

Strategies of urban resilience related to the built environment: an overview of the literature

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Abstract

Urban resilience has been an increasingly discussed topic in the scientific community. The term relates to the city's ability to return or simply not to interrupt its routine in the face of some disturbance. Cities around the world have sought to create and implement strategies to improve their resilience to cope with tensions arising from climate change, as well as issues that are already familiar to them, but which have not been overcome. Thus, studies on resilience run through urban systems and communities, which makes the theme attractive and necessary for the engineering context, since it is indispensable for the construction of a smart and prepared environment to face climate change. This article presents an overview of the current literature on the implementation of urban resilience strategies directly related to the built environment and the construction industry. Bibliographic research uses systematic mapping supported by bibliometric analysis and performs content analysis to identify trends and gaps in knowledge. As a result, several strategies, both governmental and technological, applied in various cities around the world are identified and categorized. In addition, the need for more studies on urban resilience in the built environment was perceived.

Keywords: Built environment, systematic mapping of literature, urban resilience.

1 Introduction

Cities are population concentration hubs with a forecast that will shelter 70% of the world's population by 2050 (United Nations 2019), a scenario that requires increasingly robust and efficient infrastructure. However, most cities already present serious problems in these contexts, such as lack of sanitation, solid waste management, households located in inappropriate places, high energy consumption, air and water pollution (Chang *et al.* 2016, Madeiros *et al.* 2018, Myers *et al.* 2021), among others.

In this sense, it is important to understand the role of the built environment in the well-being of cities. According (Sapeciay *et al.* 2017), the built environment is a consequence of the work of the construction industry combined with new technologies and governmental and private initiatives generating spaces for population day-to-day life. The pressure produced by the population increase generates the need to expand and adapt these urban spaces and infrastructures (Rees 1999) taking into account the issues of climate change and problems already faced by cities.

Additionally, the construction industry consumes a considerable part of the raw material extracted from nature, being responsible for one third of greenhouse gas emissions of the world and, in particular, carbon dioxide (CO₂) (World Economic Forum 2017), having extremely relevant potential for the creation of infrastructure to adapt to climate risks such as floods and rising sea levels (Park and Won 2019). Thus, the behaviour of the construction industry to support actions for urban resilience must be evaluated. The United Nations Office for Disaster Risk Reduction (UNISDR) (2012, p. 4) puts it that "All who make a city function, from municipal service providers to urban planners to the private sector and residents themselves, must be committed to building safer cities to secure resilience," which reinforces the role of the construction industry in building urban resilience.

Urban resilience is a term still under discussion due to the different connotation that can be adopted in each study area. Ribeiro and Gonçalves (2019) point out that half of the definitions are inserted in the context of threats (floods, earthquakes, etc.) and another part are inserted in the context of urban sustainability.

In a literature review, which included several papers on the subject, Meerow et.al (2016) presents the following general definition that can be applied to multiple areas: "Urban resilience refers to the ability of an urban system and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales-to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity".

Discussions on urban resilience contribute for decision-making in several cities resulting in planning proposals called "resilience strategies". In the city of Salvador (Brazil), for example, the resilience strategy was defined as a "proactive, integrated, collaborative, flexible, and long-term plan to address the challenges of the city and people in urban life" (Prefeitura Municipal de Salvador 2019, p. 10). In some places, this discussion is advanced and already have exclusive documents about it, as is the case of Salvador, mentioned above. In contrast, in other regions, such as Addis Ababa (Ethiopia, Africa), discussions are still evolving. There are still few studies on the subject. And it is noted that urban resilience studies developed in America and Europe do not suit the reality of their region (Baron and Cherenet 2018). It is important to observe how the development of research and application around the theme has been given and the relevance given to it in different regions.

Urban resilience is placed by Leitner et. al (2018) as a new urban development and governance agenda involving actors from all sectors generating globally applied standards and evaluation tools that make urban resilience technical and managerial. This makes resilience attractive to the private sector and integrating urban planning and governance structures. Programs such as Resilient Cities Network (<https://resilientcitiesnetwork.org/>), C40 (<https://www.c40.org/>) stand out supporting cities in developing their resilience strategies.

