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Analysis of the extend to which resilience has been embedded into Mexico City planning

Análisis de la integración del concepto resiliencia en la planeación de la Ciudad de México

Natalie Rosales Pérez*

Abstract

This research focused on the Mexico City Climate Change Action Program 2014-2020 case study, examines how resilience has been embedded into planning instruments. Part 1 introduces prominent themes and concepts related to the incorporation of resilience in planning practice. Part 2 analyses concepts, methodologies, and strategies for building resilience in this program. Part 3 presents a critical assessment of the framework adopted. By doing so, it aims to highlight the challenges and opportunities embedding resilience offers to building a comprehensive urban resilience strategy within a planning for sustainability framework.

Keywords*: resilience, urban sustainable planning, Mexico City, planning evaluation.*

Resumen

Esta investigación, centrada en el estudio de caso del Programa de Acción contra el Cambio Climático de la Ciudad de México 2014-2020, examina cómo la resiliencia se integra en los instrumentos de planeación. Se analizan conceptos relacionados con la incorporación del pensamiento de la resiliencia en la práctica de la planeación de las ciudades; así como los términos enfoque, metodologías y estrategias para construir resiliencia en este programa; finalmente, se presenta una evaluación crítica del marco adoptado. El objetivo es resaltar los desafíos y las oportunidades que implica construir una estrategia integral de resiliencia urbana en el marco de una planeación para la sustentabilidad.

Palabras clave: resiliencia, planeación para la sustentabilidad, Ciudad de México, evaluación de la planeación.

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Introduction

1.1. Resilience as a new framework for planning the cities

In the face of challenges such as growing inequalities, natural resource depletion, peak oil, economic crises, and climate change, the concept of resilience has crossed disciplinary discussions. It has become an approach focused on managing socio-environmental systems in a context of uncertainty, disturbances, and surprises (Biggs *et al.*, 2015). It has also been progressively embedded into policy-oriented discussions, mainly focused on climate change (Lampis, 2015).

In this way, more and more, we hear about resilience as an applicable concept to prevention strategies, community empowerment, collaborative initiatives, economic recovery, and urban planning strategies.

Following these tendencies, the concept has arrived in the urban arena. As a result, the efforts to build resilient cities have increased, generating new perspectives and urban planning frameworks to tackle the enormously complex interactions between diverse non-scalar components of socio-ecological systems (Resilience Alliance, 2020). These new perspectives include disaster risk reduction (DRR), social vulnerability; urban political ecology; and transformative resilience.

The resilience approach rooted in risk and uncertainty argues that change will occur, and unexpected shocks cannot be predicted. Therefore, cities must strengthen their capacity to handle and deal with external threats such as natural disasters (hurricanes, floods, and earthquakes), the depletion of natural resources, and shocks (Jha *et al.*, 2013).

This vulnerability paradigm focused on building resilient and intelligent urban environments that can anticipate future shocks and strengthen the ability to quickly bounce back to a stable state (UN HABITAT, 2020) has been driven mainly by international institutions. Furthermore, it has substituted a natural threats approach in the social sciences (International Council for Local Environmental Initiatives, ICLEI, 2012).

There are different initiatives focused on developing city stakeholders' capacity to address the uncertainty and changeability of all types of disturbances. Initiatives include the Resilient Cities Project from the Organisation for Economic Co-operation and Development (OECD, 2014); Resilient Cities initiatives from ICLEI (2012); 100 Resilient Cities project from Rockefeller Foundation (2013), UN-Habitat City Resilience Profiling Program, and the United Nations International Strategy for Disaster Risk Reduction (2013; 2020); to name a few.

The focus on urban risk management, which has dominated the incorporation of resilience in planning practice, clearly represents an advance in contemporary planning. Nevertheless, much of the discussion

of the literature has highlighted that this approach tends to restrict assessment and strategies to anticipate short-term disturbances; while leaving aside environmental justice and the capacity of urban systems to adapt in the broader context of long-term transformations.

From a social vulnerability perspective, advancing actions in anticipation of risk or recovery from shock and disaster impacts, require factors such as knowledge and perception of risks, alternatives, and resources, which are out of the control of communities (Wilbanks, 2008). According to Campanella (2006), specific social, ecological, political, and economic processes and structures lead to vulnerable conditions and uneven risk distribution among a specific population. From another perspective, researchers supported by a critical school of thought, remind us how ecological processes that support cities are always due to politicization (Robbins, 2019).

Scholars from critical theoretical frameworks, argue that understanding how urbanization metabolizes nature is imperative for addressing resilience at the urban scale. For example, Chelleri & Olazabal (2012) argue that the creation and distribution of risks, vulnerabilities, and opportunities among urban dwellers can be shifted onto disempowered populations (such as urban peripheries and rural and peri-urban environments). Also, it can be extended at the expense of adjacent cities (regional or national) or neighborhood levels. Therefore, to build resilient communities, there is a need for a deeper understanding of public responses to these challenges and how planning can support synergistic relationships between resilience and the environment (The Bartlett Development Planning Unit, 2016).

