

## ORIGINAL RESEARCH ARTICLE

# Resilience, architecture, and urbanization in sustainable urban development in Latin America: Lacan Cordia

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### ABSTRACT

Natural and man-made disasters, including terrorism, pose very complex challenges to urban management decision makers at the international level, who must respond correctly without adequate economic and technological resources. Therefore, it is important to consider urban resilience actions as a cohesive factor conducive to appropriate land planning. Starting with the multidisciplinary research of the Autumnal Equinox Technical University and based on the sustainable and emergency urban approach initiative proposed by the Inter-American Development Bank, as a public tool for the urban development of the county, the urban resilience improvement plan of La Concordia County, Ecuador, was formulated. As the main conclusion, this study reveals the importance of urban elasticity in urban development planning and proves the effectiveness of multidisciplinary research in urban development planning and construction.

**Keywords:** environmental risk; urban management; development planning; harmony; spatial order; urban elasticity

## 1. Introduction

In general, 80% of large cities are vulnerable to earthquakes, and 60% are at risk of rainstorms and tsunamis. All these cities are facing the impact of climate change. The goal of any sustainable development agenda must be to ensure that even the smallest development benefits are protected from losses caused by natural or man-made disasters and crises<sup>[1,2]</sup>.

One of the most relevant challenges in the current urban landscape is to determine how to develop more resilient cities in a very complex global environment in which different concepts, such as

sustainable urban design and resilient buildings, will appear in a variety of phenomena. From natural disasters caused by climate change to cyclone Harvey in Texas (United States) or Nevada in Papal Kata, Ecuador, or from a geodynamic point of view, the 2016 earthquake in Ecuador—other human activities, such as terrorist attacks in Barcelona, Brussels, Berlin, and London.

Natural and man-made phenomena have led to changes in urban public space. Strong urban furniture (large diameter bolts, large flowerpots, and other solutions) is now used to prevent vehicles from entering specific areas. Police, civil and military intelligence, and information services are also di-

### ARTICLE INFO

Received: September 23, 2022 | Accepted: November 9, 2022 | Available online: November 19, 2022

### CITATION

Leyva Ricardo SE, Pancorbo Sandoval JA, Encarnación Fernández BJ, et al. Resilience, architecture and urbanization in sustainable urban development in Latin America: Lacan Cordia. *Eco Cities* 2022; 3(2): 10 pages.

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rectly involved in urban planning and electronically control the population through security cameras (for example, in the UK, it is estimated that there is one surveillance camera for every 60 people). The phenomenon of terrorism has led to an architectural trend known as “architecture of fear”, which is characterized by protective design and outlined in the abbreviation CPTED (Crime Prevention Through Environmental Design). Therefore, this trend shows that cities are beginning to formulate urban development plans more comprehensively with a clear emphasis on resilience.

Based on the current state of international urban environmental management, the resilient city profile programmed in UN Habitat puts forward the definition of resilience, that is, the ability to absorb changes or shocks without losing urban function, minimize their impact, and restore normalcy in the shortest possible time. This means that cities must be able to reduce their vulnerability. Therefore, the main course of action is to adapt to cities and towns so that natural phenomena cause as little harm as possible<sup>[3]</sup>.

Those who are resilient, safe, and resilient to the impact of disasters<sup>[4]</sup>.

From 2010 to the present, consultations with international experts have made it possible to observe the evolution of the concept of urban resilience. Therefore, the author of this study believes that ur-

ban resilience is an interdisciplinary process. It is not only an environmental intervention technology from the perspective of risk, but also an important variable in the structure of an intelligent city, considering the various risks faced by the city in modernity. In the case of Ecuador, there is an urgent need to work in a multidisciplinary team in order to be able to respond to the high vulnerability of habitats in many cases without the need for any technical standards to ensure their seismic capacity.

These results have led to thinking about urban resilience, which authors such as Ortiz Torres<sup>[5]</sup> call multidisciplinary. The introduction of disciplines such as urban marketing, architecture, civil engineering, or informatics does not change the discipline fields and research objects related to the traditionally known environmental risks, but different disciplines put forward specific views on urban design and take urban design as a unity of multidisciplinary research. Each discipline has its own specific assessment, and all disciplines can focus on predicting habitat construction and using more inclusive models.

