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Review

A Systematic Review on Enhancement in Quality of Life through Digitalization in the Construction Industry

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Abstract: Digitalization in the construction sector is a need of the modern world. Not only the infrastructure, but also the quality of life, is improved by the digital transformation in the construction sector. Digital technologies are being widely used in construction. The impacts of implementing digital technology on transformation in the construction industry, however, have not yet been thoroughly understood. Considering this aspect of the construction industry, this study reviews the articles in the field of digitalization of various segments in the construction industry. In this manner, the Scopus database was considered to gather the relevant articles based on the keywords (((“Digitalization” OR “Digitalisation”) OR “Reforms”) AND “Construction” AND “Energy”). These keyword combinations provided a list of 126 articles and, following the protocol of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), the number was reduced to 35. The review showed that the major targeted areas in the construction sector based on digital transformation are smart construction, optimization of energy, sustainable environment, wireless technology, and economic and architectural growth in which the role of Building Information Modelling (BIM) and prefabricated construction is noteworthy. The involvement of digitalization in numerous fields has improved quality of life. It increases production and has the potential to automate the industry more effectively. This study shows how the adoption of digital technology has improved comprehension and laid the foundation for a digital transformation in the construction industry.

Keywords: digitalization; reforms; construction; energy; BIM; technologies

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1. Introduction

The construction sector is one of the globe’s leading sectors, having a substantial impact on social activities, as well as impacting economic stability [1–3]. The evolution of the world has never happened so quickly as it shifts, in recent times, due to immense growth in the population which increases the demand for social needs [4]. Hence, it is essential to examine both the micro and macro parameters involved to make continuous progress in the construction sector [5,6]. The sector is the demonstration of business growth, providing opportunities via socio-economic activities [7–9]. The growth of this sector is based on the adaptability of new technologies [10–12]. This adaptability helps construction projects to deliver in a better way by easing the mode of construction [13–15].

Digitalization in the construction sector after the introduction of the Industrial Revolution (IR) 4.0 has smoothed the ways of construction and maintenance [16–18]. Not only in the execution phase, but digitalization is also in all other phases of construction projects, providing further ease to construction parties [19,20]. This sector has changed tremendously in the past few years [21–23]; though significant reforms are not evenly distributed around the globe [24–26], they are leaving a remarkable impact where they have arrived [27,28]. In the construction industry, digital transformation requires a variety of technologies [29,30]. Over the past decades, an adaptation of technologies to this sector received significant attention, such as drones and immersive technologies [31,32].

The advent of IR 4.0 is essential for the smooth transformation of the construction industry towards digitalization [33–35]. The role of construction stakeholders is important in relation to other parties who are capable of digitalization, as their input can guide them to better implementation [36–38]. Digitalization in construction has transformed construction projects from planning to closure [39–41] due to the involvement of various technologies such as automation [42–44], cyber security [45–47], the Internet of Things (IoT) [48–50], drones [51,52], Building Information Modelling (BIM), 3D printing, and Augmented Reality etc. [53–56].

Recently, digital fabrication technology has been introduced, which is a broad field with a wide range of applications [57,58]. Automated construction procedures that are commonly characterized as subtractive, formative, or additive are combined with computational design methodologies to generate digital fabrication techniques [59]. Building sector productivity can be increased by using digital fabrication techniques, which not only result in considerable time savings for complicated designs, but also have the capacity to transmit design data straight to 1:1 assembly procedures and automated construction [58]. Digital fabrication has played an enormous role in the construction industry entering the digital age. Similarly, 3D printing technology reduces the time and cost of construction, and it has been applied in various industries such as civil engineering, construction, architecture engineering, and other fields [60,61].

Moreover, BIM is a powerful tool and is the basis of digitalization in the construction industry. It concentrates on the design and construction of a building. On the other hand, a digital twin is a replica that can serve several functions that are made from actual assets, systems, and processes. The digital twin is undoubtedly the best example of the digitization process. The application of digital twins can be seen in asset management for health monitoring and the durability of the systems. The major difference between the digital twin and conventional digital models is their capacity to track and report the structural behavior and health of a civil engineering asset, over the course of its entire service life [62]. Any digital twin requires BIM as a critical source of data. Digital twins are used in many different fields, including diagnostics, system integration, and prediction etc. For instance, TESLA wants to use digital twin technology for each of its cars. Through data transmission, each user will receive a customized maintenance schedule which will help the company make the most efficient use of its resources [63]. The operations of wind turbines are tracked using digital twins by energy corporations such as General Electric and Chevron to predict health and performance [64]. For the effective, secure, and long-term administration of civil engineering assets, the digital twin is a new development.

Figure 1 shows the literature on digitalization from 1922–14 June 2022 as per the Scopus database [65]. Initially, as demonstrated in Figure 1a, the work in this area was less significant and moving at a slow pace (red line), which boosted from the year 2000 onward, as shown in Figure 1b (green line). In recent times, digitalization has become a need of society due to the demand for Industrial Revolution adaptation. Figure 2 shows the rate of digitalization in several fields as per Scopus [65], where it can be seen that, over time, the highest digitalization occurred in the field of engineering, leaving other fields far behind. This is because the engineering sector is associated with all the other sectors [58,59], and the reforms brought to this field can contribute to other fields [66,67] and ultimately enhance quality of life [68,69].