From a transformative perspective, resilience can be understood as a dynamic process involving recovery from disturbances and incremental adjustments (adaptations) and; exploring and expanding the capacity to innovate and transform (Holling, 1973). In this line of thinking, building resilience requires: preparing for change, navigating the transition, and creating a new trajectory of development (Olsson *et al*., 2006). Evolutionary resilience frameworks have focused on how to design and implement actions to advance into desired changes progressively. This framework includes adaptation needs, collaborative learning and adaptive planning capacity; as well as long-term change and transformations (Werners *et al*., 2021).

Grounded on these different approaches, the debate about resilience has become central to urban sustainability. Mainly, because resilience thinking can support the conceptualization and development of tools to help understand cities as complex socio-ecosystems and manage urban sustainability transitions, providing a long-term perspective based on learning, adaptation, and transformation (Walker & Salt, 2012).

According to Villagra *et al.* (2016), these authors' thinking is the one that has influenced the incorporation of the notion of resilience in urban planning the most. Remarkably, the attributes of resilience to regulate human communities that these authors postulate: diversity, redundancy, multifunctionality, modularity, networks and multiscale connectivity, governance structures, and capacity to adapt with innovation, have been used in various planning instruments.

Eraydin *et al.* (2013) highlight that the resilience thinking framework provides a basis for analyzing and understanding external and nonsystemic factors and disturbances that are important in shaping urban systems. This includes the adaptive cycle of co-evolution of socioeconomic and ecological systems, which may consist of slow change processes, incremental growth, and rapid and sudden processes of destruction and reorganization in response to disturbance. Therefore, it is a useful framework that can assist planning in different ways. A pre-appraisal approach focused on the evaluation of existing plans, programs, and planning measures to identify pitfalls, as well as to evaluate the comprehensiveness of priorities. This includes the use of resilience as an heuristic tool for the identification of critical issues in the urban system and the definition of key areas and planning strategies, as well as establishing new principles in urban planning that allow developing the adaptive capacity to face changes resulting from different types of disturbances.

Also, it can be used as a post-appraisal approach to assess the effectiveness of the objectives and strategic line set in planning instruments. This is the examination of resilience indicators to assess if planning instruments have successfully created strategies for cities to create the capacity for self-organization, adaptation and transformability. In this framework of thought, resilience offers essential elements to support a change management process that allows a transition toward sustainable urbanism (Rosales, 2019).

This perspective on management change to drive urban sustainable dynamics and trigger transformative practices, defined by Rosales (2019) as planning for sustainability, calls to move mainstream urban planning toward a more comprehensive approach, which encompasses complexity and uncertainty as opportunities and contributes to exploring the capacity for self-organization adaptation and transformation of urban systems.

Regardless of the number of opportunities this heuristic tool offers, there has been limited use of the concept in praxis in diverse planning instruments. According to Villagra *et al.* (2016), the erroneous understanding of building resilience in urban planning becomes failed planning policy, either from its conceptualization or implementation. For instance, Rega and Bonifazi (2020) state that the contrasting understanding of resilience from a descriptive concept to a broader conceptual and normative

framework, generates remarkable tensions in incorporating resilience and sustainability into urban planning. They remark on three main differences:

1) a diverse focus on outcomes and processes when thinking about the uncertainty of the future
2) a narrow consideration of inter and intra-generational equity
3) the ontological separation between the internal components of a system and an external shock

Therefore, it is essential to bring an analytical gaze to the theory and planning practices that attempt to create resilient urban areas.

1.2. Aims and methodology of the study

Using the case study of Mexico City's Climate Action Program 2014-2020 (PACCM, in Spanish) (Sedema, 2014), which incorporates resilience as one of the main components, this research examines how this concept has been embedded into planning instruments. It analyzes which frameworks, methodologies, and strategic lines to build resilient cities are contemplated, and the advantages and shortcomings of the framework adopted. By doing so it aims to highlight the challenges and opportunities embedding resilience into planning offers to enable transformations towards sustainable urban futures.

The evaluation methodology comprised the following activities:

I. Revision of prominent frameworks, themes, and concepts from resilience literature to identify the approach undertaken by Mexico City Climate Change Action Program 2014-2020 (Sedema, 2014). Frameworks include disaster risk reduction (DRR), social vulnerability; urban political ecology; and transformative resilience approaches.
II. Analysis of the conceptual and procedural content of the selected planning document. The study identifies the conceptualization, methodology, strategies, and the set of sequentially ordered actions established in this sectoral government program regarding its resilience component.
III. Planning evaluation of the advantages and shortcomings of the principles adopted. The study presents a critical assessment of how the program approaches the concept. The key actions, strategies, and policies under the framework of the resilience concept are then identified in this planning document.

The evaluation is based on the theoretical foundations of how resilience thinking can support planning to prepare urban areas to cope with increasing economic, social, and ecological pressures and disturbances, as Eraydin *et al.* (2013) proposed. Elements of the analysis consider how resilience conceptualization, key actions, and strategic lines included in Mexico City Climate Change Action Program 2014-2020 (Sedema, 2014), contributed to:

- The understanding of the co-evolution of socio-economic and ecological systems.
- Providing a basis for the systemic analysis of cities and their vulnerabilities.
- Building capacity to deal with changes in the wake of different types of disturbances
- Underline the adaptive capacity of social-ecological systems.
- Highlight external and non-systemic factors and disturbances that are important in shaping the individual urban system
- Linking physical (spatial) and ecological aspects in a systematic way.

