while analyzing the case, if we consider the prices used by Servimet, including the underestimation of sales values for retail spaces, the use of LUC contradicts the theory. This is not because land values for commercial use are less profitable than residential ones but because, from the beginning, prices are distorted. On the other hand, if we consider the sale values obtained from the open market survey -higher than those used by Servimet, higher than residential values, and closer to the market prices the Urban Land Rent Theory in its differential rents of commerce component holds.

This underestimation, in the first place, alters the final result of the balance sheet. Moreover, it may have altered the decisions made during the project design and financial assessment process. For example, a group of landowners may have decided not to use the LUC, considering that the disadvantages of having a retail space are more significant than the financial benefit it could represent in their financial assessment.

Chapter 5: Conclusions

This study investigated the aftermath of Mexico City's September 19, 2017, earthquake, resulting in the collapse of 137 apartment buildings with 2,991 homes. Unable to cover the extensive damages, the city focused on public infrastructure and services using traditional financing methods. Housing recovery faced limited funding options, primarily private insurance, exposing this vital sector. An innovative mechanism was devised to address this, granting DB&LUC to affected private properties.

The principles of land rent theory, urban land rent theory, and monocentric and polycentric urban models (sections 2.1, 2.2, and 2.3 of this document) lay the foundations to propose this financing model based on LVC instruments, DB&LUC. Four components of land rent theory practically applied: primary differential rent type 1 based on location and regulation; differential rent type 2 related to land use intensity; commerce differential rents, which explains why commercial uses allow a higher rent for the landowner than residential uses; and housing differential rents, which explains why locations closer to working nodes and the transportation costs are associated to higher rents for the landowners. Mexico City's polycentric structure also impacts housing and land values.

LVC mechanisms have been extensively tested globally, both the Global North and South, for public infrastructure and affordable housing. However, their use in post-disaster housing recovery and risk prevention remains unexplored. It has been limited to a handful of LR projects in particular countries, i.e., Japan, Chile, and India, and another handful of TDR projects as those explored in the USA and Brazil.

This research aimed to identify **to what extent the use of DB&LUC enables the finance of post-disaster recovery of condominium dwelling buildings in Mexico City after the September 2017 earthquake**. From the analysis of a sample of 18 projects that reached the construction and commercialization stage and later from the in-depth analysis of three cases, it was possible to answer the research sub-questions.

Which are the key elements that allow for the finance of post-disaster recovery?

Maximizing the ability to generate revenue from selling additional units is critical to defining the SRCC. These are achieved through three main variables: a) the location of the projects, b) the use of the DB in such a way that it generates an offer of attractive products for the market, quick commercialization, and maximum price, and c) the use of LUC to produce high-priced products.

Although they were not conceived as part of the analysis elements of this research, one must recognize pre-existing enabling conditions in the context of the city, which allowed an active mechanism and quick response to an emergency. There was already an active conversation around LVC instruments in Mexico City before the earthquake. The high demand for affordable housing, the active housing market, the constant price increase, and an overall enabling legal framework allowed previous similar instruments. Implementing the financing mechanism analyzed in this document in different contexts requires further analysis.

Which variables might lead to a difference in this share? Furthermore, how can they be explained?

The sample analysis showed that the projects in the city's central areas, with higher housing prices, reached a higher recovery rate than those in lower-priced areas. It also showed that those projects that fully employed the flexibility for DB usage achieved a higher recovery ratio than those that only used a part of it. Finally, it showed that using LUC contributes significantly to

a higher recovery rate. The positive outcome of the projects, measured in terms of the SRCC, relies on these three main conditions.

1. Location close to the areas of the city with the highest housing prices.

The sample analysis and case 1 showed solid evidence regarding the housing price differential among the recovery units. The sample showed significative differences among sales prices in the different zones of this analysis: 1 Central, 2. Intermediate, and 3. External: On average, MXN 47,879, MXN 39,027, and MXN 34,192, respectively.

Consequently, these sales price differences translate into higher revenue from sales of additional units, and therefore, it directly impacts the SRCC. On average, the projects are located in zone 1. Central reached a SRCC of 88%, those in zone 2. Intermediate 67% and those in zone 3. External, only 55%.

This aligns with the concept discussed in section 2.2, Urban Land Rent Theory, specifically the notion of varying rents for housing based on factors like the distance to working nodes and transportation costs. Moreover, it aligns with the models of polycentric urban development outlined in section 2.3 regarding polycentric patterns. It resonates with earlier research in section 4.1.3 regarding the city's zoning based on condominium apartment prices.

The differences mentioned above, per se, do not represent a negative result; on the contrary, they could give rise to a mechanism that recognizes and takes advantage of it within a joint program with projects in different locations beyond the individual management of the projects.

2. Extension of the application of the DB.

The sample analysis and the in-depth analysis of case 2 provided robust evidence supporting the argument that higher land utilization intensities result in increased SRCC and, consequently, in land value.

