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Review

Construction Industry from Perspective of Force Majeure and Environmental Risk Compared to the COVID-19 Outbreak: A Systematic Literature Review

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Abstract: The COVID-19 pandemic represents a type of force majeure that significantly and unexpectedly affected all human lifestyles. This study includes an integrative review of articles published across Scopus and Web of Science journals and compiled using the systematic review methodology based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Statement and VOSreview (visualization of similarities) software by defining keywords that include "construction industry" and "force majeure" and "environmental risks" as a starting point. Moreover, the research years and the countries covered by this research were determined in a second stage. Finally, the abstracts of selected studies were reviewed in order to extract factors similar to the pandemic conditions of COVID-19 along with the brief results of the research. Out of 6384 publications identified and 56 publications reporting, 20 studies fulfilled the inclusion criteria with full text. Based on our findings, there has been a continuous growth of publications on construction risk and environmental research since 2010. Malaysia had the greatest contribution to the research topic of the countries covered by the study, followed by Egypt. The Engineering, Construction and Architectural Management journal published the greatest number of publications related to the research topic. In this review, the most important previous studies are classified according to their handling of force majeure and environmental risks and the most important factors mentioned in these studies are identified. In addition, recommendations are made for dealing with the COVID-19 pandemic and for mitigating its effects on the construction industry in the Arab world and Malaysia. The results of this review will benefit researchers and construction companies alike in furthering research on reducing the risks of COVID-19 to construction projects and avoiding the significant economic loss that results from stopping these projects.

Keywords: construction industry; force majeure; environment risk; risk management; COVID-19

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1. Introduction

In most previous studies, force majeure has been associated with wars and natural disasters, while environmental risks have been connected to safety issues, pollution, and waste management; however, today we are going through a unique situation that did not happen for decades, the spread of the COVID-19 pandemic, affecting individuals, societies and countries alike. Therefore, this study aims to verify the importance of force majeure risks and the impact of environmental factors in previous studies, and the extent of their impact on construction projects in Arab countries and Malaysia.

The suspension of certain countries' international travel is directly reflected in the contractual obligations that may affect large sectors such as construction in its various branches, with consequences on real estate construction. Thus, organizational variables

have the greatest influence on construction worker safety, whereas human factors have the least [1,2].

The World Health Organization declared on 12 May 2020 that the coronaviruses that cause COVID-19 were complex and that finding a vaccine in a short time required more research and disclosure of viral causes and behaviour. In this context, it has become necessary to search for ways to save the economy and ongoing projects, including in the construction industry, in order to adapt to the pandemic and reduce risk as much as possible while avoiding stagnation and collapse. Therefore, this study includes an initial contribution to understanding the nature of the impact of environmental risks and force majeure on construction projects and compares it with current situation and impact of theCOVID-19 pandemic. Recommendations are developed to mitigate the impact of the epidemic in the construction industry, especially in construction sites.

2. Background of Research

Policymakers need to determine the economic impacts of the COVID-19 epidemic. However, the challenges of the outbreak of the situation at an unprecedented pace have created uncertainty [3]. The details of a contract define how the force majeure case will be informed and prescribe the effects of non-compliance, defining whether it has a compulsory or a directory effect [4,5]. Moreover, environmental and safety-related factors are seen as key risk factors in oil and gas projects. Therefore, failure to comply with health, safety, and environmental standards can result in project suspension at different times [6].

An unpredictable occurrence or situation might have a favourable or negative impact on the project's aims; ref. [7] discuss in greater detail the concept of risk, and recommend using a more fundamental concept of uncertainty. Thus, it can be observed that the definition of risk applies to COVID-19, as it represents a state of uncertainty and no one expected it to happen or predicted its impact on public life in general and construction projects in particular. Universal risk management is a process of measuring and evaluating risks and developing strategies for managing them, including transferring risks to others, avoiding them, minimizing their adverse effects, and accepting some or all of their impacts. Based on [8], traditional risk management focuses on the physical and legal risks posed by such risks as natural catastrophe or fire, accident, death, and prosecution, while, financial risk management is interested in those risks that can be managed using financial barter instruments.

Risk management is a profession that teaches individuals and organisations how to deal with uncertainty by safeguarding their most valuable assets and resources. Risk management is the practice of avoiding, reducing, or controlling hazards. There should be a balance between the expense of risk management and the anticipated rewards of taking the risk. Systematic risk management is a management method that involves both practical experience and training in its application [9].

Beginning in December 2019, the COVID-19 pandemic has subsequently expanded globally. At the time of the initial draft of this publication, the virus had been detected in about 253,640,693 people, and the number is predicted to grow to more than five million. Furthermore, there have been more than 5,104,899 who died as shown in Figure 1. While some governments have successfully handled recognized instances, it is uncertain where and when more cases may emerge. Every day, more instances are recorded and other nations are added to the list, including Arab countries and Malaysia (WHO). However, it seems that Chinese instances have peaked and are currently declining. The reverse is true in Europe and America. The WHO has declared a public health emergency of worldwide significance [10].

COVID-19 has had a substantial impact on all business sectors globally, including the construction industry. The outbreak has disrupted supply lines and caused workforce shortages in numerous nations. Construction projects face many kinds of uncertainty challenges due to the various players participating in project planning, project management, and project implementation. Furthermore, the major parties in any project include the

owner, designer, consultant, manager, supplier, and producer [11]. Many risks in the construction sector cause a direct impact on project objectives, and thus lead to exceeding cost estimates and delayed implementation [12]. At present, the COVID-19 pandemic represents force majeure leading to the suspension of most construction projects in the countries where the epidemic has reached.

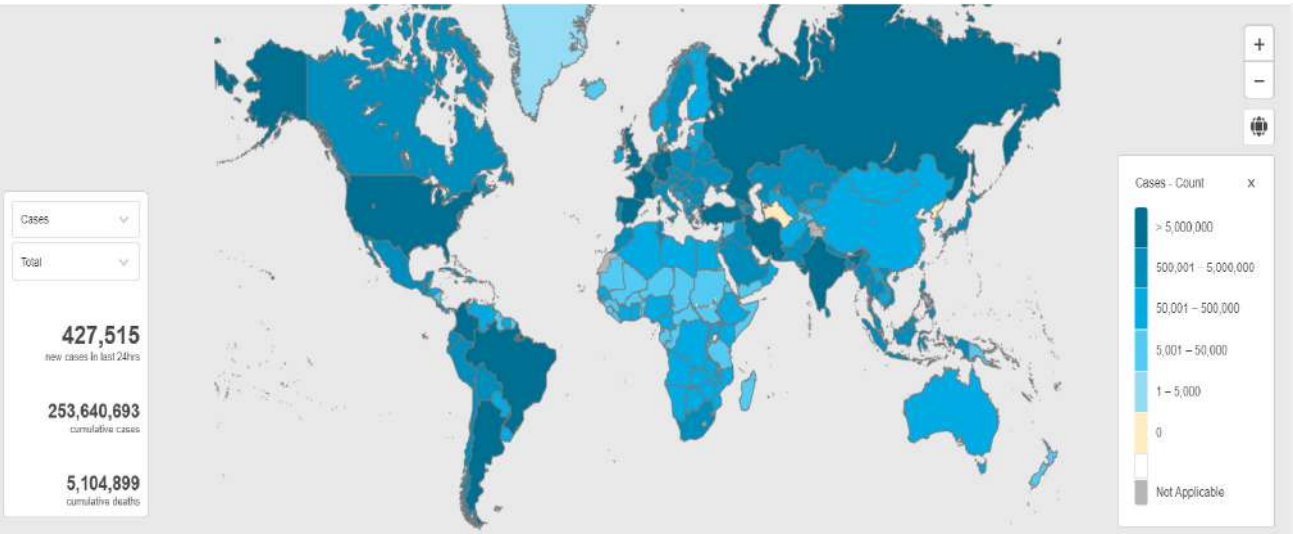

Figure 1. Global situation on 16 November 2021 of COVID-19 as per WHO report. Source: [13].

