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Improve Urban Resilience to Reduce Disaster Risk

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ABSTRACT

People are drawn to cities as centers of economic activity, opportunity, and innovation. But cities are also places where stresses accumulate or shocks occur as a result of the changes that cities are exposed to from natural disasters as well as man-made disasters. Therefore, cities have become interested in resilience, as it is one of the recent trends in sustainable urban planning. Many cities in the world have tended to the concept of resilience and its application, as the results of studies confirmed that cities that have resilience characteristics are more able to face challenges and return to normal in a shorter time than similar cities. Therefore, the research aims to study the concept of resilience from an urban perspective and at the city level, by fully identifying how urban resilience is interpreted at the present time, and its characteristics, in addition to studying the city's resilience framework, goals, and indicators, as it can be used as a tool to achieve goals and development initiatives as well as follow-up tools.

Keywords: Resilience; Disasters Risk; Urban Resilience.

1-Introduction

The word "Resilience" is believed to have been derived from the Latin verb "resilire" which means to bounce back. " Resilience " became a popular term during the second half of the

seventeenth century to explain any countermeasures in the physical aspects. Figure 1 shows the graph of the development of the concept of resilience in various fields from 1950-2020 [1].

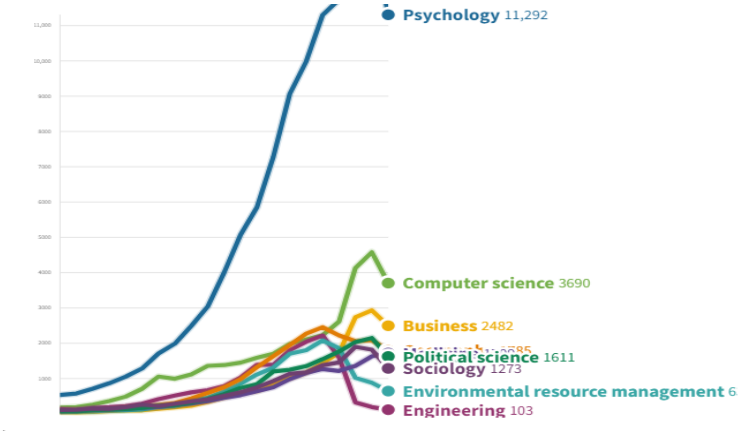

Figure 1. Resilience in various fields of study, 1950-2020 [2].

The concept of resilience has been used in various fields, including ecology, physics, sociology, urban systems, disasters, psychology, and social and environmental systems shown in Table 1. below.

Table 1. Explains the definition of resilience in various areas.

Fields of Study	Definition of resilience
Ecology	A measure of the continuity of systems and their ability to absorb change and disruption and still maintain the same relationship between populations or state variables [3].
Physics	The ability to resiliently store stress and deflection energy under load without breaking or deforming.
Social	"The ability of groups or societies to cope with external pressures and disturbances as a result of social, political, and environmental change"[4].
Urban Systems	"The degree to which cities endure change before reorganizing around a new set of structures and processes"[5].
Disasters	“The ability to prevent or protect against large multi-hazard threats and incidents, including terrorist attacks, and to recover quickly and rebuild critical services with minimal damage to public safety, health, the economy, and national security.”[6].
Psychology	“The process of coping well in the face of significant adversity, trauma, tragedy, threats, or sources of stress” such as economic, health, or family problems [7].
Social and Environmental systems	“The magnitude of change or perturbation that a system can experience without transforming into an alternative state that has different structural and functional properties and supplies”[8].

Resilience is the ability of human settlements and organizations to quickly recover and continue to thrive in the context of the increasing impacts of natural and man-made changes (e.g., increased urbanization), or disasters (e.g., industrial accidents). If we apply this to a city, a resilient city can absorb, adapt, transform, and prepare for past and future shocks and stresses. The economic, social, environmental, and institutional drivers of resilience can help cities become more adaptive, shock-absorbent, responsive to needs, resilient, resource-dependent, inclusive of all actors, and integrated across different sectors [3].

1-1. Research Aim

The study aims to take advantage of the potential of urban resilience in helping local governments monitor and review their cities in their ability to confront and reduce risks and disasters.

