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The Relationship between Smart Cities, Urban Resilience and Sustainability: Implications for Urban Planning

Akıllı şehir, kentsel direnç ve sürdürülebilirlik arasındaki ilişki: kentsel planlama için çıkarımlar

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ABSTRACT
Cities function as complex ecosystems with unique qualities, cultural diversity, and distinctive identities, requiring a comprehensive examination of interconnected factors. From an urban planning perspective, sustainability, urban resilience, and the smart city concept are of paramount importance. In urban planning, urban resilience is predominantly associated with responses to natural disasters. Despite being a relatively new concept, resilience is perceived as a transformative approach to mitigating vulnerabilities faced by cities. As concepts, sustainability and resilience are synergistic and strategic, enabling urban planning. To earn the "smart" label, a city must have urban planning that both promotes sustainability and demonstrates urban resilience. This article aims to elucidate the complex interplay between "smart cities", "sustainability" and "urban resilience" their impacts on urban planning, and their significant aspects. The study employs the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology. Subsequently, a comprehensive analysis of 95 articles, supported by the visualization of keywords using VOSviewer®, was conducted. The analyzed articles span the fields of interior architecture, architecture, and urban planning. The findings emphasize the transformative potential of integrating "smart cities", "sustainability"" and "urban resilience" principles in urban planning, leading to a paradigm shift towards more holistic and resilient urban environments. The results also highlight the interdependence of smart cities, sustainability, and resilient planning. The study concludes that smart cities cannot be considered separately from sustainability, and sustainability cannot be evaluated independently of urban resilience.

Keywords: Smart city, Urban resilience, Sustainability, Notion analyze, Meta-Analyse, Informatics and Information Technologies in Architecture

ÖZET
Şehirler, kendilerine özgü nitelikleri, kültürel çeşitlilikleri ve benzersiz kimlikleriyle birbirine bağlı faktörlerin kapsamlı bir şekilde incelenmesini gerektiren karmaşık ekosistemler olarak işlev görmektedirler. Kentsel planlama açısından sürdürülebilirlik, kentsel dayanıklılık ve akıllı şehir kavramları önemli bir yere sahiptir. Kentsel planlama alanında kentsel dayanıklılık ağırlıklı olarak doğal afetlere verilen tepkilerle ilişkilidir. Nispeten yeni bir kavram olmasına rağmen dayanıklılık, şehirlerin karşılaştığı kırılganlıkları hafifletmeye yönelik dönüştürücü bir yaklaşım olarak algılanmaktadır. Sürdürülebilirlik ve dayanıklılık, kavram olarak sinerjik ve stratejik, akıllı bir planlamayı mümkün kılar. "Akıllı" etiketini kazanmak için, bir şehrin hem sürdürülebilirliği teşvik eden hem de kentsel dayanıklılığı gösteren bir kentsel planlamaya sahip olması gerekir. Bu makale, "akıllı şehirler", "sürdürülebilirlik", "kentsel dayanıklılık" arasındaki karmaşık etkileşimi, bahsi geçen kavramların kentsel planlamaya etkileri ve bunların önemli yönlerini açıklamayı amaçlamaktadır. Çalışmada yöntem olarak, Sistematik İncelemeler ve Meta-Analizler için Tercih Edilen Raporlama öğeleri (PRISMA) metodolojisini kullanılmıştır. Sonrasında, VOSviewer® kullanılarak anahtar kelimelerin görselleştirilmesiyle desteklenen 95 makalenin kapsamlı bir analizi gerçekleştirilmiştir. Analizi yapılan makaleler, iç mimarlık, mimarlık, şehir planlama alanlarındadır. Bulgular, kentsel planlamada "akıllı şehirler", "sürdürülebilirlik" ve "kentsel dayanıklılık" ilkelerini birleştirmenin dönüştürücü potansiyelini vurgulayarak, daha bütünsel ve dirençli kentsel

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ortamlara doğru bir paradigma değişimine öncülük etmektedir. Bulgular aynı zamanda, akıllı şehirlerin, sürdürülebilirliğinin ve dayanıklı planlamanın altını çizmektedir. Çalışma sonucunda, akıllı şehirlerin sürdürülebilirlikten, sürdürülebilirliğin de kentsel dayanıklılıktan ayrı değerlendirilemeyeceği sonucuna varılmıştır.

Anahtar kelimeler: *Akıllı şehir, Kentsel dayanıklılık, Sürdürülebilirlik, Kavram analizi, Meta-Analiz, Mimarlıkta Bilişim ve Bilgi Teknolojileri*

INTRODUCTION

Cities, with their distinct attributes, cultural diversity, and unique identities (Kerestecioğlu and Akın, 2022), function as intricate ecosystems that require a comprehensive analysis of interconnected factors. The convergence of “smart cities”, “sustainability”, and “urban resilience” has emerged as a critical area of focus within the discourse of urban planning. This article aims to emphasize the complex interplay between "smart cities," sustainability, and urban resilience and to elucidate their combined impact on the evolving landscape of urban planning. Recognizing the significant influence of these elements, this research undertakes a foundational exploration of urban planning.

Urban planning represents a dynamic manifestation of the intricate interplay between governmental entities and societal forces. It is a deliberate process aimed at crafting public policies that reflect both regional and national imperatives. In the context of sustainable urban planning, the importance of well-designed cities is paramount, as they play a crucial role in optimizing resource use and mitigating environmental impacts (Kayakutlu et al., 2017; Bento et al., 2018). Thus, urban planning must take into account a broad array of environmental and socioeconomic variables, particularly in relation to population density.