2. Planning framework for building urban resilience in Mexico City: The Climate Change Action Program 2014-2020.

2.1. Background

As an international actor, Mexico City has positioned itself in the global context as one of the cities driving resilience projects due to the assumed leadership on the climate change agenda promoted since the COP 16 United Nations Climate Change Conference (UNFCCC, 2010) was held in Cancun. Hence, the debate around resilience concerning climate change has become one of the new narratives permeating the City's different planning instruments.

In 2015, the City joined the Rockefeller Foundation's 100 Resilient Cities Program and received funding of $ 200 million to boost various programs and resilience strategies. This initiative comprised four vulnerability areas: *i*) Caused by disasters; *ii*) Financing innovative technology infrastructure; *iii*) Land use; *iv*) Social and community resilience (Quintero, 2016). Additionally, in 2016, the government allocated over 17,000 million pesos to resilience strategies, representing 10% of the 2016 budget.

Under this context, Mexico City's Climate Change Action Program 2014-2020 (Sedema, 2014) can be considered one of the first efforts and examples of how the notion of resilience has been incorporated into the city's planning instruments.

Since then, the city has been increasingly introducing the notions of resilience. Nowadays, the concept appears in diverse sectorial, normative and institutional programs such as; the urban development program, Mexico City constitution, the integral management of risks and civil protection law, and the risk management Atlas.

The selection of the Climate Action Program as a case study is based on two criteria. First, this program is one of the first planning instruments that proposes to build a resilient urban area as one of its sectoral objectives. It includes the analysis of the adaptive capacity of the city in the face of possible disturbances and develops a strategy for the city to become more resilient.

The second criterion is that even though in recent years, some cities have advanced in the development and implementation of specific resilience programs and strategies, the debates aimed at incorporating resilience framework of thought into policy design continue to be developed based on strategies for the prevention and mitigation of climate change.

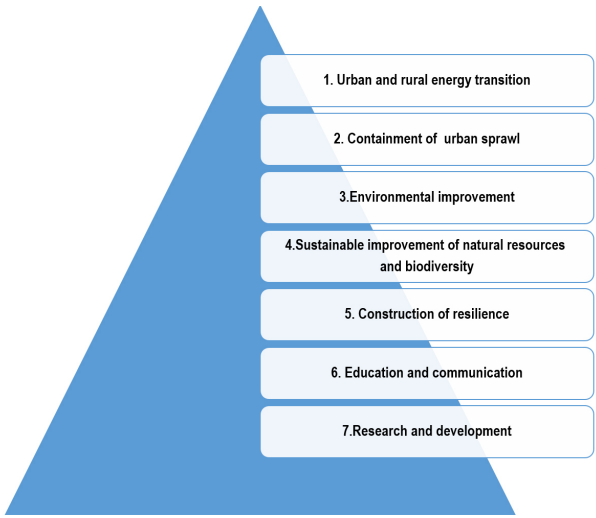
Proof of this is the Resilience Strategy for Mexico City (2016). In strategic line three planning for urban and territorial resilience, it is established that "Planning is a fundamental tool both to maintain a vision of long-term, to address current challenges in issues such as inequality, and increase resilience to new challenges generated by dynamic processes such as climate change" (Oficina de resiliencia de la Ciudad de México, 2016: 13).

2.2. Analysis of how Mexico City Climate Change Action Program approaches resilience

This program promotes actions to reduce the environmental, social and economic risks posed by climate change. It aims topromote the welfare of the city's population through the coordination of other instruments such as the Local Climate Action Strategy.

Building resilience to face the adversities under climate change conditions is a particular objective and consequently one of the main components of the program.

Figure 1
The theoretical framework. The urban resilience approach



Source: author's elaboration based on Secretaría de Medio Ambiente, Sedema (2014).

2.2.1. Conceptualization of resilience in the program.

The program conceptualizes resilience as "the ability of citizens to absorb shocks and reorganize while undergoing climate change, through decentralization of activities, the diversity of economic sources, decoupling between economic development and emissions, the integration of the city with natural ecosystems, social cohesion, and redundancy" (Sedema, 2014: 59).

In accordance with this definition, the program sets four attributes for an urban system to be resilient (Centro Mario Molina, 2014):

1. Decentralization. Spatial dispersion of the city's critical activities, so that in case of disturbance in an area of the territory, the rest of the city can continue running smoothly.
2. Diversity. Economic growth should consider green house gas (GHG) emissions and integrate environmental concerns. Urban centers should be more efficient and less polluting.
3. Flexibility. Ability to face disasters. It may be an administrative type, infrastructure, or economic activity.
4. Redundancy. It refers to the duplication of the key and essential city services. The city must continue operating by using alternative networks to avoid collapsing.

2.2.2. How does the planning document approach problems related to building resilience?

Under the risk adaptation approach, the theoretical framework focuses on the relationship between vulnerability and climate change by considering exposure to risk, sensitivity, adaptive capacities, internal social agents, and marginalization and poverty.

Overall, the framework provides an analytical foundation for understanding urban vulnerability, focusing on two main aspects; exposure to multiple risks (extreme rainfall resulting in floods or landslides, droughts, heat waves) and poverty and inequality that contribute to a high concentration of marginalized groups. Resilience is understood as a multifactorial consequence of the fragility of urban systems.