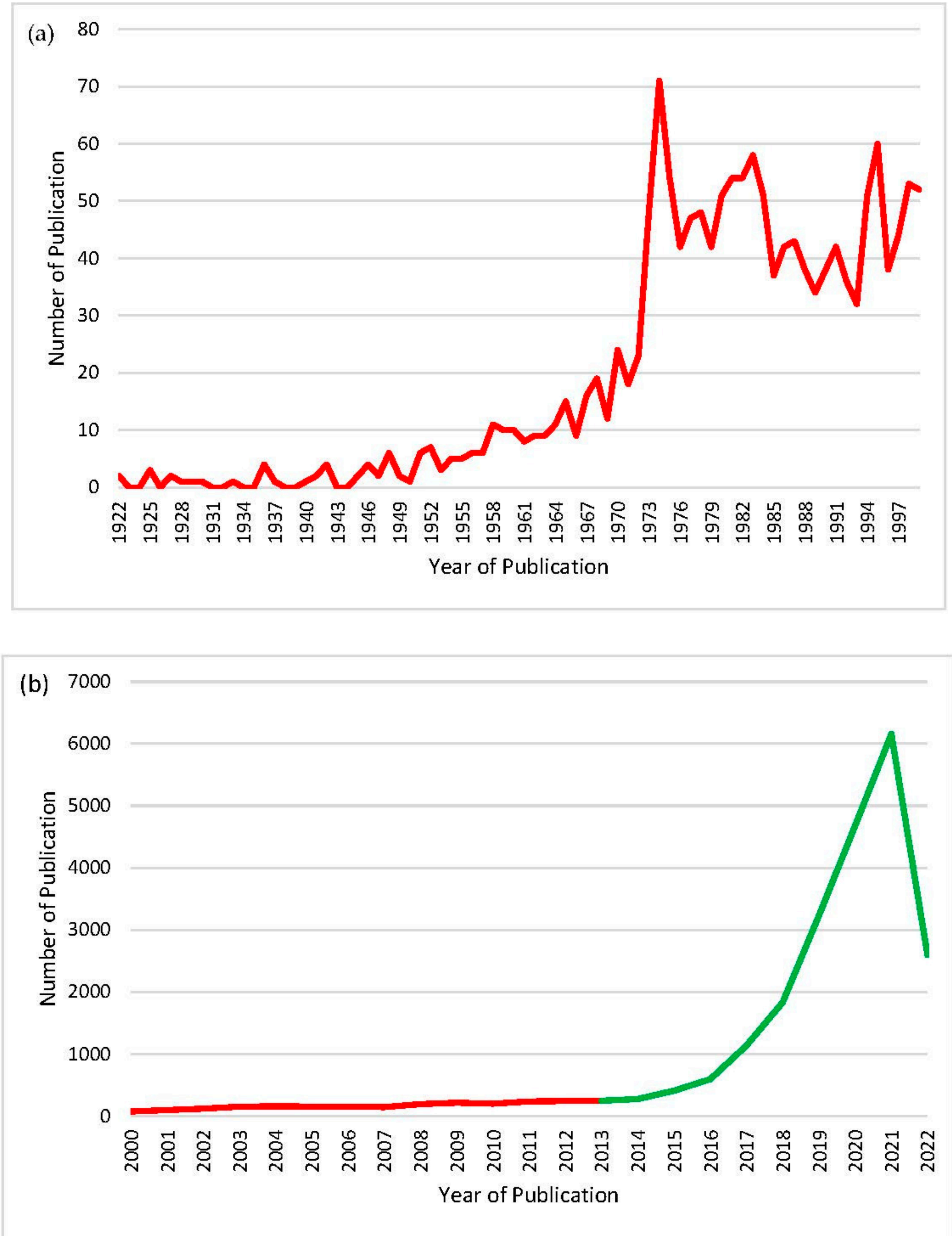

Figure 1. Publication by Year; (**a**): Documents by Year on Digitalization (1922–1999), (**b**): Documents by Year on Digitalization (2000–2022) [65].

Figures 1 and 2 demonstrate the interest of researchers and the demand of society for digitalization in the field of engineering. Based on the mapping of the analysis, as shown in Figure 3, of the keyword via VOSviewer on the gathered Scopus [65] data of digitalization, it can be observed how a revolution has occurred in the field of engineering over time. Digitalization is involved in the circular economy, sustainable development, the manufacturing industry, the construction industry, and architectural design, and has been connected with machine learning and artificial intelligence. In a nutshell, digitalization has been boosted tremendously in this field of engineering studies, especially in the department of the construction sector. Therefore, the purpose of this systematic review, followed by Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, is to gather the available knowledge on digitalization from a construction perspective and observe the reforms that have been brought to the construction industry to date. A detailed assessment has been provided in this review, showing the workability of digitalization in the construction sector.

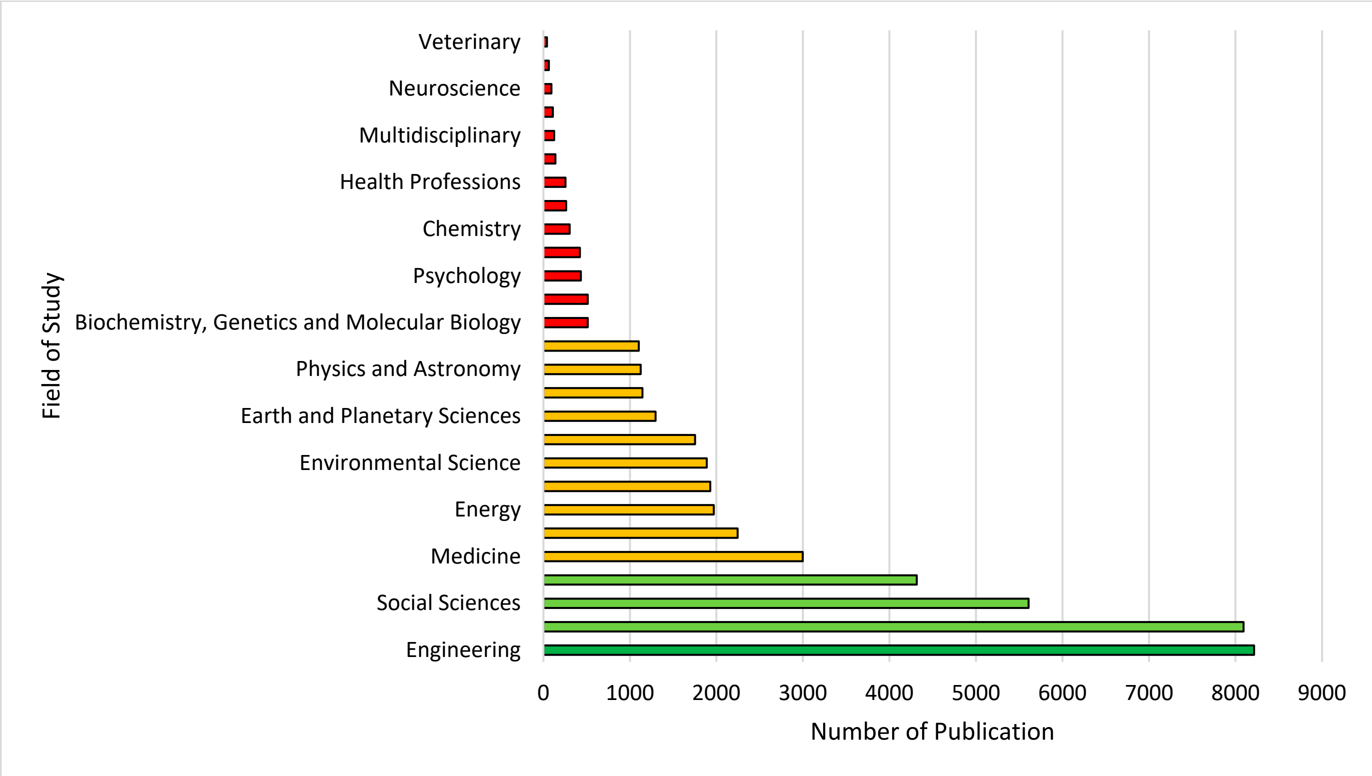

Figure 2. Number of Documents in various Fields of Studies [65].