The sample analysis found that concerning the 35% restriction on floor area, the projects that remained below the original restriction achieved a SRCC of 59% on average. While those that exceeded it achieved a SRCC of 89%, on average. When analyzed as the restriction in the number of units, the projects that remained below the original restriction achieved a SRCC of 52% on average. While those that exceeded it achieved a SRCC of 80% on average. The flexibility in applying the DB generated by the second Reconstruction Law (2018) was critical to generating more appropriate, quickly marketable, and high-priced products for the current real estate market.

This data aligns with the framework described in section 2.2 Urban Land Rent Theory. Specifically to the facet associated with primary rents, linked to the inherent attributes of a land's location and regulations. It also corresponds to differential rent type 2, related to the degree of land utilization. This data underscores that all else being equal, higher land utilization intensities result in increased land value.

3. Combination with LUC.

The sample analysis and the in-depth analysis of case 3 provided robust evidence that supports the argument that a higher profit use -office and retail space- is associated with increased SRCC and, consequently, land value.

The sample analysis showed that those projects that did not use the LUC option achieved 63%; the two projects that used it, going from residential to mixed, achieved 78%; and those that not only recovered the preexisting but increased the units achieved 90%, respectively.

Despite the initial inconsistency caused by the distortion in the prices defined by Servimet, the sample, and case 3 evidence support that the element of the Urban Land Rent Theory related to differential commerce rents holds.

Utilizing continuously updated highest prices is crucial to maximize the benefits of the financial instrument. Servimet's auction mechanism has the potential to alleviate these disparities and extract optimal value from the mechanism. Nonetheless, a more comprehensive analysis is necessary.

Therefore, given the results analyzed in this research, the financing of the reconstruction of the condominium house affected by the September 19, 2017, earthquake in Mexico City through DB&LUC is a program with variable positive results, between 32% and 133% of the recovery costs, depending on specific conditions.

This research, together with others referred to in the literature review, represents the first steps in collecting and analyzing evidence on this case, which is still under development. Further, it gives rise to an extensive field of research on LVC for post-disaster recovery. When the reconstruction of the 137 projects is completed, it will be necessary to carry out an exhaustive, comprehensive financial evaluation. Complementarily, it is necessary to understand and analyze the mechanisms: a. technical, b. legal and institutional, c. governance and social participation, which have accompanied this exercise.

The results of all these lines of research will be vital to transcend from a recovery mechanism to a prevention mechanism. A prevention mechanism that allows the framework -institutional, financial, legal, and social- to be ready to act in the event of the next earthquake while preventing severe losses. Ideally, allowing the retrofit, in advance and under controlled conditions, of buildings with characteristics similar to those damaged in 2017. Preventing the fatalities, the high costs of emergency care, and the innumerable extreme conditions that 2017 were out of control.

The climate crisis is present and palpable in the day-to-day of our lives. This research seeks to contribute to the line of research on financing for adaptation to the climate crisis with an innovative financing alternative for the potential coming disasters -displacement and urban financing due to drought, flooding, and other associated conditions-.

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Appendix 1

1. Pre-existing and additional units' size

Project location						Pre-existing / Recovery units		Additional units	
Num	Code	Street	Number	Neighborhood	Municipality	Range	Average size (m2)	Range	Average size (m2)
1	BJ_AZO_0609	Azores	609	Portales Norte	Benito Juárez	M	90	M	90
2	BJ_ESC_0010	Escocia	10	Del Valle Centro	Benito Juárez	L	160	M	106
3	BJ_PSA_0612	Patricio Sanz	612	Del Valle Norte	Benito Juárez	L	170	L	123
4	CO_CAF_1710	Cafetales	1710	Hacienda de Coyoacán	Coyoacán	M	100	S	87
5	CO_MIR_1868	Canal de Miramontes	1868	Campestre Churubusco	Coyoacán	S	85	S	69
6	CO_MIR_3004	Canal de Miramontes	3004	Los Girasoles	Coyoacán	S	75	M	100
7	CO_PAC_0223	Pacífico	223	de los Reyes	Coyoacán	M	94	M	91
8	CO_PAC_0455	Pacífico	455	La Candelaria	Coyoacán	M	110	M	94
9	CU_CHA_0444	Chapultepec	444	Roma Norte	Cuauhtémoc	M	104	S	82
10	CU_COA_0010	Coahuila	10	Roma Norte	Cuauhtémoc	M	93	M	96
11	CU_OZU_0020	Ozuluama	10	Hipodromo	Cuauhtémoc	L	150	L	131
12	GM_COQ_0911	Coquimbo	911	Lindavista	Gustavo A. Madero	L	202	M	110
13	IZ_GAL_0027	Paseo de las Galias	27	Lomas Estrella	Iztapalapa	S	75	S	70
14	IZ_GAL_0031	Paseo de las Galias	31	Lomas Estrella 2da. Sección	Iztapalapa	S	75	S	71
15	IZ_GAL_0047	Paseo de las Galias	47	Lomas Estrella 2da. Sección	Iztapalapa	S	75	S	72
16	MH_PRO_0004	Prosperidad	4	Escandón II Sección	Miguel Hidalgo	L	120	S	87
17	TL_HAE_0005	Hacienda de la Escalera	5	Prados Coapa 2a Sección	Tlalpan	L	117	M	105
18	TL_HAE_0011	Hacienda de la Escalera	11	Prados Coapa 2a Sección	Tlalpan	L	117	M	104