Methods for identifying and implementing mitigation and adaptation actions consider:

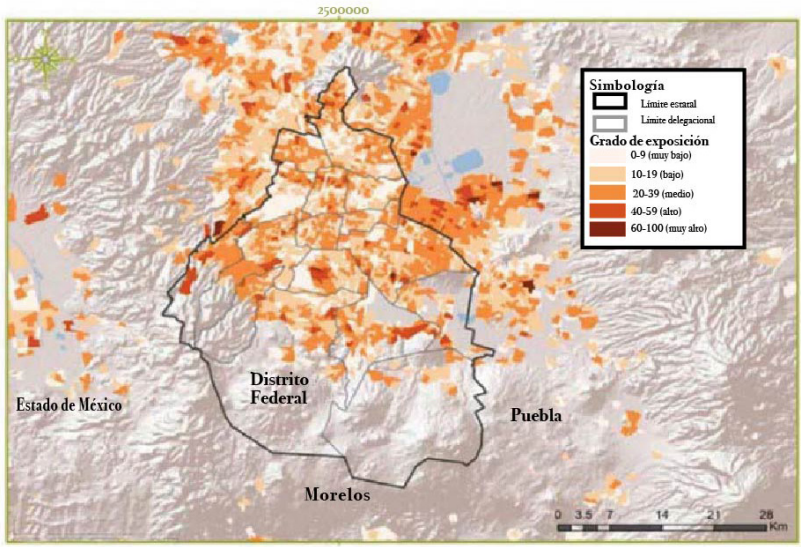
1) Climate change scenarios can include greenhouse, black carbon and fluorocarbons inventory emissions.
2) A planning evaluation system that makes the plan measurable, reportable, and verifiable. Every action has specific monitoring and impact indicators. It has an online tracking platform, which provides information for decision-making in a timely and effective manner.
3) Indicators to measure vulnerability which include exposure to risk, sensitivity, and adaptive capacities.

The plan departs from a diagnosis of the city's current situation, focusing on vulnerability. The planning document diagnosis argues that large levels of population vulnerability are concentrated in the south of the city (Tlalpan, Magdalena Contreras, Álvaro Obregón and Cuajimalpa). Medium high to very high levels of vulnerability are present in Iztapalapa, Cuajimalpa, and Xochimilco, in contrast to central areas with very low and low levels (figure 2).

The assessment vulnerability matrix model predicts climate change will bring about:

1) Water demand increment.
2) Dreadful conditions in catchment areas.
3) Reduced water quality and recharge.

Figure 2
Vulnerability and risk exposure map



Source: Centro Mario Molina (2014).

Concerning disturbances, the climate evolution patterns for Mexico City show that short (2030) and medium term (2050) future shocks could:

a) Impact agricultural cycles through changes in the seasonality of temperature and rain,
b) Create new habitats for pest or disease vectors,
c) Change biological diversity in biomes
d) Cause shortage of water resources.

As a result of analyzing indicators and climate change impacts, the program reveals peripheral municipalities will increase their vulnerability. This increment is explained by the fact that these municipalities are mainly characterized by irregular human settlement patterns, where the steep slope is very prone to washouts by water erosion.

2.2.3. Strategies for building the resilience of the city

The PACCM aims to increase the city's resiliency by ensuring the restoration of essential services and social, institutional, and economic activities.

Strategies and recommendations for building resilience are placed in the broader context of adaptation to climate change that focuses on five issues:

- Urban and rural energy transition:
  - ◊ Energy efficiency
  - ◊ Renewable energy
- Containment of urban sprawl:
  - ◊ Urban planning instruments
  - ◊ Intra-urban green spaces
  - ◊ Infrastructure mobility and transport
- Environmental enhancement:
  - ◊ Reduction of emissions
  - ◊ Integrated waste management
  - ◊ Integrated management of water resources
- Management of natural resources and biodiversity conservation:
  - ◊ Native species and wildlife
  - ◊ Soil conservation
- Building resilience of the city:
  - ◊ Prevention and mitigation

The program promotes prevention and risk mitigation, focusing on creating and promoting an environmental and economically dynamic population in the face of destabilizing events caused by extreme behavior of weather, environmental degradation, and economic and social crisis. In the document, adaptive mechanisms for building urban resilience are associated with vulnerability of the population and damage to infrastructure such as roads, hydraulic and electric, as well as public health and the government organizational capacity to move from prevention to risk mitigation.

In this regard, key actions to build resilience refer to:

1. Up-to-date Hazard and Risk Atlas
2. Prevention program (hydro-meteorological hazards)
3. Evaluation of resettlement of population situated in risk areas
4. Early warning systems to monitor and forecast hydro-meteorological conditions of the metropolitan area
5. A preventive measure system in case of extreme weather events
6. Training and dissemination of prevention strategies related to climate change, to strategic sectors
7. Monitoring and prevention of vector-borne diseases through information integration
8. Disease prevention program
9. Designing an environmental fund for climate change

The strategy also explicitly recognizes that building urban resilience to climate change cannot be achieved through one-time activities or

projects. It accentuates the importance of interventions at different scales and across diverse sectors. The program also states the role of external actors in catalyzing and supporting responses, working with and through internal agents, and influencing the allocation of investment where it is needed.