Research conducted in databases such as Scopus and Web of Science shows that there is a gap to be filled when it comes to studies on urban resilience in the context of the construction industry. There is a clear scarcity of work that addresses these areas simultaneously. In addition, the existing works are mostly found in Asian countries and usually encompass solutions aimed at specific contexts, making it difficult to spread their applications in other regions.

The aim of this article is to present an overview of the current literature on the implementation of urban resilience strategies directly related to the built environment and the construction industry. It seeks to identify how such studies recognize and treat urban resilience, based on the classification and analysis of the strategic actions they advocate.

It is expected that the results of this research can contribute to promote and direct the realization of studies related to the theme, especially in regions lacking such advance in knowledge.

2 Research methodology

The present study performs a systematic mapping of the literature (SML), supported by bibliometric indicators. To this end, we adopt the definition of SML indicated by Keele (2007), which says that systematic mapping consists of a broader approach to research, returning data that point to evidence groups or evidence deserts identifying areas that are performing well in their work or that need to develop more studies, respectively. The bibliometric analysis, in turn, is defined in this study as the process used to obtain quantitative data of interrelations between subjects and diverse scientific groups, obtaining an overview of the literature (Ellegaard and Wallin 2015).

The research was divided into two phases (Figure 1). In the first phase (Delimitation of publications), a choice of research terms, string formulation, choice of databases and article selection was made.

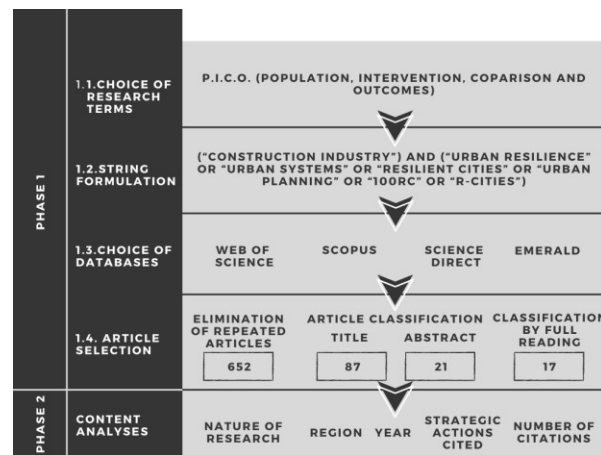


Figure 1. Research development.
Source: The authors.

The choice of search terms (Item 1.1) was made based on the adaptation of the PICO method (Population, Intervention, Comparison and Outcomes). The research terms were defined according to population, intervention, comparison and outcomes (Pai *et al.* 2004). As a result, it was defined: construction industry, urban resilience, urban systems, resilient cities, urban planning, 100RC, R-Cities. The terms were combined with Boolean operators AND and OR in order to delimit the search and gave rise to the string, as shown below: ("Construction industry") AND ("urban resilience" OR "urban systems" OR "resilient cities" OR "urban planning" OR "100RC" OR "R-Cities"). The quotation marks (" ") were used to recognize the sentence as the only term, that is, not to perform the search taking into account the words in isolation.

In the search for publications, the following databases were used: Science Direct, Web of Science, Emerald and Scopus (Item 1.3). These bases were chosen for their relevance in the dissemination of scientific production related to the built environment.

For the article selection (Item 1.4), the most relevant studies for the theme are identified. Articles that met the following criteria were selected: only articles from journals indexed in the time interval of the last 5 years and search in the title, abstract or keywords. The total return was 658 articles, 107 from the Science Direct database (16.3%), 49 from Scopus (7.4%), 384 from the Web of Science database (58.4%) and 118 from emerald base (17.9%). Then, repeated articles were removed. Six articles were excluded at this stage.

From this point, three selection processes were carried out. Initially, the first filter (Classification by title) was applied. This selection was made by reading the title of each publication and evaluating the relationship of the theme treated in the article with the research question. The second filter (Classification by abstract), the relevance of the content of the articles was evaluated by reading the abstract. Thus, only 87 of the 652 articles identified were considered relevant after reading the title. After reading the abstracts, only 21 of the 87 articles selected in the first filter were considered eligible. Finally, the third filter (Classification by full reading) was applied. At this stage, 4 articles were discarded because they presented content not related to the objective of this research. Figure 2 details the Article Selection step.