Source: Author

2. Original, recovery and additional floor area, units and land use.

Project location				Pre-existing / Recovery			Available DB		Additional units (real)			Difference available DB&LUC vs real				
Num	Code	Street	Number	Area	Apts.	Retail / office space	Area	Apts.	Area	Apts.	Retail / office space	Area (m2)	% Area over original	Apts.	% Apts. over original	LUC
1	BJ_AZO_0609	Azores	609	3,408	32	0	1,193	11	1,103	11	2	90	32%	0	34%	LUC +2
2	BJ_ESC_0010	Escocia	10	1,277	7	0	447	2	530	5	0	-82	41%	-3	71%	NO LUC
3	BJ_PSA_0612	Patricio Sanz	612	2,295	11	1	803	4	893	6	3	-90	39%	-2	55%	Recovery +2
4	CO_CAF_1710	Cafetales	1710	1,065	8	0	373	3	175	2	0	198	16%	1	25%	NO LUC
5	CO_MIR_1868	Canal de Miramontes	1868	914	9	0	320	3	140	2	0	179	15%	1	22%	NO LUC
6	CO_MIR_3004	Canal de Miramontes	3004	1,849	24	0	647	8	1,601	16	0	-954	87%	-8	67%	NO LUC
7	CO_PAC_0223	Pacífico	223	4,461	40	0	1,561	14	1,417	13	1	144	32%	1	33%	LUC +1
8	CO_PAC_0455	Pacífico	455	3,170	26	0	1,110	9	1,447	15	0	-338	46%	-6	58%	NO LUC
9	CU_CHA_0444	Chapultepec	444	2,125	21	0	744	7	250	3	0	494	12%	4	14%	NO LUC
10	CU_COA_0010	Coahuila	10	685	4	0	240	1	191	2	0	48	28%	-1	50%	NO LUC
11	CU_OZU_0020	Ozuluama	20	1,800	10	0	630	4	561	4	0	69	31%	0	40%	NO LUC
12	GM_COQ_0911	Coquimbo	911	2,829	13	1	990	5	1,326	10	4	-336	47%	-5	77%	Recovery +3
13	IZ_GAL_0027	Paseo de las Galias	27	1,680	16	0	588	6	558	8	0	30	33%	-2	50%	NO LUC
14	IZ_GAL_0031	Paseo de las Galias	31	1,399	16	0	490	6	426	6	0	64	30%	0	38%	NO LUC
15	IZ_GAL_0047	Paseo de las Galias	47	1,637	16	0	573	6	429	6	0	144	26%	0	38%	NO LUC
16	MH_PRO_0004	Prosperidad	4	3,810	20	1	1,334	7	2,191	7	4	-857	57%	0	35%	Recovery +3
17	TL_HAE_0005	Hacienda de la Escalera	5	1,683	10	2	589	4	769	7	1	-180	46%	-3	70%	Recovery +1
18	TL_HAE_0011	Hacienda de la Escalera	11	1,688	10	2	591	4	760	7	1	-169	45%	-3	70%	Recovery +1

Source: Author

3. **Project financial balance, recovery cost, additional cost, total cost, revenue and SRCC for Servimet and market prices**