At present, Latin American cities are adapting to change and learning from natural and man-made disasters in order to improve their safety and prevent future events that may affect the continuity of territorial development and the sustainability of urban systems<sup>[6]</sup>.



Figure 1. Location map of La Concordia.

Source: decentralized autonomous municipal government of La Concordia/Gobernacion DE santo Domingo de los Tsachila

According to this definition, the technical proposal will focus on the state of La Concordia in the La Achiras province of Santo Domingo. La Concordia is in the northwest of the country. Because it is a relatively young city and is still developing, it has serious environmental and social problems (**Figure 1**).

The decentralized autonomous government (DAG) and the student-scientist group Emad of

Santo Domingo considered carrying out several studies in La Concordia, taking it as a laboratory that makes it possible to evaluate the behavior of Ecuadorian cities at scale. To this end, the project to reform Simon Plata Torres Avenue, where a boulevard is planned, was selected as the object of study (**Figure 2**). The general objective was to define a plan to improve urban resilience for the La Concordia project, which will contribute to the sustainable development of the region.



**Figure 2.** Map of the boulevard DE la Concordia.

Source: in. Josue e. bolivar. Municipal gad of the concord

Specific objectives include:

- a. Identify the latest progress in measuring urban resilience at the national and international levels.
- b. Collect urban resilience assessment models suitable for research projects.
- c. Development tools/software: Practice of creating and improving urban management interfaces and developing urban resilience profiles.
- d. Formulate the urban resilience improvement plan within the Boulevard project.

Considering the national plan for a better life, the sustainable development goals and the Sendai framework for disaster risk reduction, the study aims to make the project contribute to ensuring that the launch of the Boulevard contributes to the well-being of the entire community of Concorde City.

## 2. Materials and methods

The study was conducted in consultation with international experts from the University of Kilims in Argentina, the University of Leon in Spain, the Kineme Institute of Higher Technology and the University of Sonora in Mexico, as well as officials of the decentralized autonomous government of Lacan Cordia.

It began with an exploratory study that considered 100% of the population in the study area. It also considers the existence of 120 real estate properties between real estate, housing, workshops, and enterprises.

The main tool for this work is the methodology of the sustainable and emerging cities initiative of the Inter-American Development Bank, which consists of four stages or steps (preparation, analysis, and diagnosis). This method is suitable for the research objective.

**Table 1.** Process methodology source: Adapted from the 2014 IDB methodology (emerging and Sustainable Cities Initiative)

Stage	Phase I Get ready	Phase II Diagnostic analysis	Phase III Priority	Phase IV Action plan
Activity	Information gathering Identification of stakeholders Timeline of activities	Overview of Boulevard Physical structure diagnosis of Boulevard buildings Earthquake and flood vulnerability study	Table of the cards Table of surveys Analysis of interviews	Initial study Formulation of the action plan
Deliverables	List of stakeholders Initial overview of strengths and issues	Index set analysis	List of priority actors and sectors	Action plan

As in other parts of Ecuador, the state’s urban practices are characterized by inadequate management of basic services such as waste management, water supply, and sanitation, as well as a lack of territorial development plans with a multidisciplinary perspective. This is at least the conclusion of many land management and urban development experts involved in the latest version of the Habitat III agenda in Quito<sup>[7-9]</sup>.

In terms of threats, one of the biggest threats is surface contamination of parts of the drainage from population centers. In the case of Concordia, 70% of the states lack rainwater and sanitary sewer systems. In addition, a large amount of wastewater is discharged into the feces passing through the city,

and a considerable part of the wastewater is treated in septic tanks, which poses a threat to the filtration pollution of feces<sup>[10]</sup>.

In the first phase, the preparatory phase, on-site surveys will be conducted to obtain the most relevant data and identify relevant actors. In this regard, an inventory of housing, commercial premises, workshops, and enterprises in the future Concordia Avenue area of Simon Plata Torres Avenue was conducted (**Table 2**). In order to determine the type of environmental impact caused by economic and production units in the planning space of the Boulevard, the parameters of Ecuador’s environmental legislation and ministerial agreement No. 061 were considered.