In fact, as with all contracts both parties are subject to obligations. However, a temporary event may occur that prevents the implementation of these obligations, such as the coronavirus pandemic which has affected most world countries, including the Arab countries and Malaysia. Is this pandemic a force majeure in the field of FIDIC contracts, and if so is this the case for each of the parties to the contract? The beginning of force majeure as defined by the version of Article 19.1 issued in 1999 is an exceptional event outside the control of the parties which one of the parties cannot avoid it, and must fulfill four conditions:

1. That the extraordinary event(s) were outside the control of one of the parties;
2. That the parties were not aware of the event(s) before concluding the contract;
3. That the event(s) took place after any point where the parties were able to avoid or bypass them;
4. That the event(s) were not caused by one of the parties to the contract.

The incident or scenario need not be unexpected. Other unusual occurrences or situations that may constitute force majeure if they fit the four criteria listed above are listed in Subitem 19.1:

1. Battle, hostilities, invasion, act of foreign enemies;
2. Revolt, military or usurped force, or civil war;
3. Riots, disruptions, strikes, or closures by non-contractor workers, contractors, or sub-contractors;
4. Contamination by war munitions, explosives, ionizing radiation, or radioactivity, except when the contractor used such ammunition, explosives, radiation, or radioactivity, earthquakes, storms, or volcanic activity.

Many legal concerns in industrial, commercial, and service contracts, financial responsibilities, and associated tax issues are impacted by COVID-19 on a worldwide level. The emerging circumstances may prevent the imposition of fines or compensation for delay in the implementation of these contracts [14,15].

In its attempt to suppress the COVID-19 outbreak, the Malaysian Government has enforced a Movement Control Order ('MCO') in Malaysia from 18 to 31 March 2020, now

extended to 9 June 2020 ('Relevant Period'). The MCO has influenced non-essential job efficiency, including activities at project/building sites where they are needed to interrupt the job during a specific time. Whether the COVID-19 epidemic or subsequent MCO is a force majeure case is a matter of understanding the contractual provisions. Likewise, how the epidemic or MCO impacts the parties' rights and commitments in terms of timing and costs depends heavily on the regulations of the contract.

According to [16], Saudi Arabia's construction industry has become one of the country's most heavily invested sectors. As a result, the overall value of Saudi Arabia's building projects underway as of October 2018 is USD 284 billion. Furthermore, relative to other GCC (Gulf Cooperation Council) countries, Saudi Arabian building programs accounted for almost half of all the region's construction projects. Therefore, the industry's success is of the utmost importance due to the massive funds involved [17]. Hence, we can expect an influence of COVID-19 on the construction sector in Saudi Arabia in the event of a continued state of closure and limiting of movement imposed there.

The COVID-19 outbreak has had a significant impact on the construction sector, which is generally cyclical. On the plus side, building may provide jobs which can help the industry evolve towards sustainability and digitalization. Tripartite cooperation, social discourse, and international labour rules are critical to a human-centered construction sector revival. According to [18], increased awareness of health, hygiene, and safety hazards may lead to safer work practices. Contrary to popular belief, safety leadership is vital to the safe implementation of COVID-19 working principles. COVID-19 should be integrated and promoted as part of a broader risk management approach, in part because this takes into account differing priorities for safety risks rather than focusing solely on COVID-19, and in part because integration with pre-existing safety processes can enhance COVID-19 mitigation effectiveness. While in other research [19] shows that the greatest impact of the pandemic has been on construction supplies, construction workers, and construction subcontractors. The fuzzy model's findings show a large variance in pandemic impacts across the public and private sectors. This study contributes to the body of knowledge by allowing scholars and policymakers to better understand the pandemic's effect on disadvantaged countries. Ref [20] undertook a comprehensive study on COVID-19's influence on the US construction sector through the Granger causality test and structural equation modelling (SEM) which were employed to establish the epidemic–Pi-C relationship. Another method used was multivariable LSTM networks, a deep learning algorithm, to estimate future Pi-C values. The Pi-C framework incorporated predicted Pi-C indicators in order to analyse the COVID-19 pandemic's impacts and trends in 2021–2022. The pandemic had an impact on two Pi-C dimensions (economy and stability), though not on the third (social). The Pi-C also anticipated that the pandemic would have no significant negative impact on the US construction industry until 2022. Moreover, ref. [21] confirmed that financial assistance and detailed information are required to alleviate the impacts of COVID-19. The researcher believes his findings will help governments revise their present strategic plans and establish new ones to address COVID-19's impact on building construction organizations.

Ref [22], based on 519 publications and 40 AEC practitioners, found twelve separate COVID-19 impacts and polled AEC practitioners on the criticality of the twelve effects. The authors analyzed 127 valid responses using mean ranking, ANOVA, and Spearman's correlation. The statistics were compared to past pandemic studies. Findings from the survey included "decreased construction productivity", "decreased foreign investment in the construction industry", "supply chain disruption", and "decreased number of public projects", while "Lower foreign investment in the construction industry" and "lower demand for construction-related services" affected SMEs more than large firms. Supply chain disruption and reduced construction productivity were common results across all countries analyzed, along with lower foreign investment in the construction industry, decreased demand for construction-related services, supply chain disruption, and decreased productivity.

Additionally, ref. [23] found that many stakeholders ranked COVID-19's impact on building projects at 15th. The bulk of COVID-19 effects were connected with construction

workers, engineers, and managers. Using correspondence analysis, four relationships were discovered: suppliers and subcontractors, the project team, the owner and construction business, and personnel. These relationships were considered in three dimensions: (1) membership degree; (2) decision-making power; and (3) cause-effect dependence-control.

The respondents noted the following positive themes: reduced overhead costs, remote working settings, enhanced productivity, and sustainability aims. Negative themes mentioned by respondents included poor company turnover, construction payment and production delays, difficulty working from home, and job losses. Lessons learned were related to supply chain management, construction project management improvement, health and safety, and a productive virtual workplace [24]. Therefore, we believe that it is possible to benefit from previous studies of the COVID-19 pandemic in examining the risks of force majeure in order to settle disputes that may arise as a result of delayed delivery of projects Research on environmental risks, health and safety at construction sites during the implementation of projects can aid in the development of an integrated vision for dealing seriously with the COVID-19 pandemic, its mitigation, and its huge impact on the economy.

3. Materials and Methods

A systematic review was conducted using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Statement methodology, which included the definition of keywords and their synonyms relevant to our subject. The keywords were then used to conduct a first search in the Scopus and Web of Science (WOS) databases. The keywords "Force Majeure", "Construction Project", "Environment" and "Risk Management" were selected in order to maximize the likelihood of discovering relevant articles.

The PRISMA statement technique is an evidence-based collection of important considerations when carrying out systematic and meta-analyses. PRISMA is a framework for reporting evaluations of randomized trials, and may also be used to publish systematic analyses of certain types of testing in special protocol assessments. The technique consists of the following elements.