Project						Project financial balance							
							Servimet			Market			
Num	Code	Street	Number	Municipality	Regional subsample	Costs (MXN)	Income (MXN)	Balance (MXN)	%	Income (MXN)	Balance (MXN)	%	PP Differenc
1	BJ_AZO_0609	Azores	609	Benito Juárez	1. Central	71,182,764	57,619,631	-13,563,133	**81%**	59,434,809	-11,747,955	**83%**	3%
2	BJ_ESC_0010	Escocia	10	Benito Juárez	1. Central	28,965,123	26,350,106	-2,615,017	**91%**	32,788,935	3,823,812	**113%**	22%
3	BJ_PSA_0612	Patricio Sanz	612	Benito Juárez	1. Central	50,252,147	46,672,898	-3,579,249	**93%**	56,595,135	6,342,987	**113%**	20%
4	CO_CAF_1710	Cafetales	1710	Coyoacán	2. Intermediate	18,265,569	6,120,685	-12,144,884	**34%**	7,324,194	-10,941,375	**40%**	7%
5	CO_MIR_1868	Canal de Miramontes	1868	Coyoacán	2. Intermediate	15,449,314	5,006,640	-10,442,674	**32%**	7,635,651	-7,813,663	**49%**	17%
6	CO_MIR_3004	Canal de Miramontes	3004	Coyoacán	2. Intermediate	60,341,494	57,894,128	-2,447,366	**96%**	76,228,642	15,887,148	**126%**	30%
7	CO_PAC_0223	Pacífico	223	Coyoacán	2. Intermediate	88,892,154	65,945,750	-22,946,404	**74%**	71,074,945	-17,817,209	**80%**	6%
8	CO_PAC_0455	Pacífico	455	Coyoacán	2. Intermediate	74,034,715	57,117,289	-16,917,426	**77%**	67,557,260	-6,477,455	**91%**	14%
9	CU_CHA_0444	Chapultepec	444	Cuauhtémoc	1. Central	34,235,753	13,289,610	-20,946,143	**39%**	17,966,701	-16,269,052	**52%**	14%
10	CU_COA_0010	Coahuila	10	Cuauhtémoc	1. Central	14,419,254	13,013,179	-1,406,075	**90%**	13,596,079	-823,175	**94%**	4%
11	CU_OZU_0020	Ozuluama	20	Cuauhtémoc	1. Central	35,938,776	32,238,153	-3,700,623	**90%**	47,670,302	11,731,526	**133%**	43%
12	GM_COQ_0911	Coquimbo	911	Gustavo A. Maderc	3. External	65,217,470	46,427,500	-18,789,970	**71%**	54,702,525	-10,514,946	**84%**	13%
13	IZ_GAL_0027	Paseo de las Galias	27	Iztapalapa	3. External	35,053,300	18,455,173	-16,598,127	**53%**	25,241,403	-9,811,897	**72%**	19%
14	IZ_GAL_0031	Paseo de las Galias	31	Iztapalapa	3. External	28,334,729	13,959,662	-14,375,067	**49%**	19,262,200	-9,072,529	**68%**	19%
15	IZ_GAL_0047	Paseo de las Galias	47	Iztapalapa	3. External	31,620,468	14,535,614	-17,084,854	**46%**	19,394,208	-12,226,260	**61%**	15%
16	MH_PRO_0004	Prosperidad	4	Miguel Hidalgo	1. Central	68,998,698	91,760,033	22,761,335	**133%**	188,290,070	119,291,372	**273%**	140%
17	TL_HAE_0005	Hacienda de la Escalera	5	Tlalpan	2. Intermediate	41,314,837	28,954,971	-12,359,866	**70%**	41,785,192	470,355	**101%**	31%
18	TL_HAE_0011	Hacienda de la Escalera	11	Tlalpan	2. Intermediate	41,504,540	34,274,975	-7,229,565	**83%**	42,120,340	615,800	**101%**	19%

Source: Author

4. Residual land value per project and residual land value increment considering the application of DB&LUC

Project						Residual land value (Only Servimet)										
						Potenttial income additional units		Costs			LRV			LRVI		
Num	Code	Street	Number	Municipality	Regional subsample	Subtotal Income	Total income	Sutotal recovery	Subottal additional	Total costs	Only recovery	With additional	Residual land value	RLVI %	RLVI / m2
1	BJ_AZO_0609	Azores	609	Benito Juárez	1. Central	57,619,631	198,642,167	46,129,395	25,053,369	71,182,764	94,893,141	127,459,403	32,566,262	34%	34,344
2	BJ_ESC_0010	Escocia	10	Benito Juárez	1. Central	26,350,106	75,142,763	17,287,695	11,677,429	28,965,123	31,504,963	46,177,640	14,672,677	47%	46,848
3	BJ_PSA_0612	Patricio Sanz	612	Benito Juárez	1. Central	46,672,898	129,698,496	31,074,340	19,177,808	50,252,147	51,951,259	79,446,349	27,495,090	53%	74,863
4	CO_CAF_1710	Cafetales	1710	Coyoacán	2. Intermediate	6,120,685	34,168,273	14,415,436	3,850,133	18,265,569	13,632,152	15,902,704	2,270,552	17%	11,353
5	CO_MIR_1868	Canal de Miramontes	1868	Coyoacán	2. Intermediate	5,006,640	32,619,824	12,371,557	3,077,757	15,449,314	15,241,627	17,170,510	1,928,883	13%	11,888
6	CO_MIR_3004	Canal de Miramontes	3004	Coyoacán	2. Intermediate	57,894,128	113,766,970	25,027,363	35,314,132	60,341,494	30,845,479	53,425,475	22,579,996	73%	23,919
7	CO_PAC_0223	Pacífico	223	Coyoacán	2. Intermediate	65,945,750	245,772,412	60,382,404	28,509,750	88,892,154	119,444,259	156,880,258	37,436,000	31%	27,293
8	CO_PAC_0455	Pacífico	455	Coyoacán	2. Intermediate	57,117,289	153,224,762	42,907,917	31,126,798	74,034,715	53,199,555	79,190,047	25,990,491	49%	26,905
9	CU_CHA_0444	Chapultepec	444	Cuauhtémoc	1. Central	13,289,610	54,715,289	28,763,194	5,472,559	34,235,753	12,662,486	20,479,536	7,817,051	62%	23,350
10	CU_COA_0010	Coahuila	10	Cuauhtémoc	1. Central	13,013,179	38,654,921	9,271,900	5,147,354	14,419,254	16,369,842	24,235,667	7,865,825	48%	55,746
11	CU_OZU_0020	Ozuluama	20	Cuauhtémoc	1. Central	32,238,153	121,490,268	24,364,117	11,574,658	35,938,776	64,887,998	85,551,492	20,663,495	32%	54,665
12	GM_COQ_0911	Coquimbo	911	Gustavo A. Maderc	3. External	46,427,500	141,982,847	38,296,135	26,921,336	65,217,470	57,259,212	76,765,376	19,506,164	34%	27,310
13	IZ_GAL_0027	Paseo de las Galias	27	Iztapalapa	3. External	18,455,173	58,675,282	22,739,843	12,313,457	35,053,300	17,480,266	23,621,982	6,141,716	35%	14,592
14	IZ_GAL_0031	Paseo de las Galias	31	Iztapalapa	3. External	13,959,662	53,534,438	18,938,093	9,396,636	28,334,729	20,636,683	25,199,709	4,563,026	22%	10,389
15	IZ_GAL_0047	Paseo de las Galias	47	Iztapalapa	3. External	14,535,614	55,196,398	22,159,435	9,461,033	31,620,468	18,501,349	23,575,930	5,074,581	27%	9,901
16	MH_PRO_0004	Prosperidad	4	Miguel Hidalgo	1. Central	91,760,033	213,738,240	51,580,805	17,417,893	68,998,698	70,397,402	144,739,542	74,342,140	106%	108,337
17	TL_HAE_0005	Hacienda de la Escalera	5	Tlalpan	2. Intermediate	28,954,971	79,787,358	22,800,630	18,514,207	41,314,837	28,031,758	38,472,521	10,440,764	37%	27,332
18	TL_HAE_0011	Hacienda de la Escalera	11	Tlalpan	2. Intermediate	34,274,975	88,232,577	22,868,308	18,636,232	41,504,540	31,089,294	46,728,037	15,638,743	50%	40,939