**Table 2.** List of houses, commercial premises, workshops and enterprises in Concordia Avenue area

Number	Category	Activity type	Negative environmental impact
9	Local vacuum	Not applicable	Not applicable
8	Empty batch	Not applicable	Not applicable
14	Canteen	Service	Medium
22	Workshop	Service	High
17	Residence	Not applicable	Not applicable
11	Pesticide store	Commercial	Medium
5	Educational and advisory institutions	Service	Low
3	Financial center	Service	Low
7	Beauty Salon	Service	Low
6	Positional tolerance	Service	Low
7	Hardware store	Commercial	Medium
6	Paint sales	Commercial	Medium
2	Gas station	Service	Medium
3	Pharmacy	Commercial	Low

As part of their research project, they divided their business into business and services. Classification starts with the following parameters: High, if the enterprise does not have a municipal license, it will produce hazardous waste. The production unit has no municipal license and poor waste management. If the company does not produce hazardous waste and complies with Ecuadorian laws, costs should be reduced.

In the second stage: analyze and diagnose the problems and potential of the Avenue Project from the perspective of environmental management. For the analysis and diagnosis phase, consider using two methods and tools from different experts. The first is the guidelines for community resilience assessment developed by the international humanitarian organization (goal)<sup>[11]</sup>, which allow the assessment of the resilience of residents in the area

affected by the Boulevard project (**Table 3**). In conducting this study, key thematic areas were considered: Government; risk assessment; knowledge and education; risk management, and vulnerability reduction; and emergency preparedness and response<sup>[6,12]</sup>.

The second method used is the so-called city-level vulnerability analysis designed by the National Risk Management Secretariat (SNGR) and the United Nations Development Programmed (UNDP)<sup>[13]</sup>, which diagnoses the structural physical vulnerability of the buildings of the Xiehe Avenue Project in earthquakes and floods.

**Table 3.** Thematic areas - components of resilience

No.	Thematic areas	#	Elastic component
1	Government	1	Community leadership
		2	Right awareness and influence
		3	Community inclusion and participation
		4	Threat assessment
2	Risk assessment	5	Awareness raising places and scientific methods
		6	Risk
3	Knowledge and Education	7	Public awareness and knowledge
		8	Knowledge dissemination
		9	Sustainable environmental management
4	Risk and management	10	Access to health services.
	Reduce	11	Access to social infrastructure
	Vulnerability	12	Protection of infrastructure and basic services
		13	Land use and spatial planning
5	Disaster preparedness and response	14	Preparedness and responsiveness
		15	Early warning system
			Emergency plan

The purpose of this procedure is not to accurately assess the vulnerability level of buildings, but to use a rating mechanism to determine an index on a digital scale using existing information to indicate the vulnerability of one building relative to another, so as to give priority to action to improve the urban resilience of Laconcordia Avenue.

The assessment of the structural physical vulnerability of buildings is based on the assessment method of structural characteristics of buildings, especially for natural disasters (earthquakes and floods)<sup>[13]</sup>.

Using the proposed method and the values and weights of rating and weight, according to the understanding of structural behavior, different types of buildings in the study area are successfully described to deal with different potential threats. In this regard, it draws on the documented experience of past disasters and the information in the recent global technical literature<sup>[14–16]</sup>.

The proposed resilience enhancement plan is the result of the analysis and diagnosis of the Boulevard, which shows the situation of the area at

a specific time. The information obtained is fair, objective, and verifiable. It is the working basis for the population living in the affected areas of the Boulevard and the decision-makers to make appropriate decisions according to their ability to improve resilience.

Taking into account the above aspects and the results achieved in the survey to assess the resilience of La Concordia Avenue and the earthquake and flood vulnerability assessment form, it is recommended to develop an easily compressible tool to reduce risks, improve resilience, and take comprehensive and sustainable actions, known as the “La Concordia State Avenue Urban Resilience Enhancement Plan.”

### 3. Result

The present document reflects five programs that contain a number of action strategies, are considered priorities for improving urban resilience, and serve as a reference for similar projects implemented in the city of Laconkodia that have not yet been studied for this purpose (**Table 4**).

These programmers are outlined below:

**Option 1:** Community resilience training workshop.

Action strategy 1. Community training.