1. Process and registration: Demonstrate the existence of a review process, its duration and reach (e.g., online URL), as well as, if relevant, registration information, including registration number.
2. Eligibility requirements: specify the features of the study (e.g., nations, follow-up duration) and the characteristics of the survey (e.g., years considered, language used, and status of publication) that will be used to determine eligibility and justification.
3. Data sources: Describe all data sources (e.g., repositories with dates of distribution, contact with research authors to discover particular studies) used in the search and the date of the last search.
4. Scan: Implement a complete online retrieval strategy on at least one site, including all constraints, in order to reproduce it.
5. Selecting studies: Specify the criteria for identifying studies (i.e., sampling, qualifications included in the systematic review, and, if applicable, included in the meta-analysis if you used it).
6. Data collection approach: specify the method for gathering data from records (e.g., piloted methods, separately, in duplicate) as well as the strategy for obtaining and validating data from investigators.
7. Table of Contents: Describe and identify all factors used to gather data (e.g., affiliations, funding sources), as well as any conclusions or simplifications reached.
8. Bias risk in individual studies: describe the approach used to assess the risk of bias in particular studies (including the specifics of how this was accomplished at the research or outcome stage) and if this information is included into any data synthesis.
9. Indicators of summary: Identify the major summary metrics (e.g., risk ratio, the disparity in means).
10. Synthesis of results: specify the procedures used to analyse data and integrate the results of completed analyses, as well as perform accuracy checks on each analysis.

11. Bias risk across studies: Identify any bias risk assessment that may have an effect on composite results (e.g., publishing bias, biased sample re-porting).

The systematic review consists of various express and inducible steps, including identifying all possibly-relevant data, selecting eligible studies, assessing risk of bias, data extraction, qualitative synthesis of the studies involved, and likely meta-analysis as shown in Figure 2.

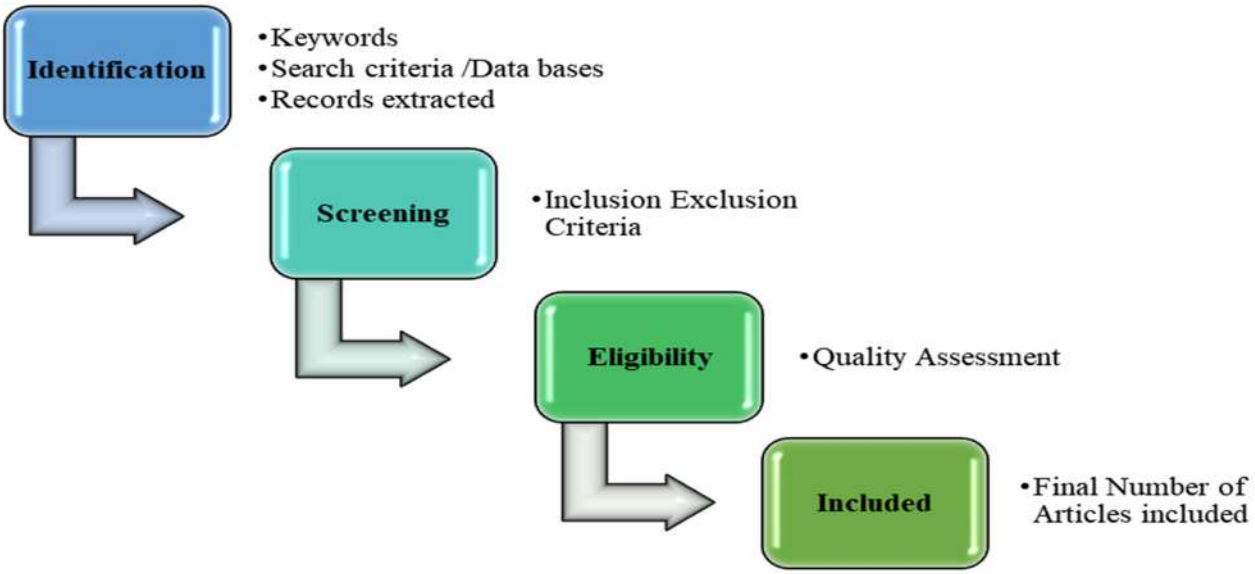

Figure 2. PRISMA framework method steps.

In addition to PRISMA, VOSviewer software was used to connect the literature review papers and explain the extent of convergence and divergence in the research study. VOSviewer is a bibliometric network creation and visualization software tool. These networks may be created via citation, bibliographic coupling, co-citation, or collaborations involving co-authorship. VOSviewer features text mining capabilities that allow it to create and visualize co-occurrence networks of relevant phrases in scientific literature.

4. Results and Discussion

The analysis process went through four stages, as explained in the Figure 3 below, until the 20 most important studies that dealt with the topic of environmental risks as a force majeure in construction projects were reached. The most important factors mentioned in these studies, the results reached by researchers, and the extent of the possibility of linking them to the situation COVID-19 pandemic were classified in an attempt to develop proposals to reduce its effects on the construction industry in the Arab countries and Malaysia.

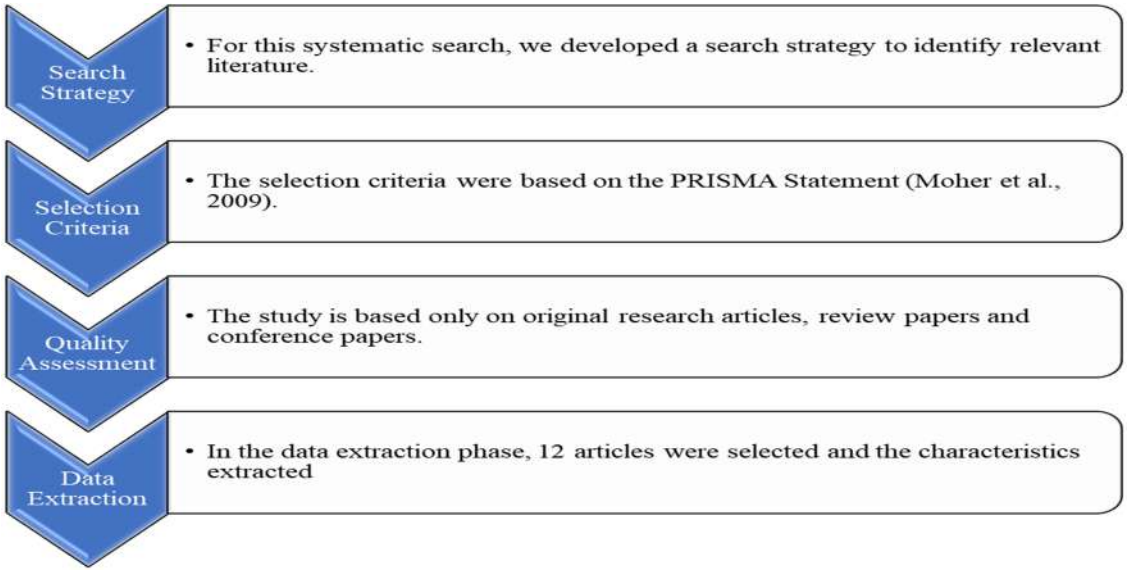

Figure 3. Analysis process stages of the systematic literature review.

4.1. Search Strategy

We created a search technique for this systematic review in order to locate relevant material. This search method was customised for two databases, Scopus and Web of Science, with the following search terms: "Force Majeure" OR "Construction project" OR "Environmental risk". Figures 4 and 5 shown the articles based on subject area and the type of published papers.