Urban planning initiatives should strive to create regional models that support decision-making processes grounded in sustainability principles (Márquez and López, 2015). However, contemporary cities are increasingly confronted with challenges arising from unchecked urban expansion (Mercado *et al.,* 2017). These challenges necessitate the development of innovative, intelligent, and sustainable urban plans that carefully consider variables aimed at reducing environmental degradation and addressing associated risks. This urgency highlights the need for a paradigm shift in urban planning strategies, demonstrating a commitment to holistic sustainability and resilience in response to the pressures of urbanization.

The concepts of smart cities, resilience, sustainability, and urban planning have been widely discussed since 2010. A review of relevant databases reveals a significant increase in scholarship on these topics after this period, making 2010 critical reference point for this study.

The study concludes that smart cities cannot be considered independently of sustainability, and sustainability cannot be evaluated without considering urban resilience. Moreover, this study uniquely positions these technologies not only for disaster preparedness and response but also to promote long-term resilience by fostering adaptable urban ecosystems that can dynamically respond to evolving challenges. Urban ecosystems refer to the complex networks of living organisms, including humans, animals, and plants, interacting with their urban environment. These ecosystems are characterized by the integration of natural and human-made elements within urban areas, such as parks, water bodies, streets, and infrastructure. The concept plays a vital role in urban planning, as it focuses on maintaining ecological balance while supporting urban development. Sustainable urban ecosystems enhance biodiversity, regulate climate, manage water resources, and improve residents

overall quality of life (Alberti, 2005). In urban planning, the preservation and integration of ecosystems into the built environment are crucial for fostering long-term environmental resilience, ensuring that cities can adapt to challenges such as climate change, pollution, and population growth (McPhearson *et al.,* 2016).

The research not only highlights global efforts towards urban resilience but also provides a roadmap for cities seeking to enhance their resilience strategies. In conclusion, this study aims to contribute to the field by offering a detailed understanding of the interconnectedness between smart cities, sustainability, and urban resilience.

Smart Cities

The concept of *smart cities* has evolved as a response to the growing complexity of urban environments and the increasing demand for sustainable development. Originating in the early 21st century, the notion of smart cities refers to cities equipped with intelligent economic, institutional, social, and physical infrastructure that enables citizens to centralize within a sustainable environment (Kassam, 2023; HABITAT, 2023). The idea behind smart cities aligns with advancements in technology, data analytics, and urban planning, creating interconnected systems that promote efficiency, innovation, and quality of life.

The *smart city* model is commonly measured across six key dimensions: economy, mobility, governance, environment, people, and living (Giffinger *et al.,* 2007). These dimensions provide a framework for assessing a city's ability to manage resources, improve urban services, and enhance civic engagement. Numerous studies have explored both the implementation of smart city technologies and the challenges they face (Allwinkle and Cruickshank, 2011; Chourabi et al., 2012; Hollands, 2008; Komninos, 2011; Lombardi *et al*., 2012; Nam and Pardo, 2011; Papa *et al*., 2015; Wolfram, 2012).

Urban planning plays a critical role in the successful development of smart cities. The goal of smart city strategies is to align top-level policies with local objectives, facilitating effective policy coordination (Walters, 2011). In this context, *smart city pilot projects* serve as platforms for testing innovative solutions in real-life environments, ensuring that they meet both short-term objectives and long-term feasibility (Bria, 2012; Carter *et al.,* 2011; González and Rossi, 2012).

Importantly, smart cities are not solely defined by technological infrastructure. Although high-tech systems play a pivotal role, technology alone does not guarantee the "smartness" of a city (Anthopoulos and Tougountzoglou, 2012; Aurigi, 2006; Hollands, 2008; Komninos and Sefertzi, 2009; Lind, 2012; Nam and Pardo, 2011). A significant body of literature emphasizes the importance of human and social capital in the development of smart cities, asserting that creativity and social engagement, supported by technology, are crucial for sustainable urban growth (Hollands, 2008; Paskaleva, 2011; Glaeser and Berry, 2006; Chourabi *et al.,* 2012; Neves, 2009). Human creativity, enhanced by digital tools, is often seen as more powerful than individual or machine intelligence (Ratti and Townsend, 2011).

One of the key objectives of smart cities is to enhance the *quality of life* for citizens. ISO 37122:2019 "Sustainable Cities and Communities- Indicators for Smart Cities" outlines strategies for providing better services and improving urban living standards (Kassam, 2023). Smart cities emphasize sustainability, participation, and resilience, adopting a holistic approach to development that aligns economic growth, environmental protection, and social well-being (Alderete, 2019; Fergnani, 2016).

Sustainability

The Brundtland Commission defined sustainability as: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development, 1987). The concept of

sustainability in urban planning has deep roots, stemming from the broader environmental movement and the global awareness of ecological limits. The International Organization for Standardization (ISO) standard 37101:2016 encourages a multi-stakeholder process for urban sustainability, incorporating economic, social, and environmental contexts (Kassam, 2023). Sustainability in urban planning goes beyond preserving natural resources; it also encompasses efforts to improve quality of life by balancing economic development, social equity, and environmental stewardship.

