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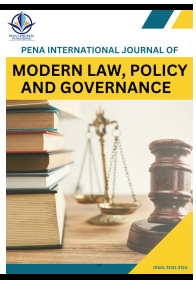

Visualization of Research Trend in Construction Law: A Bibliometric Analysis

Seng Hansen[1,*]

[1] Civil Engineering Department, Faculty of Engineering, President University, Cikarang, 17530, Indonesia

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ABSTRACT

This study aims to identify publication trends related to construction law, analyse the scientific contributions of authors in construction law research, map key topics in construction law publications, and provide recommendations for further research. It examines the trends and patterns of publications related to construction law in the last twenty years using a bibliometric approach with the tools Publish or Perish (PoP) and VOSviewer. This study explores the publication trends and authors' scientific contributions to construction law research. It has successfully identified six research clusters: sustainable built environment policies, construction law and risk management system, the legal framework for BIM-based construction, construction dispute management, sustainable development governance, and smart construction legal system. Based on these findings, this study provides recommendations for future research. This study offers originality by revealing publication patterns and trends and global collaboration networks in the construction law, which are rarely explored comprehensively. This study provides new insights into today's most relevant and emerging legal issues. In doing so, this study maps academic developments and identifies research gaps and opportunities for innovation amid regulatory and technological changes in the construction industry.

1. Introduction

The construction industry is one of the important sectors supporting a nation's socio-economic growth [1]. Likewise, the large contribution of the construction sector can be seen in many countries worldwide [2]. However, the implementation of construction projects often faces various contractual and legal issues that can threaten the project's sustainability. Construction claims often develop into disputes that even demand to be resolved in court. In addition, with large funding working on a construction project, there is great potential for misuse of budget and corruption by the parties involved in the construction project [3-4]. Therefore, construction professionals must understand and comply with construction law.

* *Corresponding author.*
E-mail address: seng.hansen@president.ac.id

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Construction law provides legal certainty for all parties involved in construction projects, such as contractors, consultants, employers, and workers. This certainty creates a safe and stable environment, which is needed to encourage investment and growth. Without clear rules, investors and construction companies may hesitate to invest in or develop new projects [5]. In addition, construction law regulates the relationship between workers and employers, ensures that workers' rights are protected, and sets occupational safety standards [6]. By providing provisions that regulate the quality of the workforce and good human resource management, construction law supports productivity and efficiency, which are important factors in the industry's growth.

By providing protection for contracts, property, and business rights, construction law creates a climate conducive to investment and innovation in this sector. Investors will be more interested in investing in the construction industry which has a clear and reliable legal framework [5]. This has an impact on increasing infrastructure projects, property development, and advances in construction technology, which in turn encourages the growth of this sector. Construction law also plays a role in regulating project financing, including loan agreements, guarantees, and insurance [7]. When these aspects are clearly regulated, construction projects find it easier to obtain financing, allowing for industry expansion and growth. Stable and transparent financing supports the development of large projects that require long-term investment.

Thus, understanding construction law provides a strong foundation for risk management, regulatory compliance, dispute resolution, and legal protection for all parties, contributing to the industry's growth and sustainability [8]. Seeing its important role, many studies have focused on construction law. For example, a normative juridical study with structured case analysis was done to examine the involvement of public officers in corruption in construction project procurement [9]. Priyanta and Zulkarnain [10] examine various regulations related to urban green open spaces in Indonesia, their problems, and alternative policies. In the context of procurement, Kurniawan *et al*. [11] developed a legal framework for sustainable construction procurement by comparing policies in Thailand, Singapore, and Indonesia. Specifically, Alhyari and Hyari [12] investigated the factors influencing authorities in evaluating bid submissions, responsiveness, and responsibility of the bidder in public procurements.