Digitalization in construction has received mixed feedback from the stakeholders of the construction industry. Not everyone is comfortable enough to be hands-on with the new technology. Most of the construction parties are reluctant in adopting the new norms of construction and are stuck with the conventional mode. This highlights the following important research question: how does quality of life get enhanced through digitalization in the construction industry?

To answer this research question, a systematic literature review approach was adopted. Hence, this review will help the bibliophiles to understand more about digitalization and reforms that have improved the living standards of human beings by enhancing their quality of life. For better clarity, a conceptual framework was also presented at the end, demonstrating the linkages of digitalization and its impact on global sustainability.

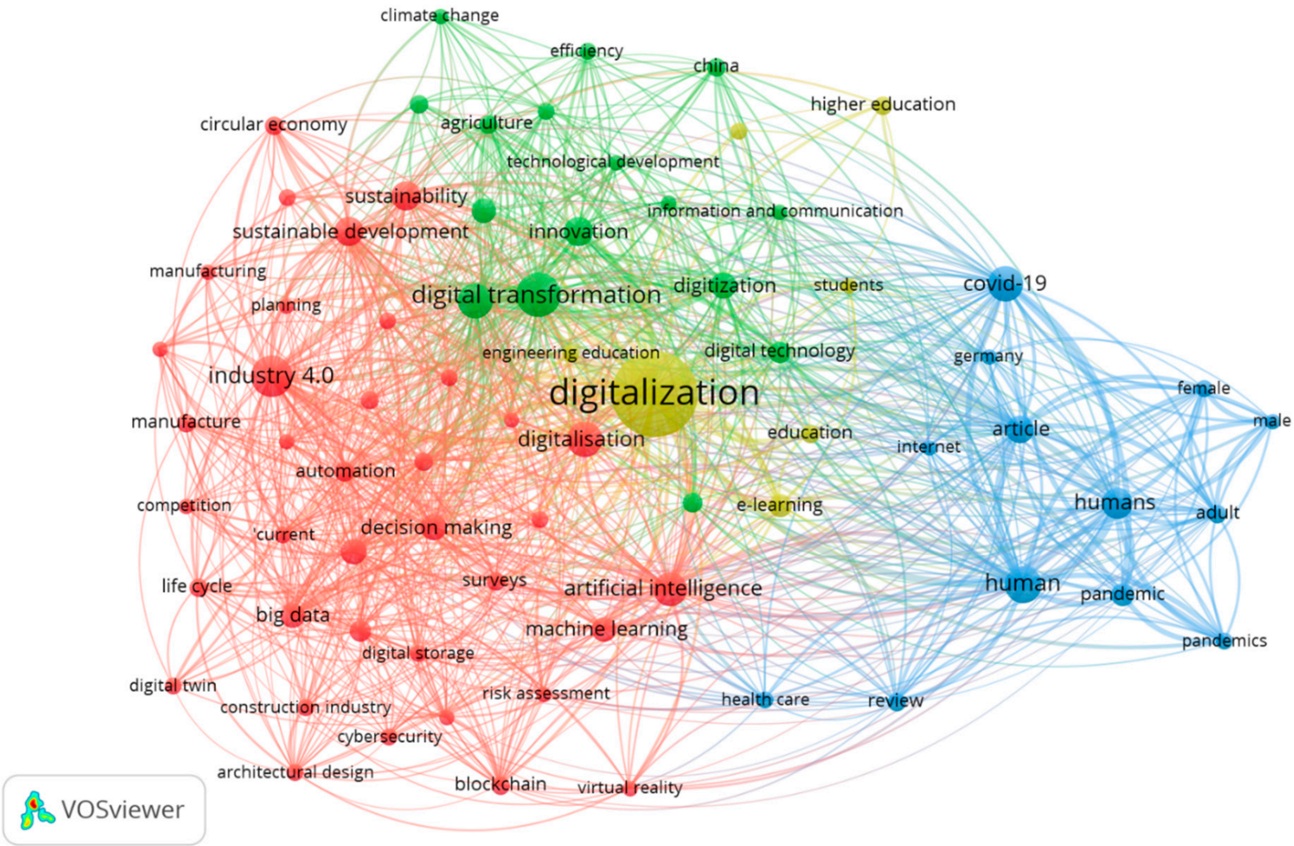

Figure 3. Overall Mapping of Digitalization.

2. Methodology

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), which is a systematic review technique suggested by various researchers [70–73], was adopted in this review. The purpose of selecting PRISMA in this review was to get the articles in a systematic and structured way, based on the specified keyword selection. The first step was the "Identification" of the relevant articles from the specified database. In this case, the Scopus database was chosen to extract the relevant published articles. The second step was "Screening" of the gathered articles, based on the title and the abstract, where various articles were omitted due to irrelevancy. The third step was "Quality assessment", where the full article text was examined and only those articles were kept for further assessment which fulfilled the scope of the work. In the fourth and final step, i.e., "Inclusion", the final gathered articles based on the scope were chosen for a detailed review process. The detailed review flow is presented in Figure 4 below:

2.1. Research Strategy

In this review, the published articles were extracted from a specified database based on the scope of work. In accordance, the Scopus database was made into consideration to get the appropriate articles. The reason behind the selection of the Scopus database in comparison to others is that it provides a variety of articles published in reputed journals and conferences. This review focuses on digitalization brought to the construction industry in terms of workability and energy. For this reason, the following keywords were chosen to obtain the articles: ((("Digitalization" OR "Digitalisation") OR "Reforms") AND "Construction" AND "Energy").