Sustainable planning is a vital tool for assessing ecological footprints, consumption patterns, and lifestyles, ultimately aiming to foster livability within cities (Wilson, 2016). The concept of *sustainability* gained prominence with the Brundtland Commission's report in 1987, which highlighted the importance of meeting present needs without compromising the ability of future generations to meet theirs. In urban planning, sustainability is often linked to efforts to reduce carbon footprints, enhance green spaces, and promote long-term social resilience (Davoudi *et al.,* 2012).

At its core, sustainability requires a multidimensional approach that integrates environmental concerns with economic and social policies. By seeking a balance between ecological preservation and human development, sustainable urban planning aims to create cities that are both resilient and adaptable to future challenges.

Resilience

Urban resilience is a key concept in contemporary urban planning, particularly in response to the increasing frequency of environmental disasters and socio-economic challenges. ISO 37123:2019 defines urban resilience as "the ability of a city to cope with all challenges of a changing world" (Gere, 2019). The concept originated from ecological systems theory in the 1970s and has since expanded to encompass cities capacity to not only withstand but also recover from extraordinary events, whether they be natural disasters, economic crises, or social upheavals. In urban planning, resilience refers to a cites ability to adapt to climate change, infrastructural shocks, and other external pressures (Suarez, 2016). The term encompasses both the ability to resist immediate shocks and the capacity to recover and rebuild in ways that strengthen future resilience. This dual focus makes resilience a critical factor in sustainable urban development. Urban resilience is framed by both theoretical and practical analyses. Conceptually, it involves evaluating a system's performance before, during, and after disruptive events (Tzioutziou and Xenidis, 2021). Several studies suggest that resilience can be understood as a process, which includes the adaptability, flexibility, and capacity of urban systems to evolve in response to changing circumstances (Jovanovic et al., 2019; Kallaos *et al.,* 2014; Ramirez-Marquez *et al.,* 2018).

The term *resilience* has progressed from being viewed as an abstract concept to a more operational framework used in urban planning. This shift underscores the importance of flexibility in designing urban environments capable of accommodating future uncertainties (Longstaff *et al.,* 2013; Lundberg, 2015). By addressing both resilience and sustainability, cities can build infrastructures that not only cope with but also thrive in the face of disruption, making resilience an indispensable feature of modern urban systems.

Urban Planning

Urban planning reflects the process of interaction between government authorities and society. Its primary objective is to formulate public policies that align with both regional and national priorities.

Thoughtfully designed cities play a vital role in advancing sustainable urban planning solutions, as they optimize resource use and reduce environmental impacts (Bento *et al*., 2018; Kayakutlu *et al.,* 2017). Consequently, urban planning must take into account environmental and socioeconomic variables linked to population density. Effective planning should facilitate the development of regional models that support strategic decision-making grounded in sustainability principles (Márquez and López, 2015).

However, contemporary cities are increasingly challenged by unchecked urban expansion (Mercado *et al.,* 2017). This has created an urgent need for innovative, smart, and sustainable urban plans that incorporate strategies to mitigate environmental degradation and associated risks.

MATERIAL METHODS

This study delved into the intricate web of relationships among "smart cities," "sustainability," and "urban resilience," along with their profound impacts on urban planning through a systematic literature review. Employing a methodical approach, we conducted an extensive review of multidisciplinary scientific journals to gain a comprehensive understanding of these interconnected concepts. Articles contributed by diverse researchers on a global scale were systematically classified and rigorously examined to uncover the nuanced relationships between the aforementioned concepts. In these articles, the words used alongside the respective expressions were analyzed through notion analysis. Table 1 presents the characteristics of the examined articles.

Table 1. Reviewed publication field

The number of reviewed articles	Articles field
12	Interior Architecture/Interior Design
48	Architecture
40	Urban and Regional Planning

The methodology involved conducting a comprehensive investigation of scholarly works to gain insights into the interplay of "smart cities," "sustainability," and "urban resilience." A systematic literature review served as the cornerstone of this methodology, facilitating the synthesis of knowledge from diverse disciplinary perspectives. Figure 1 was developed to visually depict the stages undertaken, serving as a roadmap for exploring the intricate relationships within the context of urban planning. This methodological approach ensured a thorough and rigorous examination of the subject matter, laying a solid foundation for subsequent discussion and analysis. By employing a systematic literature review, which drew upon a wide range of scholarly contributions, the study enhanced its credibility and breadth of insights.

The methodology of this study can be summarized as follows:

A compilation of information was conducted using various scientific databese (Scopus, Web of Science, and Google Scholar) employing Boolean operators "AND" and "OR". Documents containing the following keywords in their titles or abstracts were searched from 2012 to 2022.

- TITLE-ABS-KEY (“Urban Planning”) OR
- TITLE-ABS-KEY (“urban ecosystems”) AND
- TITLE-ABS-KEY (“sustainability”) OR
- TITLE-ABS-KEY (“urban resilience”) OR

- TITLE-ABS-KEY (“smart cities”)

Articles in Turkish, English, and German were included in the evaluation.

For quality assessment, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) tool was used for each article, providing an objective comparison between the articles and their classifications. Figure 1 presents the research methodology, and Table 2 provides this methodology in tabular form. The number of analyzed articles is expressed by the letter n.