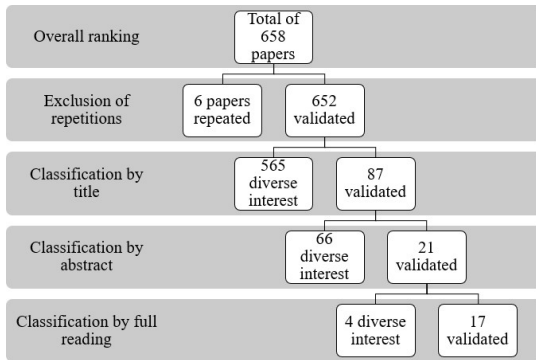


Figure 2. Article selection step.
Source: The authors.

In the second phase (Content Analysis) the results obtained in the first stage are performed. The 17 validated articles were classified by region, year of publication, number of citations, strategic actions cited and nature of research. The latter was divided into three categories: framework, case studies and literature reviews. Subsequently, the strategic actions adopted by the construction industry mentioned by the articles were evaluated, encompassing the development of models, certifications and new approaches/technologies.

3 Findings and Discussion

Figure 3 shows the classification of the selected papers by region and number of citations (A1 (Chang *et al.* 2016), A2 (Park and Won 2019), A3 (Ali *et al.* 2016), A4 (Cheshmehzangi 2021), A5 (Nelson 2016), A6 (Hatvani-Kovacs *et al.* 2018), A7 (Maund *et al.* 2018), A8 (Murtagh *et al.* 2020), A9 (Ciccaglione 2019), A10 (Bignami 2017), A11 (Göswein *et al.* 2021), A12 (Clarke *et al.* 2020), A13 (Myers *et al.* 2021), A14 (Baron and Cherenet 2018), A15 (Yaman Galantini and Tezer 2018), A16 (González *et al.* 2020), A17 (Paiva and Schicchi 2020)). It is observed that the publications are distributed as follows: Asia (24%), North America (6%), Europe (24%), Oceania (12%), Africa (18%), Euro-Asia (6%) and South America (12%). When relating this information with the number of citations of the published articles, it is observed, however, that Asia stands out with 63 citations (60%), followed by North America with 22 (21%). Oceania presents 10 citations (10%), Europe five (5%), Africa three (3%) and Euro-Asian region two (2%).

Figure 3 also shows the relationship of this information with the year in which the publications were made. It is observed that 2018 and 2020 are the years that had the most publications.

Asia stands out with the number of citations because of the article A1 entitled "Facilitating the transition to sustainable construction: China's policies" (Chang *et al.* 2016). A1 also stands out for being the most cited article among all selected ones. This research, in particular, investigates the political system in China, which has released several laws, regulations and policies in order to facilitate the transition to sustainable construction.

The South American region, in turn, presents only two articles: A16, entitled "Urban flood resilience in Chile: San Fernando and Los Ángeles experiences" (González *et al.* 2020), and A17, entitled "Regeneration and Resilience: Recent Urban Interventions at Roosevelt Square in São Paulo" (Paiva and Schicchi 2020). These articles are characterized by not being mentioned at all, by being recent (both are from 2021 and 2020, respectively) and by presenting case studies that report specific situations of each region.