Despite the growing field of construction law, there has been no comprehensive bibliometric study analyzing research publications in this field. This creates a significant research gap, as bibliometric analysis can provide in-depth insights into research trends, collaboration patterns between authors, geographic distribution, and the development of key topics in construction law over time. Without a systematic bibliometric study, it is difficult to identify the most popular research directions, the development of methodologies used, and the impact of policies or regulatory changes affecting the construction sector. Bibliometric research in this area is essential to enrich the understanding of the dynamics and directions of construction law research that can support future decision-making and policy development. Therefore, this study aims to identify publication trends related to construction law, analyze the scientific contributions of authors in construction law research, map key topics in construction law publications, and provide recommendations for further research.

2. Methodology

This study uses a bibliometric approach to analyze publications related to construction law. Bibliometric research has become an increasingly popular approach in evaluating and analyzing publication trends in various fields of science, including law and construction. Bibliometrics is a quantitative method used to analyze scientific publications through data such as the number of

articles, citations, and collaboration patterns. This approach helps identify research trends, lead authors, and collaboration networks between researchers or institutions. In the field of law, bibliometrics has been applied to study various topics, such as environmental law and international law, but its application to construction law is still limited.

This research is a descriptive quantitative study that aims to analyze the trend of construction law publications globally. The analysis was done using bibliographic data from journal articles obtained through a systematic search in the Google Scholar database using Publish or Perish (PoP) software. PoP is a program that collects and analyzes academic citations in various metrics such as the number of papers and total citations. The results of PoP can be saved in various formats for further analysis [13]. In his search, the researcher set inclusion criteria, namely: (1) publications relevant to the topic of construction law, (2) publication of peer-reviewed articles, and (3) publications within the last 20 years (2004-2024). The keywords used were 'construction law', 'construction dispute', 'construction contract', 'construction liability', and 'legal aspects in construction'. The search results were then downloaded in RIS format, including metadata: article title, author name, institution/publisher, year of publication, and number of citations. Figure 1 shows the citation metrics of the search results using PoP software.

Citation metrics Help

Publication years:	2004-2024
Citation years:	20 (2004-2024)
Papers:	994
Citations:	101918
Cites/year:	5095.90
Cites/paper:	102.53
Cites/author:	52506.06
Papers/author:	502.00
Authors/paper:	2.71
h-index:	161
g-index:	277
hI,norm:	110
hI,annual:	5.50
hA-index:	56
Papers with ACC >= 1,2,5,10,20:	
943,863,654,456,258	

Fig. 1. Publish or Perish result: citation metric

This bibliographic data was then imported into VOSviewer to produce network, overlay, and density maps. VOSviewer is software for building and visualizing bibliometric networks that include journals, researchers, publications, terms, and citations taken from a collection of scientific literature [14]. This data is stored in CSV format to perform specific analysis via Microsoft Excel. This analysis includes co-authorship analysis, which shows collaboration between authors and institutions; co-occurrence analysis, which identifies keywords that often appear together to determine the main themes of the research; and citation analysis, which identifies the most influential articles or authors based on the number of citations.

To ensure the validity and reliability of the data, the researcher checked to avoid duplication or irrelevant entries. Cleaned the data from duplication or irrelevant keywords (such as author, paper, and literature review) and retested the visualization process to ensure the accuracy of the network map. The findings are presented as a construction law publication trend graph by year and author, a network map of collaboration between authors, and a visualization of the main themes of construction law publications based on keywords. These findings provide comprehensive insight into the dynamics of construction law research and are a basis for directing future research on construction law.

3. Results

3.1 Research Trends related to Construction Law

Construction law publication trends can be analysed based on publication year, occurrences, and node connections. Research trends over time can be seen in Figure 2, which presents the evolution of research topics based on the average year. The analysis of the average year can show when a particular topic started to become popular. Since 2021, research on “blockchain” and “smart contracts” has started to become popular, and the topic of “circular economy” began to appear in 2022. Meanwhile, “construction dispute” and “procurement” have been the main topics since 2013 and 2015.