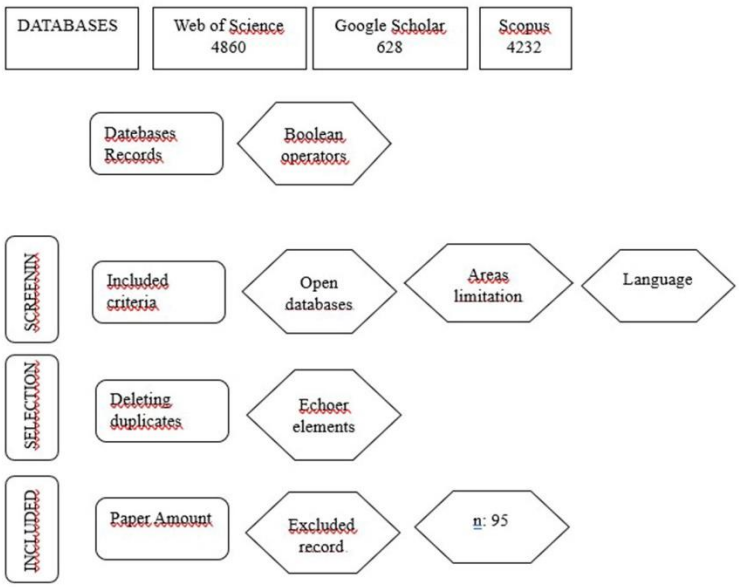

Figure 1. Methodology of the research

Table 2. Methodology of the research

Database	Web of Science 4860	Google Scholar 628	Scopus 4232	
Screning	Included criteria	Open databases	Areas limitation	Language
Selection	Deleting duplicates	Echper elements		
Included	Paper amount	Exqluded record		

When conducting notion analysis, grouping was performed using VOSviewer®, a viewer that displays keywords, assigning a weight to each word based on the number of times the word appeared in the selected studies.

FINDINGS

This study undertook a comprehensive exploration, meticulously reviewing 95 articles to unravel the intricate relationship between the concepts of smart cities, sustainability, and urban resilience, along with their collective impacts on urban planning. The methodology section provides a detailed exposition of the methods employed, elucidating that the concept of resilience serves as a foundational pillar supporting sustainability and catalyzing innovative approaches to urban planning. Noteworthy terms closely associated with resilience, namely “sustainability”, “learning,” and

"technology," received significant attention throughout the study period, indicative of their evolving relevance in the discourse.

The comprehensive methodological approach outlined in the study underscores the integral role of resilience in shaping sustainable urban planning paradigms, thereby laying the groundwork for the emergence of smarter urban environments. Figure 2 visually encapsulates the temporal trends in the utilization of key terms in conjunction with resilience, portraying a discernible escalation over the years. This graphical representation offers nuanced insight into the evolving dynamics of scholarly attention and emphasizes the growing significance of resilience, sustainability, and related terms in the realm of urban studies and planning.

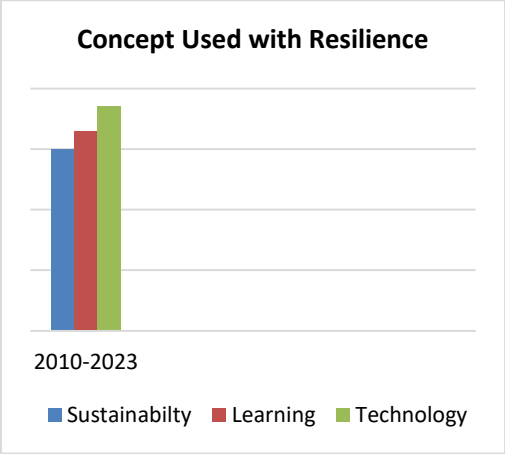

Figure 2: Concept used with resilience chancing with time

This study's findings provide important insights into the intricate relationships among smart cities, sustainability, and urban resilience, moving beyond established knowledge to offer a more integrated and dynamic understanding. A comprehensive analysis of the selected literature reveals that resilience and sustainability are deeply intertwined within the framework of smart cities, which highlights the need for a holistic approach to urban planning.

Through the systematic review, it was found that 79.83% of the examined articles analyzed resilience within the framework of sustainability, while 82.56% emphasized the critical role of sustainability principles in smart city initiatives. These figures underscore the necessity of treating these three concepts - smart cities, sustainability, and resilience- not as isolated phenomena, but as mutually reinforcing components of a robust urban planning paradigm.