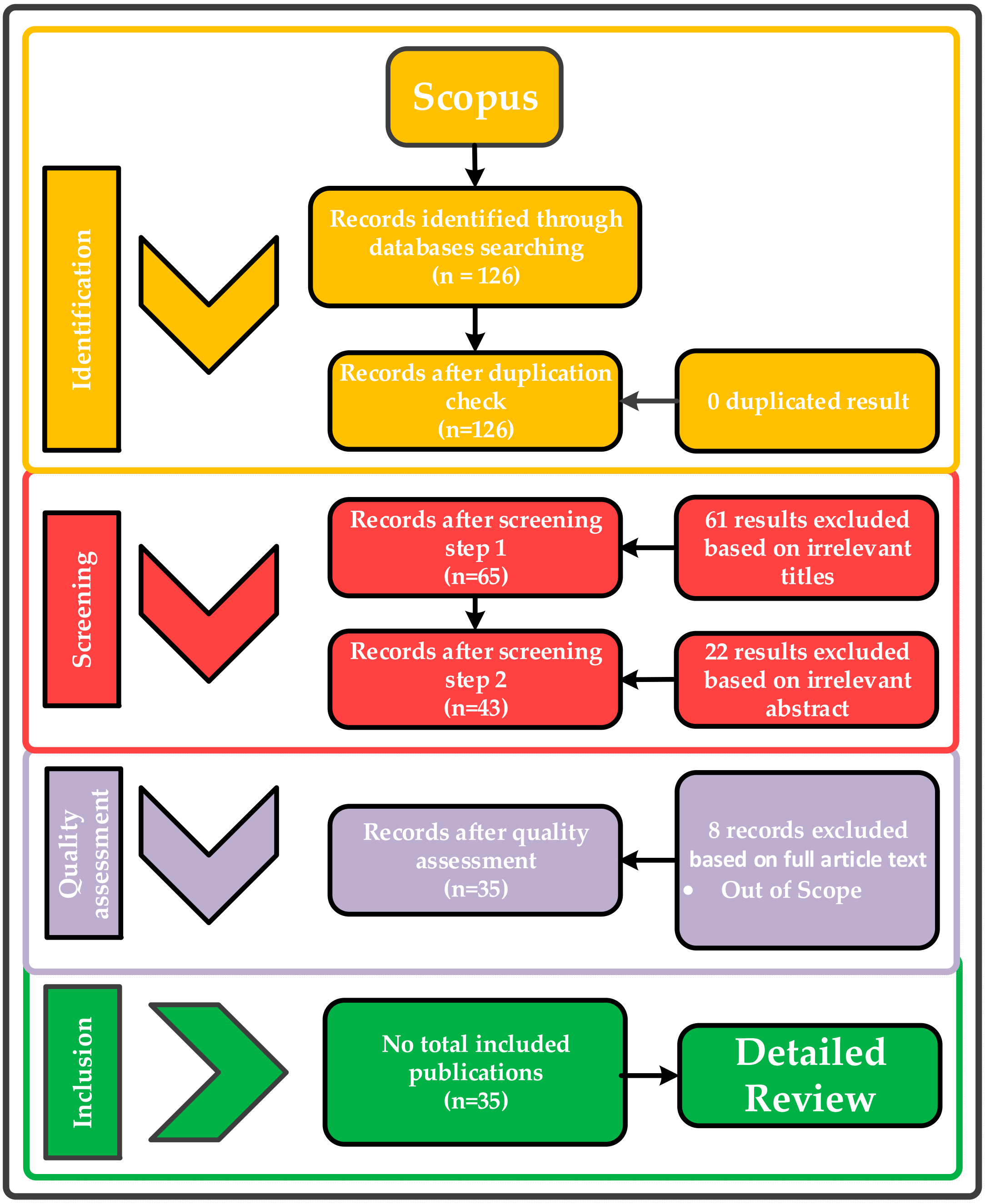

Figure 4. PRISMA framework.

2.2. Selection Criteria

As the focus of this review was on the digitalization of the construction industry, the PRISMA statement was thoroughly considered. A few limitations were applied to get articles that can cover a glimpse of the work. The first limitation was the year, where the articles from 2013–14 June 2022 were considered. The considered articles were published in conferences and journal papers in the English language, in the Engineering subject category, which gave 126 of the most relevant articles. Given below is the detailed keyword assessment coding with the applied limitation:

TITLE-ABS-KEY (((“Digitalization” OR “Digitalisation”) OR “Reforms”) AND “Construction” AND “Energy”) AND (LIMIT-TO (PUBSTAGE, “final”)) AND (LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO

(PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013)) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp")) AND (LIMIT-TO (SUBJAREA, "ENGI")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j") OR LIMIT-TO (SRCTYPE, "p")).

2.3. Quality Assessment

To get the articles under the scope and with a higher probability of assessment, a few occasional checks were applied. Initially, the articles were examined by a duplication check, where zero articles were found duplicated. After this, articles were reviewed based on title and abstract, which provided the elimination of 61 and 22 articles, respectively. In full text read, eight articles were eliminated due to scope matter. In the end, only 35 articles remained for a full critical review assessment. Although the number of final leftover articles was small, it came following the protocol of the PRISMA statement and it covered the major aspects of the area for which this review was conducted.

3. Results and Interpretation

In this section, the summary of the final gathered articles is presented. VOSviewer was also utilized for the keyword analysis of the articles, with their co-occurrence during the studied years.

3.1. Extracted Articles Summary

The final gathered articles were focused on digitalization in the construction industry, where the distribution of the published articles year-wise is presented in Figure 5. It can be observed that, over time, the rate of workability in digitalization from a construction perspective has increased. Out of 35 gathered articles, 13 are conference papers while 22 are research articles. Table 1 demonstrates the focused area of each gathered article with the author's name, published year, and the citation that has been secured to date.

