



Perspective

A Beginner's Guide to Developing Review-Based Conceptual Frameworks in the Built Environment

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Abstract: With the boom of industry 4.0 technologies and their adoption in the built environment (BE), conceptual frameworks (CFs) are increasingly developed to facilitate the adoption. It is becoming increasingly important to develop a standard or guide for new BE research entrants and aspirants who want to conduct a systematic literature review and develop such CFs. However, they struggle to find a standard and reproducible procedure to conduct systematic literature reviews and develop CFs successfully. Accordingly, the current study based on requests and inspirations from nascent BE researchers presents guidelines about conducting such studies. A simplistic yet reproducible methodology is presented that can be followed by BE research aspirants to produce high-quality and well-organized review articles and develop a CF. Using an example of big data-based disaster management in smart cities, the current study provides a practical example of conducting a systematic literature review and developing a CF. It is expected that this research will serve as a baseline for conducting systematic studies in the BE field that other fields of science can adopt. Further, it is expected that this study will motivate the nascent BE researchers to conduct systematic reviews and develop associated CFs with confidence. This will pave the way for adopting disruptive technologies and innovative tools in the BE in line with industry 4.0 requirements.



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1. Introduction and Background

With the advancements associated with Industry 4.0, various fields of science have been disrupted, and the built environment (BE) is no exception. From the disruptive Big9 technologies such as drones, the internet of things (IoT), clouds, software as a service (SaaS), big data, 3D scanning, wearable technologies, virtual and augmented realities (VR and AR), and artificial intelligence (AI) and robotics to digital twins and building information modeling (nD BIM), BE has seen a wave of disruption [1–3].

Disruptive technologies are challenging the BE field's capabilities and changing its method of operations [4,5]. For example, in the case of construction, blockchain's smart contracts are replacing traditional construction contract methods that are more secure and free from manipulation of control of a single body [6]. This is made possible due to the shared keys of the blockchains and their distributed ledgers [7]. Another example is 3D printing, where the construction time and poor workmanship issues are significantly reduced, ensuring more successful, timely, and high-quality projects [8]. Similarly, in construction education, the use of VR, AR, and gamification due to the adoption of digital technologies has shown superior performance and results from the students [9,10]. In the case of smart cities, machine learning, geographical information systems (GIS), big data, and AI have presented newer methods for effectively managing disasters such as floods [11,12]. Similarly, 5G technologies and IoT are used to increase and secure communications in smart cities [13]. The incorporation of such disruptive technologies has resulted in the up-gradation of the traditional smart city infrastructure. In the case of property

management, digital technologies such as the Big9 technologies are used to obtain more users to use the websites [4,14] and UAVs to deliver advertisement materials to potential customers [15]. In the case of architecture, digital-technology-powered 3D sketches and associated computer-based education enable a new generation of digitally equipped architects [16]. Similarly, cloud computing combined with BIM-based platforms or social media applications enhances the building design and supports effective implementation [17]. With the introduction of these technologies, the researchers are coming up with innovative conceptual frameworks (CFs) to pave the way for adopting such disruptive technologies in the BE [4,5].

Accordingly, there has been a boom in developing CFs in the BE. Ranging from the wider domains such as construction, smart cities, and architecture to case-specific contexts such as adopting blockchain-based smart contracts in real estate or developing novel Six Sigma methods for city management, the development of CFs is on the rise in BE [7,18,19].

A conceptual framework provides an overall picture to make conceptual distinctions and organize different categories of work. It is an analytical tool with several variations and contexts. Varpio et al. [20] defined CFs as follows: "A CF is the justification for why a given study should be conducted". According to the authors, it has the following key functions:

- It uses a literature review to describe the state of known knowledge.
- It identifies understanding gaps of a phenomenon or problem.
- It outlines the methodological underpinnings of the research project.

Overall, a CF answers the key questions of "Why is the undertaken research important?" and "What are the potential contributions of the findings to what is already known?" [20,21]. CFs have been used in various disciplines of science such as analyzing economic impacts of COVID-19 [22], visual perception in marketing contexts [23], strategic management [21], interactive understanding of human behavior and automated road traffic [24], understanding the contribution of building materials to the achievement of sustainable development goals (SDGs) [25], and others.

Construction and other BE domains are lagging behind the technology curve by more than five years [1]. Contrary to its industrial counterparts, such as the software industry, medical, or service industries with very advanced state-of-the-art tools, gadgets, and techniques, most BE works are managed through spreadsheets and other basic tools [9,26,27]. Therefore, in the BE context, there is a lack of CFs, mainly in industry 4.0 technologies. This is more evident in the digital technologies domain due to the lack of infrastructure and rigidity of the BE managers in adopting or investing in such technologies [5,18]. As discussed by Ullah et al. [5], the attitude by some BE managers is that "if it is not broken or not working, stick to it and keep working". Such an attitude demoralizes the younger workers and team members who are otherwise tech-savvy and open to experimentation [28]. Accordingly, this attitude is reflected in the associated research, which is inspired by industry needs. Thus, the CFs that are inspired by innovations in other fields are comparatively lower in the BE domains due to the nonflexible attitude and openness of field professionals who generally take on materializing the ideas proposed by researchers. Some ideas in this context are proposed by Salama [29] and Ullah et al. [14], who stressed involving the users in decision-making and improving services provided by the BE organizations. Further, the focus on knowledge, production, and transdisciplinarity is the way forward to motivate BE professionals and researchers to invest their time and efforts into digital disruptions. Among the relevant studies presenting CFs in the BE, these have been used for modeling safe walking and cycling routes [30], untangling the concept of urban ecosystem services [31], risk management in sustainable smart cities [19], evaluating heritage protection policies and disputes [32], modeling and implementing smart universities [33], six-sigma-based smart city management [18], blockchain smart contracts for real estate deals [7], UAV-based advertisements, and others [15].

These useful studies have presented innovative methods for proposing CFs to help BE adopt the industry 4.0 technologies. CFs are usually developed by experienced researchers

or industry professionals based on the diverse nature of experience [34,35]. However, due to the nascency of industry 4.0 technologies and the associated wave of disruptions, even the apparent field experts are challenged in terms of technology adoption and implementation in the fields. Thus, both the expert-level researchers and beginners in the BE are striving to develop CFs for facilitating such adoptions.

CFs should not be seen as celestial and have seen their fair share of criticism. For example, in the case of lean construction and city management, the vagueness around implementation and associated is widely criticized [36]. Other barriers include legal barriers, government and political support, and poor understanding of the process [37,38]. The same criticism is seen for other disruptive technologies such as BIM in construction, where unsubstantiated claims about expected benefits subvert the justification and benefits realization process as the required change management is downplayed or ignored [39]. Similarly, smart cities are laying catchups with disruptive innovation associated with disingenuous terms, technical jargon, and lack of focus on the implementation part [40]. However, as explained by Lee et al. [41] and Den Hertog et al. [42], CFs are used to propose initial ideas or service improvement methods based on established or new concepts when there is no implementation model. Accordingly, these are followed by practical and implantable models; thus, the criticism on CFs is misplaced where the CFs are critiqued for not incorporating the implementation aspect. This gives rise to the debate between conceptual and physical or working models, which are often intermixed [43,44] and beyond the scope of the current study. Nevertheless, it is unfortunate that the conceptual framework is alluded to in most serious texts on research, described in some and fully explained in few; however, this can be controlled by adopting a systemic approach [45]. Some quality checks for developing CFs include using a systematic approach, block diagrams, reproducibility, recommendations for implementation, and others [46,47].