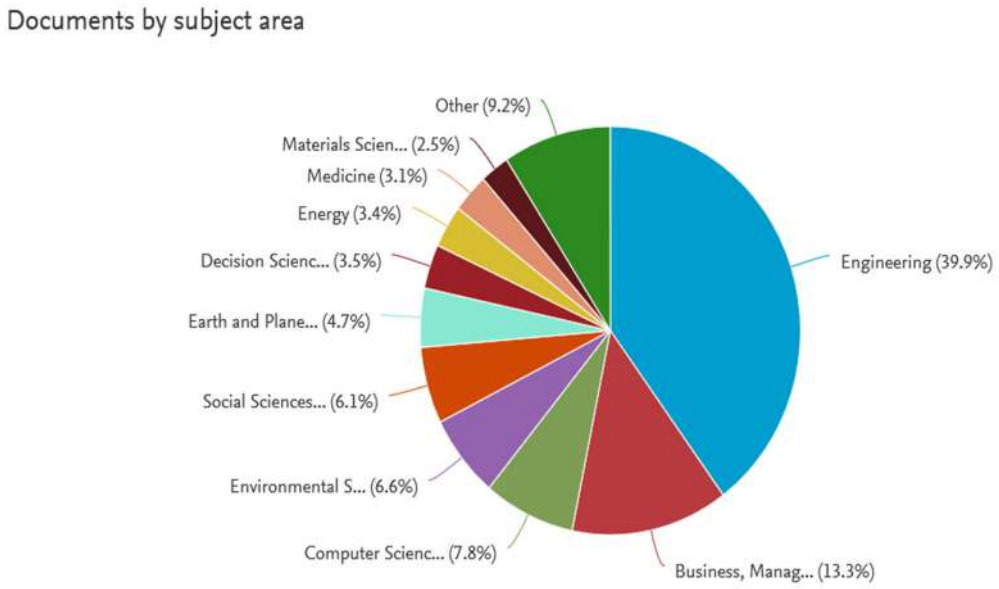

Figure 4. Document analysis by subject area in the first stage.

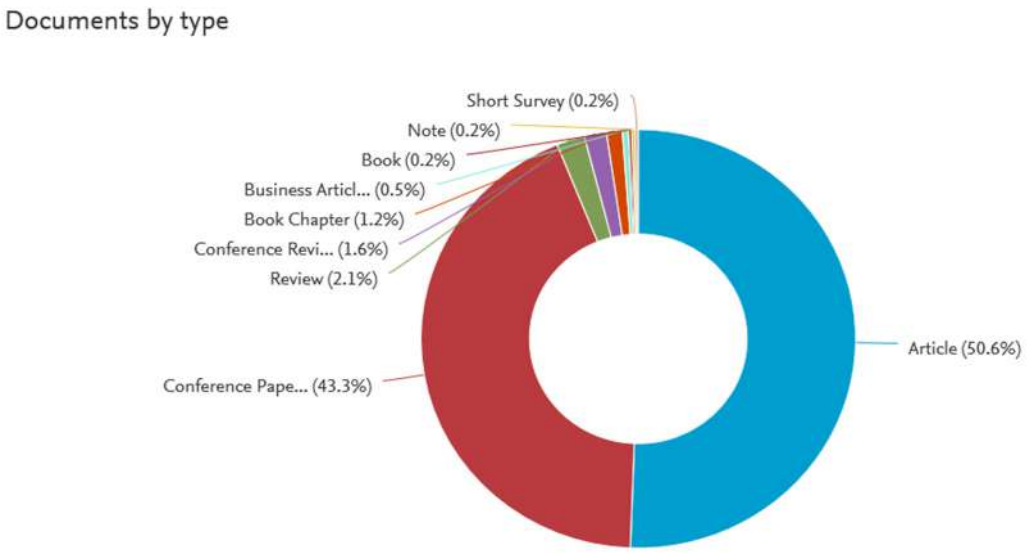

Figure 5. Document analysis by type of research in the first stage.

The searches comprised journal articles, review papers, and research reports published in English from 2000 to 2020. This stage extracted 6384 records.

4.2. Selection Criteria

The PRISMA Statement served as the basis for the selection criteria [25,26]. The search was primarily aimed at cataloguing available literature on Force Majeure and environmental risk factors in construction project management, environmental sciences, business, and economics. The subject areas of project management, environmental science, risk management, and construction business were then reduced. The search period included the years 2010 through 2020. As a result, all publications published prior to 2010 were omitted from the search at this stage.

The search was mostly limited to Arab nations and Malaysia; hence, items from other countries were omitted. At this level, 2392 research papers were eliminated. Thus, 260 records were extracted at this point.

4.3. Quality Assessment

This study relied entirely on original research publications, review articles, and conference presentations. To ensure the review's quality, any duplicates were extensively scrutinized. Abstracts of papers were thoroughly analyzed and purified in order to guarantee that the academic material included in the review process was of high quality and relevance. Each study work was subjected to a thorough examination at a later stage. The following exclusion criteria were used to restrict publications to those written in the English language. Five articles were removed from the research because they were written in a language other than English.

Furthermore, after the filtration of duplicate records 204 more articles were removed from the study. Thus, we selected 56 articles (as shown in the connection of these papers in Figure 6) after assessing each article on the inclusion mentioned above and exclusion criteria. Figures 7 and 8 shown the documents analysis by country of research and the network visualization map of countries.

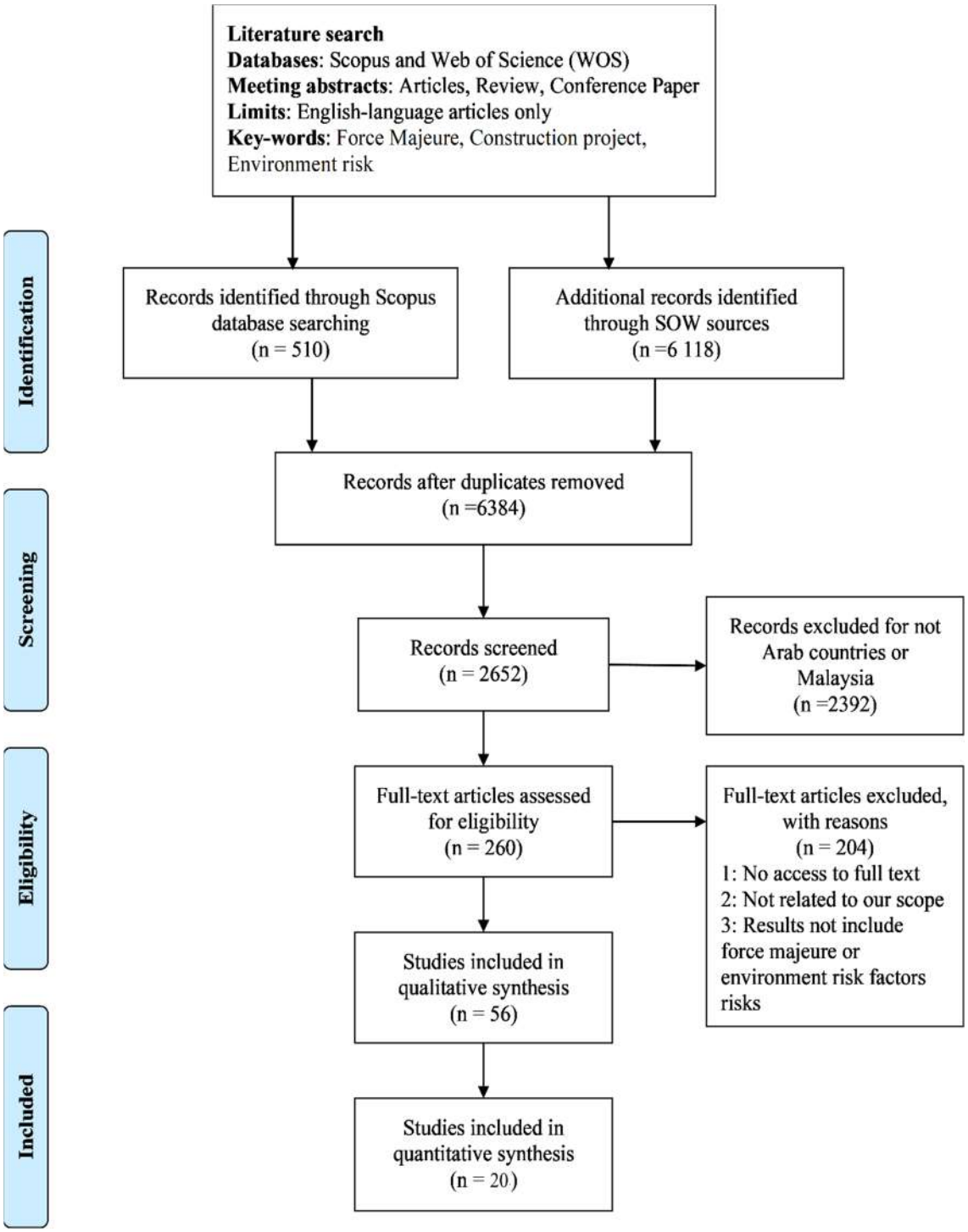

Figure 6. The literature inclusion and exclusion criteria at every stage based on the PRISMA statement.

