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Morphological Analysis of Public Spaces and Their Contribution to Urban Resilience in Guelma, Algeria

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ABSTRACT

Modern Algerian cities are facing various uncertainties, both natural and human-made. To address these risks, urban areas need to be more adaptable and responsive. The increasing impact of climate change and the recent pandemic have emphasized the importance of outdoor spaces. As people spend a significant amount of time in these areas, public spaces have become essential for urban life. This study conducts a comparative analysis of public spaces, using a grid-based methodology to identify similarities and differences between two resilient public spaces and the square of Guelma. The analysis is preceded by a literature review that establishes key conceptual frameworks. The main objective is to develop recommendations for resilient public spaces and their contribution to a city's environmental resilience, particularly its capacity to withstand climate change. By understanding how these spaces can mitigate the effects of climate change, this research aims to guide the design and management of urban environments.

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1. Introduction

Cities, like living organisms, exhibit dynamic and complex characteristics, undergoing continuous adaptation in terms of scale, social organization, political systems, and technological infrastructure (Sharifi & Yamagata, 2014; Holling, 1985). Although possessing unique urban morphologies, cultural fabric, historical trajectories, and identities, cities globally are confronted with a shared set of challenges, namely rapid urbanization, population growth, and climate change. The resilience concept's wide appeal stems from its adaptability. It can be applied to diverse urban challenges, both climate-driven and not. Deepening our understanding of resilience and how to measure it will be crucial for developing transformative approaches.

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These approaches are essential for cities to contribute to climate stabilization and achieve Sustainable Development Goals, Social cohesion, economic stability, environmental sustainability, infrastructure robustness, and effective governance are all crucial aspects of urban resilience, and each face unique challenges as documented in various studies, the recent surge in interest extends beyond resilience itself, focusing on developing assessment tools. These tools aim to capture the multifaceted nature of resilience and translate it into a clear and actionable framework for both the public and policymakers (Cutter, 2015; Fox-Lent, Bates, & Linkov, 2015). The relationship between resilience and sustainability is a topic of debate. Some argue they share a significant overlap, focusing on the same social, economic, ecological, and spatial dimensions. Others, however, see them as distinct concepts (Zhang & Li, 2018).

Social resilience is the capacity of individuals and social groups to withstand and adapt to stresses and disruptions caused by social, political, and environmental changes (Adger, 2000). More concise and impactful: Economic resilience is the ability of an economy to absorb and bounce back from economic shocks, both internal and external while maintaining its capacity for efficient resource allocation in the long term (Siavash, 2016). Ecological resilience refers to the ability of an ecosystem to adapt and recover from disturbances, even by transitioning to a new and potentially improved stable state (Folke et al., 2004). Emerging as a key concept, spatial resilience focuses on the dynamic interplay between the physical layout and various components of a system, contributing to its overall resilience (Cumming, 2011).

Examining these definitions of resilience highlights its crucial role in cities. Social, economic, built, and natural environments all contribute to urban resilience. Therefore, deepening planners' understanding of resilience and its terminology is essential. This will allow them to use resilience principles into urban conceptions, particularly through the design of resilient public spaces. This definition aligns well with the concept of systems regaining stability after a disruption, mirroring how resilience has been applied in physics. Psychology and psychiatry have adopted this same principle, using it to describe individual resilience (Chelleri & Olazabal, 2012). Philosopher Hannah Arendt viewed public space as the cornerstone of democratic citizenship.

She argued that public spaces serve as a vital sphere for citizens to come together and engage in collective action (Goodsell, 2003; Hansen, 2013). Public spaces and streets are often considered the signature features of a city. Just think of iconic landmarks like Times Square in New York or Piccadilly Circus in London – these spaces instantly conjure up the image of the city they inhabit (Public Spaces for All, UN-Habitat website, 2020). Public spaces, from grand squares and bustling boulevards to peaceful gardens and vibrant playgrounds, are the building blocks of a city's image.

Streets and public spaces form a crucial framework of a city, connecting various areas together. While they may seem like spaces between buildings, they play a vital role in social interaction, commerce, and transportation (Gehl, 2001, as cited in Rupa, 2015). Public spaces are not just amenities; they are essential assets that contribute significantly to a city's economic prosperity, environmental quality, safety, public health, social integration, and connectivity. As a result, residents' quality of life is closely tied to the quantity and quality of these spaces.

A study of the physical features of public spaces can shed light on how they can help cities become more resistant to climate change and other risks. This research is important because it focuses on Guelma, Algeria, a region that is often ignored in academic research. By looking at how the design of public spaces is related to a city's ability to endure challenges, we hope to increase our understanding of this important issue.