A recent method for CF development is using a systematic review-based approach [1,7,18,19,23]. For example, Ullah et al. [15] presented a UAV-based optimized path system for delivering smart real-estate advertisement materials. Based on a systematic review of 58 articles, the authors identified key components of advertisements and presented a UAV-based delivery system for enhancing real estate sales to move toward real estate 4.0. Real estate 4.0, referred to as smart real estate, is an amalgam of user-centered, sustainable, and innovative technologies to efficiently manage real estate resources in an urban area, ensuring smart real estate management [1]. Using these technologies, the key information is made available to industry stakeholders. However, due to the nascency of such technologies, risks are presented to the users and society, including the privacy and safety of the user data, system failures due to data overload, manipulation of the prices and other aspects of properties, and others [5,14,19]. Qayyum et al. [18] reviewed 34 systematically identified and shortlisted articles to propose a six-sigma-based method to manage smart cities. The authors identified 42 key factors and grouped them into six layers integrated into city management to help its governance team better manage the process and promote sustainability in cities. Ullah and Al-Turjman [7] reviewed the literature published between 2000 and 2020 and identified ten key aspects of blockchain smart contracts. The authors grouped these ten aspects into six layers to adopt smart contracts in smart real estate and proposed a multilayered CF to initiate, execute, and terminate smart contracts.

Other studies have used similar techniques for proposing CFs. However, due to the absence of proper guidelines to conduct the literature review systematically, different authors have developed different methods, making the reproduction of their works by nascent BE researchers difficult and often hard to pull off. This becomes more difficult when it comes to proposing CFs based on such non-standard reviews. Thus, the difficulty level is raised, and the reproducibility of the results is significantly reduced in the case of new researchers having a lesser idea about where to start reviewing relevant literature and proposing meaningful CFs. Furthermore, the complicated procedures and jumps in the process due to the greater understanding of the procedures for expert researchers demotivate the nascent researchers to produce similar works. Thus, there is a need to have

a standard and easily understandable document for developing guidelines for conducting a systematic literature review in the BE domains and proposing reproducible results by BE research aspirants at the beginners' level. The current perspective paper addresses this gap and presents guidelines for beginners to develop review-based CFs in the BE. Thus, the objectives of this paper are as below:

1. To present a standard guideline document that the nascent BE researchers can use to conduct a systematic literature review.
2. To enable and motivate the nascent BE researchers to propose CFs based on a reproducible approach.

For achieving these objectives, the current study presents a comprehensive, reproducible method for nascent BE researchers to conduct literature reviews and propose CFs. Further, an example of "big data-based disaster management in smart cities" is used to show the working out and application of the proposed method to assist the researchers in presenting their study in a meaningful way.

The rest of this perspective paper is organized as below. In the following section, the method to conduct a systematic literature review is presented, and a standard procedure is proposed to act as a guideline for developing review-based CFs in the BE. In the next section, the expected results and guidance for presenting the study findings are presented and discussed using an example case study. Finally, the study is concluded, and expectations are presented.

2. Proposed Methodology

Based on the published articles, there are three key steps in proposing CFs in the BE. These are discussed below.

2.1. Conducting the Literature Review

Conducting the literature review and convincing the reviewers to accept the review method is the hardest task for review-based studies. Accordingly, different studies have used various techniques for conducting a literature review in the BE domains. However, most of them have utilized the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [48]. The underlying reasons for this are the systematic nature and procedure of PRISMA to help streamline the process and provide a scientific approach to the pertinent analyses [7,19,49]. There are other methods as well; however, the current study limits itself to PRISMA only due to wider acceptance. Accordingly, the following steps should be followed in applying this method:

- Define the protocol and registration, such as what the review is based on? How were the keywords developed? Furthermore, what kind of search repositories have been used? It is important to note that most current studies use at least the Scopus and Web of Science (WoS) repositories for retrieving relevant literature.
- Define the eligibility criteria for the shortlisting of articles, such as the articles must have the keywords in their title, abstract, or keywords sections.
- Define the information sources used in the retrieval process, such as Google Trends, WoS, and Scopus repositories, and how these can be accessed. Here, the links to the respective websites should be provided.
- Explain and list the search process and search strings used to extract the relevant literature. These should be listed in a table along with how many articles were retrieved against each step.
- Explain the study selection process, such as searching and screening keywords, removing duplicates, qualitative analysis in the form of reading abstracts and keywords, subsequent risk extraction and quantitative analysis, and others.
- Explain how the retrieved articles were analyzed. Here, tools such as Vos Viewer, NVIVO, Excel, Publish or Perish, or other tools used to analyze the articles should be stated.

- Explain the data items of the analysis. These can include keywords, classification, scientometric mapping, yearly publication trend, article types, organizational affiliation, top sources, co-authorship, country of origin, and citation analysis of retrieved articles. Any other method or procedure introduced in the analysis can be discussed here.
- Explain how the risk of bias in individual studies was handled and how it did not affect the review process.
- Explain the summary measures adopted in the study.
- Explain the process used to synthesize the results, such as comparisons to published works and others.
- List any limiting aspects of the study.
- List and explain any additional analyses conducted in the study.

Based on the reviewed studies, it is advised to insert the standard PRISMA diagram and fill it accordingly for the study undertaken, as shown in Figure 1.