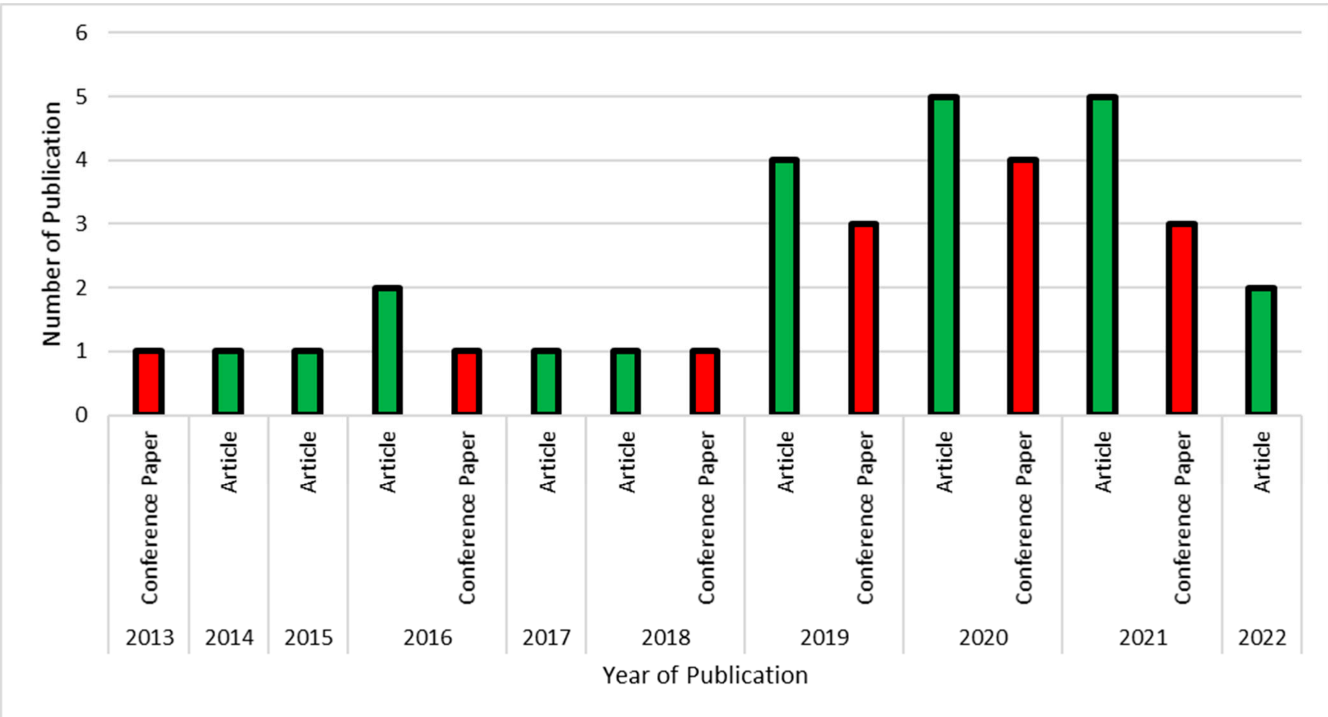

Figure 5. Year-wise Distribution of Articles.

Table 1. Summary of extract Articles.

S. No	Focused Area	Author	Year	Citation
1	Smart construction	Stojanovska-Georgievska, Sandeva [74]	2022	0
2	Energy efficiency	Chang, Hou [75]	2022	1
3	Energy efficiency	Oberti and Plantamura [76]	2021	0
4	Renovation and maintenance of buildings	Daniotti, Bolognesi [77]	2021	4
5	Energy efficiency	Alhamami, Rezgui [78]	2021	0
6	Smart construction	Mantha and García de Soto [79]	2021	1
7	Energy efficiency	Yayla, Kayakutlu [80]	2021	0
8	Architecture	Huang [81]	2021	1
9	Cleantech industry	Zheng, Shao [82]	2021	16
10	Wireless communication	Kontaxis, Tsoulos [83]	2021	0
11	Renovation and maintenance of buildings	Rinaldi, Ferrari [84]	2020	3
12	Wireless communication	Ma, Li [85]	2020	3
13	Economy	Kovacic, Honic [86]	2020	4
14	Energy efficiency	Anand, Kuanar [87]	2020	0
15	Smart construction	Xu, Chen [88]	2020	1
16	Cleantech industry	Zulkefli, Mohd-Rahim [89]	2020	4
17	Energy efficiency	Alhamami, Petri [90]	2020	7
18	Cleantech industry	Charles, Vidyaratne [91]	2020	0
19	Smart construction	Akyazi, Alvarez [92]	2020	10
20	Smart construction	Li, Greenwood [93]	2019	148
21	Smart construction	Chen, Tang [94]	2019	4
22	Economy	Turkova and Arkhi [95]	2019	6
23	Cleantech industry	Bergman, Hajikhani [96]	2019	1
24	Smart construction	Zhao, Zhang [97]	2019	4
25	Smart construction	Reddy and Kone [98]	2019	2
26	Cleantech industry	Wang, Ye [99]	2019	8
27	Cleantech industry	Wen, Hu [100]	2018	20
28	Energy efficiency	Cheng, Zhang [101]	2018	0
29	Energy efficiency	Petri, Kubicki [102]	2017	45
30	Smart construction	Park, Suh [103]	2016	17
31	Energy efficiency	Liu and Lin [104]	2016	24
32	Energy efficiency	Yu, Wang [105]	2016	3
33	Energy efficiency	Ouyang and Lin [106]	2015	20
34	Economy	Zhang, Wang [107]	2014	0
35	Smart construction	Smiley, Dainty [108]	2013	2

3.2. Keyword Analysis

The keywords are one of the main aspects of any published work which demonstrates the thrust of the conducted work. Here, the role of keyword analysis plays a vital part in research as it defines the linkages among the conducted work, and also clarifies the pattern of the work. For keyword analysis purposes, VOSviewer software was utilized to observe the co-occurrence of the keyword. Figure 6 shows the linkage of each keyword with other keywords, while Table 2 shows the number of co-occurrences of each keyword along with the designated cluster. The red color represents cluster 1, the green color represents cluster 2, while the blue represents cluster 3. All of these three clusters are interconnected with the keywords, showing the connections of the articles. It can also be noticed that the highest co-occurrence came as ten for the "construction industry" and "energy efficiency" keywords, followed by eight and seven co-occurrences for "energy utilization" and "(architectural design, building information modelling, construction)", respectively.

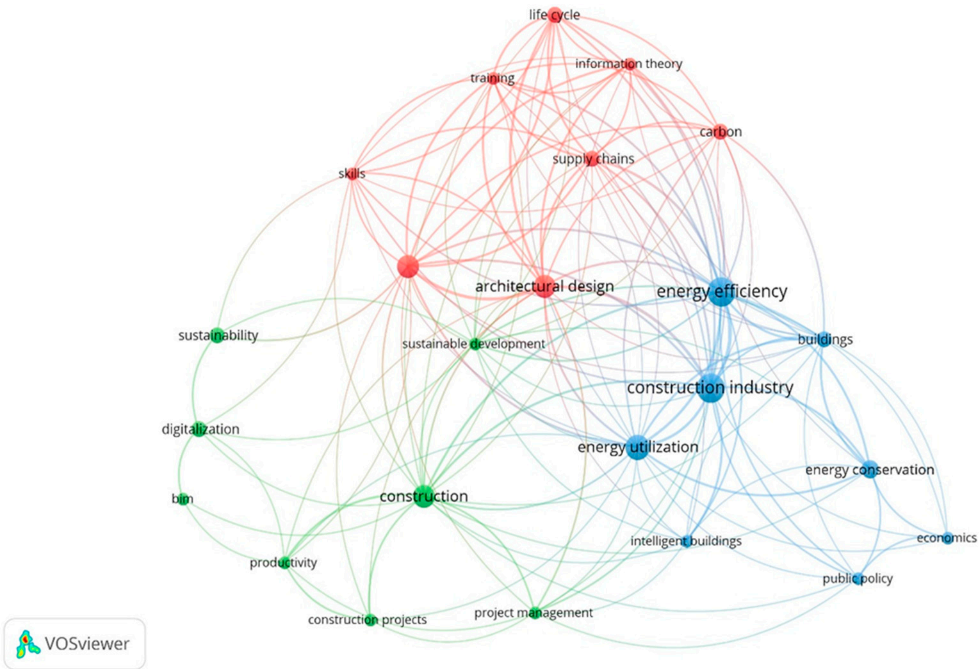

Figure 6. Visualization of keywords Co-occurrence.

