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Research Article

Assessment of Urban Resilience against Climate Change in Alexandria City, Egypt using a modified framework of Baseline Resilience Indicators for Communities

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ABSTRACT

In recent years, Climate change has added significant challenges and pressures to cities, especially coastal cities, and with the persistence or increase of these challenges, there is an urgent need for strong urban resilience frameworks to help cities enhance their resistance. In this context, this paper aims to assess the level of urban resilience of the city of Alexandria, Egypt, to help its policy makers adopt appropriate strategies and actions to enhance its resistance against the challenges resulting from the major climate changes that will occur in the near future. The process of assessing the level of urban resilience of Alexandria city was based on measuring many indicators within five main dimensions of resilience: socio-economic, community capital, environment, infrastructure and Housing in each neighborhood of the city using a modified framework of Baseline Resilience Indicators for Communities (BRIC). The index incorporated a set of relevant indicators for each dimension, and resilience scores were calculated for both individual neighborhoods and the city as a whole. The paper concluded that there are significant disparities in the level of urban resilience between the different neighborhoods of Alexandria and concluded that the level of overall urban resilience of the city needs many corrective actions in order to be able to withstand the potential environmental challenges.

Keywords: Assessment; Urban Resilience; Climate Change; Impacts; Alexandria City; Baseline Resilience Indicators for Communities (BRIC)

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1. Introduction

The destructive effects of climate change are increasingly evident through the rise in various critical phenomena: among these are abrupt shifts in weather patterns, earthquakes, volcanic activity, hurricanes, flooding, sea level rise, drought and wildfires. Coastal cities—home to a substantial portion of the global population—are anticipated to endure severe consequences, which will likely result in extensive damage to essential infrastructure. This dire situation may necessitate the relocation of millions of coastal residents (Datola, 2023; Jamali et al., 2023). The impacts of climate change extend inland, landlocked cities and many of their components such as residential and service buildings, infrastructure such as ports, highways, railways, power plants, water and sewage, as well as economic sectors such as industry, agriculture, fisheries and others, which are necessary for inland communities, are also exposed to severe risks (Michel & Pandya, 2010).

In light of these pressing concerns, the concept of "urban resilience" has assumed considerable significance as a fundamental principle for tackling the intricate challenges presented by urban shocks and disruptions. Urban resilience is essential for addressing urban shocks and disruptions; it emphasizes cities' abilities to absorb, adapt and recover effectively. Additionally, it offers valuable insights into social interactions during crises, evaluating adaptive capacities through collective identity and cohesion (Fariniuk et al., 2022).

The assessment of resilience empowers urban centers to ascertain their existing status, guide strategic initiatives and monitor progress. Urban resilience necessitates a multifaceted approach that considers complex interrelations. The Baseline Resilience Indicators for Communities (BRIC) (Sharifi, 2016) serves as a significant index for a comprehensive evaluation of disaster resilience across various dimensions.

The purpose of this study is to develop community resilience index for Alexandria utilizing an approach grounded in the Baseline Resilience Indicators for Communities (BRIC) framework. Five primary dimensions were incorporated into the index's development; housing, infrastructure, community capital, social and economic considerations and environmental concerns. The index is based on 29 carefully selected indicators that reflect different aspects of urban resilience in the city. The resulting maps illustrate the geographical distribution of resilience levels across Alexandria's neighborhoods, helping to identify areas with high resilience and those with limited capacity to adapt to climatic and urban challenges.

This study seeks to achieve the following objectives:

- Analyze community resilience in Alexandria's neighborhoods across five key dimensions.
- Identify resilience gaps to pinpoint areas vulnerable to environmental and urban risks.
- Offer an analytical tool for policymakers to enhance climate adaptation and urban resilience strategies.

2. Urban Resilience and Measurement Approaches

2.1. A Brief Insight into Urban Resilience

The term resilience has its origins in the disciplines of physics, engineering, psychology, economics, and ecology, which were between the first to use it frequently (Müller et al., 2000). In the 1970s, Holling made a significant contribution to the understanding of resilience in ecology. He systematically introduced resilience as a way to measure an ecosystem's stability and its capacity to adapt to changes while maintaining stable relationships between population dynamics and environmental factors (Holling ,1973). By the 1990s, the notion of resilience started to gain popularity in urban planning (Shi et al., 2022), mainly focusing on the sustainable development of urban systems in the wake of disasters such as floods, epidemics, and climate change.

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There are three Faces of urban resilience: engineering resilience, ecological resilience, evolutionary resilience (Lowe et al., 2021; Davoudi et al., 2013). In the engineering resilience, resilience is defined regarding the speed of recovery or return to equilibrium after disturbance where the efficiency and predictability are prioritized (Davoudi et al., 2013). This perspective highlights the critical role of infrastructure in absorbing shocks — from the physical structure of buildings to the social enablers of housing, utilities and power systems. Ecological resilience focuses on resilience under stress and recovery after disruption (Holling,1996). It measures the amount of stress a system can withstand before its structure changes (Abdulkareem et al., 2018).

Conversely, evolutionary resilience posits that long-term changes such as urbanization, socioeconomic development, demographic shifts, and city interconnections are complex and dynamic (Wardekker, 2021). Instead of a "return to normalcy," resilience is viewed as the ability of socio-environmental systems to alter, adapt, or evolve in response to stresses and strains. Systems undergo a four-stage adaptive cycle affecting their structure and functioning. This perspective emphasizes that the past is not a reliable predictor of future behavior, focusing on disturbances, whether acute shocks or chronic strains (Davoudi et al., 2012).

2.2. Assessment methods & approaches

Several authors have tried to develop methods to measure resilience. They are related to the measurement of resilience to other properties that have some means of verification, either through direct or indirect observation. Furthermore, there are different ways to measure resilience, either by using surrogates, mathematical or spatial models or more recently by developing multidisciplinary indices (Khatibi et al., 2022).

The methods used so far in evaluation fall roughly into three categories: indicators, scorecards, and tools (Cimellaro, 2016).

•An indicator combines a set of individual indicators into a single measure. Index construction is usually a top-down approach, based on existing quantitative data

•Scorecards are used to assess progress towards a given objective by asking questions about the presence or absence of certain attributes and scoring them on a scale (e.g. from 1 to 10, from very poor to excellent)

•Tools, including both models and instruments. Models create simplified representations of processes using mathematical formulas and/or matrices to approximate and understand real-world relationships and interactions. Tools or toolkits have been developed to provide guidance for assessing resilience with sample procedures and survey instruments, or data for use in compiling indicators or scorecards (Cutter,2016).

Measurable indicators are essential for several reasons. They enable monitoring of resilience building, provide objective and unbiased results, and build a knowledge base that helps make resilience more visible and tangible to decision-makers, policy-makers, and society at large (Feldmeyer et al., 2019).

Urban resilience assessment approaches vary between qualitative and quantitative approaches, with each complementing the other in providing a comprehensive picture of the resilience of urban systems.

•Using qualitative approaches always give more precise and accurate approach when it comes to knowing things from local experts and the community that is affected. Such methods are quite useful where there is no access to quantitative data however they are not mathematically accurate and that arguably is a flaw of its own (Yang et al., 2021).

• Quantitative approaches are always more effective when applied in juxtaposition with statistical models as they are then able to measure resilience on a greater level, in relation to time and cities. Such models are ideal to recognize areas of weakness and accordingly divide resources. However, there is a precise situation where these approaches are also more effective, qualitative models, aid in providing further context for resilience (Kong et al., 2022).