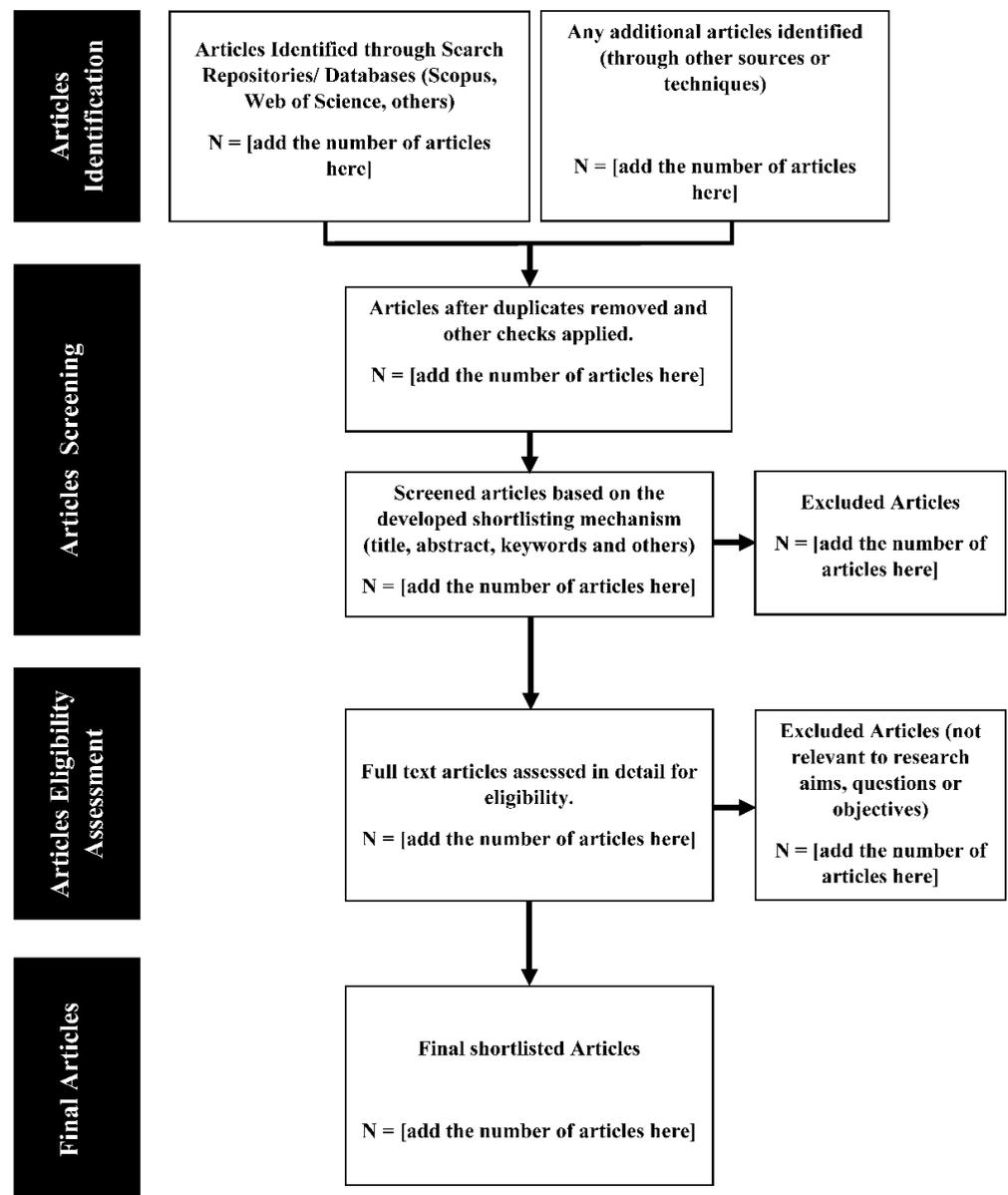


Figure 1. PRISMA diagram for systematic literature review.

A key step in this method is to develop and conduct keyword analyses on different search repositories. For this purpose, the following process given in Table 1 should be used, as is evident from the reviewed articles [7,18,19,50–52]. Generally, based on the reviewed articles, three key steps are involved in shortlisting relevant articles. These involve compiling relevant keywords that will vary from study to study and depend on the authors' target area. These keywords are joined through Boolean operators of "AND" or "OR". In the second step, the limits are applied. Here, the authors may choose what kind or type of articles they are after, what language they prefer, what kind of articles not to include, etc. In the final step, the articles retrieved because of the second step are reviewed for eligibility, and irrelevant articles are removed. Table 1 lists examples of searching for articles on Scopus, WoS, and Google Scholar. These can be expanded to other repositories as needed. Once the three-step process for the article search is concluded, all the relevant articles are downloaded and studied in detail. This way, the duplicate and any relevant articles identified because of in-depth review are removed, and the final articles are identified. It is imperative to list all the numbers against each step for the articles retrieved and the final shortlisted articles. Additionally, a suggested practice is to provide the final shortlisted articles in the appendix for the target audience to go through in case they want to know more about the underlying aspects of the conducted study.

Table 1. Literature retrieval process using search engines.

Insert Search Engines Here	Insert Strings/Conditions Here	Insert Results Here
Example 1: Scopus	ALL ("Keyword1" OR "Keyword2" OR "Keyword3" OR "Keyword4" and so on.) AND (LIMIT-TO (Insert Limits here such as DOCTYPE, LANGUAGE)) etc. Remove Irrelevant Papers	Add numbers here against each step
Example 2: Web of Science	ALL FIELDS: ("Keyword1") OR ALL FIELDS: ("Keyword2") OR ALL FIELDS: ("Keyword3") and so on Refined by: Insert limits here such as LANGUAGES. Timespan: Insert time here, such as All years. Indexes: Insert Indexes here such as SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC. Remove Irrelevant Papers	Add numbers here against each step
Example 3: Google Scholar	"Keyword1" OR "Keyword2" OR "Keyword3" and so on Limit: Irrelevant, Non-English Language Remove Irrelevant Papers	Add numbers here against each step
	Remove Duplicates	Add numbers here
	Final Shortlisted Articles	Add numbers here

After the articles are shortlisted, the database containing these files should be downloaded for further analysis. In the case of Scopus, it can be performed through the export feature of the Scopus database. Accordingly, all the data items should be selected and the file exported as comma-separated values (.csv) format for subsequent analysis. Similarly, in the WoS, the export feature should be used to download the files in Excel format, text format, or others, depending on the analysis tool. Most of the analysis tools can analyze excel and text files, so the researchers may choose to download any compatible format. A similar approach can be adopted for other databases.

2.2. Identifying the Key Factors and Conducting Basic Analyses

Before the articles are finalized, most current review studies have used Google Trends analysis to show the extent of focus on the top factors or keywords of the study [7,50,52]. This can be performed using the Google Trends website (<https://trends.google.com/trends/?geo=AU>, accessed on 25 May 2021). For this purpose, it is necessary to set the

scope of the study and the timeline of review. The trends can be presented and discussed accordingly.

Once the most relevant articles are identified, in the next step, the researchers may want to identify the key factors and keywords and conduct some primary analyses using a software package such as Vos Viewer, NVIVO, Excel, or others or text mining using software such as General Architecture for Text Mining (GATE) [7,15,18,19,21,48,50,52]. These can be qualitative, quantitative, or mixed approaches. However, based on the reviewed literature, the following basic analyses stand out for quantitative studies that the researchers are encouraged to conduct:

- Classifying the retrieved articles into various types such as journal papers, conference papers, book chapters, etc. Some researchers may want to dig deep and present another level of classification for the classified articles. For example, the articles identified as journal articles can be subdivided into case studies, original research, review studies, and others.
- Year-wise publication trends or topical focus in the form of a temporal analysis.
- Co-authorship analyses based on authors links, organizations, or countries of publication.
- Co-occurrence analyses based on all keywords, author keywords, or index keywords.
- Citation analysis based on documents, sources, authors, organizations, or countries of publication.
- Bibliographic coupling based on documents, sources, authors, organizations, or countries of publication.
- Co-citation based on cited references, cited sources, and cited authors.

For quantitative studies, these steps and analyses can be supplemented through Literature scores, factor criticality analyses, pilot surveys, or preliminary interviews [5,53,54].