For instance, it promotes an integrated approach, incorporating three topics: urban planning, mobility, and environmental enhancement. The program also remarks that mitigation actions should demonstrate co-benefits in the adaptation actions, seeking a positive impact on environmental and social development.

3. Analysis of the advantages and shortcomings of linking resilience to mitigation and adaptation measures.

Mexico City's adaptation planning framework helps illustrate how resilience undertakes within the aims and practices of contemporary planning instruments; and what are the advantages and shortcomings of the principles adopted.

Table 1
Synthesis of methodologies, tools, and evaluation frameworks

Issue	*Description*
Urban resilience approach	Building resilience is at the broader context of the adaptation strategy that addresses the specific vulnerabilities to climate change. The planning instrument considers that a city can become more resilient concerning adapting to and ensuring the restoration of basic services, as well as social, institutional and economic activities. Related concepts: The framework focuses on the relationship between vulnerability and climate change. It considers exposure to risk, sensitivity, adaptive capacities, and internal agents. Vulnerability understood as a compound consequence of the fragility of the urban systems, the capacity of internal agents - including poverty, social marginalization, and other factors such as exposure to the impacts of climate change.
Methodologies and evaluation tools	**Methodology** The planning instrument combines investigation, data, and analysis to diagnose vulnerability. The framework provides a robust analytical foundation for understanding vulnerability to climate change which then informs the identification and implementation of mitigation and adaptation actions, seeking synergies and co-benefits.

Table 1 (*continued*)

Issue	*Description*
	Analysis methods consider: Climate change scenarios which incorporate greenhouse compounds emissions, black carbon and fluorocarbons inventories. A planning evaluation system which makes the plan measurable, reportable and verifiable. Indicators to measure vulnerability include: exposure to risk, sensitivity and adaptive capacities.

Source: author's elaboration based on Mexico City Climate Change Action Program 2014-2020 (Sedema, 2014).

As Table 1 shows, applying the concept in the broader climate change framework combines investigation and data collection, providing a robust analytical foundation for understanding vulnerability to climate change impacts. In this manner, it can be argued that it helps understand urban vulnerability from a more comprehensive perspective, as it helps to identify:

Which are the threats?
Which agent or sector will be impacted by climate change and how?
What parts of the city will increase their vulnerability due to climate change?
What actions can help mitigate and adapt to climate change impacts?

This new perspective represents an advance in contemporary planning frameworks to strengthen risk prevention and management capacities, consolidate response protocols and mitigation measures in case of emergencies and disasters, recognize and forecast climate change impacts at the city level.

The use of the concept restricted to climate adaptation goals and actions is limited to understanding external and non-systemic factors and disturbances that are important in shaping the individual urban system and linking physical (spatial) and ecological aspects in a systematic and multiscalar way. As a result, it can be argued that it fails to build a comprehensive urban resilience strategy to deal with changes in the wake of different types of disturbances in many ways.

First, the focus on risk and vulnerability considers how some parts of the city will increase their vulnerability due to climate change but does not go deep into the specific social, ecological, political, institutional, and economic processes that have led to those conditions. Answering how and why vulnerability will increase is relevant to modifying the socio-environmental dynamics that constrain the capacity of internal agents to

face adversities. Even when adaptation actions can mitigate impacts, vulnerability conditions will remain or be displaced.

Second, one of the main aspects that underlies the conceptualization of the resilience approach undertaken in planning instruments is the capacity to cope with disturbances and return to a stable state. However, according to Holling (1973), resilience as a dynamic process that involves recovering from disturbances and carrying out incremental adaptations and transformations. This dynamic process implies that the system will not always return to its previous state of equilibrium. Instead, it will create new development pathways to further and future change to survive (Folke *et al.*, 2010). This challenges planning strategies to restore previous equilibrium.

Third, climate change scenarios and the vulnerability assessment overlook urban ecosystems functioning and interactions.

Pickett *et al.* (1997) argue that urban areas are responsible for many disturbances, stresses, and changes in ecological systems. Environmental conditions and dynamics such as carrying capacity and the decline in urban ecosystems services can become critical endogenous factors that could enforce changes in the urban systems that are not incorporated in the analysis of urban vulnerabilities.

The limitations of the approach undertaken represent a barrier to better understanding the urban systems' adaptive cycles, which according to Eraydin *et al.* (2013), consist of two forms of change: the slow and incremental processes of growth and accumulation and the rapid and sudden processes of destruction and reorganization in response to disturbance. Moreover, understanding the socio-environmental factors and structural conditions that trigger these different processes is essential. It allows building adaptive capacities for managing and enabling transformative changes towards a more equitable, environmentally, and promising urban future.

To make the case, following sections will focus on arguing these three limitations.