1-2. Research Methodology

The study used Theoretical study uses inductive methods to describe and define urban resilience, focusing on its concept, reasons, development, objectives, and strategies. The second phase of the research will involve the selection of case studies of cities that have implemented strategies to improve urban resilience. The selection will be based on pre-determined criteria such as the level of disaster risk, and the level of urbanization. Once the data is collected, it will be analyzed using both qualitative and quantitative methods. Key themes will be identified, and connections will be made between the factors contributing to urban resilience and effective interventions.

2. Literature review

2-1. Urban Resilience Concept

UN-HABITAT: A resilient city is a city that evaluates, plans, prepares for, and responds to all risks, whether sudden, slow, expected, or unexpected. Cities are able to protect people, secure and enhance an investable environment, and are able to keep pace with change [9].

100 Resilient Cities Foundation: The ability of individuals, communities, institutions, businesses, and systems within a city to adapt and thrive regardless of the types of chronic stresses and acute traumas to which they are exposed [10].

In a different study, **OECD: Organization for International Economic Co-operation and Development:** Resilient cities are cities that have the capacity to absorb, recover from, and prepare for future shocks (economic, environmental, social, and institutional). Resilient cities promote sustainable development, well-being, and inclusive growth. The Organization for Economic Co-operation and Development is studying how cities can increase their resilience [11]**.**

A resilient city is one that has developed capabilities to help absorb future shocks and stresses to its social, economic, and technical systems and infrastructure so that it remains able to maintain essentially the same functions, structure, systems, and identity by **Resilience Alliance** [12]**.**

Urban Resilience Hub Organization: The measurable ability of an urban system, together with its inhabitants, to maintain continuity through all shocks and stresses, while positively adapting and shifting towards sustainability [13]**.**

Definition of ResilientCity.org: It is the city that is able to absorb future shocks so that it remains able to maintain the same functions, social and economic structures, and its identity basically.

From the foregoing, a definition of urban resilience can be deduced as: "Urban resilience is a concept that includes environmental resilience, societal resilience, and engineering resilience, which allows changes to be detected and analyzed to improve the city's capacity and adapt to changes. It is the ability of individuals, communities, institutions, companies, and systems within a city to survive, adapt, thrive positively, shift towards sustainability, and return to a state of stability regardless of the Types of chronic stresses and acute shocks that they face, stressors are meant daily or periodic crises such as inefficiency of transportation, unemployment, lack of food and potable water, and pollution of all kinds.

3- The relationship between disasters and resilience

Resilience has often been associated with the ability of societies to withstand the impacts of climate change and disasters, which are the major development challenges of our time. Climate change is expected to increase the severity of the current dangers. In recent years, the definition of resilience has expanded to include key aspects that include not only natural hazards but also technological, social, economic, political, and cultural shocks and pressures.

Failure to pay attention to disaster risk reduction can lead to serious deterioration of the economy and ecosystems and loss of confidence of residents and investors. Disasters can severely disrupt community life - the systems that provide food distribution, water supply, health care, transportation, waste disposal, and communications.

We can't design for all of these unpredictable events, but we can make sure our buildings and cities are better able to weather these disruptions and bounce back afterward. More broadly, we need to be able to withstand the shocks of climate change, resource destruction and depletion, and a host of other growing challenges to human well-being [14].

3-1- Disaster risk

According to the definition proposed by the United Nations Office for Disaster Risk Reduction, a hazard is a process, phenomenon, or human activity that may cause loss of life, injury, other health effects, property damage, or social, economic, or environmental disruption. In line with this definition, it is possible to separate these hazards that cause loss of life or property as natural, technological, and man-made hazards [15].

- **Natural Disasters** are classified according to their origins as “geophysical” (earthquakes, volcanoes, land subsidence, avalanche, liquefaction, rockslide, landslide, etc.), “hydrological” (floods, landslides), “meteorological”, “climatic” (temperatures, hurricanes, etc.), and 'biological' disasters (epidemics, insect infestations). In the “Risk Classification and Risk Glossary”, disasters are categorized into 5 groups.

- **Technological disasters,** also known as man-made disasters cause massive destruction and death in society. In global databases such as the Emergency Events Database (EM-DAT), industrial disasters, nuclear disasters, dam accidents, large-scale fires, all kinds of transport accidents, and mining accidents [16].