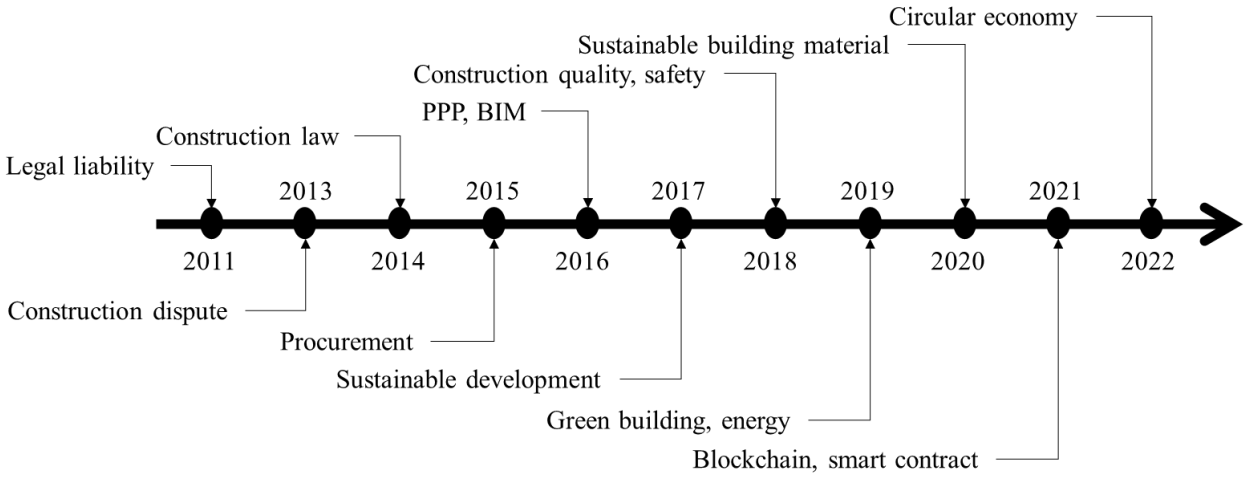

Fig. 2. Research trend

Occurrences analysis aims to identify the most frequently occurring nodes in the dataset. This indicates the popularity of a particular topic. The node with the highest frequency represents the most significant topic in the related research. Figure 3 shows the occurrences of 61 labels formed. Based on this figure, keywords such as law, construction project, obligation, policy, BIM, and litigation appear more than 30 times, indicating that these topics have been relevant in construction law research in the last twenty years.

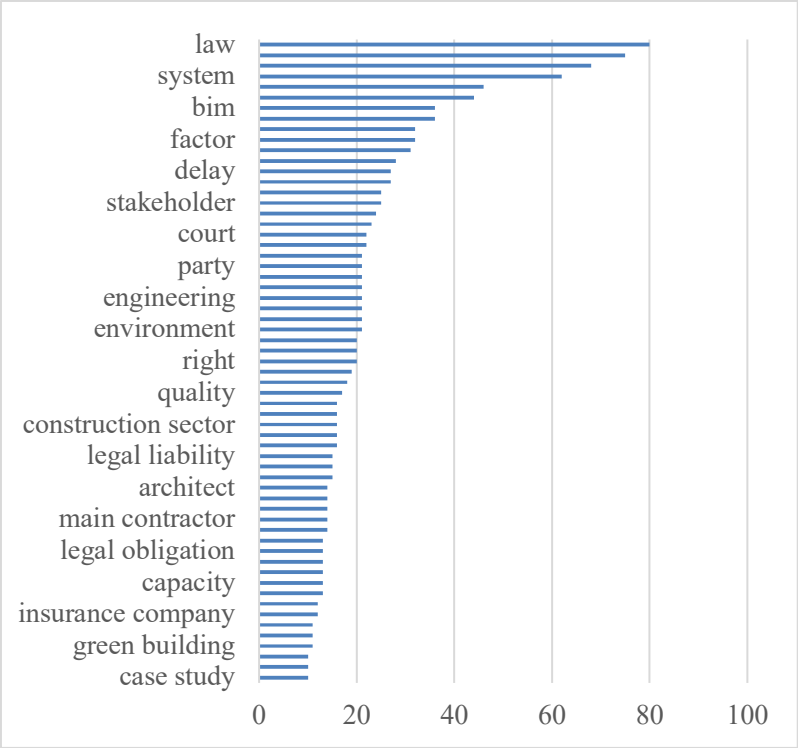

Fig. 3. Topic occurrences (2004-2024)