Action strategy 2. Organize family contingency planning workshops.

Action strategy 3. Design and launch simulations and exercises.

**Option 2:** Integrate disaster risk reduction and resilience into land planning and management.

Action strategy 1. Strengthen the classification of land use and development in urban areas according to the land development and management plan of La Concordia state.

Action strategy 2. Promote risk management within the public and private sectors in their planning processes to reduce the social and economic impact of natural or man-made threats.

Action strategy 3. Emergency planning workshop. Develop and maintain risk reduction processes through prospective intervention to prevent the occurrence of new risk conditions through preventive measures.

**Table 4.** Lacan Cordia avenue urban resilience improvement plan

#	Plan	Action strategy	Short term	Metaphase	Extended	Responsible
		Community training	X			Government Autonomy Dispersed Municipal
1	Community training workshop	Hold family emergency planning seminar	X			Community committee
		Design and implementation of simulations and drills	X		X	Government Autonomy Decentralized municipal and community committees
2	Integrating RRD and resilience into land planning and management	Strengthen the urban land use type and development of PDyOT. Promote public and private sector risk management in its planning process to reduce impact. Emergency planning workshop.	X	X	X	Government Autonomy Dispersed Municipal Government Autonomy Dispersed
				X		Municipal and community committees Community committee
3	Database design of public information system	Provide municipal public information system for RRD and resilience Draw a multi threat risk map based on the integration of community and institutional/technical knowledge		X		Government Autonomy Dispersed Municipal Government Autonomy Dispersed
				X		Municipal and community committees
4	Strengthening the early warning system	Improve and integrate timely and early monitoring and early warning systems to identify and mitigate threats and vulnerabilities of natural or man-made risks to society and the environment.		X		Government Autonomy Dispersed Municipal

Source: Field work by Eng. Josué Encarnación Bolívar.

**Option 3:** Design a public information system and public database; action strategy 1. Establish a municipal public information system for RRD and resilience.

In order to implement the strategy, the information about the project has been piloted on an open data website, where the degree of interaction between the project and other projects at the

international level will be assessed.

From the open data, users can compare, merge, and track the connections between different data sets, and track data across multiple programs and sectors. This in turn can effectively consolidate and compare data, highlight trends, identify economic and social challenges and inequalities, and take into account the progress of public programs and services.

Action strategy 2. Draw a multi-threat risk map based on the integration of community and institutional/technical knowledge.

**Option 4:** Strengthening the early warning system.

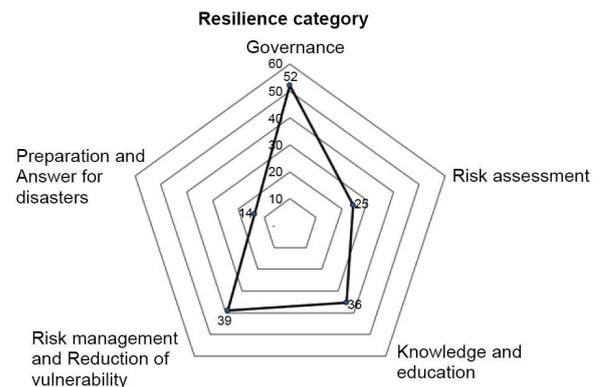
Action strategy 1. Improve and integrate timely and early monitoring and early warning systems to identify and mitigate threats and vulnerabilities of natural or man-made risks to society and the environment.

## 4. Discussion

Under the guidance of the community resilience measurement guide, the population resilience of five thematic areas and each of their 15 resilience components were analyzed and identified. In order to conduct a comprehensive analysis of the five thematic areas-resilience, governance, risk assessment, knowledge and education, risk management and mitigation, and disaster preparedness and response-issues were grouped by category and assessed using radar maps.

This chart shows that the best performing thematic area is governance in the medium resilience category (52%), as the survey shows that communities are ready to participate in training and preparation workshops to improve the resilience of their cities. In the thematic area of disaster preparedness and response, the survey results showed that resilience was the lowest due to the lack of an early warning system and the lack of communication means to report the data generated by the INAMHI

test station. In addition, due to the lack of an emergency plan, the community is not prepared. Thematic areas such as risk management and vulnerability reduction (39%), knowledge and education (36%), and risk assessment (25%) were less resilient. The overall feature of this result is that the public lacks awareness of the risks they face, and does not take measures and actions to reduce risks and respond to risks when they occur (**Figure 3**).