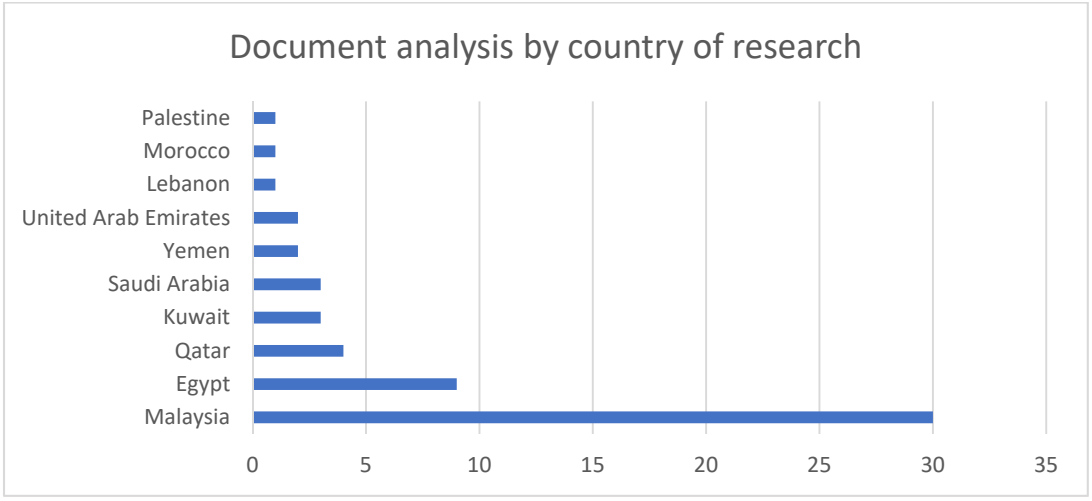

Figure 7. Document analysis by country of research in the Quality assessment stage.

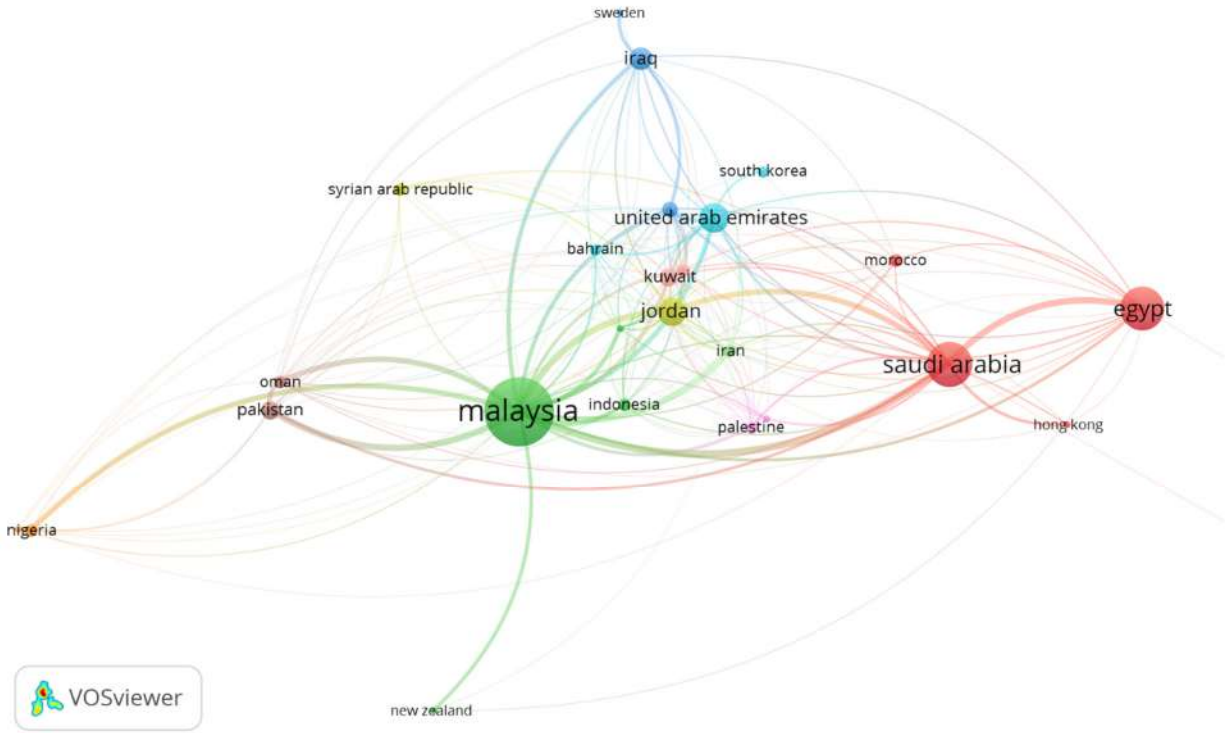

Figure 8. Network visualization map of countries. Source: VOSviewer.

4.4. Data Extraction

Twelve articles were chosen for data extraction, and the following attributes were extracted.

Articles were required to be an original article, a review article, or a conference paper. We omitted published papers and case studies. Essays were required to be written in English and to be related to the social sciences, business, or economics. Articles were culled from publications between 2010 and 2020. The collected documents came only from Arab nations and Malaysia. Figure 8 depicts a visualization map of the network based on nations.

Regarding the definition of risk, we found that COVID-19 applies to this characterization. Because this pandemic is the first in decades, we have tried to find approaches to characterize risk factors that are similar to COVID-19 and examine how previous studies have explained these factors and their impact on the construction industry. The previous

table presented the twenty most important studies we found pointing to the subject to the impact of force majeure and environmental factors as risks that may lead to the suspension of construction projects, along with the resulting effects on achieving goals according to the cost and time planned. Keywords network links are shown in Figure 9.