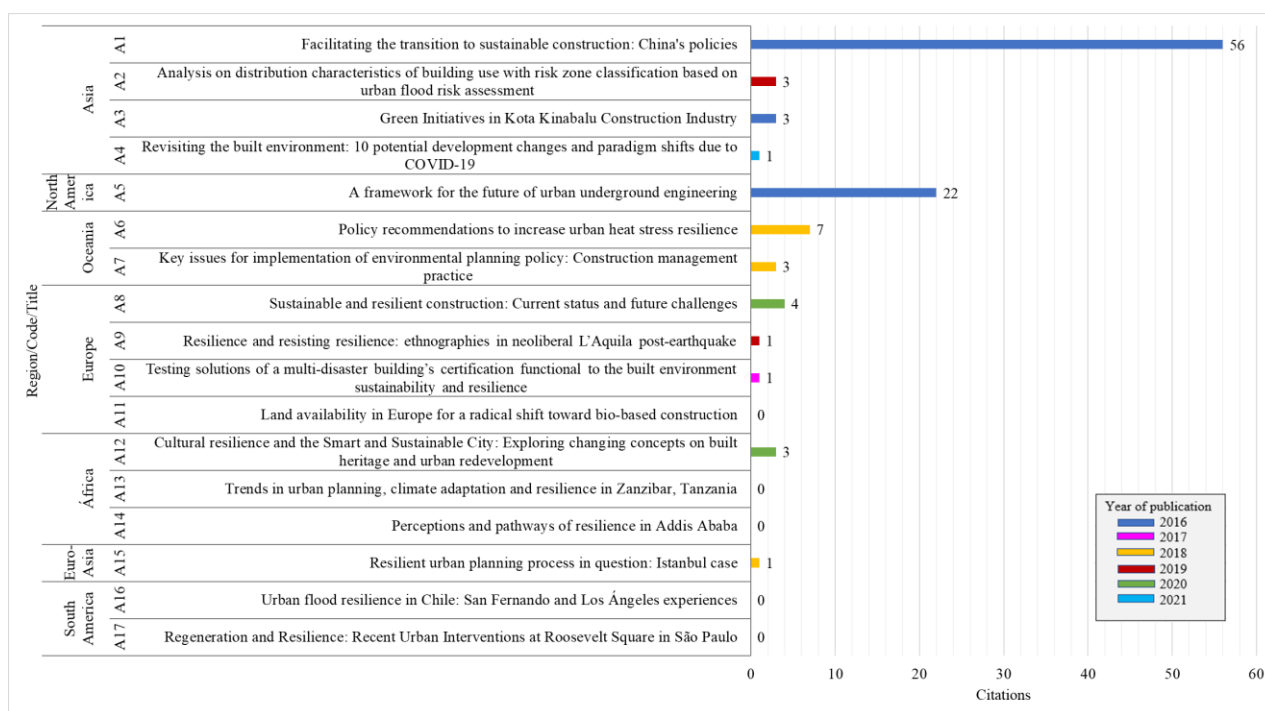


Figure 3. Region x Year x Number of citations x region
Source: The authors.

The articles were also evaluated according to the research methodology adopted (Figure 4). After analysis of the sample, it was possible to classify the surveys into three categories:

- Framework: in this category, the research that proposed to develop /present a framework on the subject of this article were classified. In this case, a framework is defined as a conceptual structure (Munck et al. 2013) based on the relations of dependence between paradigms, attributes and practices on some subject (Santos 2012).
- Case study: in this category, the studies that proposed to conduct a case study on the object theme of this article were classified. For that, it was adopted the definition of case study indicated by Noor (2008). The author indicates that a case study is an investigation of a given subject, characteristic or unit of analysis on how and why it happens in a certain way, allowing the evaluating of the differences between what was planned and what occurred.

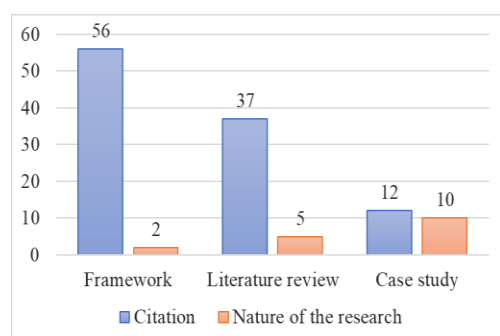


Figure 4. Number of articles by research nature x Number of citations by research nature.
Source: The authors.

- Literature review: in this category, the studies that proposed to conduct a systematic review of the literature were classified. For that, a literature review is defined as a "summary of a subject field that supports the identification of specific research questions" giving direction to future research, in addition to providing research propositions and methodologies (Rowley and Slack 2004, p. 31).

Most of the selected articles (59%) were classified as case studies that have a local approach. It is also observed that some studies do not have a replicable character. However, in some cases the results obtained point to the possibility of expanding the knowledge acquired to other regions, such as the article A16 (González *et al.* 2020).

The studies that showed the lowest number of citations were classified as case studies (Figure 4). However, when analyzing the year of publication of articles, this trend is justified, since most of the studies listed as a case study are more recent.