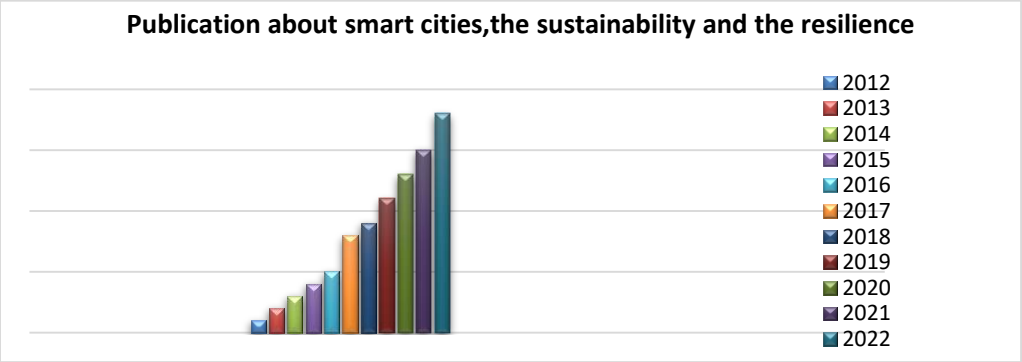

Figure 3: Publication about smart cities, sustainability and resilience

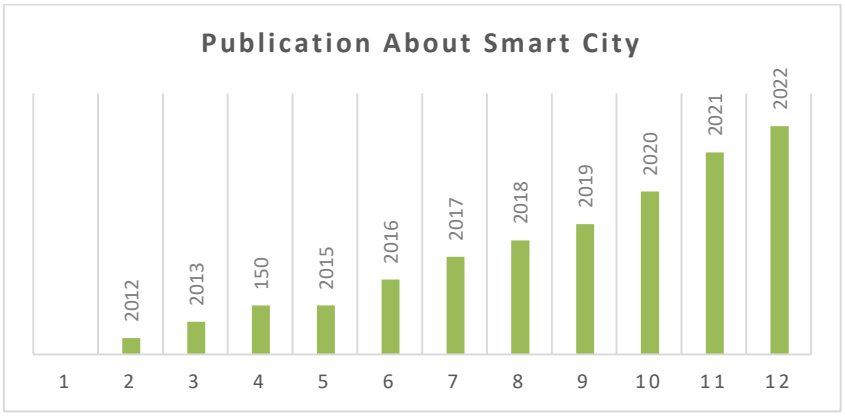

Figure 4: Publication About Smart City

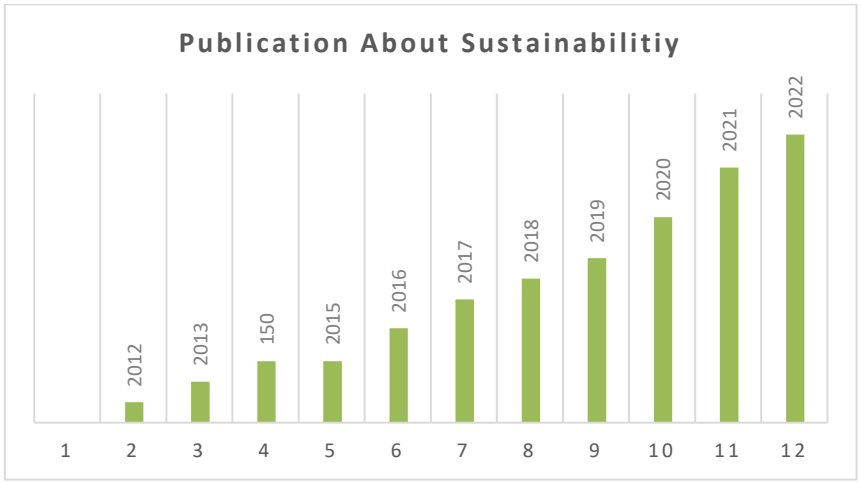

Figure 5: Publication About Sustainability

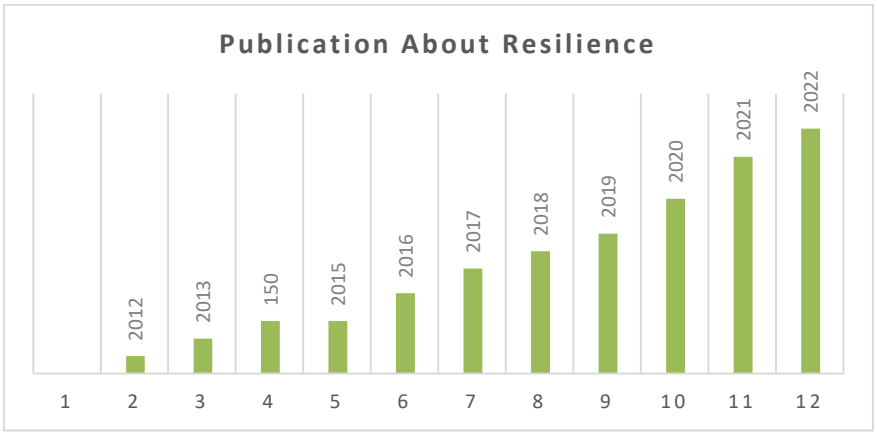

Figure 6: Publication About Resilience

Concept Used with Resilience

The conceptual landscape of resilience has undergone significant evolution in the last decade, exhibiting notable breadth and adaptability. Over this period, three pivotal concepts -sustainability, learning, and technology - have emerged prominently within scholarly discourse. Among the 95

publications scrutinized in this study, a significant majority, precisely 83.15% (79 publications), have referenced at least one of these central notions. This statistical prevalence underscores the substantive influence and relevance of sustainability, learning, and technology in shaping the contemporary discourse surrounding resilience.

To visually depict the prevalence and interplay of these emerging concepts, Figure 7 provides a clear representation of their frequency of occurrence within the reviewed publications. This graphical depiction serves as a valuable analytical tool, offering insights into the thematic paths that have gained prominence within the academic exploration of resilience. The recurrent inclusion of sustainability, learning, and technology suggests a notable synergy between these concepts and resilience, emphasizing their integral role in contemporary discussions pertaining to urban planning and resilience studies.