Table 1
Top 20 topics based on link and TLS values

Label	Link	Label	TLS
safety	22	party	36
legal issue	22	blockchain	37
legal liability	23	construction contract	37
barrier	23	barrier	38
construction contract	24	stakeholder	38
stakeholder	24	time	38
time	25	legal issue	39
bim	25	procurement	40
party	26	court	43
procurement	26	delay	47
china	26	owner	52
delay	28	litigation	54
litigation	28	bim	57
policy	29	client	59
owner	30	china	61
client	31	policy	61
system	38	system	82
law	39	obligation	90
obligation	41	law	117
construction project	44	construction project	124

Node connection analysis aims to understand the relationship between nodes to identify interconnected research themes. Nodes with many connections reflect themes that often interact with other nodes. Links are used to identify the number of connections owned by a node, while Total Link Strength (TLS) shows the intensity of the node's relationship with other nodes. Table 1 presents the top 20 topics based on Link and TLS values.

3.2 Scientific Contribution of Researchers in Construction Law

Furthermore, this study investigates the scientific contributions of researchers in construction law. The criteria set are researchers with at least two articles, so from 2118 authors, 204 authors were selected. However, some of these selected authors are not connected to each other, so the largest set of connected authors consists of 105 authors. Table 2 presents the top five authors in the field of construction law, both for the most contributors based on the number of documents and the most active collaborators based on TLS. While Figure 4 displays the author network diagram consisting of 105 authors.

Table 2
Top 5 authors by contributor and collaborator

Most contributor		Most active collaborator	
Author	Documents	Author	TLS
chan, apc	22	chan, apc	27
darko, a	8	chong, hy	16
chong, hy	7	darko, a	12
li, y	7	liu, b	11
zou, pxw	6	li, y	10