3.1. Underlying socio environmental risk and vulnerability factors as the main concerns to anticipate, mitigate and build the capacity to adapt to future shocks tend to be overlooked

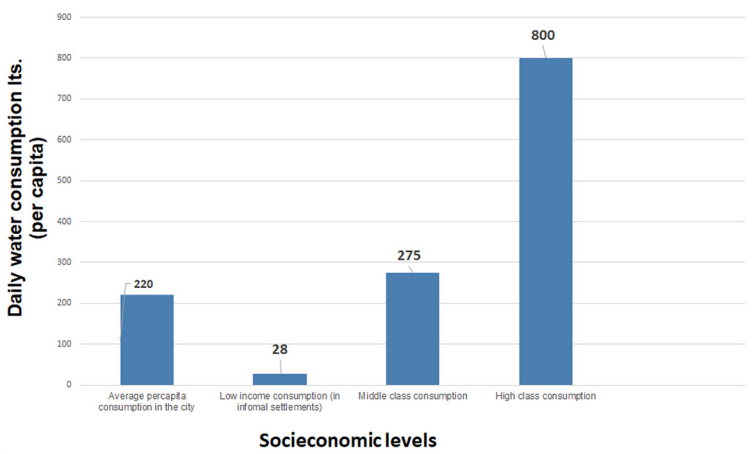
Resilience is a powerful concept to understand better complex interactions between the different components of socioecological systems, including social dynamics, resource flows, built environment, and governance networks; their strengths and weaknesses to build new development trajectories.

An underlying aspect interwoven among these components is the notion of risk and vulnerability, which is not only related to exposure, sensitivity, and adaptive capacities of a population but also to the specific social, ecological, political, and economic processes that lead to vulnerable conditions (Campanella, 2006).

Therefore, to design resilience strategies focused on supporting synergistic relationships to mitigate vulnerabilities, it is relevant to consider that risk varies not just according to the hazardous agent, as it is distributed unevenly among population and communities (Campanella, 2006; Wilbanks, 2008). To illustrate this, the following paragraphs present data on water consumption and disparities in infrastructure provision.

The water consumption figure 3 shows how levels of vulnerability depend on the specific social-economic condition of the area in such a way that disparities in the access to resources and the allocation of infrastructure affects mainly the population which has the lowest income levels.

Figure 3
Inequities in water consumption



Source: author's elaboration based on data by López (2006).

According to the Mexico City Climate Change Action Program, the degree of risk exposure in the city varies from low to critical. Municipalities localized in the south show high levels of concentration of marginalized groups. These central municipalities are characterized by irregular human settlement patterns, where the steep terrain slope favours washouts and water erosion, and has critical levels of exposure to multiple risks (extreme rainfall resulting in floods or landslides, droughts, heat waves).

Table 2
Degree of exposure to multiple climate change risks (extreme rainfall resulting in floods or landslides, droughts, heat waves)

Municipalities	*Vulnerability Levels*
Iztapalapa, Álvaro Obregón, Tlalpan, Tláhuac, Xochimilco and Milpa Alta	Critical
Azcapotzalco, Gustavo A. Madero, Cuajimalpa, Iztacalco, La Magdalena Coyoacán, Contreras and Venustiano Carranza	Medium
Benito Juárez, Cuauhtémoc and Miguel Hidalgo	Above average

Source: Sedema (2014).

Following the assessment presented in the program, when adding effects of climate change such as increase in water demand, increased degradation in catchment areas, reduced water quality and recharge, among others, it is possible to foresee how some municipalities will increase their vulnerability. However, this diagnosis does not go deep into the roots of urban vulnerability conditions, such as the unequal distribution of metabolic flows within the city and the opportunities among urban dwellers at different scales. Moreover, strategies to overcome the city's vulnerability restrict the evaluation of resettlement of populations situated in risk areas.

Understanding how and why the growing inequalities in the cities can constrain or trigger conditions of risk and vulnerability in a broader context is of particular interest in assessing resilience strategies, as inequalities are connected in a broader context. According to Heynen *et al*. (2006), through infrastructure, cities metabolize nature and can lead to the empowerment of already powerful and advantaged groups while disempowering others. To exemplify this, figure 3 shows average water consumption in Mexico City.

Water consumption in the city already presents critical levels of disparity and inequity. Figure 3 shows average water consumption per person/per day according to socio economic levels. As shown, while higher-income sectors consume over 80%, an inhabitant from the lowest income levels located in informal settlements only consumes 20 liters a day, which represents the 28%.

This unequal consumption can be understood when analyzing water infrastructure disparities. According to Peña García (2007), athough insufficient water is a problem of territorial distribution, it is also a matter of social and spatial inequality.

Secondly, as Chelleri and Olazabal (2012) argue, vulnerability can be shifted onto disempowered populations (such as urban peripheries and rural and peri-urban environments) or gained at the expense of adjacent cities (regional or national) or smaller urban systems. To illustrate, in 2012, the average wastewater production in Mexico City, amounted to 1.66522 million m^3. Seventy-eight percent of this wastewater reached treatment plants, and the water waste re-usage has come up to only 4 %. Then, 22% of the negative externalities are transferred to other regions, displacing environmental risk and vulnerability to rural areas (Rosales, 2018).

Such negative externalities can be perceived through the levels of concentration of pollutants in soils in the Mezquital Valley, Hidalgo State. According to Vázquez *et al.,* (2001) Mexico City wastewater, which contains hydrocarbons such as gasoline, oil, diesel, highly polluting chemicals such as cyanide, lead, and iridium, as well as contaminants such as pesticides and herbicides is used to irrigate these lands. Data obtained from his studies demonstrates high ratios of cadmium, nickel, and lead in water, soil, as well as in maize, wheat, and alfalfa. The study concludes that there is a process of accumulation of those metals in wheat grain, indicating a potential health hazard for consumer organisms (Vázquez *et al*., 2001). In addition, it must be remarked that the Valley comprises municipalities mainly populated by the Otomí indigenous community.