Source: Author

5. Case 1. Financial model for sample units. Ozuluama 20 and Paseo de las Galias 31.

RESIDUAL LAND VALUE SIMULATOR FOR BUILDINGS UNDER RECONSTRUCTION

CU OZU 0020 — **BALANCE** -$3,700,623

% of cost cover by income **90%**

PLOT DATA

Street	Ozuluama
Number	20
Neighborhood	Hipodromo
Municipality	Cuauhtémoc
Plot size	378

ORIGINAL CHARACTERISTICS, POTENTIAL (LdR 2017) & BUILT (2023)

	Original	+35%	Potential	Built	Difference
Area	1800	630	2430	560.84	69.16
Levels	6	2	8	NA	NA
Apartments	10	4	14	4	0
Retail space	0			0	0
Office space	0			0	0

CONSTRUCTION COSTS

Construction costs

Recovery units

	Type	Parametric cost	Area	Cost
Housing	Middle income	$ 13,536	1800	$ 24,364,117
Retail	Social interest	$ 10,090	0	$ -
			Subtotal construction costs	$ 24,364,117

Additional units

	Type	Parametric cost	Area	Cost
Housing	Semi luxury	$ 22,054	525	$ 11,574,658
Others	Social interest	$ 10,090	0	$ -
Retail	Social interest	$ 10,090	0	$ -
Office	Middle income	$ 13,536	0	$ -
			Subtotal construction costs	$ 11,574,658

Total construction cost (Recovery + addtional) $ 35,938,776

Additional costs

Financial costs	0%	$ -	
Preliminary studies	0%	$ -	
Project cost	0%	$ -	
Management cost	0%	$ -	
Comercialization cost	0%	$ -	
		Total additional costs	**$ -**

Total costs $35,938,776

INCOME FROM ADDITIONAL UNITS

	Offer Amount	Offer Area	Total Servimet prices	Total Market prices	
Apartment	4	524.84			
Terrace	0	0			
Balcony	0	0			
Roof Garden	0	0			
Parking	0	0			
Storage	0	0			
Retail space	3	36			
Office space	0	0			
Total income			$ 32,238,153	$ 47,670,302	
Difference					$ 15,432,149
%					*48%*

PROJECT BALANCE

	Servimet	Market
Costs	$ 35,938,776	$ 35,938,776
Income	$ 32,238,153	$ 47,670,302
Balance	**-$3,700,623**	**$11,731,526**
	90%	*133%*

RESIDUAL LAND VALUE

	Recovery	Additional	
Potential income			
Apartments	10	4	
Other			
Retail			
Office			
Average area per apartment	150		
Price per m2	$ 59,501		
Subtotal	$ 89,252,115	$ 32,238,153	
Total potential income		##########	
Costs			
Subtotal	$ 24,364,117	$ 11,574,658	
Total costs		$ 35,938,776	
RLV	$ 64,887,998	$ 85,551,492	
Residual land value increment (RLVI)	**Total**	**$ 20,663,495**	*32%*
	Per square meter	**$ 54,665.33**	