3-1-1-Urban challenges

From earthquakes to floods, and rapid migration to cyberattacks, all cities face a range of shocks and stresses, both natural and man-made. Today, urban dwellers face additional and magnified challenges as a result of rapid urbanization, climate change, and political instability. Urban challenges have been identified by international organizations [17], namely:

- **World Bank,** Urbanization can contribute to sustainable growth if managed well by increasing productivity, allowing innovation and new ideas to emerge. The global need for

investment in urban infrastructure is more than $4.5 trillion annually, of which an estimated premium is 9%-27% to make this infrastructure low-emissions and climate-resilient.

• **UCCRN 2018,** 70 percent of cities are already dealing with the effects of climate change, and almost all are at risk. For example, more than 90 percent of all metropolitan areas are coastal, which puts most cities worldwide at risk of flooding due to rising sea levels and strong storms [18].

3-1-2 Natural Challenges

The United Nations Framework Convention (UNFCCC) defines climate change as "climate change attributable directly or indirectly to human activity altering the composition of the global atmosphere and this in addition to natural climate change. Climate variability is observed over similar time periods."[19].

• **Floods,** occur as a result of climatic changes in the UK, and because floods can be frequent and devastating, particular attention has been given to designing flood-resistant development. The average annual damage from coastal and riverine floods is estimated to be around £800 million [20].

Figure 2. Flooding in Houston, Texas in the aftermath of Hurricane Harvey

Figure 3. Eureka Missouri floods. Second major flood to hit the city in less than 18 months

• **Climate change,** Cities are central to the climate change challenge. On the other hand, urban areas are concentrated centers of economic activity, production, and consumption, and urban dwellers are responsible for the majority of greenhouse gas emissions. This makes cities crucial to the effective mitigation of climate change. On the other hand, urban areas are often particularly vulnerable to climate impacts, such as sea level rise, extreme heat, and flooding, making cities the focus of adaptation efforts. Climate risks are not distributed equitably within or between cities, with the poor and cities in the Global South affected disproportionately. To complicate matters

further, unequal climate impacts are often exacerbated by other political and economic processes, such as globalization [21].

3-1-3- Disaster Effects

Disasters take on new forms every year and their numbers and impacts increase [22]. It has been reported that the intensity of natural and man-made disasters has increased especially in the past ten years. The results of the study prepared by the Center for Research on the Epidemiology of Disasters (CRED) appeared in 2020 and covered the period 1980-2019. Between 1980 and 1999, 4,212 disasters were reported worldwide. While 3.25 billion disaster victims have been reported, and economic losses amounted to 1.63 trillion dollars; In the ten years that followed this period (2000-2009), 7,348 disasters were reported in our world. As a result of these disasters, 1.23 million people lost their lives, 4.03 billion people were affected by disasters, and economic losses amounted to 2.97 trillion countries. It was determined that disasters had increased very sharply compared to twenty years ago[23].

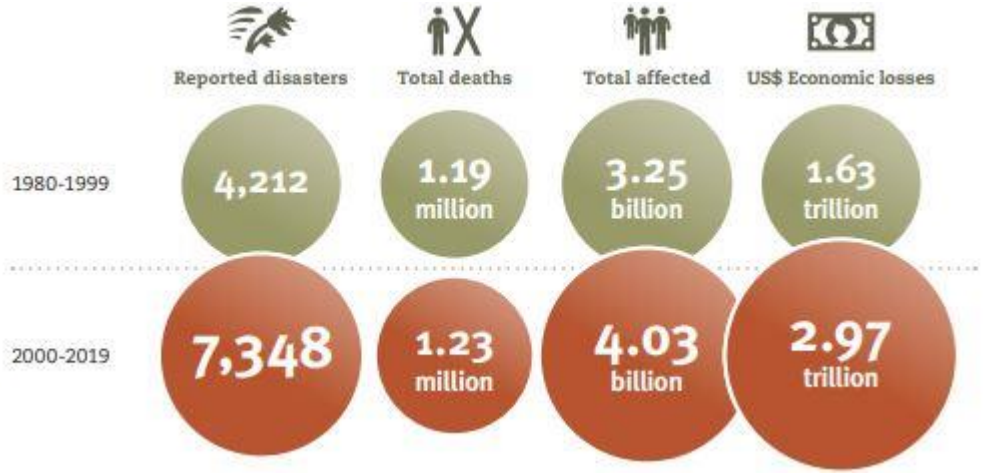

Figure 4. Disaster impacts between 1980-2019 [24].