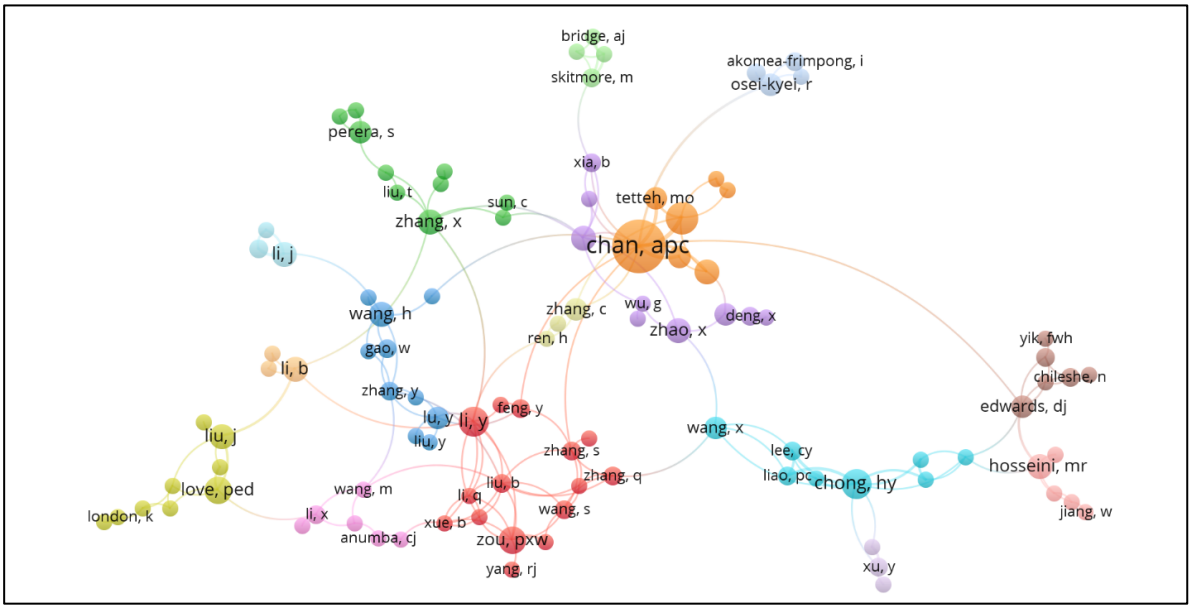

Fig. 4. Author network

3.3 Research Themes in Construction Law

To investigate research themes in construction law, this study sets the minimum number of occurrences of a term at 10, so that out of 5532 terms, 134 terms meet the threshold. Furthermore,

only 60% of this number are considered the most relevant terms, so 80 terms are selected. The validation results are presented in Figure 5, which illustrates the main theme clusters and how they are related. VOSViewer creates this network visualization based on similarities of the words using the association strength [14]. Six different colored clusters represent six different main research themes, namely (1) red cluster: sustainable built environment policies, (2) green cluster: construction law and risk management system, (3) blue cluster: legal framework for BIM-based construction, (4) yellow cluster: construction dispute management, (5) purple cluster: sustainable development governance, and (6) tosca blue cluster: smart construction legal system. In addition, these themes can be mapped to track how the focus of construction law research has shifted over time. Figure 6 presents an overlay visualization depicting construction law publication trends. Nodes in blue indicate mature themes and perhaps less discussed at present, while nodes in yellow indicate emerging topics.