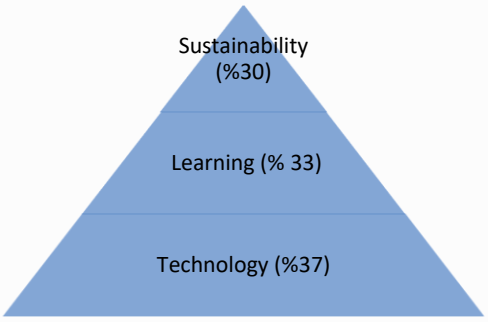

Figure 7: The notions in articles related to resilience

The words associated with the term “resilience” are provided in Figure 4. In this context, sustainability ranks third at 30%. Additionally, learning comes in second place with 33%, while the concept of technology is observed to be in first place at 37%.

SUSTAINABILITY IN SMART CITIES

The escalating concerns regarding global warming and its deleterious consequences in the 1970s found expression at the inaugural World Climate Conference held in Geneva in 1979. The original nomenclature of the Brundtland Report, commissioned for the United Nations in 1987, was denominated as "Our Common Future." In the context of climate change mitigation, a reduction in CO^2 emissions has been advocated (Zillman, 2009). This imperative was delineated within the auspices of the Intergovernmental Panel on Climate Change (IPCC) in 1988 (Caselles Moncho *et al.,* 2008). The surge in resource consumption attributed to population growth has precipitated environmental predicaments. Ensuring environmental sustainability, constituting one of the tripartite pillars of sustainability alongside social and economic dimensions, assumes paramount importance. Realizing environmental sustainability necessitates the cultivation of environmentally conscious individuals, as enshrined in the 1977 Tbilisi Declaration of the Soviet Union, elucidating the tenets of environmental ethics (Walker, 1998; Prieto Barboza, 2013; López and Lopez, 2019; Rincón-Ruíz, 2014).

In the year 2000, developmental objectives were articulated to enhance the circumstances of the nation’s signatory to the Tbilisi Declaration. The Johannesburg Summit reaffirmed pre-established strategies for these developmental goals and introduced diverse financial mechanisms for sustainable development initiatives in developing nations.

A critical distinction must be elucidated between sustainable development and sustainability. Sustainability can be construed as the overarching goal or the ideal state to be aspired to, whereas sustainable development is a multifaceted concept encompassing social, environmental, and

economic dimensions. In 2015, recognizing the imperative for more stringent measures aligned with the sustainable development paradigm, the 2030 Agenda for Sustainable Development was implemented. These goals, colloquially known as the Global Goals, represent a universal call to action to eradicate poverty, safeguard the environment, and ensure universal well-being and prosperity (Suárez Casado, 2016). However, comprehending the various paradigms of sustainability requires an examination of the constructs crystallized at the Brundtland Summit, as per the United Nations" directive. The first element revolves around the concept of the "needs of generations" while the second element entails considerations for both "present and future generations" (Suárez Casado, 2016; Lopera, 2019; Veza, 2013).

The keystone of the sustainable development paradigm resides in the "green economy" or "sustainable economy"" model. The United Nations Environment Programme (UNEP) inaugurated the "Green Economy Initiative" (GEI) in 2008, elucidating that a green economy substantially mitigates environmental risks and ecological scarcities while concurrently enhancing human well-being and societal equity (UNEP, 2011). Within the contours of the "2030 Sustainable Development Goals" delineated by the United Nations, 11 sustainable cities and communities are identified. The overarching objective lies in the judicious utilization of resources and the environment concomitant with the augmentation of well-being and the enhancement of the quality of life. Indicators for quality of life and well-being, as encapsulated in ISO 37120, assume pivotal significance in the pursuit of sustainable living.

RESILIENCE in SMART CITIES

Cities confront a formidable challenge in the form of exponential growth, with projections indicating that by 2050, over 70% of the global population will be concentrated in urban areas. This demographic trend raises concerns about the substantial consumption of natural resources, prompting decision-makers to seek viable solutions to mitigate these issues

The concept of resilience, as applied to cities, is understood as the preparedness for extreme weather events and local disruptions (Asprone and Manfredi, 2015; Pumain, 2006).

The integration of the resilience concept into urban planning and its contribution to sustainability warrant emphasis. In 1973, ecologist C.S. Holling articulated resilience as "the persistence of relationships within a system and is a measure of the system"s ability to absorb changes in state variables, driving variables, and parameters, and still persist. Accordingly, resilience is a property of the system, and persistence or the probability of extinction is a result" (Holling, 1973). Researchers, leveraging Holling's theory, initiated its practical applications at Columbia University (Folke, 2006; Asprone and Manfredi, 2015). By 1998, Simon Levin from the University of Cambridge expanded the concept beyond its ecological roots, recognizing its applicability to diverse systems.

In response to the escalating impacts of climate change in 2005, including rising sea levels and extreme weather conditions leading to increased diseases and species extinction, world leaders convened at the "World Conference on Disaster Reduction" in Kobe. This assembly culminated in the establishment of a resilience action framework spanning from 2005 to 2015 (Nieto and Potes, 2018; Rincón-Ruíz, 2014). Subsequently, in 2015, concomitant with the introduction of the Sustainable Development Goals, the BM-Habitat report delineated urban resilience as the "capacity of urban systems to withstand any event caused by natural or human-induced destructive events." The primary objective is to prevent such events from evolving into disasters, gauged against the variables

of stability and renewal. Addressing the challenges in achieving the Sustainable Development Goals, the UN developed an urban resilience guide for member countries in 2016 (UN-HABITAT, 2016).
Key to understanding urban resilience are the pivotal terms "hazard," "exposure," and "vulnerability." Notably, "exposure" represents a critical characteristic determining a community"s sensitivity to harm resulting from a hazard (Rincón-Ruíz, 2014). The resilient cities guide categorizes events that a region may be exposed to and that could significantly impact it, as outlined in Table 3.