Because a well-functioning city relies on the integration, interconnected performance, and interactive capabilities of complex infrastructure systems and services, enhancing its performance will increase resilience and improve disaster management. Timely emergency communication, for example, is critical, but existing systems fall short in terms of detecting, alerting, and assisting crises [25].

3-2. Dimensions of urban resilience

Building resilience requires a multisectoral, multidimensional effort and coordination of diverse interests and groups. Resilience must be taken into account more broadly, for example, at the level of what the OECD defines as urban areas, defined as “functional urban areas”. The global assessment tools for city resilience were developed. All the tools were based on the main topics considered by specialists as the main principles of city resilience [26].

There are four basic principles on which the idea of resilient cities is based, as shown in Figure 5:

- Health and quality of life
- The economy and society
- Infrastructure and environmental systems
- Governance and Strategic Leadership

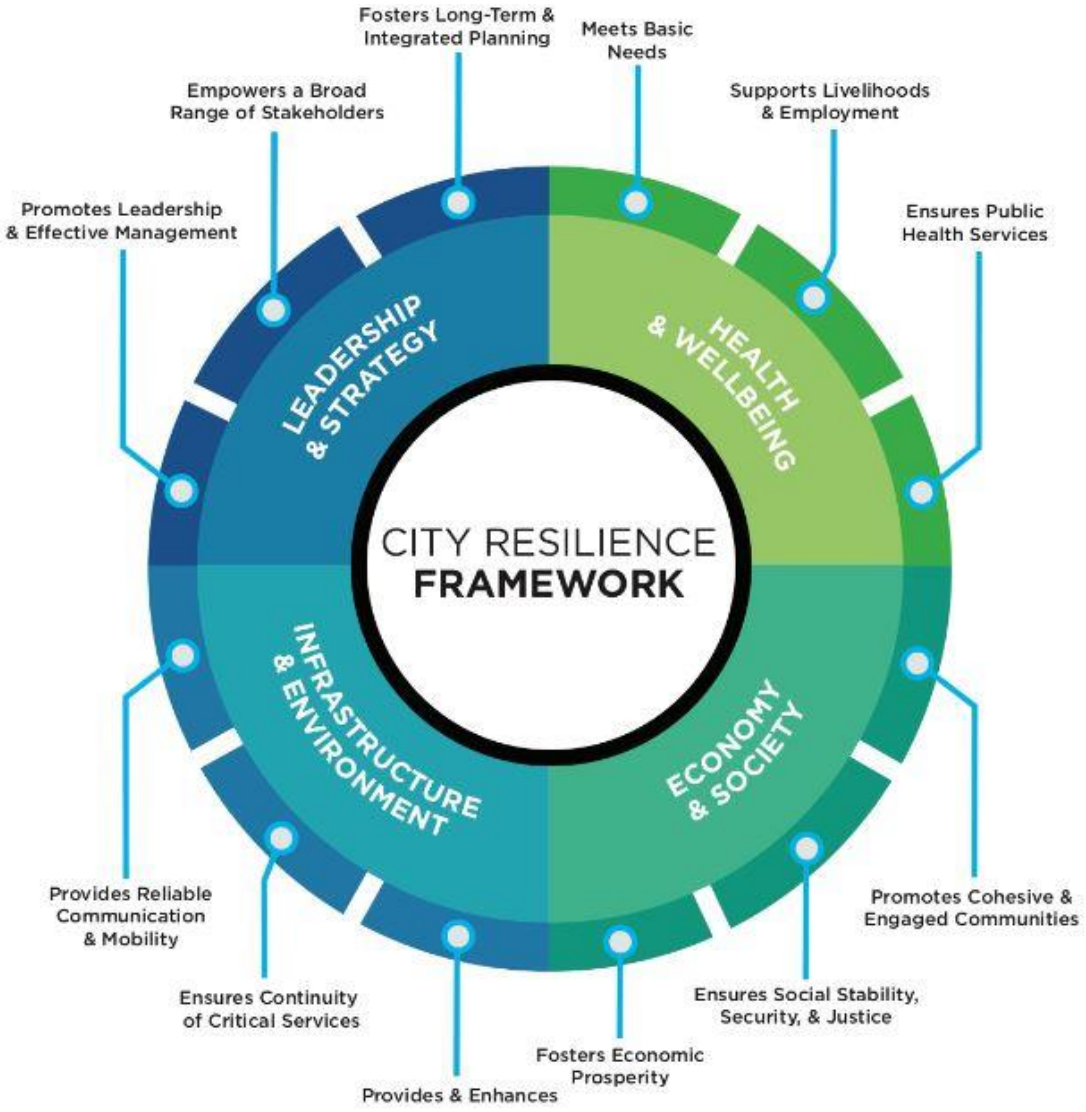

Figure 5. The 100RC made use of the City Resilience Framework (CRF) [27].

3-3. Urban resilience and its indicators

Specific and measurable outcome indicators can be used to track progress towards goals and resilience. This could include indicators on resource use, consumption, air and water quality, and green space measures. Examples include the ecological and water footprint, food supply, transportation shares, and solid waste generation and disposal. Additional indicators should be used to track social aspects such as social cohesion, which are also essential to strengthening

resilience. Monitoring systems should be based on common indicators, as far as space is concerned, in order to ensure effective use of reporting and reduce the burden on cities [28].

4. Method

This part provides a list of different criteria that can be used to develop a resilience assessment system. Although issues of contextual privacy should be taken into consideration when developing evaluation frameworks, attention is required to all relevant criteria to enhance the integrity and validity of content in the evaluation system. A detailed content analysis of 6 resilience assessment frameworks was conducted to extract key dimensions and criteria related to the resilience of urban systems. A full list of these assessment frameworks can be found in Table 2.

Table 2 Explored a list of resilience indicator systems.

Indicator systems	Year	The main focus	Developer(s)
Australian National Disaster Resilience Index (ANDRI**)** [29]	2020	**The resilience of society** In the face of natural hazards. It is based on two sets of capabilities: adaptive capacities and adaptive capacities.	Parsons et al., 2020 [29]
Resilient Capacity Index (RCI**)** [30]	2018	The way to assess the region's resilience is its quality to deal with future challenges and respond effectively to future pressures.	Resilience Index [31]