**Figure 3.** Resilience category.

Source: Authors.

In the thematic area of disaster response and resilience, the implementation rate is very low (14% in the area of thematic response and resilience).

In the thematic area of governance, 52% of respondents were willing to participate in training, workshops, and actions that contribute to urban resilience and risk reduction. The results achieved in other areas such as risk management and vulnerability reduction (39%), risk assessment (25%), and knowledge and education (36%), indicate the need to integrate these themes into the above-mentioned training activities.

### 4.1. Physical performance analysis of the seismic vulnerability of building structures

The seismic vulnerability of 120 buildings in the Concordia Avenue area in the future is analyzed and determined. Among them, 5% are areas without buildings, and the remaining 95% of buildings show vulnerability between low vulnerability (58.1%), medium vulnerability (29.9%), and high vulnerability (12% of buildings). These results are

samples of the physical vulnerability of building structures on the Boulevard. Eleven of these countries show a high degree of vulnerability because of their fragile structural systems, usually metal structures, kana structures, or portable walls, and because of their terrain and soil characteristics, they are more sensitive to earthquakes (Figure 4).

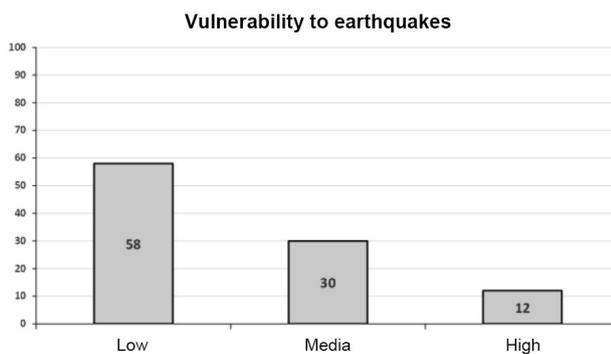


Figure 4. Seismic fragility.

#### 4.2. Flood vulnerability analysis results of physical structures of buildings

With regard to the structural physical vulnerability of buildings on La Concordia Avenue, 72% of the buildings analyzed have low vulnerability, while few buildings are at high vulnerability because

these buildings are located below the road level and are prone to flooding in cases of strong rainfall (Figure 5).

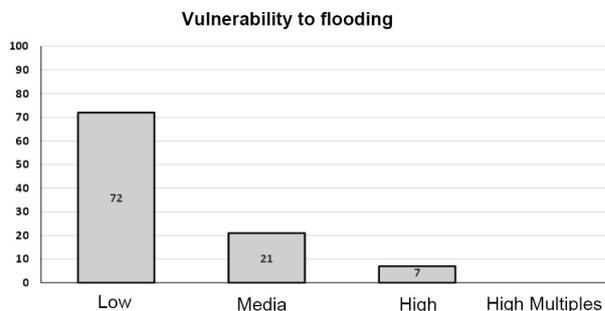


Figure 5. The extent to which buildings are affected by earthquakes.

The Sankey chart shows the measurement results of different grouping components. Within the range of results, the governance score is 52%, which is the highest in this study because it is at the medium resilience level, while the disaster preparedness and relief score is the lowest, which is 14%, which means that it has the lowest resilience level (Figure 6).



Figure 6. The measurement results of different grouping components.

### 5. Conclusions

The proposed resilience plan should be able to establish linkages between all stakeholders (public and private institutions, business and civil society),

urban systems, and risks in selected research cities.

It identified economic and social trends, challenges, and inequalities, as well as progress made in public programs and services in medium-sized cities such as Laconcordia.

The Environmental Management and Planning Bureau should study the location of incompatible services in the Boulevard area, because these services are mainly productive activities and are having a negative impact on the environment in the form of uncontrolled pollution.

It is suggested that the avenue project include a renewable energy gymnasium designed by students of the Department of Architecture at the Kineme Institute of Higher Technology in Sonora, Mexico.

Ecuador and other Latin American cities have demonstrated the feasibility of this procedure.

## Conflict of interest

The authors declare no conflict of interest.

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