Once these basic analyses are conducted, the researchers can investigate the retrieved articles manually and identify the key factors or critical success factors (CSFs) that are supposed to formulate the CFs. Various scoring mechanisms can be introduced, such as literature scoring adopted in various qualitative and quantitative studies where the CSFs are ranked and scored as high, medium, or low for filtering the most important factors from the least- or less-important factors [53,54]. A normalized scoring approach can also be adopted [55]. Various mechanisms have been used, ranging from a sliding scale to a fixed scale, such as assigning factor scores or category scores for scoring CSFs in various studies. In this context, Equation (1) can be used to assign a normalized score to the CSFs. The rationale for assigning a normalized score is to have a uniform scale of importance for all CSFs, making the comparison more reasonable.

$$NS = \frac{\text{Count of Factor /Group/Category}}{\text{Sum of the Factor /Group/Category}} \quad (1)$$

The number of papers using or relying on the CSF in focus must be counted to apply this formula. Other qualitative studies have supplemented this normalization with the intensity of discussion, such that the CSF is regarded as of high importance, medium importance, or lower importance. To do so, the tone and context of the CSF usage are analyzed by the authors. Context-specific matrices can be developed for conducting such analyses. Based on this method, the factors or groups can be ranked to highlight the topmost CSFs and use them for further analysis. In such studies, the author bias must be kept in check through techniques such as all authors reviewing all the papers or using a set of rules. Similarly, pilot surveys and preliminary interviews can also be conducted to ask the industry experts about the impacts and probabilities of the factors or the risks posed by non-achievement of various CSFs. The scoring mechanisms vary widely, and a universal mechanism or guideline is hard to pull off. However, the authors can base their studies on widely adopted methods such as pilot surveys and interviews. In other domains, techniques such as formulation of focus groups, control groups for

conducting experiments, and simulation-based experiments are conducted in addition to proposing CFs. However, these are not possible in the BE domains due to the nascency of the industry 4.0 technologies, the rigid nature of the field practice, and the reluctance of the managers to invest in disruptive digital technologies. Nevertheless, simulations and hypothetical scenario-based experimentation can still be conducted in the BE domain to conduct qualitative analyses of the CSFs and address the quality vs. quantity concerns.

2.3. Grouping the Factors into Clusters for Proposing the Conceptual Frameworks

The CSFs in this paper refer to topic-specific key factors and enablers for ensuring the adoption of digital technologies. Depending on the topic or technology in focus, these can range from planning-level factors to execution or control measures in the implementation part. Once the CSFs are identified and ranked, these may be grouped into various categories to propose the CFs layers. Then, these layers can be defined using one of the following approaches:

- The natural clustering of factors, if evident from the scientometric analysis [7].
- Conducting a pilot expert survey and asking them to group the factors [54].
- Reviewing existing studies and using their classifications to group the identified CSFs [18,19].

Once the groups are formulated, the CFs can be proposed. For this purpose, it is important to focus on the links between the groups, clusters, or layers and the topic in focus. This should be supported through published literature; the working out must be explained in detail and highlight aspects of the CF discussed. This way, a comprehensive CF can be developed using the proposed method.

3. Results, Representations, and Discussions

To show the application of the proposed guidelines, consider the example of big data usage for disaster management in smart cities. The potential keywords are “big data, smart cities”, “big data, smart cities, disaster management”, and “big data, cities, disasters”. The analyses mentioned in the method section will be shown here in the results section for these keywords used on various databases, and the steps will be applied to show what to expect in the results section and how to convey the importance of the findings to the readers.

3.1. Google Trend Analysis

The Google Trend analyses conducted for the keywords are shown in Figure 2. The timeline is restricted to post-2004, when Google Trends were introduced, hence covering all possible searches on the topic to date. The scale is worldwide and inclusive of all search categories. Accordingly, the highest search term is “big data city”, which outperforms the other keywords. The authors producing such studies are encouraged to search in detail for the potential reasons for such superior performance and discuss accordingly. For example, in this case, this signifies that most researchers are interested in using big data in smart cities; however, the focus is not necessarily on managing disasters. Similar meaningful inferences must be made from the findings to highlight the usefulness of the analysis.

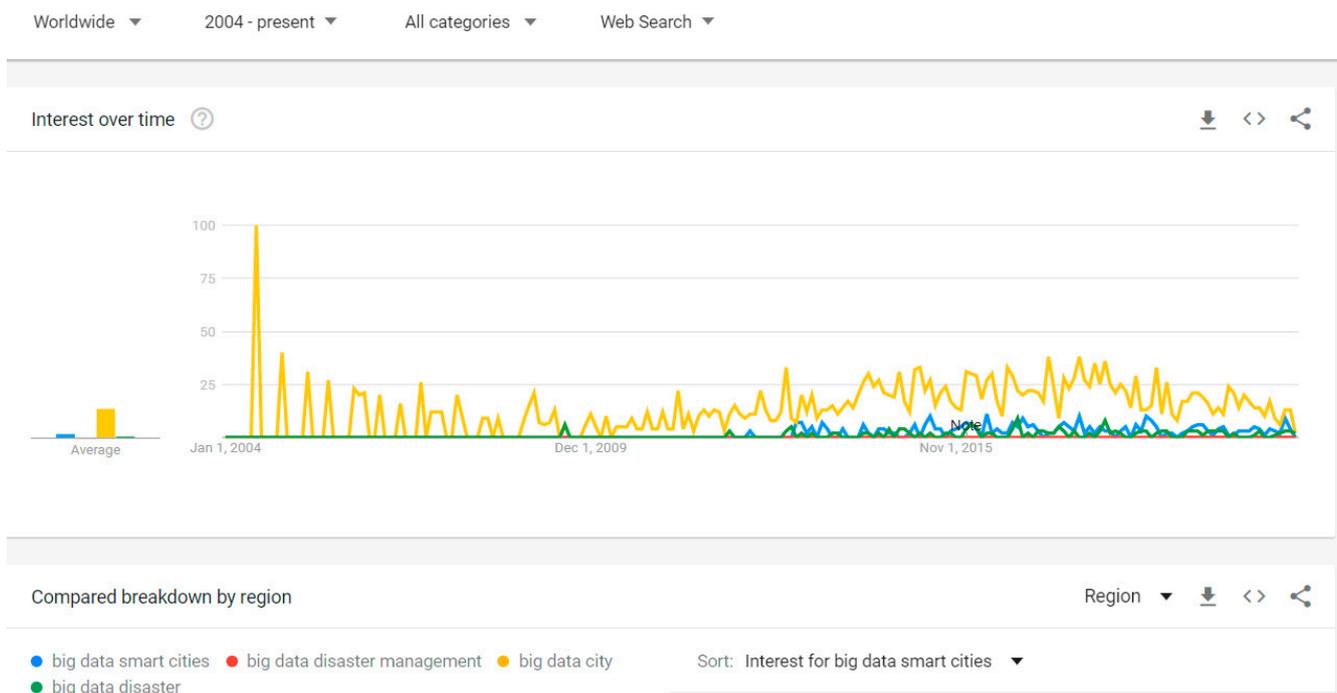


Figure 2. Google Trend Analysis for the keywords.

3.2. Search Strings and Databases Search Results

Scopus retrieved articles are used as an example in this section to show the analysis techniques and results. The analysis tool used is that of Vos Viewer. The researchers can use alternative tools to reproduce similar data.