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2.3. BRIC: Baseline Resilience Indicators for Communities

The Baseline Resilience Indicators for Communities (BRIC) seem to use the Place Resilience Model (DROP), which was designed to analyze the various aspects of community resilience to natural hazards as its theoretical guide. The DROP model aims to provide a comparative evaluation of the potential for disaster recovery at the local community level by depicting the interaction of the factors of inherent resilience (resilience before any event) and inherent vulnerability. This helps to understand why some communities are better prepared to deal with disasters than others (Cutter et al., 2008)

The BRIC index assesses and visualizes agglomeration before the occurrence of any major disaster. It employs a top-down method where Neighborhoods are treated as complex systems that are composed of social, economic, infrastructure, and other forms of capitals, all of which exist primarily to supplement the ability of the community to withstand or recover from crises. Community resilience is assessed using the BRIC methodology in six dimensions, each of these also has specific indicators that are theory justified. A total of 49 indicators are analyzed, covering various aspects of resilience. These dimensions include the economic capacity and sustainability of the community, social cohesion and adaptability to risks, the role of social capital in improving disaster response, the ability of institutions to manage crises, the capacity of infrastructure and housing to withstand unforeseen events, and the resilience of ecosystems in the face of climate change and natural disasters (Cutter et al.,2014)

3. Materials and Methods

The construction of the resilience index for Alexandria is based on the BRIC framework, which was designed by Cutter et al. for the American context (Cutter et al.,2014). However, due to the unique contextual circumstances, it was necessary to adapt the list of indicators, following the approach in these studies (Singh-Peterson et al., 2014; Scherzer et al., 2019; Javadpoor et al., 2021). Overall, the BRIC framework was used as a guide for selecting and developing indicators and dimensions.

3.1. Study area

Alexandria, located on the Mediterranean coast at 29.87°E longitude and 31.17°N latitude, is Egypt's second-largest city and the Mediterranean's most significant urban center. The city is divided into nine districts, including Montazah (1,2), Sharq, Wasat, Gharb, Gamrak, Ajamy, Ameriya (1,2) (World Bank, 2008), as shown in Figure1.

Alexandria has a semi-arid climate, with hot, dry summers and mild, wet winters, receiving 200 mm of annual rainfall—higher than Egypt's national average (Khatri et al.,2007). Heavy rains from October to March often overwhelm the city's insufficient drainage systems, causing flooding and infrastructure disruptions. Climate change is expected to intensify these challenges, increasing extreme weather events and worsening urban resilience.

Figure 1. Alexandria Governorate and its administrative divisions, showing the study area (Alexandria City)

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3.2. Indicator Selection

In the first phase of indicator selection, an initial list of 134 indicators was drawn from various references (Cutter et al., 2010; Aksha et al.,2020; Singh-Peterson et al., 2014; Scherzer et al., 2019; Javadpoor et al., 2021; Burton et al., 2014; Pazhuhan et al., 2023; Moghadas et al., 2019; Opach et al., 2020). However, some indicators were deemed unfeasible for implementation in Egypt due to the absence of relevant programs, such as the percentage of communities classified as "Storm". After refining the selection, 33 indicators were chosen based on data accuracy, reliability, and relevance to the Egyptian context. The data sources included the Central Agency for Public Mobilization and Statistics and the General Administration for Information and Documentation in Alexandria Governorate. The final selection prioritized accessibility, quality, and pertinence, ensuring a comprehensive yet precise representation of Alexandria's social and economic environment.

Due to variations in measurement units and data scales, a standardization method employing minimum and maximum values was implemented. This technique transformed all indicators into a common scale (0 to 1), thereby eliminating the influence of extreme values while maintaining comparability.

To maintain consistency in result interpretation, indicator directions were adjusted so that higher values corresponded to greater resilience. The highest resilience level was represented by 1, while the lowest was marked as 0. For indicators requiring reversal, standardized scores were recalculated as 1 minus their values. This adjustment ensured a unified and intuitive approach to analyzing and comparing resilience levels across Alexandria's neighborhoods.

3.3. Development of Dimensions and indicators for the Community Resilience Index (BRIC)

Every indicator belongs to a particular BRIC framework dimension to maintain systematic assessment of resilience. The accurate assessment of resilience demands careful selection and justification of indicators because of its complicated nature. Additional references in Appendix 1 provide further insights. The institutional dimension was excluded due to unreliable data.

The social dimension contains nine different indicators which comprise both working-age population as well as healthcare accessibility (Cutter et al.,2014). The working-age population enhances community strength but both children and the elderly remain vulnerable (Cutter et al., 2010). The economic dimension contains six indicators which assess economic stability through employment levels yet this sector together with agricultural production and tourism remain at risk (Scherzer et al., 2019).

Community capital indicators (four) explore social networks and participation, while the infrastructure and housing indicators (seven) measure road maintenance and delivery of emergency services and access to contemporary housing. Seven indicators in the environmental dimension evaluate food security and sustainability according to Scherzer et al. (2019). Table 1 provides statistical data.

Table 1. Statistics related to final indicators in the Community Resilience Index.

Resilience Dimension	Indicator Description	Max. Value	Min. Value	Mean	Standard Deviation
Social Dimension					
SOC1	Percentage of population in working age (15-65 years)	72.2%	44.3%	59.3%	7.85%
SOC2	Percentage of households with phone service	100%	6.5%	70.5%	27.22%
SOC3	Literacy rate (able to read and write)	98%	28.4%	65.9%	16.19%
SOC4	Percentage of population not dependent on social welfare	99.6%	79.3%	90.8%	5.85%
SOC5	Percentage of population with health insurance coverage	70.3%	13.8%	31.6%	18.36%

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SOC6	Percentage of population without sensory, physical, or mental disabilities	99.6%	79.3%	91.7%	6.63%
SOC7*	Population change over the last 10 years	14.3%	-2.3%	4.3%	5.6%
SOC8	Number of doctors per 1000 people	3.83	0.07	0.879	0.736
SOC9	Ratio of men to women	1.2	0.98	1.06	0.051
Economic Dimension					
ECO1	Percentage of housing units occupied by owners	85%	16.3%	30.9%	16.71%
ECO2	Percentage of employed workforce (employed persons)	95.3%	63.2%	88.5%	6.05%
ECO3	Percentage of female workforce participation	22.5%	5.4%	12.3%	4.07%
ECO4	Number of licensed vehicles per 1000 people	214.9	17.6	89.104	44.602
ECO5	Percentage of workers in public administration, defense, social security, or municipal activities	28%	1.2%	7.7%	6.62%
ECO6	Percentage of workers not in primary economic sectors (agriculture, fishing, mining, or tourism)	94.4%	58.3%	83%	8.53%
Human Capital Dimension					
HC1	Childcare facilities per 1000 people	0.149	0.01	0.084	0.034
HC2	Number of non-governmental organizations per 1000 people	1.43	0.042	0.496	0.278
HC3	Number of sports facilities per 1000 people	0.54	0.007	0.1005	0.1316
Infrastructure and Housing Dimension					
INF1	Hotels and motels per 1000 people	0.148	0	0.029	0.029
INF2	Fire, police, and ambulance stations per 1000 people	0.057	0.003	0.022	0.0127
INF3	Schools per 1000 people	0.75	0.098	0.422	0.17
INF4	Paved road length (km) (internal roads)	644.17	18.7	285.6	175.6
INF5	Percentage of residential buildings built in the last 30 years	98.9%	21.1%	71.1%	23.8%
INF6	Number of hospital beds per 1000 people	8.33	0.0326	2.05	2.24
INF7	Vacancy rate of housing units	64.8%	3.5%	29.4%	14.68%
Environmental Dimension					
ENV1*	Average energy consumption per capita (million kWh)	5574	145.3	1753.8	1322.1
ENV2*	Average annual water consumption (thousands m^3/year)	179484	9485	72822	39040
ENV3	Percentage of public garden area	2.8%	0%	1.2%	0.85%
ENV4	Percentage of arable land (cultivated)	96.4%	0%	19.2%	28.16%

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Note: Asterisks (*) indicate variables measured inversely during the process

3.4.Constructing the index

A key advantage of using Baseline Resilience Indicators for Communities (BRIC) lies in its inherent simplicity and its structured design. BRIC employs a hierarchical approach predicated on aggregation and averaging. The process commences with data transformation utilizing minimum-to-maximum scaling method (Equation 1). Indicators within each sub-dimension are aggregated into sub-indicators (Equation 2) which, however, are re-scaled for consistency prior to final aggregation into the resilience index (Equation 3). BRIC studies (Cutter et al., 2008; Cutter et al.,2014; Javadpoor et al., 2021; Cutter et al., 2010) assign equal weights to all indicators and sub-indicators; this ensures a balanced assessment, although some may argue that it overlooks potential disparities.