2. State of the art

2.1. Risilient urban space

A study by Degros, Knierbein, and Madanipour (2014) highlights the challenges many cities face in managing open spaces as they undergo structural transformations. These challenges are further

amplified by external pressures, whether a slow decline due to factors like demographic shifts or rapid shocks caused by climate change, Public open spaces are confirmed as key contributors to urban resilience, encompassing economic, social, environmental, and spatial aspects. Research by Ruchinskaya (2018) emphasizes that resilient public spaces are crucial for strengthening existing communities and fostering social cohesion, especially during and after crises. These spaces become even more vital in both everyday life and emergencies (Allan & Bryant, 2010, cited in Ruchinskaya, 2018).

Resilient public spaces effectively combine the characteristics of urban resilience with the essential features of well-designed public spaces. Urban spatial resilience focuses on the interconnectedness of a city's natural and built environments, with a emphasis on how activities and spatial arrangements contribute to its overall resilience. As a result, the indicators used the spatial organization of the urban system is a critical factor in assessing urban spatial resilience (Fariba Gharai et al., 2018). Public spaces, through inclusive practices and collective creativity, enhance urban resilience comprehensively (Ruchinskaya, 2018).

Resilient public spaces have gained increasing significance in the transformation of cities. They are no longer considered as leftover spaces, but rather as key focuses in urban development and regeneration. The design and use of public spaces have evolved due to changes in society and the economy, resulting in the need for a new theory and architectural tactics for creating successful temporary public spaces. Public spaces are recognized as essential components of urban environments, promoting social interaction and sustainable development. However, concerns remain regarding the impact of globalization, consumerism, and gentrification on public spaces. The introduction of new technologies has created a duality in public spaces, with digital aspects shaping borders and social interactions. Using digital technologies in urban spaces can transform boundaries and promote new types of social interaction. Traditional public spaces were downgraded in the past, but there is now a growing recognition of their importance in creating healthier and more vibrant cities.

2.2. Urban Morphology: A Foundation for Spatial Resilience

By examining urban morphology, researchers can identify and analyse changes in urban spatial structure and form over time. This necessitates comprehensive, multi-temporal datasets covering entire urban areas. Fortunately, advancements in geospatial technologies have made high-resolution remote sensing data widely available and affordable. To inform urban planning and disaster preparedness, researchers investigating urban recovery from traumatic events (Vale, 2005; Prasad et al., 2009; Clark, 2010) have focused on identifying urban system vulnerabilities. The effects of change can manifest at various spatial scales, ranging from the neighbourhood to the global level (Müller, 2010). Although concentrated at specific scales, these impacts frequently reverberate across multiple levels due to intricate interdependencies.

Müller (2010) emphasizes the difficulty of identifying resilience qualities specific to different scales because of the complex and interconnected nature of urban and regional systems. It is crucial to develop reliable methods for analysing resilience across varying scales. In a related work (2007), Müller highlights four key dimensions of urban life and function. By examining the concept of a resilient urban form and the role of governance, this study seeks to understand how the built environment can be designed and managed to adapt to changing circumstances.

Urban morphology describes the form and development of human settlements, influenced by a combination of factors including urban fabric, natural and human structures, street networks, architectural complexity, building materials, and human behaviour (Sharifah et al., 2013). Urban morphology plays a crucial role in urban resilience. As cities deal with rapid population growth and development pressures, it is vital to focus on sustainable urban growth. Unplanned urban expansion can

result in significant environmental degradation, as seen in the case of Granada. Despite these challenges, the importance of urban morphology in planning is often overlooked (Whitehand, 2004).

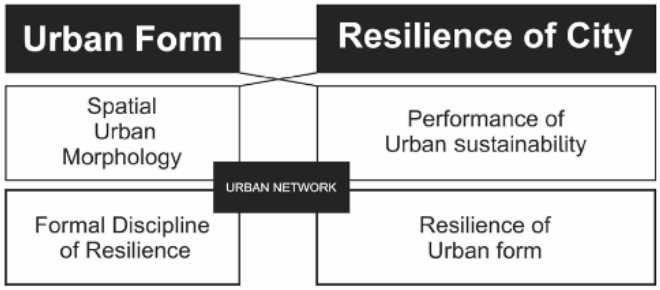

Figure 1. Structure of the study.

3. Methodology

Public spaces' morphology is crucial in enhancing urban environmental resilience. Analysing the structure and design of public spaces within cities aims to understand how these spaces can contribute to mitigating the impacts of climate change and improving overall urban resilience. The importance of urban morphology in shaping cities that are adaptable, sustainable, and capable of responding effectively to environmental challenges. Through methodologies that integrate spatial analysis (Djouad, 2021), urban morphology, and environmental considerations (Djouad, 2021), experts seek to create frameworks that guide the development of public spaces to enhance environmental resilience and reduce the vulnerability of urban areas to various threats (Mretto,2023).