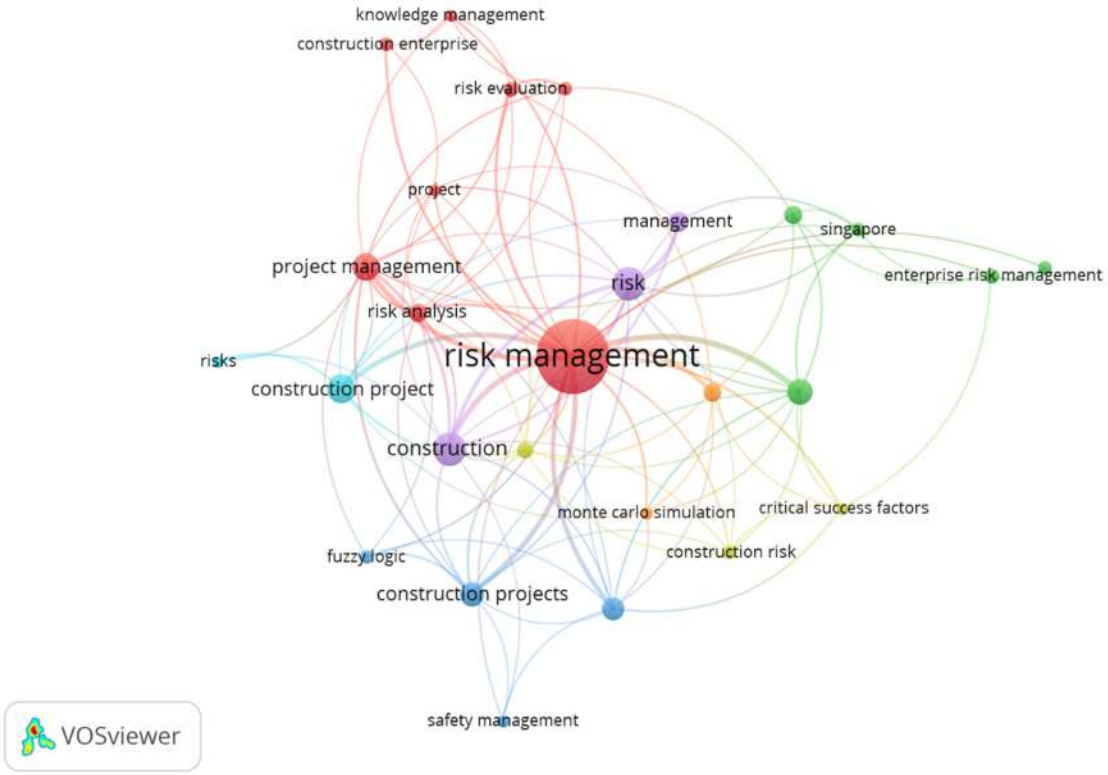

Figure 9. Network visualization map of keywords. Source: VOSviewer.

Refs [27,28] identified the force majeure risk in Yemen, which was considered the third general category of project disruptions. These disruptions are commonly referred to as "acts of God" because no party can be held liable for their occurrence.

Most contracts enable the contractor to receive a time extension for acceptable delays, but not for extra money. Studies on oil and gas projects include force majeure as a major risk element [29].

Most of the companies operating in Yemen have stopped working due to the conditions of force and the war that has been going on for five years, and the remaining companies operating have recently stopped because of the pandemic, which has caused a massive burden and a negative impact on the already deteriorating Yemeni economy.

In Malaysia, the Malaysian Ministry of Finance stated in a series of frequently asked questions ('FAQs') that the outbreak of COVID-19 falls within the Public Works Department Form's force majeure clause and that, for contracts without a force majeure clause, the Malaysian Government may still invoke the 'principle and procedure of force majeure' to deal with it. Additionally, for contracts including a force majeure provision, the Malaysian government may construe it as a non-exclusive list of occurrences on which any party may depend. However, no Malaysian decision has been made thus far about whether or not the principal force of events should be stated in the form of the Public Works Department (Shannon Rajan 2020). As a result, the construction sector will face competition from a total of 17,000 enterprises, the majority of which are substantial drivers. Figure 10 shows the network visualization map based on journal title.

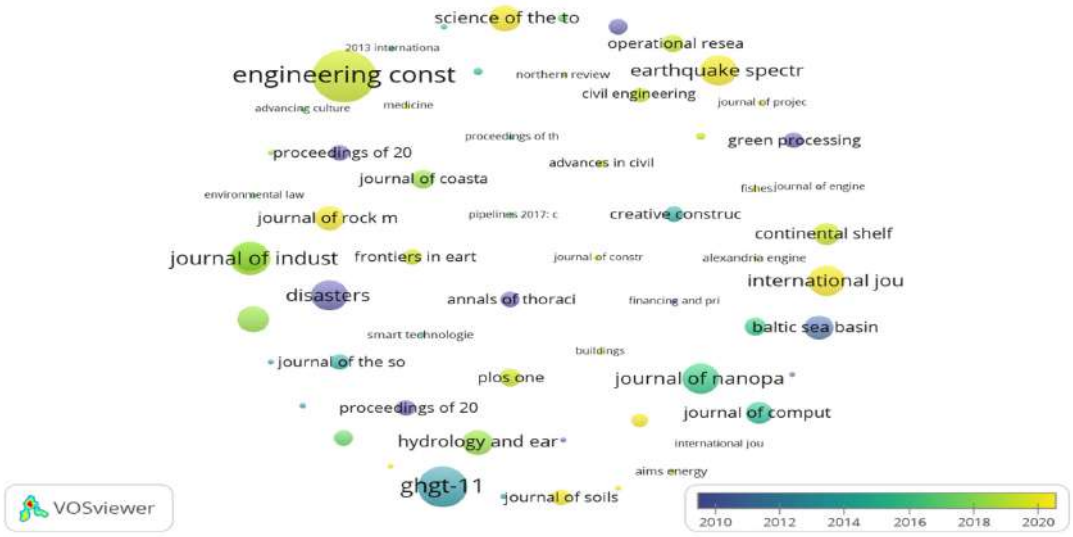

Figure 10. Network visualization map of journal title. Source: VOSviewer.

According to the Malaysian Construction Industry Development Board [30] statistics, the sector constitutes the majority of the staff and labor force, representing 850,000 workers. After MCO (Movement Control Order), many foreign workers are likely to return to their country of residence due to fear and confusion. While construction at a site can be resumed legally by all contractors, harm has nevertheless been done.

The matter is not very different in the rest of the Arab countries that have been mentioned in the previous table. For example, Saudi Arabia and the rest of the Arab Gulf countries have a large surplus of foreign laborers in the construction sector; the survival of this large workforce in quarantine or the application of social distancing policy because of the provision of COVID-19 will constitute a significant financial burden on the companies and countries in which they operate and lead to the creation of claims and conflicts between companies and individuals, including resulting salary cuts and the disposal of excessive labor as a result of the stoppage of construction projects on which they work. In addition, previous studies referred to in the table have identified environmental factors and force majeure factors that can cause construction projects to cease working. As a result of this unique situation unprecedented in previous decades, there is a pressing need to conduct further research and arrive at solutions that clarify how to deal with crises caused by viruses and environmental pandemics.

5. Recommendations

The recommendations below have been developed to reduce the effects of force majeure factors and risks as well as to reduce the impact of COVID-19, as mentioned in Table 1 previously. Because the construction sector is one of the sectors of greatest importance in the overall economies of these countries and because it affects the rest of the economic sectors and the growth of the gross domestic product both positively and negatively, in addition to being a labor-intensive sector, the disruption of this sector accelerates the transformation of a state of stagnation into a state of total depression which all countries seek to avoid. Thus, it was felt that fundamental policies should be developed in order to help the sector overcome the period of the epidemic while maintaining the integrity of financial relations between companies operating in the sector and between customers, lenders, suppliers and end users until activity recovers, especially given the cumulative negative effects that the sector has suffered. It was found that even if the spread of the virus is contained in the short term, the suffering of construction companies from these effects will continue for several months to come before the construction activity returns to normal, whether in terms of effects on contracts, project delays, or disruptions in supply chains.

Table 1. Final analysis and data extraction phase: Top 20 Studies.