The equations employed within this framework are:

The min-max normalization: this equation serves to standardize the data, with each value of the indicator modified into a spectrum that spans from 0 to 1.

$$Min - Max : X_0 = \frac{X - X_{min}}{X_{max} - X_{min}} \quad (1)$$

Sub-indicator calculation: After normalization, the transformed values of the individual indicators within each sub-domain of resilience are summed, and then the average of these values is calculated to form the sub-indicator.

$$Dimension\ Score: D = \frac{1}{N}\sum_{i=1}^{n} X_{i\ (norm)} \quad (2)$$

Formation of the final community resilience index: the sub-indicators are aggregated to obtain a final value that represents the overall community resilience index.

$$BRIC(score) = \sum_{i=1}^{n} D_i \quad (3)$$

To evaluate resilience across multiple dimensions, mean ± SD (Z scores) were utilized to classify districts into five unique levels of resilience.

$$Z = \frac{x-\mu}{\sigma} \quad (4)$$

Districts that achieved Z scores exceeding 1.5 were categorized as possessing a high level of resilience; however, those whose scores fell between 0.5 and 1.5 were seen as demonstrating a comparatively high resilience. Scores that ranged from -0.5 to 0.5 signified moderate resilience, while those from -1.5 to -0.5 indicated relatively low resilience. Finally, scores that dropped below -1.5 were interpreted as reflective of low resilience.

The Moran's I spatial autocorrelation test was utilized to examine the spatial distribution of resilience. This test assesses the extent of spatial dependence among districts; categorizing distribution patterns as clustered when Moran's I approaches +1, dispersed when it nears -1 and random when it hovers around zero. This methodology identifies whether resilience levels demonstrate spatial correlation across districts, thereby highlighting patterns of clustering, dispersion, or randomness (Ren et al., 2020). The formula is:

$$I = \frac{N}{\sum_j \sum_i w_{ij}} * \frac{\sum_j \sum_i w_{ij}(X_i - \bar{X})(X_j - \bar{X})}{\sum_i (X_i - \bar{X})^2} \quad (5)$$

In this formula, N is the total number of spatial units, X_i and X_j are variable values in regions i and j, and $\bar{X}$ is the mean value. w_{ij} represents spatial weights, defining interactions between regions, while $\sum_j \sum_i w_{ij}$ sums all spatial weights

3.5. Internal Consistency of the Community Resilience Index

The reliability of index ensures accuracy in assessing resilience: Cronbach's alpha measures internal consistency within each dimension, with values ranging from 0.70 to 0.95 indicating strong reliability (Cutter et al.,2014; Cronbach, 1951). When calculating reliability of index as a whole, however,

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Stratified Alpha is employed instead of Cronbach's Alpha; this is because Stratified Alpha proves to be more appropriate in instances where indicators are aggregated into multiple sub-dimensions that differ in nature (Rae, n.d.).

After removing four indicators that were compromising the reliability of the index, the stratified alpha coefficient improved to 0.718, indicating an acceptable level of reliability, as shown in Table 2.

Table 2. Cronbach's alpha and correlation coefficients for dimensions.

Resilience Dimensions	Number of Indicators	Cronbach's Alpha	SOC	ECO	HC	INF	ENV
SOC	9	0.766	1				
ECO	6	0.216	0.913**	1			
HC	3	0.493	0.634**	0.647**	1		
INF	7	0.357	-0.161	-0.020	0.278*	1	
ENV	4	0.176	-0.346**	-0.363**	-0.037	0.047	1
Resilience Index	29	0.692	0.731**	0.758**	0.897**	0.347**	0.121
Stratified Coefficient Alpha	**0.718**						

Note: ** indicates a significant correlation at $p<0.01$ p<0.01, and * indicates a significant correlation at $p<0.05$ p<0.05.

The social dimension showed the highest reliability (α = 0.766), indicating strong internal consistency. The economic dimension had lower reliability (α = 0.216) but a strong correlation with the social dimension (r = 0.913, p < 0.01), as shown in Figure 2. Community capital exhibited moderate reliability (α = 0.493) and significant correlations with social (r = 0.634) and economic (r = 0.647) dimensions. Infrastructure (α = 0.357) and the environment (α = 0.176) had weaker reliability, with the latter negatively correlating with social and economic resilience.

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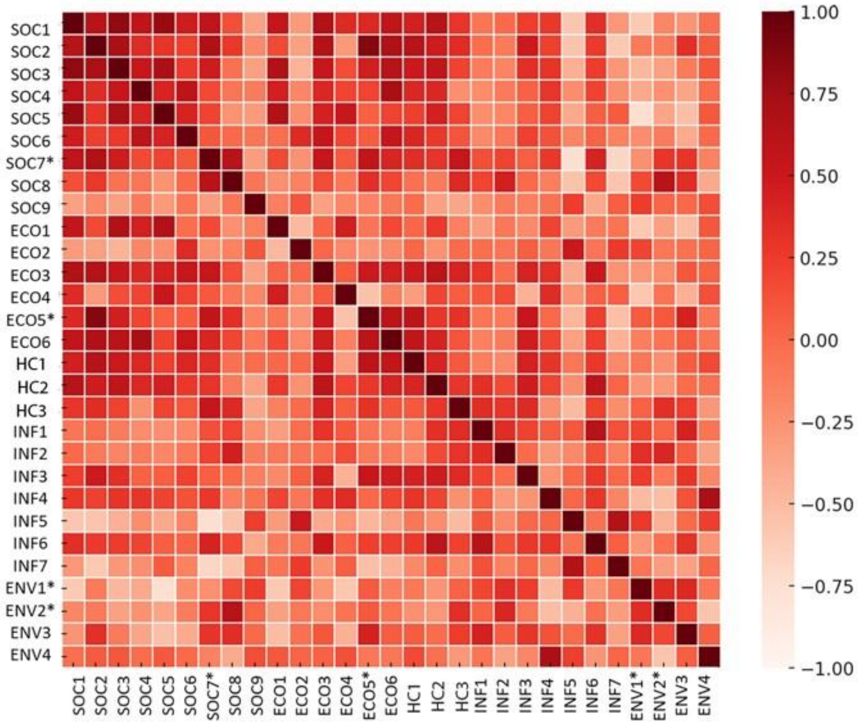

Figure 2. Correlation Matrix of Pearson Coefficients for 29 Indicators

3.6. Robustness check test

Test robustness is a procedure used to verify the stability and accuracy of results when certain assumptions or input data are changed. Its aim is to ensure that the model or indicator reflects consistent and generalizable results, even with slight changes in the inputs (Lu & White, 2014). To test robustness, an alternative indicator was created using Principal Component Analysis (PCA), where seven components were retained, explaining 82.6% of the variance in the data. Before applying PCA, the suitability of the data was verified using the KMO and Bartlett's Test. The KMO value was 0.651, which is within the acceptable range (more than 0.6), indicating that the sample is sufficient for analysis. The results of Bartlett's Test showed that the Chi-Square value was 1797.169 with 406 degrees of freedom, and the statistical significance was less than 0.001, which means that there is sufficient correlation between the variables.

PCA was applied to reduce the dimensions of the data and extract the main components that explain the largest portion of the variance. The principal components were used to determine the weights upon which the alternative indicator was constructed. Then, the alternative indicator was compared with the original indicator using Pearson's correlation coefficient, with the result showing a strong relationship ($r = 0.828$), indicating that the alternative indicator reflects the same patterns as the original indicator. This strengthens the credibility of the alternative indicator and confirms the robustness of the original indicator.

4. Results and discussion

4.1. Urban resilience in Alexandria: Neighborhood Variations

The average overall resilience index for the seven neighborhoods was 2.225, with a standard deviation of 0.314. Figure 3 shows the results of urban resilience in Alexandria city at the level of the five dimensions. The "Wasat" neighborhood recorded the highest score of 2.702, while the "Ameriya" neighborhood had the lowest score of 1.610, as shown in Table 3.