Baseline Resilience Indicators Communities (BRIC)[32]	2014	**The resilience of society** It is a complex process of interactions between different social systems, each with its form and function	Cutter et al., 2014 [32]
community disaster Resilience Index (CDRI)	2010	**Multiple dimensions** Social capital, economic capital, human capital, physical capital	Coastal Services Center and NOAA. Center [33]
Community Resilience Index (CRI2**)**[34]	2010	**Multiple dimensions** Cultural, physiological, economic, institutional, and natural factors all have a role.	Dr. Susan Cutter and her colleagues at the Hazard & Vulnerability Research Institute at the University of South Carolina
Disaster Resilience of Place (DROP)	2010	**Resilience is a set of capabilities** That can be strengthened through interventions and policies, which help build and strengthen the capacity to respond and recover from disasters.	Hyogo Framework [35]

Source: Author

A full list of these assessment frameworks can be found in Table 3. The extracted criteria have been divided into five categories (each referring to a specific dimension) according to their similarities. These are environmental materials and resources, society and well-being, economy, built environment and infrastructure, and governance and enterprise [36].

Table 3. Combined Resilience Indicators.

Sector	Dimensions	Factors	Indications	Resilient
Economy	**Information and Communication Technology**	ICT Infrastructure	1. The existence of wired and wireless networks	√
			8. Social and economic access to digital technologies, and the affordability of ICTs	√
			9. Enhancing Infrastructure Efficiency (Technology Modernization, Measurement)	√
			10. Emergency communication infrastructure (before, during, and after a disaster)	√
		Public sector	1. Availability and dissemination of data to make information open to the public	√
			2. E-Government	√
			3. Public sector e-procurement	√
			4. Public-private partnership	√
	Productivity	Innovation and the knowledge economy	1. Research and development expenditures	√
			2. Patents	
			3. Project funding (public/private, etc.) for smart cities.	√
			5. Number of new businesses and companies registered annually	√
			6. Investing in green jobs and the green economy (self-sufficiency, urban agriculture)	√
			7. Diversified economic structure and livelihood strategies	√
		Employment and unemployment	1. Unemployment rate	√
			2. Youth unemployment rate	√
			3. Employment rates and opportunities	√
			4. Job intensity (proximity to housing and work; extent of commuting outside the home)	√
			5. The working population's age distribution	√
			6. Qualifications of people in their working years	√
			7. Employment in the ICT sector	
			8. Savings by individuals and communities (stock of supplies, cash, etc.)	√
			9. Achieving a balance between supply and demand in the local labor market	√
			10. GDP per worker	√
		Transport	1. Intelligent/automatic street/pedestrian lighting management system using ICT	√
			2. The public transportation system, its quality, diversity, and multimodal	√
			3. In public transportation, performance, safety, and efficiency are essential factors	√
			4. Share transportation	√