No	Title	Authors/Year	Data Collection Method	Methodology	List of Risk Factors	Findings
1	Assessment of the Effect of External Risk Factors on the Success of an Oil and Gas Construction Project	[29]	Questionnaire	PLS-SEM	1. Environmental protection pressure 2. Health and safety 3. Waste treatment 4. Inclement weather, flood, fire, and landslip 5. Unforeseen circumstances 6. War in the country	The findings showed that economic, political, and security risks influenced the project's success.
2	Saudi Arabian aviation construction projects	[31]	Review and Semi-structured interview	Literature Review	1. Threat of war 2. Earthquakes 3. Fires 4. Floods 5. Severe weather conditions.	Consequently, 54 new risks are recognized and categorized into three levels: internal, external, and force majeure.
3	Risk identification and assessment in sustainable construction projects in the UAE	[32]	Questionnaire	Risk Severity Analysis	1. Inadequate sustainable project planning 2. Poor sustainable construction project management skills 3. Low labour and equipment productivity in green construction 4. Labor shortage in sustainable building.	Design modifications, inadequate or erroneous data on sustainable design, an unjustifiably tight deadline for sustainable construction, and a standard definition of scope are the five key concerns.
4	A partial least squares structural equation modeling (PLS-SEM) of barriers to sustainable construction in Malaysia	[33]	Questionnaire survey	PLS-SEM	1. Sustaining economic growth 2. Limited knowledge of the specific benefits of sustainable practices 3. Lack of knowledge on sustainable technologies 4. Protection of health and comfort 5. Preservation of natural conditions	Results of this research reveal the essential considerations constraining SC in Malaysia in the areas of Government, cost, information and knowledge, workforce, clients, and markets.
5	Ranking of delay factors in construction projects after the Egyptian revolution	[34]	Questionnaire survey	Relative Importance Index (RII)	1. Unfavourable weather conditions. 2. Global financial crisis 3. Labour strikes due to revolutions 4. Shortage of labor 5. Low productivity of labor	Time is one of the most crucial factors of the project and the driving force behind its success. Unfortunately, time lag is a common occurrence in practically all construction projects.

Table 1. *Cont.*

No	Title	Authors/Year	Data Collection Method	Methodology	List of Risk Factors	Findings
6	Malaysian construction firms' social sustainability via organizational innovativeness and government support: The mediating role of market culture.	[35]	Questionnaire	PLS-SEM	1. Health and safety are essential sustainable construction considerations 2. Accessibility is an essential sustainable construction consideration 3. Social involvement is an essential sustainable construction consideration 4. Worker welfare is an essential sustainable construction consideration	In order to increase social sustainability, construction enterprises should implement management efforts to comply with government laws.
7	Delay and Cost Overrun in Infrastructure Projects in Jordan	[36]	Case Study	Statistical analysis	1. Terrain conditions 2. Weather conditions 3. Availability of labor 4. Planned time for project construction 5. Emergency works	The results suggest that the terrain and weather conditions are the primary causes of project delays and cost overruns in Jordan.
8	Malaysian Construction Sector and Malaysia Vision 2020	[37]	Questionnaire	Quantitative paradigm	1. The Malaysian construction sector is an essential gear in the wheel, boosting the Malaysian economy. 2. The construction sector plays a pivotal role in Malaysia's transformation, industrialization, and urbanization process from developing nation status to developed nation status as imagined in Vision 2020.	Construction has played an important part in the Malaysian economy, contributing to income production, capital formation, and job creation, eventually promoting Malaysia's GDP and socio-economic growth.
9	A risk assessment approach for enhancing construction safety performance	[38]	Expert Judgment	Six Sigma	1. Overloading/Dropped loads 2. Insecure counterweights/Overturning 3. High winds Foundation failure 4. Lack/Improper use of PPE 5. Extensive exposure to the sun	The biggest risk catastrophe was "dropping items"; however, the main cause was strong winds at the project site.

Table 1. *Cont.*

No	Title	Authors/Year	Data Collection Method	Methodology	List of Risk Factors	Findings
10	Analyzing the critical risk factors associated with oil and gas pipeline projects in Iraq	[39]	Questionnaire	Risk Management Model (RMM)	1. Thieves, Terrorism and sabotage 2. Threats to staff (kidnapping and murder) 3. Risks of soil movement and landslides 4. Animal mishaps; car mishaps 5. Non-compliance with safety rules; absence of warning indications 6. Natural catastrophes and weather 7. Lack of historical records about accidents and risk registration	The findings demonstrate that terrorism, sabotage, oil transport, and theft are the most critical safety risks, while official corruption and lawlessness are the most influential factors for regulatory risks.
11	The Impacts of Environmental Practice Characteristics on Its Implementation in Construction Project	[40]	Questionnaire	PLS-SEM	1. Air emissions 2. Noise 3. The need for environmental practices 4. Solid waste 5. Water consumption	The results suggest that the relative advantage and compatibility significantly impact the implementation of environmental practices in construction projects.
12	Importance of Having a Good Robust Crisis / Emergency Response System During a Major Project in Yemen	[41]	Review internal project	Statistical analysis	1. Operations 2. Logistics 3. Human Resources 4. Corporate Affairs 5. Security 6. HSE 7. Force majeure	Systems have been developed/implemented and enforced such that there is a continuous process of improvement that incorporates learning at all times.
13	Impact of COVID-19 on health and safety in the construction sector,	[18]	Review	Literature Review and data analysis	1. Health 2. Hygiene 3. Safety risk	Rather than unduly focusing on COVID-19, a broader risk management strategy should be used that incorporates it.

Table 1. *Cont.*

No	Title	Authors/Year	Data Collection Method	Methodology	List of Risk Factors	Findings
14	COVID-19 and the world of work: Impact and policy responses	[14]	ILO Monitor	Regular updates	1. The quantity of jobs (both unemployment and underemployment) 2. The quality of work (e.g., wages and access to social protection) 3. Effects on specific groups who are more vulnerable to adverse labour market outcomes	Small and large firms alike are experiencing substantial problems, particularly those in the aviation, tourism, construction, and hospitality sectors where revenue drops, insolvencies, and job losses are all possible.
15	Impact of COVID-19 on Construction Projects in Developing Countries	[19]	Questionnaire	Fuzzy inference system and U test	1. Contractual implications 2. Construction financial market 3. Supply chain operations 4. Safety and risk management	Materials, labour, and subcontractors are the most affected by the epidemic.
16	Impact of COVID-19 on the US Construction Industry as Revealed in the Purdue Index for Construction	[20]	Data collection	Statistical analysis-SEM and LSTM.	1. Labor shortage 2. Suspension and cancellation of projects 3. Disrupted supply and logistics	The pandemic had large implications on two Pi-C dimensions (economy and stability), with no significant effects on the remaining Pi-C dimension (social).
17	Effect of COVID-19 on building construction projects: Impact and response mechanisms	[21]	Individual interviews	Thematic analysis approach	1. Operational issues 2. Financial issues	These results will aid policymakers in improving current strategic plans and developing new policies to deal with COVID-19 among building construction firms.
18	Critical analysis of pandemic impact on AEC organizations: the COVID-19 case	[22]	Questionnaire	Statistical analysis	1. Decreased construction productivity 2. Decreased foreign construction investment 3. Less demand for building jobs 4. Supply chain disruption 5. Fewer public projects	Low levels of foreign investment in the construction sector, supply chain disruption, and low levels of construction productivity all have moderate connections.

Table 1. *Cont.*

No	Title	Authors/Year	Data Collection Method	Methodology	List of Risk Factors	Findings
19	Influence between COVID-19 Impacts and Project Stakeholders in Chilean Construction Projects	[23]	Semi-structured interviews.	Qualitative content analysis (QCA).	1. Construction workers 2. Project administration team 3. Company 4. Suppliers and Subcontractors 5. Owner/Developer 6. Public agencies	COVID-19 affected six construction stakeholders, with 15 effect categories identified.
20	Lessons learned from the impact of COVID-19 on the global construction industry	[24]	Questionnaire	Zoho analytics	1. Health and safety 2. Improved productivity 3. Sustainability	The study's results highlight the need to strengthen onsite and occupational health and safety procedures to future-proof the construction sector.