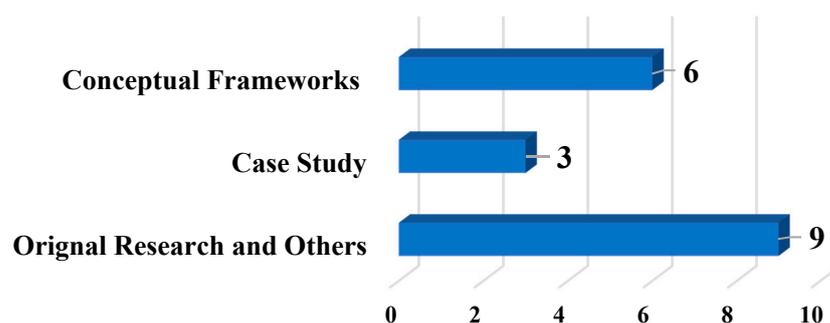
In Table 2, using the Scopus repository from Table 1, the assumed keywords “big data AND smart cities”, “big data AND smart cities AND disaster management”, and “big data AND cities AND disasters” are investigated. Using these search strings on the Scopus repository found here (<https://www.scopus.com/search/form.uri?display=basic#basic>, accessed on 23 May 2021), the search yielded 53 articles. If these are searched for in the title, abstract, and keywords, the Scopus strings will be “(TITLE-ABS-KEY (big AND data AND smart AND cities) AND TITLE-ABS-KEY (big AND data AND smart AND cities AND disaster AND management) AND TITLE-ABS-KEY (big AND data AND cities AND disasters))”. Now, in terms of limits, let us restrict these articles to English only, document type as articles only, and publication date to post-2010. These limit results to 17 articles, and the associated string added to the previous string will be AND PUBYEAR > 2010 AND (LIMIT-TO (DOCTYPE, “ar”)) AND (LIMIT-TO (LANGUAGE, “English”)). Accordingly, these can be read in detail for relevance and final shortlisting. Using the same procedure, other databases can be explored. Since a single database is consulted in the example, there are no duplicates; however, for multiple databases, duplicates are common and must be removed to obtain the final shortlisted articles. As a good practice as suggested in the method, the 17 retrieved articles are presented in Appendix A.

Table 2. Search strings and results for the sample case.

Search Engine	Search Strings	Results
Scopus	(TITLE-ABS-KEY (big AND data AND smart AND cities) AND TITLE-ABS-KEY (big AND data AND smart AND cities AND disaster AND management) AND TITLE-ABS-KEY (big AND data AND cities AND disasters))	53
	AND PUBYEAR > 2010 AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English"))	17
	Duplicates	0
	Final shortlisted articles	17

3.3. Basic Analyses Results

Following the method section, various analyses are conducted on the sample case and its retrieved articles. As the retrieved documents are restricted to “journal articles” only, the classification into conference papers and others cannot be conducted for this case. However, the journal articles have been divided into various subtypes, as shown in Figure 3. Accordingly, most of the retrieved articles are classified as original research and others followed by conceptual frameworks and case studies. The significance of such classifications must be stated in the studies. For example, in this case, the presence of a large number of conceptual frameworks signifies the nascency of big data in smart city disaster management and the keenness of the researchers to develop their adoption frameworks. Such nascency is accompanied by the conceptual clarity of data, driven by the industrial push to adopt disruptive technologies to compete with other fields. This is further complicated by the lack of data handling infrastructure, the rigid attitude of senior managers, and the lack of research and development funds in the industry [5]. The added security concerns, information mismanagement, and data manipulations also add to the lack of adoption of big data in BE [12,19].

**Figure 3.** Classification of the retrieved journal articles into various types.

After classifying the articles into various types, the year-wise publication trends should be presented as given in the method section. Accordingly, for the current study, most of the retrieved articles are published in 2020, as shown in Figure 4. The researchers need to discuss the importance of such findings in their studies. For example, the extraction of most articles published in 2020 in the current study shows the recent focus on the topic under investigation. This supports the development of a CF for the topic under investigation due to its nascency and lack of clarity. This also supports the statement that the retrieved literature is up to date and can infer reliable results.

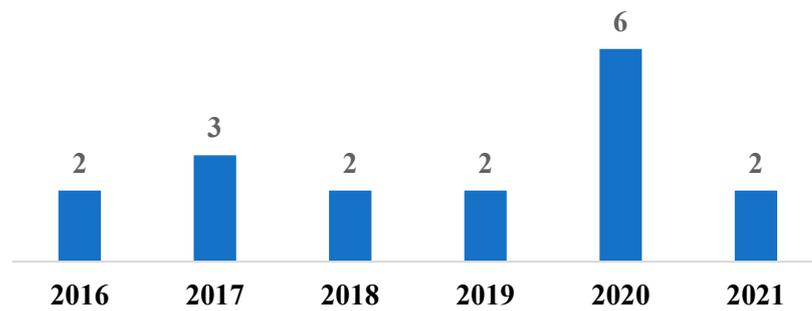


Figure 4. Year-wise publication trends.

Afterward, co-authorship analyses based on the author's links can be conducted as discussed in the method. While conducting these analyses may give rise to the debate over its landscape of inquiry, several benefits encourage such investigations. For example, obtaining a systematic list or mapping of the most renowned authors working in the topic under investigation provides a roadmap and guidance to researchers about where to look for high-quality articles. Further, it provides potential collaboration opportunities with established researchers in the future by filtering the researchers with greater contributions to the topic under investigation. Figure 5 shows the co-authorship based on authors' links for the sample case. The limits here include a minimum number of documents set as one and the minimum number of citations set to five. Accordingly, 39 authors meet the criteria based on the analysis. However, when the links are considered, only 13 authors can be linked, as shown in Figure 5. Figure 5 shows that the max number of articles and citations is associated with the author "Park S" (2 articles and 21 citations). Thus, this author is the main link between the others and is involved in most of the research conducted on big data in smart cities disaster management.

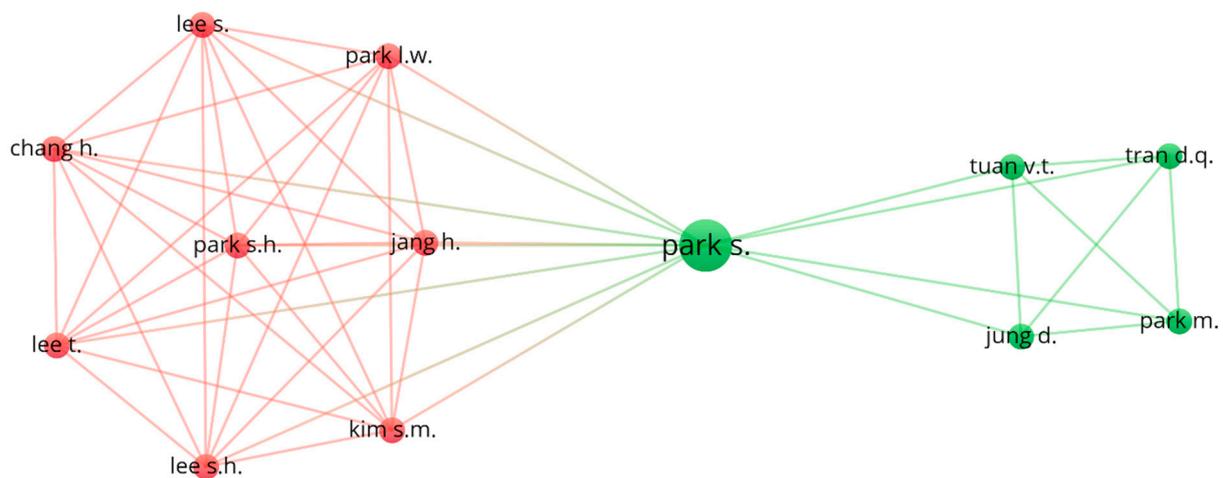


Figure 5. Co-authorship analysis results of the sample case.