			12. Operation and maintenance of efficient transmission	√
		Urban/Integrated Planning	1. Pedestrian infrastructure	√
			2. Street type and connection	√
			3. Urban development and spatial planning	√
			4. Comprehensive city monitoring and data management	√
			5. Green and blue infrastructure	√
			6. Online access and coordination of all urban public services	√
			8. Site selection and avoidance of danger areas and habitat areas (flood plains, prone to flooding; exposed coastal area, green fields)	√
			9. sustainability of public buildings	√
			10. Integrated Building Management Systems in Public Buildings	√
Environmental	**Environmental and Energy Sustainability**	air quality	1. Air pollution	√
			2. Greenhouse gas emissions	√
		Waste	1. Management of materials and resources (production, consumption, conservation, recycling)	√
			2. Efficient and intelligent collection, disposal, and treatment of solid waste	√
		environmental quality	1. Exposure to electromagnetic fields	√
			2. Exposure to noise	√
			3. Initiatives for green infrastructure and green cities	√
			4. Activities and initiatives to safeguard the environment and ecosystems	√
			5. Sustainable management of natural resources	√
		Public places and nature	1. Green/blue spaces (per person)	√
			2. Easy access to the green area	√
			3. Natural protected areas	√
			4. Recreational facilities	√
		energy	1. Renewable energy consumption	√
			2. Electricity consumption	√
			3. Energy intensity for the economy	√
			4. Resource availability and accessibility (air, energy, water, food, soil, etc.)	√
Social and cultural	**Education, health, and culture**	education	1. Students' use of ICT	√
			2. E-learning and distant education systems' availability and penetration	√
			3. School attendance	√
			4. Higher education degrees	√
			5. Adult Literacy	√
		health	1. Electronic health records/cards	√
			2. Life expectancy	√
			3. Death rate	√
			4. Medication Accreditation (Diagnostic and Telemedicine)	√
			5. Health care services and infrastructure for the individual	√

			6. Physical and mental health	√
			7. Preventive health measures	√
			8. Responsive health measures	√
			9. Health insurance/public health coverage	√
		culture	1. Cultural expenses	√
			2. Positive social, cultural, and behavioral norms	√
			3. Cultural infrastructure (attractions, sports infrastructure).	√
			4. The size and quality of community centers and public entertainment venues are important considerations.	√
			5. Protection and management of cultural heritage	√
	Safety, housing, and social inclusion	housing	1. Quality of housing (space per capita), reduction of slums	√
			2. Housing expenses	√
		Social integration	1. Gender equality in income	√
			2. Gender, racial, and cultural equality (access to opportunities)	√
			3. Attachment and a sense of belonging and interdependence to society	√
			4. Volunteering and civic participation in social networks	√
			5. Poverty rate	√
			6. Availability of child care	√
		Safety and Security	1. Disaster prevention, prediction, control, and emergency response using ICTs	√
			7. Use of technology and information and communication technology to predict, prevent and combat crime	√
			8. Security services such as the police	√
			9. Community safety and crime rate (for example, the number of crimes per 100,000 inhabitants)	√
			10. Digital security, information privacy, and security management (against hackers, etc.)	√

Source: Author

The indicators serve as a tool for monitoring and analyzing the current state of the cities, as well as a follow-up and evaluation tool for how the goals are being achieved. In order to monitor progress in becoming more resilient, local authorities should use indicators that measure resilience and analyze different schemes to find out the most important common indicators and the importance of the indicators.

Resilience indicators can significantly increase the resilience of basic infrastructures such as energy and water supply, mobility, information and communication networks, and stakeholder engagement. The indicator strategy takes into account human hardships as well as social and economic concerns. Three pillars underpin the proposed resilient cities measurement framework: improving people's well-being and building more inclusive, sustainable, and resilient societies.