This empirical evidence demonstrates a resilience strategy to reduce exposure of vulnerable population, based on just ensuring the restoration of essential services without addressing a vital issue of environmental justice and urban flows at different geographical scales, which seems to be insufficient. Moreover, because it will keep the *status quo* of inequalities, it requires changing the conditions that have given rise to a high concentration of vulnerability in marginalized groups.

3.2. Strategies focus on returning to a stable state instead of building the adaptive capacity of urban systems to deal with socio-environmental changes in the wake of different disturbances

An overarching limitation in the application of resilience in this program, especially in managing and enabling transformative changes, relies on the idea of returning to a stable state after coping with disturbances.

Resilience literature remarks that this concept is a value-free property, where the ability of a system to absorb disturbance and reorganize can be neither good nor bad. O'Connell *et al*. (2015) argue that any system can have a high level of resilience to maintain the same identity despite shocks, whether in a desirable or an undesirable state. For instance, an urban area can become highly resilient to a decline in ecosystem services. Likewise,

citizens can adapt to poor environmental conditions such as polluted air, contaminated water, and so on.

Mexico City has developed the flexibility to cope and absorb multiple disturbances from socio-environmental dynamics and interactions such as social inequality, uncontrolled growth of urban sprawl, informal settlements, natural resources scarcity, and ecological systems degradation. The City experienced a fast urbanization process from 1940 to 1960, creating a growing demand for urban land, infrastructure, and services (Sánchez, 1996). The geographical expansion created pressures on urban ecosystems. The tensions due to the rapid growth, together with the decline in ecosystem services, have generated traffic congestion, high energy consumption, air pollution, and water scarcity, which has increased the city's vulnerability. At the same time, socio-economic and institutional factors have driven poor people, with little choice, into building houses on steep hillsides and to occupy environmentally protected areas.

Under these circumstances, the poor and vulnerable have developed the ability to absorb shocks and reorganize while moving forward, as that is how they live their lives. As a result, the city and its inhabitants have reached a precarious balance that maintains the urban system's functionality despite ecological overshoot, which according to Rosales (2018), surpasses its carrying capacity by 90%.

This data highlights the urgency of an urban ecological restructuring that can change the current development trajectories. Therefore, a key question arises about the convenience of maintaining this fragile socio-environmental equilibrium and the *status quo*.

3.3. The urban ecosystem dynamics and interactions are not fully considered.

Even though the approach to resilience includes some spatial-environmental dynamics, underlying forces from urban ecosystem dynamics and interactions are not fully considered.

More promising and sustainable futures require comprehending fragility, non-linear interactions among flows, and exploring the capacity of urban systems to cope with short and long-term disturbances and changes.

Pickett *et al.* (1997) argue that the main reason to study urban ecosystems is that urban areas are responsible for many disturbances. Also, Biggs *et al.* (2015) state that an ecological knowledge base perspective helps build adaptive processes and shift current development trajectories toward new urban scenarios.

Therefore, exploring ecological aspects such as carrying capacity, environmental efficiency, and stability of ecosystem functions beyond climate change circumstances is vital to understanding endogenous factors that could drive disturbances and changes in urban systems. This aspect is a limitation of the approach to building Mexico City's resilience strategy.

To make the case, Table 3 presents information based on land uses to represent Mexico City's biocapacity (Rosales, 2018). This concept (biocapacity) relates to "the ecosystems' capacity to produce biological materials used by people and absorb waste generated by humans, under current management schemes and extraction technologies" (Global Footprint Network, 2022).

Tabla 3
Mexico City's biocapacity

Carrying Capacity	*Ha*
Capacity of fossil energy absorption. Capacity of fossil energy absorption is related to forest surfaces (172.22 km^2) and reforested areas (4 km).	17,622
Local capacity to support urban infrastructure. This is correlated with total built area, which corresponds to urban and industrial land use	59,192
Capacity for food production Food production is related to the agricultural and cultivable areas.	37,184
Pastures are associated with grassland, desert scrub and secondary vegetation.	34,527
Forest	17,222
Water and the category sea (water) is related to water bodies	284
TOTAL	166,031

Source: Rosales (2018).

At the same time, understanding the implications of this ecological base knowledge as an indicator of carrying capacity understood by Di Pace, (2012) as the maximum rate of consumption of natural resources and production of waste that can occur in a given region, without progressively destroying the functional integrity and productivity of the ecosystems on which it depends.

For instance, natural water availability shown in figure 3 confirms water scarcity scenarios and points out the city's significant vulnerability due to the strong dependency on external supply sources.

According to Comisión Nacional del Agua (Conagua, 2018), water stress in the region is up to 120%. This demand-driven scarcity implies that water supply systems operate beyond their limits. Water availability in the different municipalities already presents critical levels of scarcity.

However, World Resource Institute predictions (WRI, 2022) and data from Conagua show that the city is at risk of reaching Day Zero by 2028. This year could be the beginning of the point of no return and could lead the urban systems to a new state. Therefore, the functional integrity and productivity of the ecosystems on which the city depends should be considered an essential endogenous factor that could drive sudden changes and perturbances. Moreover, the decline in ecosystem services functionality impacts other urban subsystems. For example, water scarcity impacts energy consumption and fossil absorption. According to Tudela (1991), water transfer to supply the increasing demand extends about 130 kilometers, equivalent to the burning of 3.4 million barrels of fuel per year.