Source: Author

RESIDUAL LAND VALUE SIMULATOR FOR BUILDINGS UNDER RECONSTRUCTION

IZ GAL 0031

BALANCE -$14,375,067

% of cost cover by income **49%**

PLOT DATA

Street	**Paseo de las Galias**
Number	**31**
Neighborhood	**Lomas Estrella 2da. Sección**
Municipality	**Iztapalapa**
Plot size	**439.22**

ORIGINAL CHARACTERISTICS, POTENTIAL (LdR 2017) & BUILT (2023)

	Original	+35%	Potential	Built	Difference
Area	1399.13	489.6955	1888.83	426.08	63.6155
Levels	5	1.75	6.75	NA	NA
Apartments	16	6	21.6	6	0
Retail space	0			0	0
Office space	0			0	0

CONSTRUCTION COSTS

Construction costs

Recovery units

	Type	Parametric cost	Area	Cost
Housing	Middle income	$ 13,536	1399.13	$ 18,938,093
Retail	Social interest	$ 10,090	0	$ -
			Subtotal construction costs	$ 18,938,093

Additional units

	Type	Parametric cost	Area	Cost
Housing	Semi luxury	$ 22,054	426	$ 9,396,636
Others	Social interest	$ 10,090	0	$ -
Retail	Social interest	$ 10,090	0	$ -
Office	Middle income	$ 13,536	0	$ -
			Subtotal construction costs	$ 9,396,636

Total construction cost (Recovery + addtional) $ 28,334,729

Additional costs

Financial costs	0%	$ -	
Preliminary studies	0%	$ -	
Project cost	0%	$ -	
Management cost	0%	$ -	
Comercialization cost	0%	$ -	
		Total additional costs	**$ -**

Total costs $28,334,729

INCOME FROM ADDITIONAL UNITS

	Offer Amount	Offer Area	Total Servimet prices	Total Market prices	
Apartment	6	426.08			
Terrace	0	0			
Balcony	0	0			
Roof Garden	0	0			
Parking	0	0			
Storage	0	0			
Retail space	0	0			
Office space	0	0			
Total income			$ 13,959,662	$ 19,262,200	
Difference					$ 5,302,538
%					*38%*

PROJECT BALANCE

	Servimet	Market
Costs	$ 28,334,729	$ 28,334,729
Income	$ 13,959,662	$ 19,262,200
Balance	**-$14,375,067**	**-$9,072,529**
	49%	*68%*

RESIDUAL LAND VALUE

	Recovery	Additional	
Potential income			
Apartments	16	6	
Other			
Retail			
Office			
Average area per apartment	75		
Price per m2	$ 32,979		
Subtotal	$ 39,574,776	$ 13,959,662	
Total potential income		**$ 53,534,438**	
Costs			
Subtotal	$ 18,938,093	$ 9,396,636	
Total costs		$ 28,334,729	
RLV	$ 20,636,683	$ 25,199,709	
Residual land value increment (RLVI)	**Total**	**$ 4,563,026**	*22%*
	Per square meter	**$ 10,388.93**	

Source: Author

6. Case 2. Financial model for sample units. Chapultepec 44 and Coahuila 10.

RESIDUAL LAND VALUE SIMULATOR FOR BUILDINGS UNDER RECONSTRUCTION

CU CHA 0444

BALANCE	-$20,946,143
% of cost cover by income	**39%**

PLOT DATA

Street	**Chapultepec**
Number	**444**
Neighborhood	**Roma Norte**
Municipality	**Cuauhtémoc**
Plot size	**334.78**

ORIGINAL CHARACTERISTICS, POTENTIAL (LdR 2017) & BUILT (2023)

	Original	+35%	Potential	Built	Difference
Area	2125	743.75	2868.75	250.1	493.65
Levels	10	3.5	13.5	NA	NA
Apartments	21	7	28.35	3	4
Retail space	0			0	0
Office space	0			0	0

CONSTRUCTION COSTS

Construction costs

Recovery units

	Type	Parametric cost	Area	Cost
Housing	Middle income	$ 13,536	2125	$ 28,763,194
Retail	Social interest	$ 10,090	0	$ -
			Subtotal construction costs	$ 28,763,194

Additional units

	Type	Parametric cost	Area	Cost
Housing	Semi luxury	$ 22,054	247	$ 5,436,234
Others	Social interest	$ 10,090	4	$ 36,325
Retail	Social interest	$ 10,090	0	$ -
Office	Middle income	$ 13,536	0	$ -
			Subtotal construction costs	$ 5,472,559

Total construction cost (Recovery + addtional) $ 34,235,753

Additional costs

Financial costs	0%	$	-
Preliminary studies	0%	$	-
Project cost	0%	$	-
Management cost	0%	$	-
Comercialization cost	0%	$	-
		Total additional costs	**$** -

Total costs $34,235,753

INCOME FROM ADDITIONAL UNITS

	Offer Amount	Offer Area	Total Servimet prices	Total Market prices	
Apartment	3	246.5			
Terrace	0	0			
Balcony	2	3.6			
Roof Garden	0	0			
Parking	0	0			
Storage	0	0			
Retail space	0	0			
Office space	0	0			
Total income			$ 13,289,610	$ 17,966,701	
Difference					$ 4,677,091
%					*35%*