4-1. Case Study

The COVID-19 pandemic has highlighted urban residents' growing importance of economic, environmental, and societal-cultural dimensions in their cities, indicating a growing resilience. Criteria for selecting a study sample:

a. The characteristics of the study sample are consistent with the research objectives.

b. Their achievement of resilient city indicators. Table 4 shows the city profile.

4-1-1. The Selected Case Study of New York City

It is the largest city in the United States and the most populous city in the United States. New York continues to invest in transportation, environment, safety, and other areas. **Table 4** shows the city profile [37].

Table 4. Information about New York City.

City profile	New York City
Inhabitants	8900000
Area	783.8 km2
City GDP	$1.5 trillion
Inflation Rate	4.4%
Household Income	US$67046

Source: Author

New York City, situated on the eastern coast of New York, spans 789 square kilometers and is surrounded by the Hudson and East Rivers. With an average elevation of six meters, the city's infrastructure is highly vulnerable to storms and has experienced multiple past hits.

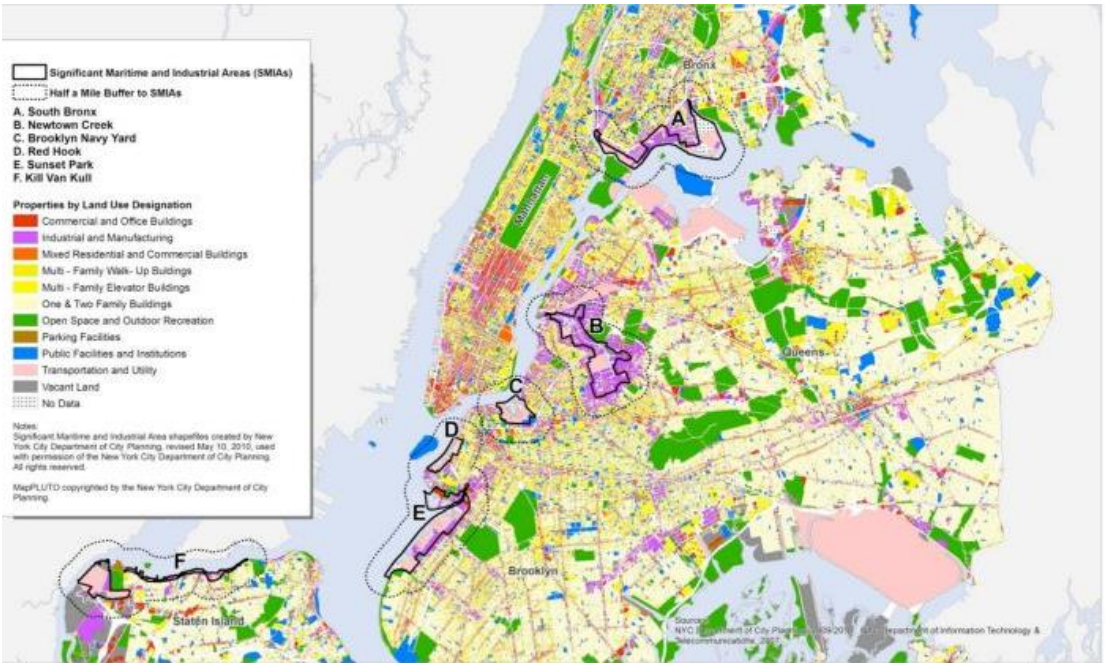

Figure 6. Land Use Map of New York [38].

4-1-2. Urban Resilience in New York

In 2015, New York City implemented a resilience plan focusing on four visions: thriving cities, fair and just cities, sustainable cities, and resilient cities. The plan prioritizes infrastructure, social resilience, community capital, environmental resilience, institutional resilience, and economic resilience. To become a resilient city, New York aims to respond to adverse events like Hurricane Sandy, provide jobs and essential services, and emerge stronger as a society. The plan includes upgrading private and public buildings, enhancing energy use and resilience to climate change, adapting infrastructure to weather extremes, and strengthening coastal areas against floods and sea level rise [39].

- **The Challenges face in New York City**

New York City has a large population, many economic activities, improved infrastructure, and social services. The problems facing New York City [40].