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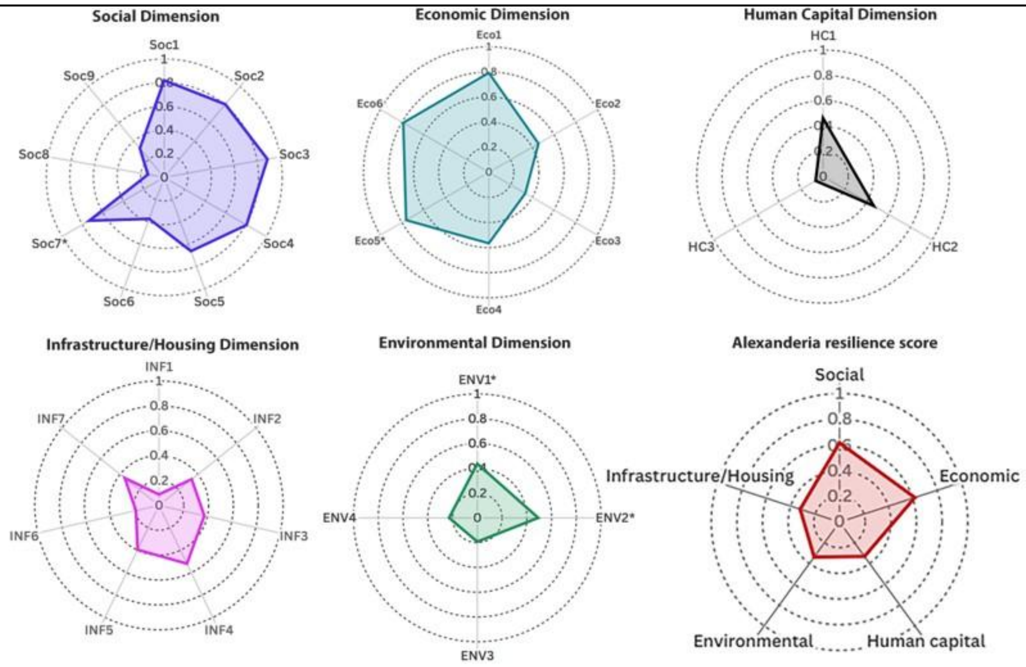

Figure 3. Values of the dimension's indicators for the city and the overall resilience index for the city of Alexandria.

Table 3. Resilience Scores and Z-Scores for Alexandria Districts Across Dimensions.

District	**SOC**	**ECO**	**HC**	**INF**	**ENV**	**Resilience Index**	**Z-Score**
Montazah (1-2)	0.616 (6)	0.675 (2)	0.309 (4)	0.334 (3)	0.175 (6)	2.109 (6)	-0.520
Sharq	0.640 (3)	0.679 (1)	0.358 (2)	0.313 (5)	0.458 (1)	2.448 (2)	0.735
wasat	0.637 (5)	0.624 (4)	0.563 (1)	0.465 (1)	0.413 (3)	2.702 (1)	1.498
Gharb	0.668 (2)	0.569 (6)	0.286 (6)	0.225 (7)	0.375 (4)	2.122 (5)	-0.510
Gamarek	0.685 (1)	0.616 (5)	0.339 (3)	0.248 (6)	0.449 (2)	2.337 (3)	0.377
Agamy	0.640 (4)	0.648 (3)	0.308 (5)	0.325 (4)	0.322 (5)	2.242 (4)	0.071
Ameriya (1-2)	0.429 (7)	0.509 (7)	0.155 (7)	0.347 (2)	0.170 (7)	1.610 (7)	-1.967
Total Alexandria	**0.617**	**0.617**	**0.331**	**0.323**	**0.337**	**2.225**	**-0.036**

This variation in scores reflects the significant differences in adaptive capacity between the neighborhoods. These scores represent a comprehensive measure that combines the five dimensions, where the resilience score for each dimension is calculated based on a set of sub-indicators. The results are illustrated in Figure 4.

The social dimension results indicate that over half of Alexandria's neighborhoods demonstrated moderate resilience levels, with the district of Gamarek achieving the highest score (0.685) as shown

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in Figure 5. This district's superior performance can be attributed to its demographic stability and favorable age distribution, with a high proportion of its population in the working-age group (15-65 years) (Timalsina & Songwathana, 2020; Cvetković & Šišović, 2024). This demographic composition facilitates economic activity and reduces dependency rates, allowing resources to be allocated more efficiently. Additionally, Gamarek benefits from relatively stable population growth, which mitigates the strain on public services and infrastructure. In contrast, Ameriya recorded the lowest social resilience score (0.429), primarily due to imbalance between male and female ratio, a high proportion of dependents (children and elderly), and limited access to social safety nets such as health insurance.

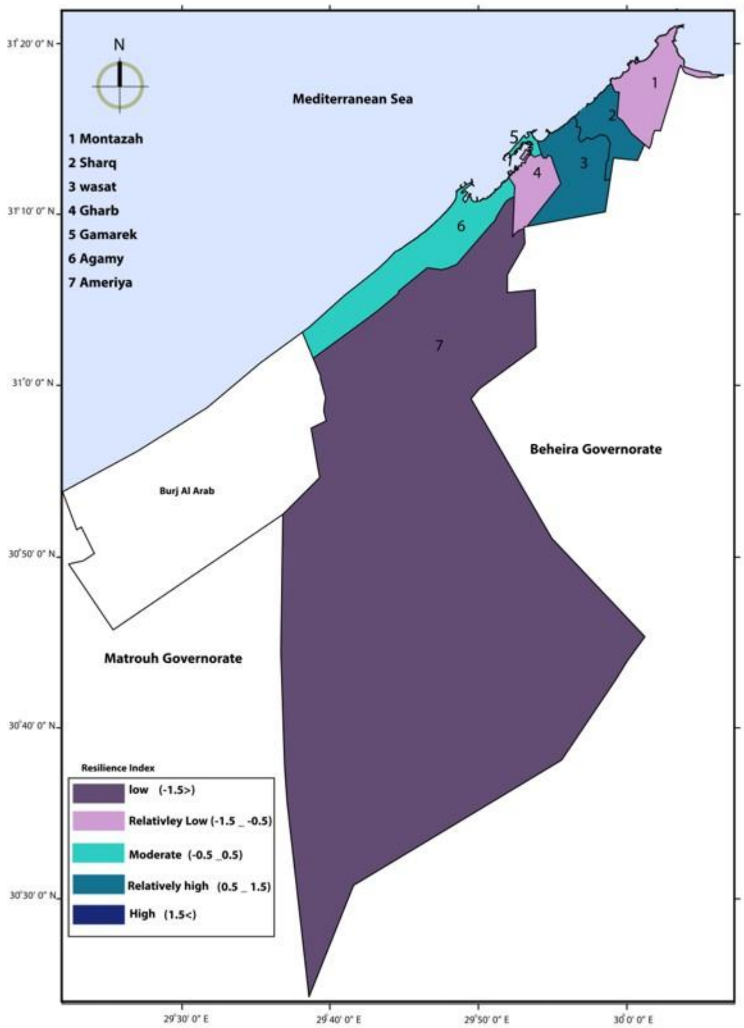

Figure 4. Final Resilience Index Results for City Neighborhoods

Economic resilience varies significantly between districts; Sharq, for instance, has the highest score (0.679), mostly because of its diverse economy and high female employment participation rate (Altuzarra et al., 2019; Cochrane et al., 2023). It is in a good position to handle both economic and climate-related challenges because of its adaptability. Ameriya, on the other hand, has the lowest score (0.509) because to its heavy reliance on agriculture (Kalogiannidis et al., 2023), and limited workforce participation, which makes it even more susceptible to changes in the economy.

Regarding community capital, Wasat emerges as the leader (0.563), attributable to its strong social infrastructure—this includes community organizations and sports facilities that effectively foster civic engagement (Sherlock, 2024; Kangana et al., 2024). However, Ameriya, with a mere score of 0.155,

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suffers from an absence of such facilities; this absence weakens social cohesion, thereby complicating residents' ability to respond collectively to crises.