From the detailed reading of the articles, it was also possible to identify and classify strategic actions that involve the construction industry and have the potential to improve urban resilience. Such actions are addressed directly or indirectly by the selected literature. A total of 47 actions were identified, which could be classified into three categories, described below:

- **Model development:** This category classified the actions related to the development / implementation of quantitative, qualitative and management models applicable in a given subject.
- **Certification:** This category classified the actions that proposes to develop / implement certifications that seek to measure the performance of a particular technology or structure as a whole. A certification covers specific criteria for each type of product and establishes a ranking according to how much the product fits the established criteria adding value to the object of study (Devine and Kok 2015).
- **New approaches/technologies:** This category classified actions that promote the use of research results, propose suggestions of what still needs to be done, and / or encourage the development or improvement of technologies.

Figure 5 shows the relationship of these categories with the research methodologies adopted in the selected articles. It is possible to observe that the studies classified as case studies do not present a relevant number of actions, even though this category represents the major amount of publications analysed. The largest number of actions can be found in the literature review articles, where it was possible to identify 18 linked actions (38% of the total strategic actions identified). As expected, since a literature review study brings together placements of several studies, thus addressing several solutions.

It is also observed that most of the actions identified are classified as actions related to new approaches / technologies. All suggested actions could be viewed in more detail in Table 1. This table presents the strategic actions identified by type and by region.

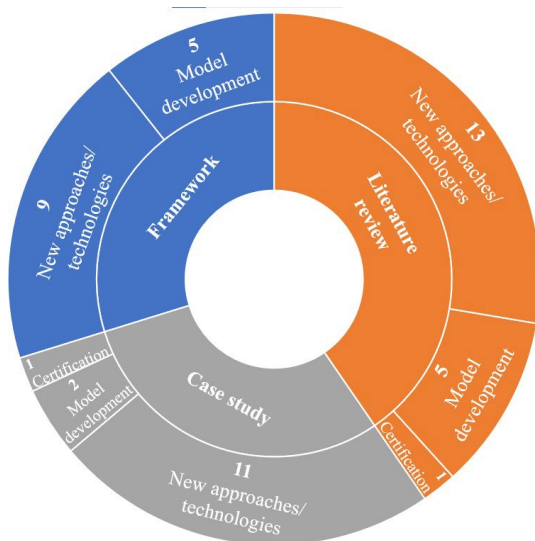


Figure 5. Methodology x Types of actions x Actions.
Source: The authors.

The model development actions mostly seek to measure the resistance of structures to disturbances, in order to design more efficient structures, in addition to, from these models, determining the types of technologies and management models that best suit specific situations. This category has as strong allied technological tools for the creation and validation of methods and models. It also includes actions involving structural, architectural and governance changes.

Table 1. Actions identified in selected articles

Region	Model development	New Certification	New approaches/site technologies	Actions
North America	X			Performance Response Function (PRF) analysis
	X			Engineers need to learn how to engage and communicate with social scientists and planners.
			X	Develop cyber-environments
	X			To develop functional computational models
	X			To develop the information for model validation
Asia	X			Establish a market for underground space
		X		Develop life cycle decision models
	X			Be aware of new technologies
South America	X			Guidelines to heat stress resistant building design
	X			Financially incentive heat stress resistant design
		X		Showcase heat stress resistance public buildings
	X			Integrate heat stress resistance into the Australian National Construction Code (NCC)
Oceania	X			Implement Building Energy Performance Certification (EPC)
	X			Address non-compliance issues
Europe	X			Create or review policies with clear and objective goals
	X			Improve communication and coordination between government and non-governmental sectors
	X			Improve collaborative and professional partnerships to advance the implementation of activities
Africa	X			Invigorated research focus on how construction can add to the built environment to the altered future due to climate change
	X			Provide legal framework to application of bio-based materials
Euro-Asia	X			Ensure that reconstruction is not evaluated as a resilience action without taking into account other variables
	X			Certification Tool for Disaster Resistance Predisposition of Buildings (CePRED)
	X			Decline in car-based transportation infrastructure
Asia	X			A push for information-based construction management methods
	X			Increase in off-site construction and engineering

Source: The authors.