Table 3: Disasters within the scope of resilience

VARIETY	SORT
Geological	Volcanism Earthquakes Tsunamis Instability of the slopes Flows Falls or collapses Sinking Subsidy
Hydro-meteorological	Cracking Warm and cold waves Droughts Hailstorms Snowstorms Tropical cyclones Tornadoes Dust storms Electrical storms Extreme rains
Sanitary-ecological	Epidemics Pests Air pollution Water pollution Soil contamination Massive movements
Socio-organizational	Large concentrations Terrorism Sabotage Vandalism Air accidents Maritime accident Land accident

In recent times, there has been a concerted effort to introduce novel parameters for the assessment of urban resilience. Cities aspiring to be more resilient and sustainable, particularly those adopting smart city initiatives, are foundational to mitigating the impacts of natural disasters such as floods, earthquakes, hurricanes, uncontrollable fires, chemical leaks, or power outages (Davalos and Pérez, 2017). Notably, several global organizations exerting substantial influence, including the Resilience Alliance, Community and Regional Resilience Institute, Resilient Cities, Resilient Regions Building Network, and the City Resilience Index, assume pivotal roles in both the formulation and dissemination of resilience frameworks (Suárez Casado, 2016; Lanfranchi, Herrero, 2016; Méndez, 2012).
These organizations collectively contribute to the discourse on urban resilience, bringing forth diverse perspectives and methodologies. The Resilience Alliance, for instance, serves as a

collaborative network of researchers and practitioners dedicated to advancing understanding and application of resilience concepts. Similarly, the Community and Regional Resilience Institute focus on enhancing the resilience of communities and regions through research, education, and outreach efforts. Resilient Cities and Resilient Regions Building Network are dedicated to fostering resilience at the urban and regional scales, respectively. The City Resilience Index, on the other hand, provides a structured framework for assessing and measuring the resilience of cities.

The multifaceted engagement of these organizations underscores the growing recognition of the intricate nature of urban resilience. As cities increasingly grapple with diverse challenges, ranging from climate change-induced disasters to technological disruptions, the concerted efforts of these global entities contribute significantly to the development and implementation of effective strategies for enhancing urban resilience. This collaborative approach reflects the acknowledgment of the interconnected and complex nature of urban systems, necessitating comprehensive frameworks and indices to guide cities towards greater resilience and sustainability.

One of the key contributions of this study is its demonstration that evaluating smart cities independently of sustainability and resilience is insufficient. While previous research has explored these concepts in silos, this study establishes that their integration is essential for advancing both academic inquiry and practical applications in urban planning. By synthesizing perspectives from multiple disciplines, this study highlights how resilience should not only focus on immediate disaster response but also be built into the long-term sustainability of urban environments, creating smarter cities that are adaptable and future-proof.

Furthermore, this study offers a new framework for understanding resilience in the context of smart cities, based on the analysis of frequently associated terms (Figure 4). Notably, technology (37%), learning (33%), and sustainability (30%) are identified as the primary keywords linked to resilience, demonstrating the growing recognition that resilience in smart cities is a multi-faceted construct. The emergence of technology as the most frequently associated term underscores the crucial role of technological innovation in enhancing urban resilience, which adds a fresh perspective to the ongoing discourse in the literature.

A key insight that emerges from these findings is the imperative of integrating technological advancements with sustainability principles to build resilient urban systems. The role of smart technologies- such as data analytics, real-time monitoring, and IoT systems - has been discussed extensively in the literature. However, this study uniquely positions these technologies as essential not only for disaster preparedness and response but also for fostering long-term resilience by promoting adaptive urban ecosystems that can respond dynamically to evolving challenges.

Additionally, the exploration of green economy principles within the context of smart cities offers another important contribution. The link between urban resilience and sustainability goals, especially the 2030 Sustainable Development Goals (SDGs), has been well-documented. However, this study provides new insights by positioning urban resilience as a core driver in achieving these global objectives. The evidence suggests that urban resilience must be viewed as a long-term investment, requiring continuous integration with sustainability efforts to meet the SDGs, particularly in cities facing rapid urbanization and resource challenges.

Lastly, the study makes a practical contribution by showcasing how global organizations such as the Resilience Alliance, the City Resilience Index, and Resilient Regions Building Network contribute to shaping the resilience frameworks of cities around the world. By presenting an in-depth analysis of their methodologies and strategies, this study not only highlights the global efforts towards urban

resilience but also offers a roadmap for cities seeking to enhance their resilience strategies. The findings suggest that cities adopting smart city initiatives should prioritize the development of comprehensive resilience indices that incorporate sustainability metrics, thereby fostering a more resilient, adaptable, and sustainable urban future.