As an example of co-occurrence analysis for keywords of the sample case, the limit is set to a minimum of two keywords. As a result, out of the total 238 keywords in the reviewed papers, 27 meet the criteria, as shown in Table 3. As expected, the top-occurring keyword in the shortlisted articles is "smart city", having a 13% share, followed by big data, disasters, disaster management, and others. Using a similar approach, the researchers can identify and subsequently discuss the main keywords of the shortlisted articles in their topic of interest. For example, in the current study, the extraction of large share keywords associated with smart city, big data, disasters, and disaster management shows the retrieved articles' relevance for inferring valuable results.

Table 3. Keywords and their occurrences in the retrieved articles of the sample case.

Keywords	Occurrences	Percentage Share in Shortlist
Smart city	11	13%
Big data	8	9%
Disasters	6	7%
Disaster management	5	6%
Disaster prevention	5	6%
Internet of things	5	6%
Decision making	4	5%
Information management	3	3%
Social networking (online)	3	3%
Air quality	2	2%
Artificial intelligence	2	2%
Behavioral research	2	2%
City	2	2%
Climate change	2	2%
Cost effectiveness	2	2%
Data analytics	2	2%
Data visualization	2	2%
Decision support system	2	2%
Floods	2	2%
Geographic information system	2	2%
Geographic information systems	2	2%
Infrastructure managements	2	2%
Internet of things (IoT)	2	2%
Local government	2	2%
Network security	2	2%
Smart cities	2	2%
Urban transportation	2	2%

As an example of the citation analysis, the country-based analysis was conducted for the retrieved articles in the current study. Here, the limits are set as a minimum of two documents per country. Accordingly, out of the 23 countries associated with the articles, only four meet the criteria. China has six documents with 17 citations, the USA with three documents having 27 citations, South Korea with two documents having 21 citations, and Italy with two documents having four citations. Discussion around these countries can be initiated by the researchers interested in reproducing such results where the focus should be on what “specifically” the country has achieved that should be supported by relevant literature. In this sample case, China and the USA emerge as the world leaders for big data research in smart cities due to their large investments in the big data disaster management schemes and well-developed research facilities. These findings can also be represented as world maps, as shown in the studies of Qayyum et al. [18] and Ullah et al. [19].

As an example of the bibliographic coupling, the retrieved articles in the current study were subjected to an organization-based study. A minimum of one document per organization with at least ten citations was set as the inclusion limit. Due to this, among the 51 organizations, 10 met the criteria, as shown in Table 4. The findings show that the documents published by researchers from Qatar, Estonia, Turkey, and Pakistan are doing very well in terms of attracting citations. This is mainly due to the comprehensive nature of the studies conducted in the relevant retrieved articles supported by a rigorous literature review and key definitions. The researchers following such works generally find it helpful when the studies provide definitions and wider coverage of the literature related to the topic as it acts as a one-stop guide for them. In addition, these articles support conducting rigorous literature reviews for proposing big data CFs, thus occupying the top position in the current study due to the relevance of the extraction criteria. Further, these studies have emphasized the usage of CSFs to develop value-added conceptual frameworks, making them more relevant to the sample case in the current study.

Table 4. Organization-based bibliographic coupling of the articles retrieved in the sample case.

Department	University	Country	Documents	Citations
Department of Geomatics Engineering, Civil Engineering Faculty	Istanbul Technical University	Turkey	1	25
Department of Information Technology, Engineering and Management Sciences	Balochistan University of Information Technology	Pakistan	1	25
Department of Software Science	Tallinn University of Technology	Estonia	1	25
Division of Information and Computing Technology, College of Science and Engineering	Hamad Bin Khalifa University	Qatar	1	25
It Security Labs	National University of Computer and Emerging Sciences	Pakistan	1	25
Department of Civil Engineering	The Catholic University of America	USA	1	18
Lyles School of Civil Engineering	Purdue University	USA	1	18
Department of Information Management	National Taichung University of Science and Technology	Taiwan	1	14
Department of Industrial Security School of Electrical and Electronics Engineering	Chung-Ang University	South Korea	1	13
Computer Science and Technology Institute	Zhejiang University	China	1	12

Similarly, in terms of co-citation analysis based on the cited sources, 597 sources were highlighted in the current study. The limits applied in this case were that of a minimum of five citations to a source or journal. As a result, ten sources met the criteria, as shown in Figure 6. Among these, the highest recorded citations were for the journal “Automation in Construction” (12), followed by “ASCE Journal of Water Resources Planning and Management” (10) and “MDPI Sensors” (09). These journals were cited the most by the downloaded articles. The emergence of these journals is in line with their scopes, where more focus is placed on automation, technologies, and sensors used in their published articles, which is relevant to the theme of this perspective paper.

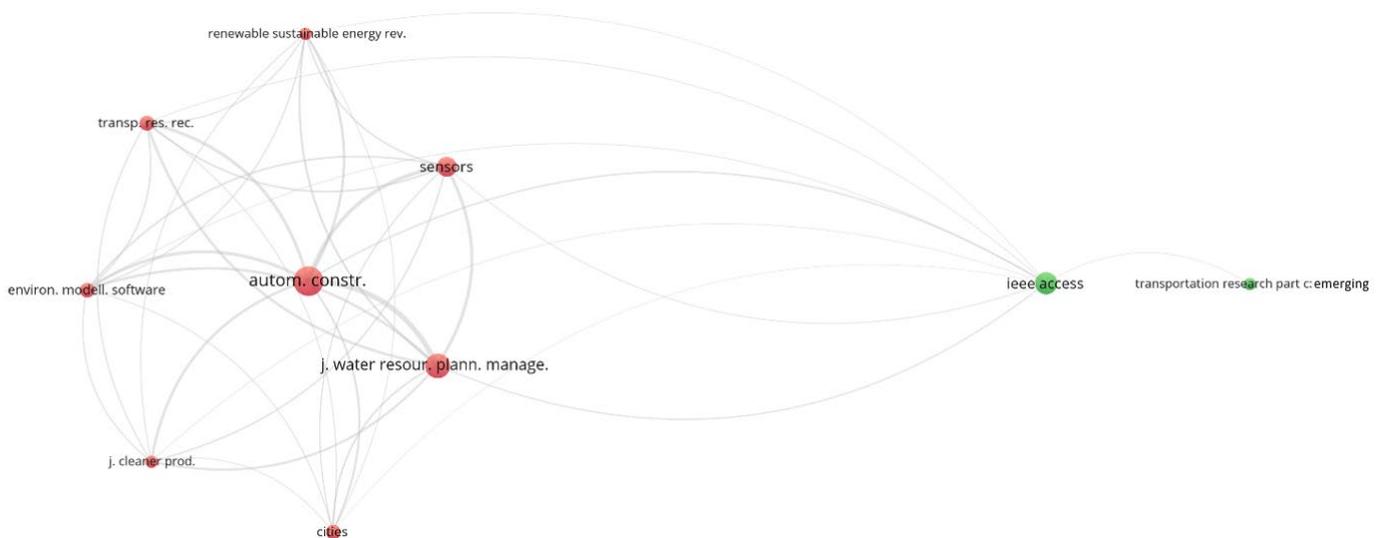


Figure 6. Co-citation analysis for the retrieved articles in the sample case.