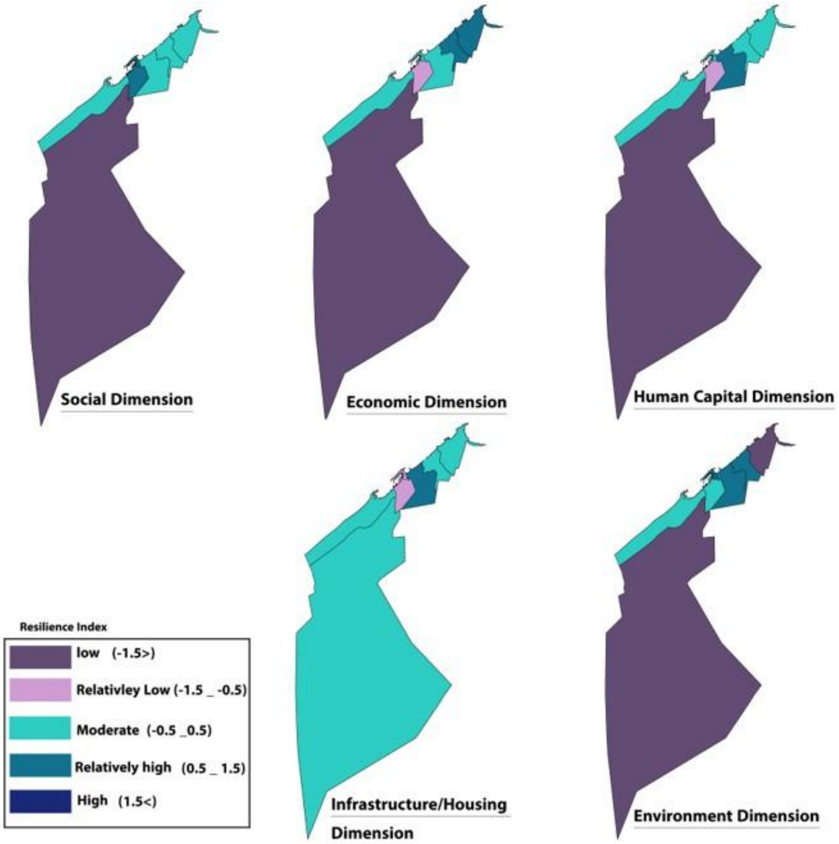

Figure 5. Resilience scores for five dimensions.

Infrastructure resilience dimension is another area where significant differences are apparent. With its well-kept road network and easy access to essential amenities, including hospitals and schools, Wasat earned the highest score of 0.465. These elements strengthen the district's ability to support residents during emergencies and maintain long-term urban functionality. Gharb received the lowest score (0.225) due to its poorly maintained roads and lack of emergency services, in contrast.

The environmental resilience dimension (which encompasses various factors) underscored significant challenges; however, only a few districts exhibited strong performance. Sharq attained the highest score (0.458), driven by its energy-efficient practices, and availability of green spaces (Mukherjee & Takara, 2018), and agricultural land. Conversely, Ameriya recorded the lowest environmental resilience score (0.170) because of critical issues such as excessive water consumption (Dowlati et al., 2023; Kohlitz et al., 2020) and the lack of green spaces (Braubach et al., 2017). Although the differences in scores are stark, this highlights the need for comprehensive strategies to enhance resilience across all districts.

4.2. Spatial Analysis of Urban Resilience

The Moran's I analysis of urban resilience dimensions in Alexandria reveals varied spatial patterns, as shown in Table 4. Social and economic dimensions show strong clustering, as shown in Figure 6, indicating concentrated resources in specific areas, emphasizing the need for equitable policies. In contrast, community capital exhibits a random distribution (p = 0.3473), suggesting a lack of targeted planning for social development. Infrastructure and housing exhibit a dispersed pattern, presenting a negative, yet insignificant Moran's I (p = 0.9574), which reflects an imbalanced distribution of services. The environmental dimension, however, reveals a random pattern (-0.0165), underscoring uneven environmental conditions and the necessity for strategic interventions. These findings illuminate the disparities in resilience levels across various neighborhoods, emphasizing the critical need for policy measures to tackle social, economic and environmental inequalities. This study highlights the multifaceted nature of resilience and the urgent need for targeted strategies to promote sustainability and urban equity in Alexandria.

Table 4. Moran's I spatial correlation test results.

Dimension	Moran's I	p-Value	z-Score	Pattern
SOC	0.3013	0.0206*	2.0416	Clustered
ECO	0.3319	0.0166*	2.1296	Clustered
HC	-0.0565	0.3473	0.3927	Random
INF	-0.5893	0.9574	-1.7209	dispersed
ENV	-0.0165	0.2634	0.6329	Random

*Statistically significant at $p < 0.05$

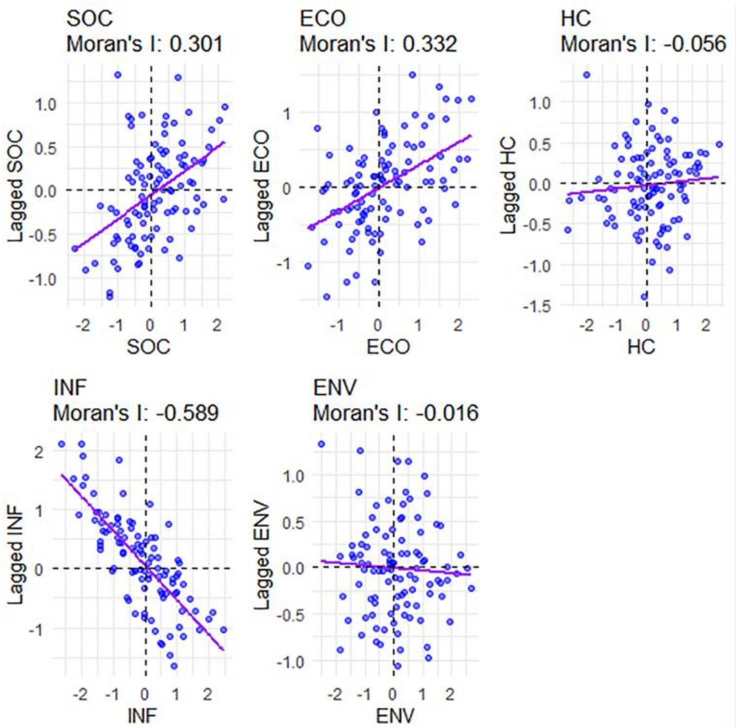

Figure 6. Spatial Autocorrelation of Resilience Dimensions.

4.3. limitation &future studies

This research has made significant strides in revealing the resilience of Alexandria's urban environment, but it has some limitations that hinder its completeness and precision. A significant limitation is the absence of the institutional aspect, owing to insufficient and unreliable data. Disaster management programs, policies (stewardship programs), budgets and relief mechanisms are all institutional factors that shape resilience, and neglecting these determinants will hinder a holistic assessment of resilience in neighborhoods. Future research should adopt a combination of top-down and bottom-up approaches to assess resilience since this study mainly depends on top-down evaluation methods. Future research needs to increase the scope of neighborhood datasets together with using Ridge regression to reduce multicollinearity issues while enhancing model generalizability.

5. Conclusions

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This study was guided by the baseline resilience indicators for communities framework, which was crafted to assess the resilience of Alexandria's neighborhoods. Five principal dimensions—social, economic, community capital, infrastructure and environ-mental—were integrated into this framework, with each dimension defined by pertinent indicators. Data from a variety of sources were employed to calculate resilience scores for every neighborhood, alongside dimension-specific scores.

Across Alexandria, the results uncovered a significant spatial variation in resilience. Central neighborhoods like Wasat and Sharq displayed stronger social networks, economic stability and well-established infrastructure, which greatly contributed to their enhanced overall resilience. Conversely, peripheral regions like Agamy and Ameriya were less resilient, primarily due to inadequate infrastructure, limited economic opportunities in the short- and medium-term, and environmental challenges. Although Gamarek is situated near high-risk coastal regions, it possesses moderate resilience through the use of local adaptive measures. Conversely, Agamy's surprising lack of resilience reveals how vulnerable communities are to the constraints of infrastructure and capital.