3.3. Interpretation of Articles

The thirty-five (35) papers that were finally selected focused on the effects of digitalization on energy efficiency, smart construction, economic growth, renovation, and maintenance of buildings, wireless technologies, architecture, and the cleantech industry. A detailed analysis of the articles has been completed for comprehensive insight to answer the research question.

3.3.1. Digitalization and Energy Efficiency

Digital technologies can optimize the amount of energy used in a variety of energy-intensive operations, from creating an industrial product to cooling a house. It provides a unique opportunity to optimize energy efficiency. A co-integration method has recently been used to determine the potential for energy savings in the Chinese building materials industry, as well as the various factors contributing to energy consumption [106]. The researchers have proposed some methods for energy optimization; a study of an office block in rural troposphere-Gunupur has been published, based on energy plus and open studio [87]. Furthermore, a building information modelling (BIM)-based methodology was proposed to reduce carbon emissions and maintain energy performance in the construction industry. Energy monitoring, decision support, and discovering consumption trends through BIM can provide energy efficiency. However, BIM requires special skills and training for the construction industry. The digitalization in the energy sector through BIM provides a unique opportunity for the optimization of energy [90,102].

Table 2. Keyword co-occurrence list.

S. No	Label	Cluster	Co-Occurrence
1	architectural design	1	7
2	bim	2	3
3	building information modelling	1	7
4	buildings	3	4
5	carbon	1	4
6	construction	2	7
7	construction industry	3	10
8	construction projects	2	3
9	digitalization	2	4
10	economics	3	3
11	energy conservation	3	5
12	energy efficiency	3	10
13	energy utilization	3	8
14	information theory	1	3
15	intelligent buildings	3	3
16	life cycle	1	4
17	productivity	2	3
18	project management	2	3
19	public policy	3	3
20	skills	1	3
21	supply chains	1	4
22	sustainability	2	4
23	sustainable development	2	3
24	training	1	3

Note: Cluster Red = 1, Cluster Green = 2, Cluster Blue = 3.

Additionally, BIM has also been applied for energy efficiency in the development of a country. In the case of Saudi Arabia, analysis has been carried out to determine the gaps for BIM skills related to the training. Also, because of this analysis, it was found that an online training set is required to fulfil these gaps. It was concluded that Saudi Arabia's construction sector required more training programs to be adopted to enhance energy efficiency using BIM [78]. The use of BIM in the design phase of buildings reveals that the digitalization of the construction industry leads to a more sustainable environment [80]. Overall, BIM can improve building energy efficiency and assist in the digitalization of the construction sector.

Another attempt was made to design a nearly zero-energy building based on rural housing in Xi'an, China. Photovoltaic and storage battery systems were incorporated to reduce the energy demand. Due to the installation of the newly constructed systems, the energy demand has been decreased to meet the standards of China. This study shows that digitalization has a positive impact on the energy sector and that energy demand can be decreased by the implementation of newly developed strategies [75]. Another study based in China revealed that promoting technical innovation is a crucial strategy for achieving green building. Energy pricing reforms and tax policies should be employed to mitigate the energy rebound effect that can be beneficial for the attainment of green building construction [104].

The factors influencing the energy consumption for existing residential buildings in China are also investigated, and it can be found that better results and economic growth can be attained through green transformation [105]. Additionally, a method was proposed to control the cost of a new energy power generation project to increase overall benefits and save cost-effectively. The use of new energy can make the construction process effective, reusable, and greener. By taking effective measures for cost control, a better environment for the construction of power projects can be made possible [101]. Similarly, 3D printing technology has evolved in the past decade, but its implementation in the construction sector has been slower compared to other areas of research. 3D printing is effective in terms of the calculation of material required during the design phase. Consequently, it reduces the construction waste by 30 to 60%. Overall, the use of 3D printing is effective in terms of the construction process and the environment [76].

3.3.2. Cleantech Industry and Digitalization

Industrialization is the result of technological advancements such as the utilization of iron and steel, coal and steam, and the factory system. In addition to this, industrial parks are of immense importance as they promote urbanization, gathering resources, and the development of new industries. However, industrial growth promotes severe pollution and high resource consumption.

Various initiatives have been taken by China to develop a circular economy (CE) that can reduce pollution and offer high-efficiency production [100]. Concerning several environmental issues, the idea of developing green cities is currently gaining momentum. BIM has shown potential in greening cities as it is considered a keystone in the digitalization of the construction industry, by forming models that can conduct environmental analysis and preside over various factors responsible for the damage. Overall, BIM can help in improving the performance of existing buildings [89].

Additionally, green roofs are recognized to replace the greenery wiped out by urbanization, but the concept is still new and developing in Sri Lanka. A green roof, also referred to as a living roof, can be economically advantageous because it lowers the amount of energy needed by buildings for cooling and heating, lowers the temperature of the city's surface, and offers several other advantages. The development of buildings and industrialization have several adverse effects. Numerous environmental advantages come from greenery, which also lessens the negative consequences of urbanization and high buildings [91]. In addition to this, the main cause of climate change is carbon emissions from human activity. Low-carbon cities are of great importance as they optimize the energy and industrial structure. A pilot program in China was employed to analyze the impact of low-carbon cities on the economy and climate. The study showed a significant effect on industrial structure and the reduction of carbon emissions [82]. Another study showed an effective measure for the improvement of CO_2 emission efficiency in China. Generalized principal component analysis and super-Slacks-based measures have been used to investigate the level of CO_2 emissions and marketisation in China. It serves as a resource for decision-makers to continuously promote economic and market reform, while enhancing CO2 emission efficiency [99]. Furthermore, for the development of the cleantech industry, cognitive construction shows the role of managerial cognition and social construction. The findings imply that the cognitive construction view of the industry offers a chance to clarify the intricate dynamics of the energy transition and anticipate industry development within the rapidly evolving industrial environment [96]. It shows that digitalization in the cleantech industry has several positive effects in developing green cities and reducing contamination caused by industrialization.

3.3.3. Smart Construction and Digitalization

Construction that fully utilizes industrialized technical approaches and digital innovations to increase profitability, decrease expenses, and improve sustainability, is referred to as smart construction. It provides quality of life with the ease of remotely controlling various objects and offers a more secure environment. The Internet of Things (IoT) offers improved productivity and work management with the automation of various tasks and the elimination of the human workforce. It creates a fine line between conventional and smart construction by providing better quality in construction and reducing problems by using smart technologies and sensors [98]. Towards smart construction, the prefabricated building has gained considerable momentum in recent years as a means of addressing China's architecture, engineering, and construction (AEC) sectors' serious productivity reduction, excessive energy consumption, and large resource waste. A five-dimensional BIM was introduced for the efficient management of prefabricated construction projects in China, and it digitalizes the AEC sector. This study provides a framework for the improvement of productivity and feasibility for prefabricated construction [94]. Another study related to the accurate tracking of productivity in an efficient manner is proposed in Finland and China using 3G/4G and Bluetooth low energy technology as a method of connection to locate the onsite workers efficiently, and manage the flow of work effectively [97].