The certification category is the result of research and case studies. This information is synthesized and structured in a tool that allows you to measure the performance of a construction on the subject covered by it. The certifications, placed here as actions, deal with measuring the energy performance

of a building and measuring the predisposition to resilience to disasters. It is worth mentioning the Certification Tool for Disaster Resistance Predisposition of Buildings (CePRED) (Bignami 2017). The author signals that it can become a tool for resilience measurement that is something much broader than the initial proposal put by him. Studies around certification continue to be improved with this objective.

Considering the new approaches/technologies category, governance actions stand out bringing suggestions for new policies and revision of existing ones. The actions of direct intervention in the design and construction of structures are also highlighted, suggesting the use of new materials, technologies and approaches. Cheshmehzangi (2021), author of the paper A4, entitled "Revisiting the built environment: 10 potential development changes and paradigm shifts due to COVID-19", makes a place on the trend of reducing workspaces in public buildings, commercial buildings, offices and the like, due to the new reality imposed by the pandemic, where the number of people in these physical spaces has decreased considerably. The category also addresses actions on choking between the community and those responsible for decision-making (government, private sector and engineering professionals), research and qualification of the professionals involved. It is noteworthy that engagement and communication between the various spheres is a gap pointed out by some of the works. These works highlighted the need of communication with communities, since they enjoy the benefits and disadvantages to which cities are exposed.

When assessing actions by region, it is noted that Euro-Asia and Oceania have a greater focus on government policies, but in Oceania interventions in building projects with heat stress also stand out. The North American region has a greater focus on technical advancement. Europe has a greater focus on adapting the built environment to climate change by implementing bio-based materials and measuring the resilience of buildings to disasters. The Asia focuses on improving construction productivity by adopting new construction and management techniques, new ways of designing spaces in the face of the pandemic scenario, in addition to making the user an active part of the process rather than just spectator. In South America, the approach is more focused on the development of a flood resilience assessment model and the physical and social impacts that interventions on public spaces cause. In Africa it tends to take social issues more into account in decision-making and the use of existing structures, as well as reinforcing the need for more research on urban resilience that appropriates its reality. Some issues are highlighted, such as the reuse of existing structures, cited both in the Africa region and in Europe, which can and should be taken into account elsewhere. In addition, the search for the engagement of society as a whole in decision making, as it was put by Africa, South America, Euro-Asia and Asia and the implementation of new technologies, as perceived in North America.

4 Conclusions and Further Research

The SML tool initially returned a significant sample of papers published in the last five years. However, when the selection criteria were applied, the sample was reduced to 17 articles that effectively involve the concept of resilience and built environment. This sampling, obtained through the aforementioned method, reveals that there is still much to be done in the context of the construction industry addressing strategies that make urban environments more resilient. This sector plays an important role in adapting to climate risks, since consumes large amounts of insum, generates a lot of waste and, moreover, the products generated by it continue to consume natural goods. This reinforces the need for the sector to be thought of with greater discretion.

By categorizing strategic actions of urban resilience adopted by the construction industry, it was noticed that a pattern of innovation and governance tools, showing that the innovation movement of

the sector is evolving. In contrast, it is also necessary that these changes receive support from government policies, and are accompanied by professional training programs for the sector. For changes to actually happen, it is necessary to establish dialogue between all the authors involved, government authorities, the community and professionals in the construction industry and other areas of knowledge. The engagement between professionals from diverse knowledge areas and engineers is pointed out as a difficulty for engineering professionals (Nelson 2016).

The results also point to the need to investigate urban resilience in different regions, since the strategies applied in a given place may not apply in the other regions. The regions of Asia, South America, Euro-Asia and Africa have shown an approach that takes more account of the social aspect and role of the construction industry in this context, while North America, Europe and Oceania are more focused on government policies and technological and constructive advances. Thus, as a suggestion for future work, an investigation could be made in specific regions, aiming to evaluate with has the interrelationship between urban resilience and built environment.

Finally, it is worth noting that this study is restricted to the results obtained from the search string and the databases adopted. The sample analysed does not necessarily include the entire state of existing knowledge related to the subject but analyses a representative sample of articles on the subject.

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