Social development clustering: using data science to identify vulnerable neighborhoods in Mexico City

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Introduction

Cities occupy just 3% of Earth's land, however, they account for 80% of the world's GDP, around 60 to 80% of its energy consumption and 70% of its carbon emissions (UNDP, 2021). Additionally, it is estimated that 68% of the world's population will live in urban areas by 2050. Hence, addressing the necessities of people living in cities will increasingly become more complex and more important. According to the World Economic Forum (WEF, 2018), cities will face 5 main challenges in the 21st century, which we list below.

1. Environmental threats: because infrastructure is not built to withstand the increasing extreme weather events linked to climate change, such threats often result in financial loss and death.
2. Resource availability: cities need resources such as water, food, and energy to be livable, but with a growing population, urban areas must plan to become self-sustainable to avoid destroying neighboring natural ecosystems while extracting resources.
3. Inequality: the gap regarding the provision of basic resources and resilience to environmental threats between urban super-rich and poor is widening, which can destabilize society and upend any benefits of urban development if left unchecked.
4. Technology: the only way to develop resilient and environmental-friendly infrastructure that is livable and connects citizens is to use technology and smart planning within cities.
5. Governance: the general objectives of urban governance in the future should address issues of equity, liveability and sustainability for all citizens, which will require constant innovation to meet them.

In comparison with the global panorama, Mexico faces an even more complex situation, since nearly 80% of the country's population already lives in urban settlements (United Nations Department of Economic and Social Affairs Population Division, 2019). The problem with these cities is that they have grown in a disproportionate and inequitable manner, and without a long term vision that provides their inhabitants with decent living conditions (Centro Para el Futuro de las Ciudades del Tecnológico de Monterrey, 2019). In addition, Mexican experts on business and social transformation believe that a key strategy to foster prosperity in Mexico is to turn cities into sustainable, fun, and innovative hubs to attract and retain talent in the country (Sobrino, Garrocho, Graizbord, Brambila & Aguilar, 2015).

Mexico City exemplifies the need to address all the previously mentioned issues. Mexico City is the largest city in the Western Hemisphere, with more than 20 million inhabitants. However, a large percentage of this population lives in extremely vulnerable conditions: there is proliferating informal employment, a lag in infrastructure, strong social inequality, and the city's geographical conditions make it highly susceptible to seismic hazards and flooding (Resilient Cities Network, 2016). Aware of these challenges, Mexico City's government has created a resiliency strategy focusing on regional coordination, resource availability, mobility and innovation. Although this plan encompasses a global vision to create an equitable society, its success will require the engagement of multiple stakeholders and researchers, as well as the use of modern digital technologies (CDMX Resilience Office, 2016).

Problem statement

Recently, a revision of Mexico City's resilience strategy proved that its implementation still requires granularization and incorporating learning systems that allow the government to take dynamic responses to how the city changes (Urban Sustainability Exchange, 2020). For this reason, the purpose of this project will be to categorize Mexico City's neighborhoods based on their performance in 5 main topics: resilience to environmental threats, resource availability, inequality, technology access, and fun. By performing this analysis, we hope to provide open access, reliable information on the progress of Mexico City's resilience agenda, as well as helping Mexico City's government identify the most vulnerable neighborhoods within the city.

Data description

Measuring Mexico City's performance on the selected topics is not an easy task, and the information needed for the analysis is complex, since it comes from multiple sources. For convenience, Table 1 summarizes all indicators selected to evaluate each topic, a description of what the indicator measures and its scale, as well as the data source where it is taken from. All data sources are cited in the references of this document.

Table 1. Evaluation areas, indicators, and data sources			
Evaluation area	Indicators	Description	Data source
Demographics	Population	Total population of a neighborhood, measured in natural numbers.	SIDESO (2010)
Resilience to environmental threats	Housing quality index	Indicator that measures the overall material, quality, and available space per inhabitant of the houses in one neighborhood, measured from 0 to 1, where 1 means the best resilience.	SIDESO (2010)

Resource availability	Sanitary Index	Indicator that measures the availability of drinking water, sewage systems and toilets in the houses of a neighborhood, measured from 0 to 1, where 1 means the best access to water and sanitation.	SIDESO (2010)
	Energy Access Index	Indicator that measures the overall access to Mexico City's electric system of the houses in one neighborhood, measured from 0 to 1, where 1 means the best access to electricity.	SIDESO (2010)
Inequality	Education Gap Index	Indicator that measures the overall literacy and school level of the inhabitants of a neighborhood, measured from 0 to 1, where 1 means the greatest literacy and school level.	SIDESO (2010)
	Health Access Index	Indicator that measures the overall access to social security and health services of the inhabitants of a neighborhood, measured from 0 to 1, where 1 means the best access to social security and health.	SIDESO (2010)
	Social Development Index	Indicator that measures the overall performance of a neighborhood regarding the housing quality index, health access index, education gap index, durable goods index, sanitary index, and energy access index. It is measured from 0 to 1, where 1 means the greatest social development.	SIDESO (2010)
Technology access	Durable Goods Index	Indicator that measures how many of the basic home technology devices (telephone, television, refrigerator and washing machine) that the homes in a neighborhood have, measured from 0 to 1, where 1 means the most devices.	SIDESO (2010)

	Internet Access Points	Indicator that measures how many free Wi-Fi access points with at least a 20 mbps capacity are there within a 1 km radius from the center of a neighborhood, measured in natural numbers, where the greater the number, the more internet access.	Gobierno de la Ciudad de México (2020) & Gobierno de la Ciudad de México (2021)
Fun	Venues	Indicator that measures how many venues are there within a 1 km radius from the center of a neighborhood, measured in natural numbers, where the greater the number, the more fun activities are available for the population.	Foursquare API

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