Digitalization is a key factor in increasing the productivity of the sector. It can bring improvement and automate the process; as a result, efficiency is enhanced and it can save financial resources. North Macedonia, which relies on the construction industry for its economic growth, is falling behind in terms of productivity levels due to a lack of smart technologies and digitalization. The adoption of BIM in the construction industry is a step in the direction of digitization. The survey conducted showed that digitalization by utilizing the BIM framework can help to overcome challenges and offers productivity [74].

Towards the development of digital safety systems during the development phase, a method was proposed to counter the cyber threats to nuclear facilities. The proposed method involves the four main activities for digital safety systems which are a security assessment, a security test during software development, a penetration test and cyber security team organization. It is anticipated to help system designers and developers comprehend the entire security operations of the safety system [103]. Similarly, the protection of industrial IoT systems is of immense importance as they consist of various devices, governed by various organizations that do not entirely trust one another. The upcoming blockchain technology offers a potential tool for industrial IoT system administration and protection. To build a trusted environment, a field programmable gate array (FPGA)-based blockchain mechanism was proposed that offers better management, and it is feasible for various industrial IoT applications [88]. In addition to this, blockchain technology advancements, also known as distributed ledger technologies (DLT), are being examined more and more as a component of the construction industry's digital transformation. The research demonstrates that there is a significant opportunity for DLT to help digitalization in the construction sector. The critical areas of research interest of DLT could be found in the categories of smart homes, construction management, smart cities, and energy [93]. Another study indicates the importance of cybersecurity in the AEC industry, and it is getting more prone to cyber-attacks due to digitalization. The research suggests that the AEC industry requires cybersecurity, and it is lagging due to a lack of awareness in this area of research [79].

Furthermore, the civil engineering sector is facing several challenges due to financial crises and digitalization. To solve this problem, there is a need for skilled workers that can handle the challenges due to technological innovation and global crisis. The first step is the identification of the skillset required by the civil engineering sector. After the identification of the required skills, there should be effective training programs to enhance or improve the skills of the workers [92]. A more comprehensive philosophical and theoretical discussion is required within the construction management community regarding the need to better interact with, and comprehend, the cultural sources influencing the ongoing problem of policy formulation and diffusion in the built environment that consistently fails to produce expected reforms [108].

3.3.4. Digitalization and Economic Growth

With the increase in a lack of resources such as sand and building materials etc., digital technologies can have a significant effect on the AEC industry for the estimation of resources, optimization of energy, and prediction of upcoming waste. Digital technologies are causing changes in the industry's traditional value chains and procedures [86]. An essentially important cornerstone of the country's economy is the construction sector. The industry life cycle must be calculated, and its future development must be forecasted so that governments can formulate a suitable strategy to promote healthy and sustainable progress. Growth curve measurement models have been used for the analysis of the life cycle of the national construction industry [107]. A recent development in the economic sector is the implementation of digital technologies; it offers improved productivity as it automates the process through smart technology. This paper covered the principles of the Irkutsk region's digital economy infrastructure, where digital data play a crucial role in infrastructure developments, raising living conditions, increasing population awareness, and expanding access to public services. The Irkutsk region's economy will develop sustainably due to the digital economy, which will also increase decision-making efficiency and facilitate rapid evaluation of different management strategies [95].

3.3.5. Digitalization in the Field of Architecture

The discipline of architecture has recently seen the emergence of artificial intelligence (AI) and machine learning (ML) applications. For the generation of building plans, newly developed tools have been used based on supervised machine learning algorithms. In addition to increasing effectiveness and efficiency, ML creates new possibilities for creative design work. Reinforcement learning (RL), which is another subgroup of ML, is also being investigated more and more in the design sector because of its interactive capability. The proposed research discusses the potential of the RL-based method for the implementation, designing, and construction of an architecture that can offer a zero-waste design–build strategy [81].

3.3.6. Wireless Communication and Digitalization

The inability to easily access information about a building's existing performance makes it extremely difficult to design the necessary modifications. Furthermore, accident statistics for the construction sector show that exposure to hazardous environments in confined spaces can result in deaths and major injuries. BIM has the potential to offer effective monitoring measures on confined sites by utilizing wireless sensor technology. The wireless sensors support BIM methods in the construction industry to fully automate the process, the accessibility of related information, and helps in decision support. Wireless technology can track real-time data and it can provide various measurements of interest [83].

In addition to this, IoT is gaining importance with an expansion in the economic sector and distributed energy is connected to the power grid. This increases the pressure on the power system as a result the management and administration must face various operational challenges. Ubiquitous power IoT is of immense importance in reforming the country's energy structure, optimization, and coordination of source network load storage, and it can improve energy consumption. It is an intelligent system capable of transmission and transformation of power, consumption, and power generation; it employs modern technology for the interconnection in all facets of the power system with the characteristics of efficient information processing. For communication purposes, ubiquitous power IoT can be dependent on wired or wireless communication. Wireless communication offers flexible networking, simple construction, high security, and fast transmission speed [85].

3.3.7. Renovation and Maintenance of Buildings using Digital Technology

IoT technology has also been employed in the renovation and maintenance of buildings to model a framework which can make the renovation process easier and more flexible. Digitalization by using modern technology in the maintenance of buildings offers various advantages, such as ease in gathering data, monitoring, and maintenance of renovated buildings. A cognitive building approach is introduced that calculates the set of adjustments from user preferences. It improves quality of life and offers comfort to users through a relationship between humans and machines. As a result, it can reduce the consumption of energy and enhance comfort. The research examined how cognitive-based methods are used when renovating buildings. The idea behind this technique is to create architectural elements that are used in renovations with integrated sensors and networking characteristics. It is anticipated that the proposed method will be able to replace existing methods and provide novel revenue streams [84].

Furthermore, utilizing digital technologies inside a BIM framework is one step toward the renovation process. A BIM-based toolkit can improve the renovation process by managing the information flow and the exchange of data at various stages. The proposed method offers ease in the flow of information during different stages of the process, speeding up the survey process and improving the quality of work by keeping a record using a digital logbook, to avoid inadequate information that can be a hurdle in the renovation process. Future renovation projects on a significant number of buildings constructed in the last century that need to improve their performances and quality can be managed using the developed toolkit [77].