It provides important information for urban planning and policymaking in Alexandria. It provides a basis for focused actions to improve urban resilience by identifying the strengths and weaknesses of each neighborhood. The results also indicate that a comprehensive approach that considers social, economic, and environmental factors is crucial. The methodological approach of the study reinforces the validity of resilience assessments, suggesting that urban resilience strategies ought to be spatially and socially inclusive. To ensure long-lasting resilience, it's advisable to periodically update the framework and recalibrate the indicators with new data. By doing this, policymakers can track time fluctuations, evaluate the effectiveness of resilience measures, and adjust strategies accordingly. Additionally, the implementation of a multi-stakeholder approach can result in unified comprehension and joint endeavor to strengthen Alexandria's community.

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Appendix 1

Appendix 1. Preliminary Indicators of the Community	**Time**	2017	2017	2017	2017	2017	2017	2017	2017	2017
	Data Source	CAMPAS	IDSC, A. G.	CAMPAS	CAMPAS	CAMPAS	IDSC, A. G.	CAMPAS	CAMPAS	CAMPAS
	Reference	(Cutter et al., 2014; Burton 2014;	(Javadpoor et al., 2021; Singh-Peterson, et al.	(Pazhuhan, et al. 2023; Javadpoor	(Scherzer et al., 2019)	(Singh-Peterson, et al. 2014; Cutte	(Cutter et al., 2014; Burton 2014;	(Cutter et al., 2010; Singh-Peterson, et	(Pazhuhan, et al. 2023; Moghadas,	(Javadpoor et al., 2021; Singh-Peterson, et

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y Resilience Index		Cutter et al., 2010; Singh-Peterson, et al. 2014; Scherzer et al., 2019)	2014; Cutter et al., 2010)	et al., 2021)		r et al., 2010)	Scherzer et al., 2019; Singh-Peterson, et al. 2014; Javadpoor et al., 2021)	al. 2014)	et al. 2019)	al. 2014; Pazhuhan, et al. 2023)
	Relevance	• They have the physical ability to respond to and recover from climate-related emergencies. Additionally, the elderly and children are more	• Phone service provides access to vital information about evacuation routes, shelter locations, and available resources during a disaster.	• Higher literacy rates enable individuals to understand and interact with information about climate risks, adaptation strate	• Economically capable individuals are better prepared to respond to climate-related events, reducing the immediate burden on emerg	• Health insurance reduces medical expenses borne by individuals, preventing financial crises from unexpected health	• Ensures the availability of more medical specialists to provide effective and timely care during climate-related emergencies.	• Non-disabled individuals are generally more mobile and able to respond independently to climate emergencies, such as evacuations or finding	• Gender imbalances affect vulnerability in cities. Women are often more vulnerable to climate change due to social and economic	• Rapid population growth typically increases demand for infrastructure and resources, such as housing, water, sanitation, and energy.

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		vulnerable to disasters.		gies, and emergency procedures.	ency services.	issues during climate events.		shelter.	factors.	
	Description	Percentage of population in working age (15-65 years)	Households with phone service	Percentage of literate population (reads and writes)	Percentage of population not dependent on social assistance	Percentage of population with health insurance coverage	Number of physicians per 1,000 population	Percentage of population without sensory, physical, or mental disabilities	Ratio of men to women	Population change over the last 10 years*
	Indicator	1. Working Age	2. Communication Ability	3. Literacy Rate	4. Social Assistance	5. Health Insurance	6. Physicians	7. Special Needs	8. Gender	9. Population Growth*
									Dimension	**Social**

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Time	2017	2018	2017	2017	2017		2018	2018	2018
Data Source	CAMPAS	IDSC, A. G.	CAMPAS	CAMPAS	CAMPAS	CAMPAS	IDSC, A. G.	IDSC, A. G.	IDSC, A. G.
Reference	(Burton 2014; Cutter et al., 2010; Singh-Peterson, et al. 2014; Scherzer et al., 2019)	(Cutter et al.,2014; Burton 2014; Cutter et al., 2010; Opach, et al. 2020)	(Cutter et al., 2010; Burton 2014; Scherzer et al., 2019)	(Cutter et al.,2010; Cutter et al., 2014)	(Cutter et al., 2010; Burton 2014; Pazhuhan, et al. 2023; Scherzer et al., 2019)	(Javadpoor et al., 2021; Scherzer et al., 2019; Opach et al. 2020)	(Cutter et al.,2010; Opach et al., 2020; Singh-Peterson et al. 2014)	(Opach et al., 2020; Singh-Peterson et al. ,2014)	(Opach et al. ,2020; Scherzer et al., 2019; Singh-Peterson et al., 2014)
Relevance	• Homeowners invest in maintaining and upgrading their homes to protect property values, leading	• Increased vehicle ownership facilitates rapid evacuation during climate emergencies. • Enhan	• A larger workforce provides more human resources for climate adaptation projects or community	• Women's economic participation enhances access to better healthcare and social services,	• Non-primary sector jobs (e.g., services, technology, and finance) are less directly impact	• Social security and municipal workers provide essential social services and support for vulnerable populations,	• Places of worship serve as focal points for community gatherings and social support, enhanc	• Nurseries can serve as community centers, fostering social ties and collaboration among	• NGOs provide essential services and support to communities, including those vulnerable to climate impacts

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	to a more resilient residential infrastructure capable of withstanding climate impacts.	ces access to essential services, such as hospitals and shelters, during and after disasters.	resilience initiatives.	improving public health and community resilience	ed by extreme climate event .	including during and after climate-related events	ing social cohesion, which is critical for collective action and resilience.	families.	
Description	% of housing units occupied by the owner	Number of licensed vehicles per 1,000 people	Percentage of employed workforce	Percentage of females in the workforce	% of workers in non-primary economic sectors (excluding agriculture, mining, and tourism)	% of workers in public administration, defense, social security, or municipal activities	Worship places per 1,000 people	Nurseries per 1,000 people	Number of NGOs per 1,000 people

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Indicator	10. Housing Ownership	11. Vehicle Ownership	12. Employment	13. Female Employment	14. Dependence on Primary Sectors	15. Public Sector Employment	16. Worship Places	17. Childcare	18. Civil Engagement
							Dimension	**Economic**	**Human capital**
Time	2018	2018	2018	2018	2018	2017	2018	2017	2018
Data Source	IDSC, A.G.	IDSC, A.G.	IDSC, A.G.	IDSC, A.G.	IDSC, A.G.	CAMPAS	IDSC, A.G.	CAMPAS	IDSC, A.G.
Reference	(Scherzer et al., 2019; Javadpoor et al., 2021; Opach et al. ,2020)	(Scherzer et al.,2019; Singh-Peterson et al. ,2014 ; Burton , 2014)	(Scherzer et al.,2019; Burton ,2014; Cutter et al.,2010; Singh-Peterson et al. ,2014)	(Burton,2014; Cutter et al.,2010; Scherzer et al.,2019)	(Scherzer et al.,2019; Burton ,2014; Cutter et al.,2010)	(Burton ,2014; Cutter et al.,2010; Singh-Peterson et al. ,2014)	(Singh-Peterson et al. ,2014; Javadpoor et al.,2021)	(Singh - Peterson et al. ,2014; Cutter et al.,2010)	(Scherzer et al.,2019; Burton ,2014)

Relevance	• The number of sports facilities affects urban resilience by promoting physical and mental health, strengthening social cohesion, and supporting community engagement.	• They serve as temporary shelters for displaced individuals during climate-related disasters	• Increased number ensures faster and more effective emergency responses during climate-related disasters, essential for managing impacts through rescue, medical care, and safety.	• Schools educate communities on climate change, provide emergency preparedness training, and can act as shelters during climate-related disasters.	• Facilitates access for emergency services during disasters and provides safe evacuation routes for residents during extreme weather.	• Older buildings are more vulnerable to climate impacts; modern materials are more resilient to environmental stresses.	• A higher number ensures healthcare capacity during climate-related events.	• Vacant units can serve as temporary shelters during climate emergencies or be used for relocation from high-risk areas.	• Absorbs and slows floodwaters, reducing urban flood risk and regulating temperatures.