3.4. Factors Grouping and Proposing a Conceptual Framework

Following the proposed methodology, the 17 retrieved articles were read in detail to identify the CSFs and group them. Accordingly, Table 5 shows the count of the factors and their normalized scores in a percentage calculated using Equation (1). The highest reported CSF is “big data analytics”, followed by “disaster management and mitigation systems”, “decision support systems”, and “IoT”. Again, the researchers producing such works are encouraged to discuss these factors in detail. In addition, a thorough comparison must be made with the published literature to discuss what is interesting, what is new, and the important findings. Such discussions are very important for establishing the importance of the study and highlighting its effectiveness and contributions to the body of knowledge.

Table 5. Critical success factors retrieved from the shortlisted articles of the sample case.

Factor	Count	Normalized Score	References
Big Data Analytics	12	13%	[56–67]
Disaster Management/Mitigation System	7	8%	[56,58,60–62,64,68]
Decision Support System	6	6%	[56,59–61,65,69]
IoT	6	6%	[58–62,64]
City Resilience	5	5%	[56,59,62,64,65]
Government Policies	4	4%	[57,62,70,71]
Cloud Applications	3	3%	[62,68,72]
Crowd Sourcing	3	3%	[62,71,72]
GIS	3	3%	[58,66,70]
Risk Management	3	3%	[58,59,72]
Smart Infrastructure	3	3%	[64,69,72]
Smart water systems	3	3%	[65,67,72]
Transportation systems	3	3%	[67,69,72]
Web and Social Media Analytics	3	3%	[62,63,67]
Air Quality Control	2	2%	[70,72]
Augmented Reality	2	2%	[64,66]
Crowd and Population Density Control	2	2%	[57,58,72]
Smart Communications Networks	2	2%	[60,71]
Smart Drainage	2	2%	[58,67]
Smart Fire Fighting	2	2%	[59,64]
Smart Sensors	2	2%	[72]
Smart Technologies	2	2%	[66,72]
Virtual Enterprises	2	2%	[68,71]
Artificial Intelligence	1	1%	[61]
Data Security	1	1%	[68]
Digital Twin	1	1%	[64]
Flood Management	1	1%	[65]
Smart Buildings	1	1%	[64]
Smart Energy Control	1	1%	[72]
Solid Waste Management	1	1%	[72]
Underground Structures	1	1%	[58]
Urban Heat Islands	1	1%	[70]
Virtual Reality	1	1%	[66]
Visual Analytics	1	1%	[60]
Total	93	100%	

Once the CSFs are retrieved, the next step is grouping these CSFs into layers of the CF. According to the method section, there can be natural, expert-based, or literature-based grouping. There is no natural grouping trend evident from the scientometric analysis in the current example, as opposed to Ullah and Al-Turjman [7]. Thus, literature-based grouping is adopted based on reviewed articles such as Qayyum et al. [18]. Accordingly, the CSFs are grouped into four main layers: the data collection layer, the data transfer layer, the data application layer, and the data integration layer, using the work of Wang et al. [58]. These layers are adopted in the current example to present the CF. Figure 7 presents the CF layers

with pertinent CSFs or tools for big data applications in managing disasters in smart cities. All the CSFs are placed in the CF based on the groupings in the published literature. Again, the researchers need to explain the workings of the envisaged CF. The layers and elements of the CF must be discussed in detail to add value to the body of knowledge.

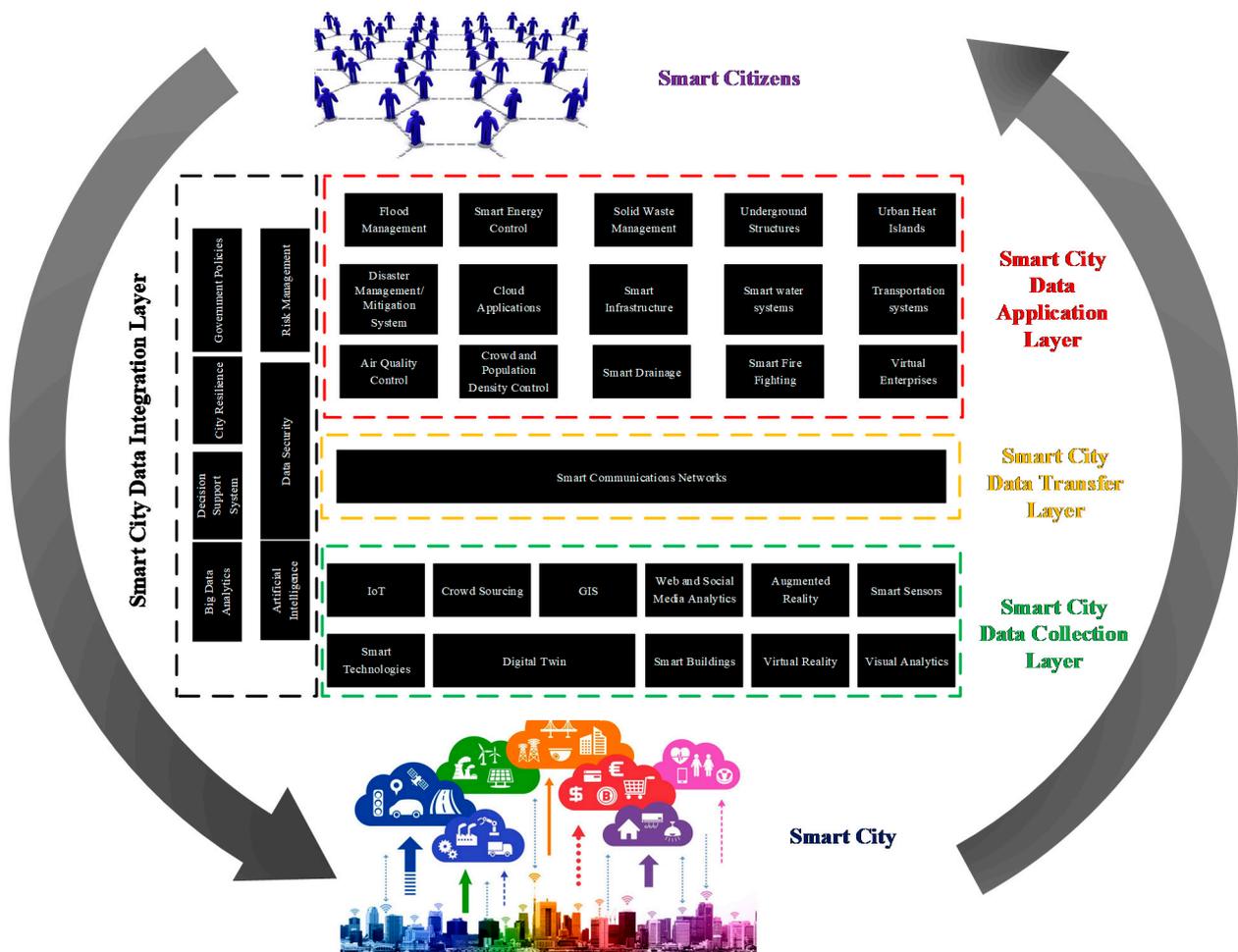


Figure 7. The conceptual framework developed based on the retrieved articles in the sample case.