3.3.8. Consideration of Research Question

The retrieved articles provide essential information on the performance outcome of digitalization, the enhancement of quality of life, and the digitalization strategies being employed in the construction industry, which is the research question formulated for this study. By looking at the literature, it is observed that digitalization can improve the performance of a sector by optimization of the amount of energy used and introducing several technical and digital approaches to increase productivity, profitability, and security [75–78,80,87,101,102,104–106]. It has a great impact on the economic growth of a country by automating processes through digital technology [95,107]. It enhances the overall performance of the building industry by making use of AI and ML-based applications, and expedites the procedure which eventually increases the efficiency of the building industry and provides better outcomes [81]. Digitalization helps in the development of green cities, which is a way to reduce pollution and it lowers the required amount of energy needed [89,91]. Analysis of the level of CO_2 emissions was made possible by the latest technology, and it provides a good way to enhance CO_2 emission efficiency, offering a clean environment [99]. As a result, digitalization has several favorable effects on the development of green cities that ultimately improves quality of life [82]. From this systematic review, the following methods have been adopted for digitalization in the construction industry:

- Building information modelling (BIM) [74,78,80,83,89,90,94,102]
- Co-integration methods [106]
- Photovoltaic and storage battery systems [75]
- 3D printing technology [60,61,76]
- Concept of green roofs [91]
- Principal component analysis and super-Slacks-based measures [99]
- Internet of things (IoT) [84,85,88,98]
- Prefabricated buildings [94]
- Digital safety systems [103]
- Blockchain technology [79,93]
- Use of machine learning (ML) and artificial intelligence (AI) [81]

These strategies showed a positive impact in several areas of the construction industry such as energy efficiency, cleantech industry, smart construction, economic growth, architecture, wireless communication, and renovation and maintenance of buildings.

4. Critical Discussion and Conceptual Framework

Recently proposed methods used digital technology for the development of the construction sector, optimization of energy, sustainable environment, smart construction to offer a better quality of life, economic and architectural growth, wireless technology for effective communication, and maintenance of buildings. Specifically, the BIM system is being implemented in several construction-related areas for various purposes such as reduction in carbon emissions, and the use of BIM to create a sustainable environment through digitalization. It is regarded as a cornerstone in the digitalization of the building industry and has demonstrated potential for greening cities by creating models that can perform environmental analysis. BIM has its efficiency in smart construction by providing effective frameworks that can offer a good quality of life with automation and smart technologies. BIM has also been applied for the advanced monitoring of sites using wireless sensor technology, and its use can be seen in the renovation process. BIM mitigates the chance of a lack of information and offers an easy flow of knowledge. Although, there is still a need for different training programs to raise or strengthen the workers' skill levels. Data is enhanced through digitization, which also makes it easier to access and connect with other networks, and facilitates maintenance and quality monitoring. It improves communication, and productivity, and enhances managerial tasks. Similarly, IoT demonstrated its strength in the shift from manual to automatic industry. IoT technology offers enormous promise for boosting on-site safety, operational effectiveness, and productivity. It helps in providing security and protection through various applications, and offers effective communication through wireless technology. Tracking of real-time data and analysis of the progress of work is made possible through digitalization. Overall, this technological advancement can transform various aspects of the construction. It will offer more productivity and can offer the automation of the sector with improved efficiency. Based on the indicated argument, a conceptual framework has been mapped showing the impact of digitalization on sustainability aspects. Figure 7 shows how digitalization is involved in different fields which are improving the quality of life of the end user. Digitalization has a direct impact on all the aspects of sustainability, from economic to social and environmental. With digitalization, not only the quality of life is enhanced, but it also reduces CO_2 emissions.

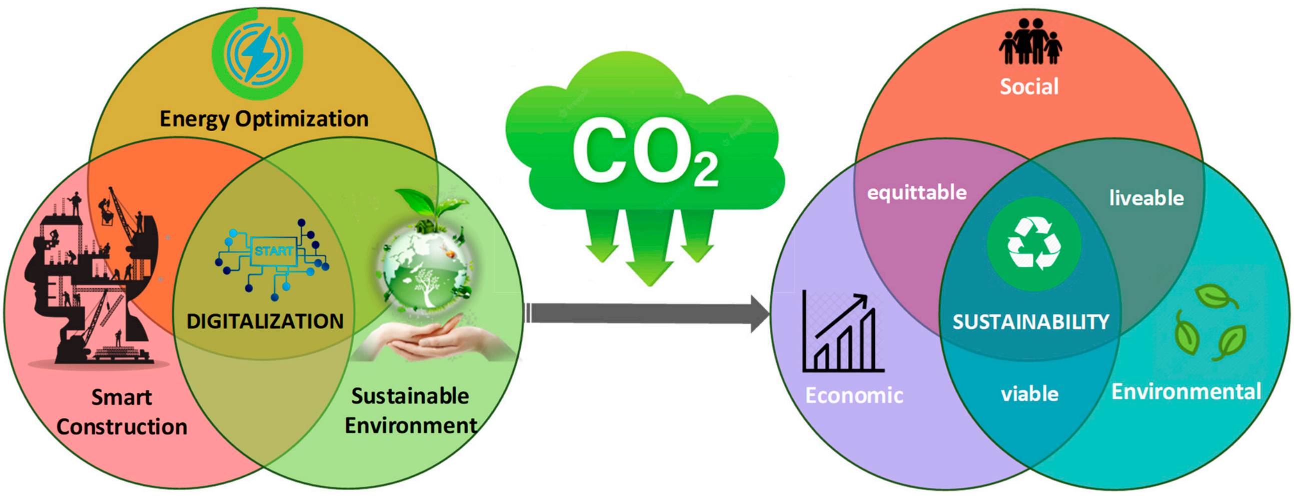

Figure 7. Conceptual Framework.

5. Conclusions

Digitalization is the new norm in the construction industry, following the adaptability of the Industrial Revolution. This study intends to review the articles on digitalization in the construction industry by following the guidelines of the PRISMA statement. The Scopus database was chosen to extract the articles, which provided 126 articles with a selective keywords combination. Following the refinement criteria, 35 articles were left for further review. It was assessed, based on the carried-out review, that over time, construction parties have accepted digitalization techniques in their construction projects in a significant manner. Digitalization in the construction industry has also impacted quality of life and enhanced social sustainability. BIM was found as one of the most key deliverables of the construction projects, where the construction parties are relying on it to complete their project in a much faster and smoother manner. Although the digitalization in the construction industry is astonishing, there is still a lot more potential in this sector to be focused on. Moreover, its implementation in the global market is a challenge which requires affordable efforts.

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