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Description	Sports facilities per 1,000 people	Hotels and motels per 1000 people	Fire, police, and ambulance stations per 1000 persons	Schools per 1000 persons.	Length of paved internal roads (km).	Percentage of residential buildings built less than 30 years ago	Number of hospital beds per 1000 persons	Percentage of vacant housing units	Percentage of land area functioning as natural flood barriers (e.g., wetlands, mangroves, dunes).
Indicator	19. Sports Facilities	20. Hotels	21. Emergency Response Facilities	22. Schools	23. Paved Roads	24. New Residential Buildings	25. Hospital Beds	26. Vacant Units	27. Natural Barriers
Dimension	**Human capital**	**Infrastructure and Housing**							**Environmental**

Time	2018	2018	2018	2018	2018	2018	Note: Asterisks (*) indicate variables measured inversely during
Data Source	IDSC, A.G.	IDSC, A.G.	IDSC, A.G.	IDSC, A.G.	IDSC, A.G.	Egyptian Press	
Reference	(Cutter et al., 2014)	(Pazhuhan et al. ,2023; Moghadas et al. ,2019)	(Pazhuhan et al. ,2023; Scherzer et al.,2019)	(Scherzer et al.,2019; Javadpoor et al.,2021)	(Javadpoor et al., 2021; Scherzer et al.,2019)	(Javadpoor et al.,2021; Scherzer et al., 2019; Cutter et al., 2014)	

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Relevance	• Cities with lower energy consumption can better integrate renewable energy and reduce greenhouse gas emissions, mitigating climate change.	• Lower consumption helps maintain stable and secure water supplies, critical for urban resilience during extreme weather events.	• Parks moderate urban temperatures, improve air quality, and serve as natural flood barriers during heavy rains.	• Higher holdings indicate greater local food production capacity, enhancing food security and providing green spaces for environmental benefits.	• Supports food security during climate extremes, local economic stability, and environmental sustainability.	• Higher frequency indicates greater climate-related risks. Understanding these helps cities plan effective strategies.	the process. CAMPAS: Central Agency for Public Mobilization and Statistics IDSC, A.G.: Information and Decision Support Center – Alexandria Governorate
Description	Megawatt hours per energy consumer *	Average annual water consumption *	Percentage of public park area.	Agricultural holdings per 1000 persons.	Percentage of arable land area.	Average number of extreme weather events causing losses over 5 years *	
Indicator	28. Energy Efficiency*	29. Water Consumption*	30. Public Parks	31. Agricultural Holdings	32. Arable Land	33. Natural Hazards*	
					Dimension	**Environmental**	

References

[1] Datola, G. Implementing Urban Resilience in Urban Planning: A Comprehensive Framework for Urban Resilience Evaluation. Sustain. Cities Soc. 2023, 98, 104821. https://doi.org/10.1016/j.scs.2023.104821

[2] Jamali, A.; Robati, M.; Nikoomaram, H.; Farsad, F.; Aghamohammadi, H. Urban Resilience and Climate Change: Developing a Multidimensional Index to Adapt Against Climate Change in the Iranian Capital City of Tehran. Urban Sci. 2023, 7(7). https://doi.org/10.3390/buildings12030340

[3] Michel, D.; Pandya, A. E. Coastal Zones and Climate Change. The Henry L. Stimson Center, Washington DC, 2010. Retrieved from https://www.stimson.org/wp-content/files/file-attachments/Introduction_1.pdf

[4] Fariniuk, T. M.; Hojda, A.; Simão, M. M. Searching a Resilient City: A Study About Theoretical-Conceptual Joints Between Smart City and Urban Resilience. In Urban Resilience: Methodologies, Tools and Evaluation; Springer Cham: Switzerland, 2022; pp. 1–16. https://doi.org/10.1007/978-3-031-07586-5

[5] Sharifi, A. A Critical Review of Selected Tools for Assessing Community Resilience. Ecol. Indic. 2016, 69, 629–647. https://doi.org/10.1016/j.ecolind.2016.05.023

[6] Müller, F.; Hoffmann-Kroll, R.; Wiggering, H. Indicating Ecosystem Integrity: Theoretical Concepts and Environmental Requirements. Ecol. Modell. 2000, 130(1), 13–23. https://doi.org/10.1016/S0304-3800(00)00210-6

[7] Holling, C. S. Resilience and Stability of Ecological Systems. Annu. Rev. Ecol. Syst. 1973, 14, 1–23. https://www.jstor.org/stable/2096802

[8] Shi, W.; Tian, J.; Namaiti, A.; Xing, X. Spatial-Temporal Evolution and Driving Factors of the Coupling Coordination between Urbanization and Urban Resilience: A Case Study of the 167 Counties in Hebei Province. Int. J. Environ. Res. Public Health 2022, 19(20), 13128. https://doi.org/10.3390/ijerph192013128

[9] Lowe, M.; Bell, S.; Briggs, J.; McMillan, E.; Morley, M.; Grenfell, M.; Sweeting, D.; Whitten, A.; Jordan, N. Urban Resilience for Local Government: Concepts, Definitions, and Qualities. The University of Melbourne, 2021.

[10] Davoudi, S.; Brooks, E.; Mehmood, A. Evolutionary Resilience and Strategies for Climate Adaptation. Plann. Pract. Res. 2013, 28(3), 307–322. https://doi.org/10.1080/02697459.2013.787695

[11] Holling, C. S. Engineering Resilience Versus Ecological Resilience. In Engineering Within Ecological Constraints; National Academy Press: Washington, DC, 1996; pp. 31–44. https://nap.nationalacademies.org/read/4919/chapter/4

[12] Abdulkareem, M.; Elkadi, H.; Bneane, M. From Engineering to Evolutionary, an Overarching Approach in Identifying the Resilience of Urban Design to Flood. Int. J. Disaster Risk Reduct. 2018, 28. https://doi.org/10.1016/j.ijdrr.2018.02.009

[13] Wardekker, A. Contrasting the Framing of Urban Climate Resilience. Sustain. Cities Soc. 2021, 75. https://doi.org/10.1016/j.scs.2021.103258

[14] Davoudi, S.; Shaw, K.; Haider, L. J.; Quinlan, A. E.; Peterson, G. D.; Wilkinson, C.; Fünfgeld, H.; McEvoy, D.; Porter, L.; Davoudi, S. Resilience: A Bridging Concept or a Dead End? Reframing Resilience: Challenges for Planning Theory and Practice. Plann. Theory Pract. 2012, 13(2), 299–333. https://doi.org/10.1080/14649357.2012.677124

[15] Khatibi, H.; Wilkinson, S.; Williams, P.; Khatibi, H. Choosing a Holistic Urban Resilience Assessment Tool. Int. J. Disaster Risk Reduct. 2022, 71. https://doi.org/10.1016/j.ijdrr.2022.102789

[16] Cimellaro, G. P. Resilience Indicators. In Urban Resilience for Emergency Response and Recovery: Geotechnical, Geological and Earthquake Engineering; Springer: Cham, 2016; pp. 49–69. https://doi.org/10.1007/978-3-319-30656-8_3

[17] Cutter, S. L. The Landscape of Disaster Resilience Indicators in the USA. Nat. Hazards 2016, 80, 741–758. https://doi.org/10.1007/s11069-015-1993-2

[18] Feldmeyer, D.; Wilden, D.; Kind, C.; Kaiser, T.; Goldschmidt, R.; Diller, C.; Birkmann, J. Indicators for Monitoring Urban Climate Change Resilience and Adaptation. Sustainability 2019, 11(10). https://doi.org/10.3390/su11102931

[19] Yang, Y.; Fang, Y.; Xu, Y.; Zhang, Y. Assessment of Urban Resilience Based on the Transformation of Resource-Based Cities: A Case Study of Panzhihua, China. Ecol. Soc. 2021, 26(2). https://doi.org/10.5751/ES-12280-260220

[20] Kong, L.; Mu, X.; Hu, G.; Zhang, Z. The Application of Resilience Theory in Urban Development: A Literature Review. Environ. Sci. Pollut. Res. 2022. https://doi.org/10.1007/s11356-022-20891-x