Figure 7 shows a CF for providing big data-powered services to smart citizens of smart cities while managing disasters using the four layers. First, data are collected from smart city components and sensors such as smart buildings, IoT, GIS, Crowd Sourcing, AR, VR, and smart sensors in the first layer. Then, the collected data are transferred through smart communications in the smart city data transfer layer to the smart city data application layer. In this layer, communication technologies and networks such as 5G and the internet are used. Finally, in the application layer, the big-data-powered services are provided to the smart citizens through smart services such as disaster management services, smart energy control systems, smart infrastructure, smart transportation systems, and others. The whole process is controlled through an iterative layer of smart city data integration where decision support systems are used to provide big data analytics, ensure proper risk management, and ensure data security through government policies and AI-powered bots.

Using a similar approach, newbie researchers in BE can develop conceptual frameworks by systematically retrieving and analyzing the pertinent literature. Accordingly, the current study can help serve as a guideline for BE research aspirants.

4. Conclusions

The current study provides guidelines for researchers at the beginners' level aiming to develop CFs in the field of BE. The study has perks for new entrants and existing researchers struggling to find an appropriate literature review method and CF development techniques. This is especially relevant to developing new CFs for adopting and implementing disruptive digital technologies that facilitate the industry 4.0 transformation and can be equally used by new and expert researchers.

Using an example of big data in the smart city disaster management, the current study provides guidelines for systematically conducting literature reviews and developing CFs. It presents both basic analysis and detailed analysis procedures expected to be adopted by future studies in BE.

The current study provides a baseline for conducting a systematic literature review in BE domains and can be adopted by other disciplines. The inspiration was received from nascent researchers in BE who struggle to find a reproducible CF development and systematic review method in the published literature. It is expected that this method will motivate BE research aspirants to take on systematic literature reviews with confidence and help expand the body of knowledge through high-quality and well-organized scientific contributions.

At the end, as a limitation of the applicability of the current study, the researchers are cautioned to ensure the novelty of the area of the research before developing conceptual frameworks and avoid re-inventing the wheel. As far as a systematic literature review is concerned, the method is universal and can be applied to any topic. However, the research area and the research gap become extremely important for conceptual framework development. Therefore, before investing such exhaustive efforts into developing a conceptual framework, it must be ensured that the gap is real and demands the development of a conceptual framework. Further, the proposed guidelines may not apply to contexts such as developing consensus on nascent topics such as big data, smart cities, smart real estate, and others or addressing the information overloads. Instead, these are proposed for facilitating the adoption of nascent technologies and techniques, especially those relevant to Industry 4.0 in the BE and similar domains. Another limitation of the study is that it has not been tested in practice with researchers since it aims at developing the CFs part, not the implementation aspect. It is purely based on insights from published literature and hence may not address the implementation concerns of the industry. In addition, researchers are encouraged to supplement their studies with qualitative checks such as interviews, pilot surveys, focus group consultation, and the usage of simulations and hypothetical test cases.

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Appendix A

In line with the recent trends, it is always helpful for increasing the reproducibility of the work that the reviewed articles are listed in the appendix. Accordingly, the 17 articles used as an example in the current study are provided in Appendix A.

Table A1. Details of the 17 papers retrieved in this study.

Authors	Title	Year	Source Title
Bellini E., Bellini P., Cenni D., Nesi P., Pantaleo G., Paoli I., Paolucci M.	An IOE and big multimedia data approach for urban transport system resilience management in smart cities	2021	Sensors (Switzerland)
Zhou H., Zheng Z., Cen X., Huang Z., Wang P.	A Data-driven urban metro management approach for crowd density control	2021	Journal of Advanced Transportation
Wang Z., Xu J., He X., Wang Y.	Analysis of spatiotemporal influence patterns of toxic gas monitoring concentrations in an urban drainage network based on IoT and GIS	2020	Pattern Recognition Letters
Azeemi N.Z., Al-Basheer O., Al-Utaibi G.	Zero down time-smart data guard for collaborative enterprise dataware systems	2020	Journal of Theoretical and Applied Information Technology
Guowei Z., Su Y., Guoqing Z., Pengyue F., Boyan J.	Smart firefighting construction in China: Status, problems, and reflections	2020	Fire and Materials
Berglund E.Z., Monroe J.G., Ahmed I., Noghabaei M., Do J., Pesantez J.E., Khaksar Fasaee M.A., Bardaka E., Han K., Proestos G.T., Levis J.	Smart Infrastructure: A Vision for the Role of the Civil Engineering Profession in Smart Cities	2020	Journal of Infrastructure Systems
Song X., Zhang H., Akerkar R.A., Huang H., Guo S., Zhong L., Ji Y., Opdahl A.L., Purohit H., Skupin A., Pottathil A., Culotta A.	Big Data and Emergency Management: Concepts, Methodologies, and Applications	2020	IEEE Transactions on Big Data
Jung D., Tuan V.T., Tran D.Q., Park M., Park S.	Conceptual framework of an intelligent decision support system for smart city disaster management	2020	Applied Sciences (Switzerland)
Shah S.A., Seker D.Z., Rathore M.M., Hameed S., Ben Yahia S., Draheim D.	Towards Disaster Resilient Smart Cities: Can Internet of Things and Big Data Analytics Be the Game Changers?	2019	IEEE Access
Shalamberidze I., Akhobadze M.	Web platform for “Smart City” data collection and analytics	2019	Economia Agro-Alimentare
Park S., Park S.H., Park L.W., Park S., Lee S., Lee T., Lee S.H., Jang H., Kim S.M., Chang H., Park S.	Design and implementation of a Smart IoT-based building and town disaster management system in Smart City Infrastructure	2018	Applied Sciences (Switzerland)
Chen G., Yang T., Huang R., Zhu Z.	A novel flood defense decision support system for smart urban management based on classification and regression tree	2018	International Journal of Security and Networks
Sinha K.C., Labi S., Agbelie B.R.D.K.	Transportation infrastructure asset management in the new millennium: continuing issues, and emerging challenges and opportunities	2017	Transportmetrica A: Transport Science
Tsinganos K., Gerasopoulos E., Keramitsoglou I., Pirrone N., ERA-PLANET Team	ERA-PLANET, a European network for observing our changing planet	2017	Sustainability (Switzerland)
Toth C.	The future of remote sensing: Harnessing the data revolution	2017	Geoacta (Argentina)
Chang C.-I., Lo C.-C.	Planning and Implementing a Smart City in Taiwan	2016	IT Professional
Zhang N., Chen H., Chen J., Chen X.	Social Media Meets Big Urban Data: A Case Study of Urban Waterlogging Analysis	2016	Computational Intelligence and Neuroscience

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