In conclusion, this study contributes to the field by offering a nuanced understanding of the interconnectedness of smart cities, sustainability, and resilience. By demonstrating that these concepts must be integrated into urban planning to address future challenges effectively, this study provides both theoretical advancements and practical recommendations for policymakers and urban planners. This research reinforces the need for cities to adopt a multidimensional approach to resilience, one that blends technology, sustainability, and community engagement to create smarter, more resilient urban ecosystems.

DISCUSSION

The practice of urban planning has been a defining characteristic of human development, evolving from basic land organization into a complex, political instrument with wide-ranging implications. One of the core elements of contemporary urban planning is the integration of water resources, which play an essential role in sustaining human well-being and comfort. As cities face increasing pressures from climate change and population growth, water management has become a central component in resilient urban planning (Márquez and López, 2015). Effective management of these resources is foundational not only for physical infrastructure but also for ecological and socioeconomic systems, highlighting the interconnectedness of urban ecosystems and human life.

Socioeconomic conditions exert significant influence on ecosystems, necessitating the development of robust political structures to support planning processes. Planning tools must address key aspects such as land use, social stratification, and environmental protection to foster urban sustainability and resilience. International frameworks, such as those established during the 1992 Rio Summit, underscore the global commitment to sustainable development, biodiversity, and environmental protection (Guerra *et al.,* 2017). These frameworks have strengthened the legal and institutional foundation of urban planning, embedding sustainability as a core principle in regional and local planning tools.

The Brundtland Commission’s definition of sustainable development "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" remains a cornerstone of urban planning theory and practice (Veza, 2023). Sustainable development necessitates a regional approach that prioritizes the preservation of ecological processes, biodiversity, and the sustainable use of resources within a city’s carrying capacity. Within this context, urban planning has shifted from solely focusing on economic growth to incorporating environmental stewardship and social equity. This transformation has been reinforced by environmental education and ethics initiatives, such as those outlined in the Tbilisi Declaration, which call for greater awareness and integration of ecological principles in planning (Casaus, 2018; Lipp, 2018).

Urban resilience, as a concept, has gained increasing importance in the planning discipline, particularly in the context of responding to natural disasters and climate change. Resilience encompasses the capacity of urban systems to absorb shocks, adapt to changing conditions, and recover from disruptions. This dynamic interaction between resilience and sustainability is essential for long-term urban survival. Resilience operates as a multi-dimensional framework, with each

component- exploitation, protection, empowerment, or reorganization- working in harmony to achieve urban stability and functionality. By understanding and managing these interactions, cities can develop tools to assess carrying capacity and measure environmental footprints, essential components of resilient urban systems (Folke, 2006).

Resilience is also deeply interconnected with risk management. Developing resilient cities involves not only physical infrastructure capable of withstanding disasters but also social and institutional mechanisms to protect citizens and recover quickly from crises. The strategic integration of resilience into urban planning improves overall quality of life, helping cities become less vulnerable to external shocks (Rincón-Ruíz, 2014). Resilience is thus not just a reactionary measure but a proactive approach to urban development, encouraging cities to evolve and transform in response to future challenges.

The interconnection between resilience, sustainability, and smart city development lies at the heart of modern urban planning. Smart cities, which leverage technology to improve infrastructure, governance, and citizen engagement, are inherently linked to both resilience and sustainability. Smart technologies facilitate real-time data collection and analysis, enabling cities to respond swiftly to environmental, economic, and social challenges. However, technology alone is insufficient. The true "smartness" of a city lies in its ability to foster resilience and sustainability by integrating human capital, governance, and environmental considerations (Bria, 2012; Angelidou, 2014).

In conclusion, resilience and sustainability are not merely complementary concepts but foundational to the development of smart cities. The synergy between these concepts enables strategic, forward-looking urban planning, where technology and human ingenuity work together to create cities that are not only sustainable but also resilient to the uncertainties of the future. The planning of cities that can adapt to and recover from disasters aligns with the broader goals of sustainability, ensuring that urban areas can thrive in the face of both environmental and social challenges. As cities evolve, the integration of resilience and sustainability will be crucial in shaping smarter, more adaptable urban environments.

CONCLUSIONS

The unstoppable-volution of urban planning, sustainability, resilience, and the concept of smart cities underscores their inevitability. Particularly within the domain of resilience, exposure to natural disasters accentuates human vulnerability. In response to such challenges, the imperative arises to reconfigure land use, coalesce around a shared objective ensuring ecosystem well-being, and shift urban planning paradigms from a human-centric orientation to an environmentally focused structure.

The overarching goals of smart city planning should be centered on sustainable development and sustainability. This study delves into the intricate relationship between smart cities, sustainability, and urban resilience, addressing a discernible gap in comprehending the profound impacts of these concepts on urban planning. A comprehensive examination of 95 articles reveals the pivotal role of resilience in the sustainability of smart cities.

Sustainability serves as a generative force, providing tools that steer long-term societal transformation. In contrast, sustainable development operates as a roadmap, facilitating the restructuring of public institutions and policies. For the realization of a smarter city, a pragmatic methodology that comprehensively addresses and categorizes environmental, social, and economic variables while preparing the region for potential disasters is imperative. Alignment with the

Sustainable Development Goals assumes paramount importance in preserving the physical, chemical, and biological components of ecosystems. The success of sustainable urban development is contingent on the quality of the environment. Importantly, the integration of technology and learning emerges as influential forces shaping resilience, thereby engendering the creation of smarter cities.

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