The methodology of this research is based on a comparative approach between a resilient public space and the case of studying that aims to study the morphological effect of public spaces on urban environmental resilience:

A. Morphological Analysis (UM): This involves a detailed study of the physical form and layout of the urban fabric, plot systems, and how they've evolved.
B. Pedestrian Movement Flow Analysis (PMF): This analyzes pedestrian movement patterns within the urban space, considering factors like physical layout.

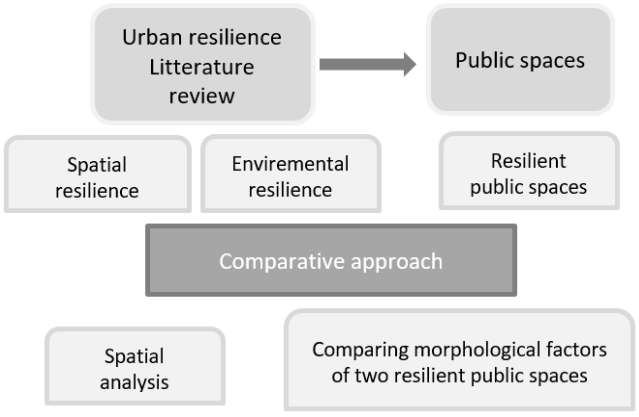

Figure 2. Structure of the study

C. Case of studying:

The square, named the open place of Martyrs "Saint Augustin," is served by four lanes and features a mineral pavement and a kiosk in the centre (fig 02). Over time, it has undergone various changes,

including the addition of a fountain, extension, and a stele. Its prime location in the heart of the colonial centre adds to its significance.

Figure 3. Case of studying open space in Guelma city (Source: Google Earth).

4. Analysis:

The analysis revealed that the resilient public space exhibited distinct morphological characteristics that contributed significantly to its resilience. These characteristics included:

a) Spatial diversity: This means a mix of open green spaces, pedestrian areas, and civic infrastructure, which enhanced the space's adaptability to various activities and user needs.

b) Connectivity: The space was integrated with the surrounding urban fabric through a network of paths and connections, promoting accessibility and facilitating social interaction.

c) Flexibility: The space's design allowed for multiple uses and adaptations over time, ensuring its continued relevance.

d) Resilient materials: Durable and sustainable materials were used to enhance the space's resistance to environmental stressors and reduce maintenance requirements.

5. Results:

Urban morphology delves into the essence of a city by analysing its urban fabric. This fabric, a unique tapestry woven from buildings, streets, and open spaces, reflects the conscious and unconscious design choices that have shaped the physical city, while urban morphology emerged in the 1950s to understand the challenges of modern cities, it's now evident that its true strength lies in its integration with other disciplines and tools. This collaborative approach equips us to better address the evolving needs of society and its citizens.

Table 1. Comparing morphological characteristics. Source: author, 2024.

Studycase/ comparative cases	**Square of martyrs**	**Resilient P S (A)**	**Resilient P S (B)**
			
Shape	Regular	Nearly a regular	Nearly a regular
Urban fabric	Colonial	Ancient	ancient
orientation	North-eastern	Due north	Due north
Surface (m²)	190	225	210
Compactness	slightly compact	Extremely compact	Extremely compact
buildings closeness	slightly	Highly	Highly
Openness /fermeture	slightly	Highly	Highly
Buildings elevation	slightly	slightly	slightly
Buildings height	Colonial	Ancient	Ancient
Existence of nature	Green elements	Bleu elements	Bleu elements
Historical value	slightly	Highly	Highly

Characteristics of a resilient design of a public space encompass various elements that contribute to its ability to withstand challenges and promote sustainability. These characteristics, as indicated in the provided sources, include considerations such as spatial distribution, environmental features, safety measures, inclusivity, and adaptability to community needs. Resilient public spaces are designed to foster community well-being, enhance safety perceptions, and integrate green infrastructure to mitigate environmental risks. Additionally, features like lighting, accessibility, landscape design (Djouad, Spiga, 2010), and maintenance play a crucial role in creating public spaces that are inclusive, safe, and capable of supporting sustainable urban development. The design of resilient public spaces is guided by principles that aim to address the diverse needs of urban communities while promoting environmental resilience and social cohesion.

Table 2. Pedestrian Movement Flow Analysis. Source: author, 2024.

Case of studying/comparative cases	Square of martyrs	Resilient P S (A)	Resilient P S (B)
			

The square of martyrs experiences a distinct pattern of pedestrian movement throughout the day. A dominant flow (A1) enters the public area from the west side in the morning and heads towards the centre. Another significant flow (A2) reaches the northern edge of Guelma's urban fabric.

6. Discussion:

The concept of a "resilient morphology" applied to a square specifically might not be a perfect fit. Resilience is typically used for a system or an entity that can adapt and recover from disturbances. A square itself, being a geometric form, would not inherently possess the characteristics of resilience.