[21] Cutter, S. L.; Barnes, L.; Berry, M.; Burton, C.; Evans, E.; Tate, E.; Webb, J. A Place-Based Model for Understanding Community Resilience to Natural Disasters. Glob. Environ. Change 2008, 18(4), 598–606. https://doi.org/10.1016/j.gloenvcha.2008.07.013

[22] Cutter, S. L.; Ash, K. D.; Emrich, C. T. The Geographies of Community Disaster Resilience. Glob. Environ. Change 2014, 29, 65–77. https://doi.org/10.1016/j.gloenvcha.2014.08.005

[23] Singh-Peterson, L.; Salmon, P. M.; Goode, N.; Gallina, J. Translation and Evaluation of the Baseline Resilience Indicators for Communities on the Sunshine Coast, Queensland, Australia. Int. J. Disaster Risk Reduct. 2014, 10, 116–126. https://doi.org/10.1016/j.ijdrr.2014.07.004

[24] Scherzer, S.; Lujala, P.; Rød, J. K. A Community Resilience Index for Norway: An Adaptation of the Baseline Resilience Indicators for Communities (BRIC). Int. J. Disaster Risk Reduct. 2019, 36. https://doi.org/10.1016/j.ijdrr.2019.101107

[25] Javadpoor, M.; Sharifi, A.; Roosta, M. An Adaptation of the Baseline Resilience Indicators for Communities (BRIC) for Assessing Resilience of Iranian Provinces. Int. J. Disaster Risk Reduct. 2021, 66, 102609. https://doi.org/10.1016/j.ijdrr.2021.102609

[26] World Bank. Alexandria City Development Strategy: Process and Results 2004-2008. Cities Alliance, GOPP, and Bibliotheca Alexandrina, 2008. Retrieved from https://documents1.worldbank.org/curated/ru/945091468026411178/pdf/703370ESW0P0890200800Updated0July010.pdf

[27] Khatri, P. B.; Van der Steen, P.; Veluwenkamp, K. Climate Change: Alexandria – Egypt. UNESCO-IHE, Delft, The Netherlands, 2007. Retrieved from https://research.fit.edu/media/site-specific/researchfitedu/coast-climate-adaptation-library/africa/egypt-amp-libya/Khatri-et-al.-2007.-Alexandria-Affects-of-CC.pdf

[28] Cutter, S. L.; Burton, C. G.; Emrich, C. T. Disaster Resilience Indicators for Benchmarking Baseline Conditions. J. Homeland Secur. Emerg. Manag. 2010, 7(1). https://doi.org/10.2202/1547-7355.1732

[29] Aksha, S. K.; Emrich, C. T. Benchmarking Community Disaster Resilience in Nepal. Int. J. Environ. Res. Public Health 2020, 17(6), 1985. https://doi.org/10.3390/ijerph17061985

[30] Burton, C. G. A Validation of Metrics for Community Resilience to Natural Hazards and Disasters Using the Recovery from Hurricane Katrina as a Case Study. Ann. Am. Assoc. Geogr. 2014, 105(1), 67-86.

[31] Pazhuhan, M.; Moradpour, N.; Hesarakizad, A.; Sharifi, A. District-Based Baseline Resilience Indicators for Communities (DBRIC) for Assessment of a Global South City. Sustain. Cities Soc. 2023, 96, 104563. https://doi.org/10.1016/j.scs.2023.104563

[32] Moghadas, M.; Asadzadeh, A.; Vafeidis, A.; Fekete, A.; Kötter, T. A Multi-Criteria Approach for Assessing Urban Flood Resilience in Tehran, Iran. Int. J. Disaster Risk Reduct. 2019, 35, 101069. https://doi.org/10.1016/j.ijdrr.2019.101069

[33] Opach, T.; Scherzer, S.; Lujala, P.; Rød, J. K. Seeking Commonalities of Community Resilience to Natural Hazards: A Cluster Analysis Approach. Norsk Geogr. Tidsskr. 2020, 74(3), 181-199.

[34] Ren, H.; Shang, Y.; Zhang, S. Measuring the Spatiotemporal Variations of Vegetation Net Primary Productivity in Inner Mongolia Using Spatial Autocorrelation. Ecol. Indic. 2020, 112, 106108. https://doi.org/10.1016/j.ecolind.2020.106108

[35] Cronbach, L. J. Coefficient Alpha and the Internal Structure of Tests. Psychometrika 1951, 16, 297–334. https://doi.org/10.1007/BF02310555

[36] Rae, G. A Note on Using Stratified Alpha to Estimate the Composite Reliability of a Test Composed of Interrelated Nonhomogeneous Items.

[37] Lu, X.; White, H. Robustness Checks and Robustness Tests in Applied Economics. J. Econometrics 2014, 178, 194-206. https://doi.org/10.1016/j.jeconom.2013.08.016

[38] Timalsina, R.; Songwathana, P. Factors enhancing resilience among older adults experiencing disaster: A systematic review. Australas. Emerg. Care 2020, 23, 11–22.

[39] Cvetković, V. M.; Šišović, V. Understanding the Sustainable Development of Community (Social) Disaster Resilience in Serbia: Demographic and Socio-Economic Impacts. Sustainability 2024, 16(7), 2620. https://doi.org/10.3390/su16072620

[40] Altuzarra, A.; Gálvez-Gálvez, C.; González-Flores, A. Economic Development and Female Labour Force Participation: The Case of European Union Countries. Sustainability 2019, 11(7), 1962. https://doi.org/10.3390/su11071962.

[41] Cochrane, W.; Poot, J.; Roskruge, M. Urban Resilience and Social Security Uptake: New Zealand Evidence from the Global Financial Crisis and the COVID-19 Pandemic. The Australasian Journal of Regional Studies 2023, 29(2), 155–184.

[42] Kalogiannidis, S.; Papadopoulou, C.-I.; Loizou, E.; Chatzitheodoridis, F. Risk, Vulnerability, and Resilience in Agriculture and Their Impact on Sustainable Rural Economy Development: A Case Study of Greece. Agriculture 2023, 13(6), 1222. https://doi.org/10.3390/agriculture13061222

[43] Sherlock, T. The Role of Community Sports Programs in Promoting Social Cohesion. Int. J. Arts Recreat. Sports 2024, 3(5), 15–27. DOI: 10.47941/ijars.2073.

[44] Kangana, N.; Kankanamge, N.; De Silva, C.; Goonetilleke, A.; Mahamood, R.; Ranasinghe, D. Bridging Community Engagement and Technological Innovation for Creating Smart and Resilient Cities: A Systematic Literature Review. Smart Cities 2024, 7(6), 3823–3852. https://doi.org/10.3390/smartcities7060147

[45] Mukherjee, M.; Takara, K. Urban Green Space as a Countermeasure to Increasing Urban Risk and the UGS-3CC Resilience Framework. Int. J. Disaster Risk Reduct. 2018, 28, 854-861. https://doi.org/10.1016/j.ijdrr.2018.01.027

[46] Dowlati, M.; Seyedin, H.; Behnami, A.; Marzban, A.; Gholami, M. Water Resources Resilience Model in Climate Changes with Community Health Approach: Qualitative Study. Case Studies in Chemical and Environmental Engineering 2023, 8, 100521. https://doi.org/10.1016/j.cscee.2023.100521

[47] Kohlitz, J.; Chong, J.; Willetts, J. Rural Drinking Water Safety under Climate Change: The Importance of Addressing Physical, Social, and Environmental Dimensions. Resources 2020, 9(6), 77. DOI: 10.3390/resources9060077.

[48] Braubach, M.; Egorov, A.; Mudu, P.; Wolf, T.; Ward Thompson, C.; Martuzzi, M. Effects of Urban Green Space on Environmental Health, Equity, and Resilience. In Nature-Based Solutions to Climate Change Adaptation in Urban Areas; Kabisch, N., Korn, H., Stadler, J., Bonn, A., Eds.; Theory and Practice of Urban Sustainability Transitions; Springer: Cham, Switzerland, 2017; pp. 187-205. DOI: 10.1007/978-3-319-56091-5_11.