PROJECT BALANCE

	Servimet	Market
Costs	$ 34,235,753	$ 34,235,753
Income	$ 13,289,610	$ 17,966,701
Balance	**-$20,946,143**	**-$16,269,052**
	39%	*52%*

RESIDUAL LAND VALUE

	Recovery	Additional
Potential income		
Apartments	21	3
Other		
Retail		
Office		
Average area per apartment	104	
Price per m2	$ 18,968	
Subtotal	$ 41,425,679	$ 13,289,610
Total potential income		**$ 54,715,289**
Costs		
Subtotal	$ 28,763,194	$ 5,472,559
Total costs		$ 34,235,753
RLV	$ 12,662,486	$ 20,479,536

Residual land value increment (RLVI)	**Total**	**$ 7,817,051**	*62%*
	Per square meter	**$ 23,349.81**	

Source: Author

RESIDUAL LAND VALUE SIMULATOR FOR BUILDINGS UNDER RECONSTRUCTION

CU COA 0010

BALANCE	-$1,406,075
% of cost cover by income	**90%**

PLOT DATA

Street	**Coahuila**
Number	**10**
Neighborhood	**Roma Norte**
Municipality	**Cuauhtémoc**
Plot size	**141.1**

ORIGINAL CHARACTERISTICS, POTENTIAL (LdR 2017) & BUILT (2023)

	Original	+35%	Potential	Built	Difference
Area	685	239.75	924.75	191.4	48.35
Levels	6	2.1	8.1	NA	NA
Apartments	4	1	5.4	2	-1
Retail space	0			0	0
Office space	0			0	0

CONSTRUCTION COSTS

Construction costs

Recovery units

	Type	Parametric cost	Area	Cost
Housing	Middle income	$ 13,536	685	$ 9,271,900
Retail	Social interest	$ 10,090	0	$ -
			Subtotal construction costs	$ 9,271,900

Additional units

	Type	Parametric cost	Area	Cost
Housing	Semi luxury	$ 22,054	191	$ 4,221,076
Others	Social interest	$ 10,090	92	$ 926,278
Retail	Social interest	$ 10,090	0	$ -
Office	Middle income	$ 13,536	0	$ -
			Subtotal construction costs	$ 5,147,354

Total construction cost (Recovery + addtional) $ 14,419,254

Additional costs

Financial costs	0%	$ -	
Preliminary studies	0%	$ -	
Project cost	0%	$ -	
Management cost	0%	$ -	
Comercialization cost	0%	$ -	
		Total additional costs	**$ -**

Total costs $14,419,254

INCOME FROM ADDITIONAL UNITS

	Offer Amount	Offer Area	Total Servimet prices	Total Market prices	
Apartment	2	191.4			
Terrace	0	0			
Balcony	0	0			
Roof Garden	2	91.8			
Parking	0	0			
Storage	0	0			
Retail space	0	0			
Office space	0	0			
Total income			$ 13,013,179	$ 13,596,079	
Difference					$ 582,900
%					*4%*

PROJECT BALANCE

	Servimet	Market
Costs	$ 14,419,254	$ 14,419,254
Income	$ 13,013,179	$ 13,596,079
Balance	**-$1,406,075**	**-$823,175**
	90%	*94%*

RESIDUAL LAND VALUE

	Recovery	Additional
Potential income		
Apartments	4	2
Other		
Retail		
Office		
Average area per apartment	93	
Price per m2	$ 68,929	
Subtotal	$ 25,641,742	$ 13,013,179
Total potential income		**$ 38,654,921**
Costs		
Subtotal	$ 9,271,900	$ 5,147,354
Total costs		$ 14,419,254
RLV	$ 16,369,842	$ 24,235,667

Residual land value increment (RLVI)	**Total**	**$ 7,865,825**	*48%*
	Per square meter	**$ 55,746.46**	

Source: Author

7. Case 3. Financial model for sample units. Escocia 10 and Patricio Sanz 612.

RESIDUAL LAND VALUE SIMULATOR FOR BUILDINGS UNDER RECONSTRUCTION

BJ ESC 0010 — **BALANCE** -$2,615,017

% of cost cover by income **91%**

PLOT DATA

Street	Escocia
Number	10
Neighborhood	Del Valle Centro
Municipality	Benito Juárez
Plot size	313.2

ORIGINAL CHARACTERISTICS, POTENTIAL (LdR 2017) & BUILT (2023)

	Original	+35%	Potential	Built	Difference
Area	1277.2	447.02	1724.22	529.5	-82.48
Levels	5	1.75	6.75	NA	NA
Apartments	7	2	9.45	5	-3
Retail space	0			0	0
Office space	0			0	0

CONSTRUCTION COSTS

Construction costs

Recovery units

	Type	Parametric cost	Area	Cost
Housing	Middle income	$ 13,536	1277.2	$ 17,287,695
Retail	Social interest	$ 10,090	0	$ -
			Subtotal construction costs	$ 17,287,695