However, we can discuss how the design of a square or plaza can contribute to the overall resilience of an urban area. Here are some ways a square can be designed with resilience in mind:

a) Multifunctionality: The Square can be designed to accommodate a variety of activities, such as markets, gatherings, or even temporary shelters during emergencies. This allows the space to adapt to different needs over time.

b) Connectivity: The Square can be a key element in the pedestrian network, connecting different parts of the city and encouraging walking and cycling. This can be important during emergencies when car traffic might be disrupted.

c) Environmental design: The Square can be designed to reduce the impact of climate change, such as incorporating green spaces for shade and rainwater management or using materials that reflect heat.

d) Social cohesion: The Square can be designed to be a welcoming and inclusive space that fosters a sense of community. This can be important for social support and recovery after disasters.

Pedestrian flows can significantly affect a city's environmental resilience in several ways:

a) Mitigating Urban Heat Island Effect: Higher pedestrian traffic can encourage the creation of shade through street trees and awnings. Shade reduces heat absorption by pavement and buildings, lowering overall ambient temperatures. Increased pedestrian activity can lead to a reduction in car traffic, thereby decreasing heat generated by vehicle emissions.

b) Promoting Sustainable Transportation: Dense pedestrian networks encourage walking and cycling, reducing reliance on private vehicles and their associated greenhouse gas emissions. Improved pedestrian infrastructure like dedicated lanes and safe crossings incentivize walking and cycling, contributing to cleaner air.

c) Enhancing Urban Microclimates: Pedestrian activity can generate a slight cooling effect through body heat dissipation, although this impact is minimal compared to other factors. Well-designed pedestrian zones often incorporate water features, green spaces, and permeable surfaces. These elements can help regulate temperature, manage stormwater runoff, and improve air quality.

d) Social Resilience and Community Building: Vibrant pedestrian areas foster a sense of community and ownership. This can lead to increased social interaction and collective action on environmental issues. Active public spaces encourage residents to spend time outdoors and connect with their surroundings, fostering a sense of stewardship for the environment. Here are some additional points to consider:

e) Pedestrian flow density: While a certain level of pedestrian activity is beneficial, excessively crowded spaces can negate some of the environmental advantages. Striking a balance is crucial. Mixed-use development: Integrating residential, commercial, and recreational areas within walking distance promotes pedestrian activity and reduces reliance on cars.

f) Walkability and connectivity: A well-connected pedestrian network with safe and accessible routes encourage walking and cycling.

7. Limit of research:

The availability of comprehensive data on public space characteristics, usage patterns, and climate-related impacts was limited, which could affect the depth of analysis. The accuracy and reliability of data sources, particularly historical data, could potentially influence the research outcomes. Comparing only two resilient public spaces might not provide a sufficiently broad range of case studies to draw robust conclusions. This approach might overlook certain qualitative aspects of public space morphology that could be relevant to resilience. The study primarily focuses on environmental resilience, potentially neglecting other dimensions of urban resilience such as social, economic, and institutional resilience.

8. Conclusion

This research underscores the critical role of public space morphology in enhancing urban resilience, particularly in the face of climate change. By conducting a comparative analysis of public spaces, this study has demonstrated that specific morphological characteristics, such as spatial diversity, connectivity, flexibility, and the use of resilient materials, are essential for creating resilient urban environments.

The findings highlight the need for a reorientation of public space design and planning practices to prioritize resilience. By incorporating these morphological principles, cities can significantly improve their capacity to adapt to and recover from various shocks and stresses.

However, it is essential to acknowledge the limitations of this study, including its geographical focus and potential data constraints. Further research is needed to explore the generalizability of these findings to different urban contexts and to delve deeper into the complex interplay between public space morphology and other dimensions of urban resilience.

Ultimately, this research contributes to a growing body of knowledge on the importance of public spaces in building resilient cities. By understanding the critical role of morphology, policymakers and urban planners can develop strategies to create more sustainable, equitable, and resilient urban environments for future generations.

As an environmental infrastructure, it allows solving the problems of wastewater and nitrified water through ecological systems, covering small peri-urban sectors, where low density makes the

implementation of traditional sanitation networks very expensive. On the other hand, the incorporation of solutions based on nature allows the creation of lagoons for water treatment with less impact on historical agricultural landscapes. Future research should analyse the validity of the model in other agricultural settings subject to environmental impacts.

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Data availability statement
The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Ethics statements
Studies involving animal subjects: No animal studies are presented in this manuscript.
Studies involving human subjects: No human studies are presented in this manuscript.
Inclusion of identifiable human data: No potentially identifiable human images or data is presented in this study.

Conflict of Interests
The author declares no conflict of interest.

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