One more relevant environmental issue for the systemic analysis of cities and their vulnerabilities, as shown in table 3, is the limited local capacity to support urban dynamics, regarding energy supply. The city location is in a basin with no infrastructure for electricity generation, oil activities, or heavy manufacturing. Only 20% of electricity is generated within the area, while the rest comes from the National Interconnected System (Secretaría de Energía, SENER, 2009). These facts imply that the city is vulnerable to possible environmental sustainability crises such as energy shortages and needs to move towards alternative (backup) and diverse energy supplies.

At the same time, data on bio capacity provides a basis for the definition of key areas and planning for sustainability strategies. For instance, according to Climate Change Program (Sedema, 2014) the city produced 31.842 million tons of CO2 equivalent emissions (CO2e). Eighty percent is produced mainly through transport's energy consumption (electricity and fossil fuels) and solid waste (Centro Mario Molina, 2014). Modeled future scenarios estimate CO2e will increase to 37 million tons by 2025, while the actions proposed in PACCM 2014-2020 will only contribute to the reduction of 8 million tons of CO2e (Sedema, 2014). This information remarks on decarbonization's importance and demonstrates that increasing fossil energy absorption of 17,622 ha should be a key element in a resilience strategy.

The limited space available for food production shown in table 3 also becomes a critical environmental fact to contemplate when building the adaptive capacity of social-ecological systems. Climate change models

forecast substantial impacts on agriculture systems due to water shortages. These intertwined aspects make it a priority to think about food self-sufficiency and how to trigger sustainable urban agriculture as part of an urban resiliency strategy. Overall, the ecological information shows limiting factors, which are critical elements in understanding the co-evolution of socio-economic and ecological systems. Future shocks and disturbances could come from resource scarcity and ecological overshoot. These scenarios of resource scarcity could lead the city to a condition of ecological hysteresis. As Nikanorov and Sukhorukov (2008) defined, this concept relates to a process of degradation, which is not reversible by merely eliminating disturbances and may lead to new states. Also, this ecological knowledge makes evident that resilience strategies need to drive a dynamic process of adapting, transforming, and moving the city towards the water, food, and energy transitions.

Conclusions

This work examines how Mexico City Climate Change Action Program 2014-2020 approaches resilience and what are the advantages and shortcomings of the framework adopted to enable transformations toward sustainable urban futures. The literature review of prominent frameworks from resilience thinking shows that the theoretical foundation of this planning instrument is the disaster risk reduction approach. The examination of the conceptual and procedural content reveals that linking resilience to climate change mitigation and adaptation measures can assist in building the capacity to deal with changes in many ways.

It is evident that the systemic analysis of cities and their vulnerabilities helps consolidate response protocols to certain urban risks and natural disaster situations, like earthquakes, floods, and resource scarcity. Further benefits of linking resilience to tackling climate crisis include compact city policies, energy efficiency to reduce gas emissions, environmental enhancement, and containment of urban sprawl.

However, the critical assessment of the methodologies, strategies, and assumptions adopted in this planning instrument demonstrates three main shortcomings in disaster risk reduction to tackle resilience fully.

First, it overlooks underlying socio-environmental risk and vulnerability factors. The incorporation of resilience as a key concept in the climate change agenda, takes into account that the most vulnerable and poorest groups are more exposed to shocks and that they may not have the necessary resources to recover. However, development strategies to prepare urban areas to cope with increasing pressures and disturbances do not

analyze or present measures to change the conditions that give rise to vulnerability. Structural risk and vulnerability factors that are not considered are the unequal access to natural resources, disparities in infrastructure allocation, and preexisting environmental conditions. A second limitation is the poor way urban ecosystem dynamics and flows are considered to assess disturbances, stresses, and changes in socio-ecological systems. As demonstrated in this study, underlying environmental conditions such as biocapacity and ecological overshoot might represent endogenous factors leading to further slow and sudden changes in urban subsystems.

Third, strategies based on restoring preexisting conditions, which is one of the main assumptions of this approach, might preserve the *status quo* of more significant undesirable dynamics such as threatening environmental functionality, social inequality, and institutional inertia. Therefore, efforts should focus on building the adaptive capacity to change and transform these dynamics towards new development trajectories that are more sustainable. Resilience thinking, entails a transformative component that resonates within guiding cities towards sustainable transitions. Building urban environments that are more favorable for human life, preserving natural resources, and mitigating the effects on the environment must be part of a broader strategy focused on establishing transformative practices that could drive sustainable urban trajectories. Such urban transformative practices include solutions on how to carry out incremental adjustments to move the city to a circular metabolism (e.g., slow exploitation, goals for dematerialization, closing loops of water cycles, incorporating urban food systems, green and blue infrastructure; restoring environmental functionality of the ecosystems as a priority; and social justice and equity. There is an opportunity here: use the concept to forward a comprehensive change management process for transforming urban development in favor of human settlements to be inclusive, prosperous, resilient, and environmentally sustainable, as stated in Goal 11 of the 2030 Agenda for Sustainable Development (United Nations, 2015).

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