Additional units

	Type	Parametric cost	Area	Cost
Housing	Semi luxury	$ 22,054	530	$ 11,677,429
Others	Social interest	$ 10,090	0	$ -
Retail	Social interest	$ 10,090	0	$ -
Office	Middle income	$ 13,536	0	$ -
			Subtotal construction costs	$ 11,677,429

Total construction cost (Recovery + addtional) $ 28,965,123

Additional costs

Financial costs	0%	$	-
Preliminary studies	0%	$	-
Project cost	0%	$	-
Management cost	0%	$	-
Comercialization cost	0%	$	-
		Total additional costs	$ -

Total costs $28,965,123

INCOME FROM ADDITIONAL UNITS

	Offer Amount	Offer Area	Total Servimet prices	Total Market prices	
Apartment	5	529.5			
Terrace	0	0			
Balcony	0	0			
Roof Garden	0	0			
Parking	0	0			
Storage	0	0			
Retail space	0	0			
Office space	0	0			
Total income			$ 26,350,106	$ 32,788,935	
Difference					$ 6,438,829
%					*24%*

PROJECT BALANCE

	Servimet	Market
Costs	$ 28,965,123	$ 28,965,123
Income	$ 26,350,106	$ 32,788,935
Balance	-$2,615,017	$3,823,812
	91%	*113%*

RESIDUAL LAND VALUE

	Recovery	Additional	
Potential income			
Apartments	7	5	
Other			
Retail			
Office			
Average area per apartment	160		
Price per m2	$ 43,565		
Subtotal	$ 48,792,657	$ 26,350,106	
Total potential income		**$ 75,142,763**	
Costs			
Subtotal	$ 17,287,695	$ 11,677,429	
Total costs		$ 28,965,123	
RLV	$ 31,504,963	$ 46,177,640	
Residual land value increment (RLVI)	**Total**	**$ 14,672,677**	*47%*
	Per square meter	**$ 46,847.63**	

Source: Author

RESIDUAL LAND VALUE SIMULATOR FOR BUILDINGS UNDER RECONSTRUCTION

BJ PSA 0612

BALANCE	-$3,579,249
% of cost cover by income	**93%**

PLOT DATA

Street	**Patricio Sanz**
Number	**612**
Neighborhood	**Del Valle Norte**
Municipality	**Benito Juárez**
Plot size	**367.27**

ORIGINAL CHARACTERISTICS, POTENTIAL (LdR 2017) & BUILT (2023)

	Original	+35%	Potential	Built	Difference
Area	2295	803.25	3098.25	893.35	-90.1
Levels	9	3.15	12.15	NA	NA
Apartments	11	4	14.85	6	-2
Retail space	1			3	2
Office space	0			0	0

CONSTRUCTION COSTS

Construction costs

Recovery units

	Type	Parametric cost	Area	Cost
Housing	Middle income	$ 13,536	2295	$ 31,064,249
Retail	Social interest	$ 10,090	1	$ 10,090
		Subtotal construction costs		$ 31,074,340

Additional units

	Type	Parametric cost	Area	Cost
Housing	Semi luxury	$ 22,054	739	$ 16,298,779
Others	Social interest	$ 10,090	155	$ 1,564,279
Retail	Social interest	$ 10,090	130	$ 1,314,749
Office	Middle income	$ 13,536	0	$ -
		Subtotal construction costs		$ 19,177,808

Total construction cost (Recovery + addtional) $ 50,252,147

Additional costs

Financial costs	0%	$	-
Preliminary studies	0%	$	-
Project cost	0%	$	-
Management cost	0%	$	-
Comercialization cost	0%	$	-
		Total additional costs	**$ -**

Total costs $50,252,147

INCOME FROM ADDITIONAL UNITS

	Offer Amount	Offer Area	Total Servimet prices	Total Market prices	
Apartment	6	739.05			
Terrace	2	77.03			
Balcony	6	78			
Roof Garden	0	0			
Parking	3	130.3			
Storage	0	0			
Retail space	2	24			
Office space	0	0			
Total income			$ 46,672,898	$ 56,595,135	
Difference					$ 9,922,237
%					*21%*

PROJECT BALANCE

	Servimet	Market
Costs	$ 50,252,147	$ 50,252,147
Income	$ 46,672,898	$ 56,595,135
Balance	**-$3,579,249**	**$6,342,987**
	93%	*113%*

RESIDUAL LAND VALUE

	Recovery	Additional	
Potential income			
Apartments	11	6	
Other			
Retail			
Office			
Average area per apartment	170		
Price per m2	$ 44,399		
Subtotal	$ 83,025,598	$ 46,672,898	
Total potential income		##########	
Costs			
Subtotal	$ 31,074,340	$ 19,177,808	
Total costs		$ 50,252,147	
RLV	$ 51,951,259	$ 79,446,349	
Residual land value increment (RLVI)	**Total**	**$ 27,495,090**	*53%*
	Per square meter	**$ 74,863.43**	

Source: Author

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