While it is still premature to assess the full impact, if the coronavirus continues to have a significant impact after the second wave it will cause significant project delays, meaning that construction companies need to be at the forefront of proactive action. To mitigate those impacts on its business, the impact of the pandemic will appear in all sectors of the construction industry, both operationally and financially.

Some of the operational effects have become evident in current contracts through delays in completion, suspension and termination of contracts, or delays that have crystallized many disputes due to cash demands. In another sector, which is the human resources sector, the negative impact is represented by the availability of manpower due to cases of injuries and deaths, or the costs and incentives required to maintain key skilled cadres. Negative effects in the supply sector are represented by the slowdown in supply from the affected areas around the world as construction projects move at a slower pace than usual during the outbreak of the epidemic due to suppliers facing challenges represented in re-closure, reducing operations, and escalating prices of materials, equipment and labor, which in turn lead to a decline in the use of production capacity. The fourth area severely affected by the pandemic is the work site, where additional expenses are required to maintain the security of closed sites, manage health and safety risks, and project stoppage costs, with materials in these closed sites exposed to natural factors which led to their damage and result in losing required properties.

The financial effects of the pandemic appear in three areas, the first of which is revenue. Canceling or delaying contracts has serious effects on revenue values. The second is working capital, which suffers from severe pressures affecting the liquidity situation. The third is financing; when it takes longer than expected to obtain new supporting capital, financiers question companies' ability to repay loans on time and risks escalate, causing borrowing costs to rise and exposing financial vulnerabilities which may have accumulated over previous years. In order to confront all these repercussions in a proactive way, companies must carry out assessment and planning work for administrative procedures in these specific sectors. Actions include carefully considering clauses that refer to force majeure, emergency circumstances, government intervention, or legislative changes. Additionally, customers must be made aware that frequent communication with employers is key to managing expectations and reducing negative effects in the management and implementation of projects.

In the employment sector, special care is required in managing personnel costs and participation in the face of business disruption, as during the period of suspension of activity companies must evaluate the process of reducing personnel costs, reducing wages, and compressing expenses; this can be achieved by finding alternatives to cash payment and through good planning, assessing staffing requirements, and working to retain key skilled staff.

With respect to site security (health and safety), during the closure of sites it is possible to take into account the appropriate security measures for sites and the procedures in place to maintain the infrastructure of important sites. In addition to avoiding any risks to health and safety in the short term, insurance policies should be reviewed in detail in order to ensure compliance with all requirements for coverage for closed sites, or if there is a difficulty in that, insurance companies must immediately be dealt with. The speed of the outbreak of the epidemic of COVID-19 and the policy of social distancing followed as a result will continue to have a significant impact on the construction sector around the world, especially in the Arab countries and Malaysia, according to the factors previously mentioned, unless treatment or vaccines are found to eliminate and limit the virus. Therefore, the authors suggest a set of recommendations and proposals to deal with this pandemic for construction workers on-site:

- Keep a record of those you meet or interact with (name, date, time, and location if possible)
- Wear suitable PPE at all times and avoid the use of another person's PPE outside of life-threatening conditions

- Enforce social distancing on all types of business
- Health tests and checks should be carried out continuously (know the symptoms and do temperature checks on yourself)
- Emergency management plans and medical teams that can respond to on-site emergencies
- Set access limits for staff and guests on site
- Create a protocol to verify staff when entering or starting work shifts, abide by applicable legislation/regulations, and restrict unnecessary access to the site
- Provide a protocol/action to detect symptoms in another person
- Establish a detailed protocol for the periodic disinfection of risk surfaces, tools, equipment, plants, and vehicles
- Video records for locations and offices may provide contact tracking visitor records
- Have a dynastic plan in case you lose a significant person on the team
- Provide a one-user protocol for using tools, equipment, plants, vehicles, mobile phones, and keyboards
- Develop easily accessible points and provide personnel with hand disinfectants
- Create readily available points for disposal of contaminated equipment and used PPE equipment
- Continually update and train health and safety officers and security personnel on the complementary site rules and regulations
- Constantly instruct staff on supplementary and new regulations
- Detailed monitoring of policies and procedures that may be put in place as soon as contact is known to have taken place
- Audit of sanitization requirements against chemical sensitivities of equipment
- Try to split teams in half in order to limit exposure to critical personnel resources (lowest possible workforce plan)
- Create a procedure and apply small tasks where applicable or possible
- Provide health insurance for all human resources in the company
- Divide lunchtime into shift patterns to minimize staff concentration in designated lunch locations
- Provide meals for workers in packages and based on health and safety regulations
- Review project members for critical equipment operations and maintenance skills needed at sites
- Recognize crucial points of contact within your company that could be disrupted by disease or isolation
- Remember to check backup copies taken for essential files, such as financial documents
- Frequently conduct healthy verification of equipment before use

We have used the health and safety bulletins and instructions provided by the World Health Organization (WHO) and the International Federation of Consulting Engineers (FIDIC) to develop these recommendations, which reduce the risk of infection and are not a substitute for treatment or vaccine [42]. This research could significantly contribute to conducting more in-depth research about adding diseases and epidemics as potential risks that could lead to the suspension of construction projects and increase the project cost and the schedule specified in the contracts. In addition, further recommendations and proposals can be developed to confront COVID-19 and other diseases and methods in the future. We expect this study to be useful for researchers, companies, and governments regarding the construction industry's risks.

Finally, supply chain and subcontracting companies must constantly monitor the extent of disruption to supply chains and the way in which this may affect the scarcity of goods and inputs in the short and medium term, and must formulate contingency plans for alternative supply and proactively search for alternatives to essential goods and critical services in order to have multiple options once sites reopen.

6. Conclusions

The conclusion of this research is an introduction to other research in this field and an opportunity to highlight the importance of COVID-19 on one of the largest industries, namely the construction industry, with its high cost and large workforce on projects worldwide.

This study has begun by finding approaches to cases similar to the COVID-19 pandemic in previous studies. We have found a remarkable similarity between the factors of risk force and environmental factors in their impact on construction projects. As we did not find specific research about the effects of COVID-19, especially in the countries specified in the study, we relied on government reports issued in this regard and then collected the most critical points affecting COVID-19 in the construction industry to make them accessible to researchers in the medical, health, safety and environmental fields as well as to researchers in the field of construction management, representing an effective contribution to finding practical proposals to save the construction industry from impending recession.

A systematic literature review can be beneficial in reaching the essence of a problem, and was adopted in this research. Moreover, the Scopus and WOS database was highly reliable. However, we relied on government reports and WHO reports as well due to the lack of research that dealt with the effect of this virus on the construction industry. The most important studies linking force majeure factors and risks to the impact of COVID-19 on the construction industry were collected in one table, and the results reached by the researchers were compared. Accordingly, recommendations were developed to overcome the effects of the main factors involved on the construction industry and thereby reduce losses and advance the sector from the stagnation that it has suffered as a result of the unexpected COVID-19 epidemic.

These recommendations include mitigating the financial and operational impacts, ensuring occupational health and safety at the workplace, security measures, the impact of factors affecting supply chains due to the pandemic, and contractual obstacles between owners and contractors. We recommend that future researchers conduct further studies on the impact COVID-19 has had on timely delivery of projects according to the cost stipulated in the contract, and that they verify the impact of COVID-19 on the quality of projects implemented during the epidemic period.

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