- Traffic congestion and housing cause inconveniences, delays, stress, and pressure.
- Air, water, and land pollution due to industrial and residential wastes.
- Developing slums with poor living conditions occupied by the unemployed and immigrants.

- Increased crime rates and social problems such as drug addiction due to the unemployed, such as immigrants.
- Ease of spread of infectious diseases due to the population such as cough, influenza and tuberculosis.
- Population unemployment leads to poor living standards.
- Limited land for expansion on Manhattan Island which makes land expensive.
- Racial discrimination such as African-Americans and immigrants caused conflicts and tension.
- Increasing the cost of living due to paying for basic needs such as food, shelter, and sanitation causes poverty

4-1-3. Results and Discussion

By reviewing New York's trends regarding achieving a resilient city through indicators resulting from the theoretical study. New York City has undertaken the necessary strategies and initiatives to improve the efficiency of a resilient city and is able to withstand disasters. The following are some of the main aspects of the experiments to achieve the development of a resilient city:

- Advanced Infrastructure: It has modern infrastructure including a robust transportation system, high-speed broadband networks, and a comprehensive waste management system.
- Use of technology: Embrace technology and data to drive innovation and improve urban services.
- Smart grid systems to improve city operations and services to implement integrated and sustainable transport systems, green mobility solutions, and develop flexible infrastructure to adapt and deal with risks.
- Enhancing citizen participation and cooperation through digital platforms and open data initiatives
- Investing in education, research, and innovation to support the development and implementation of energy-efficient buildings and renewable energy sources

5. Conclusion

Resilient cities are those that plan proactively and plan strategies that will help them develop the capabilities needed to meet the challenges of tomorrow. A resilient city can stand up to both expected and unexpected developments on a global, regional, and local level. That is, it is a socially, physically, and digitally resilient city that takes measures to reduce its vulnerabilities.

The resilience of cities includes several dimensions: social, economic, environmental, and infrastructural. Social resilience refers to the ability of societies and individuals to deal with pressures and crises, maintain social networks, and stakeholder needs. As for economic flexibility, it emphasizes the ability of the local economy, promoting the green economy, preserving job diversity and income, and supporting business continuity. Environmental resilience refers to the ability of urban systems and infrastructure to adapt to changing environmental conditions, maintain environmental balance, and support the continuity of basic services.

The study contains the most important challenges, including: In building resilient cities: insufficient funding, conflicting priorities, lack of coordination among stakeholders, and insufficient public participation and awareness. Despite these challenges, cities can improve their resilience through partnerships with cities and organizations, and prepare the city for disasters using ICTs.

In the end, this research sought to clarify the role of indicators as a tool for monitoring and analyzing the current situation of cities, as well as tools for follow-up and evaluation of how to achieve the goals. This research suggested a complete indicator through the conceptual suggestion of chosen methods to assess indicators in Figure 7.

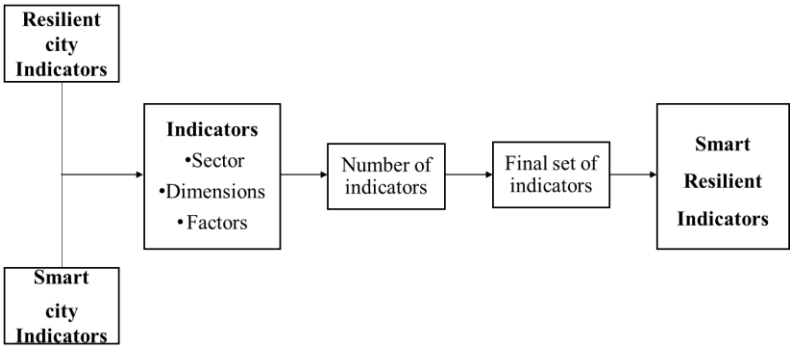

Figure 7. Evaluation of performance in the direction of a smart resilient city [41].

6- Future work

As new technologies emerge, it may be necessary to investigate their potential applications in improving urban resilience. For example, artificial intelligence and big data analytics may be useful in predicting disaster events and identifying vulnerable populations.

Engaging with stakeholders to promote the implementation of recommended strategies will be essential for success. Future work should focus on developing effective engagement strategies to facilitate collaboration between policymakers, urban planners, and community leaders.

- **Conflict of Interest**

  The authors declare no conflict of interest.

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