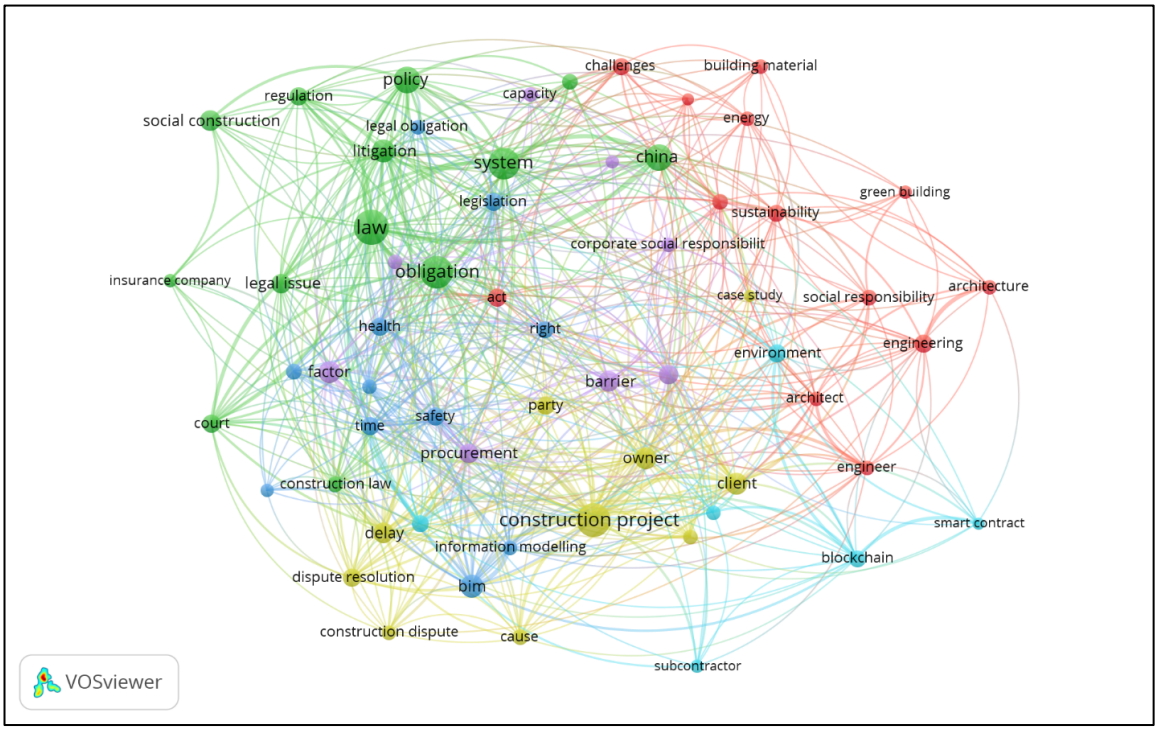

Fig. 5. Keyword co-occurrence network

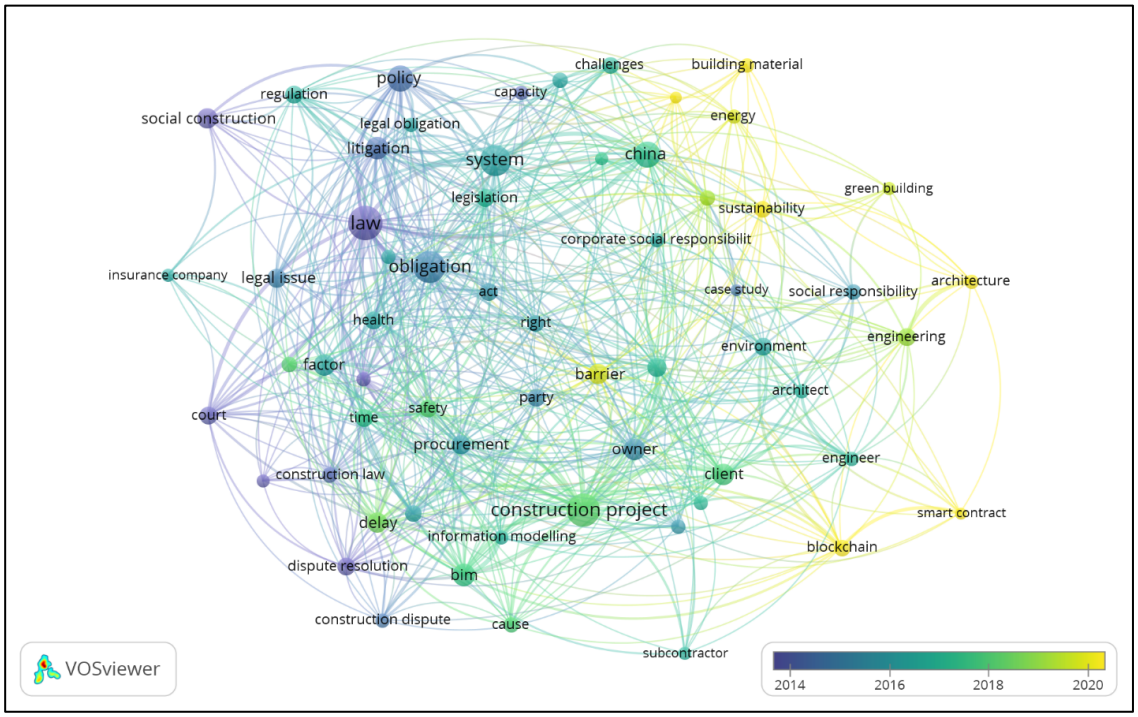

Fig. 6. Overlay visualization

3.3.1 Red Cluster: Sustainable Built Environment Policies

Environmental laws, green contracts, and project sustainability have become increasingly important topics in recent years. These publications fall under the Sustainable Built Environment Policies cluster, which refers to a holistic approach that integrates sustainability principles throughout the life cycle of a construction building, from planning and design, material selection, and implementation to operation and recycling, taking into account aspects of the circular economy, social responsibility, and environmental challenges. The focus is creating an environmentally friendly, energy-efficient construction sector contributing to sustainable development. This is related to various legal considerations to: minimize carbon emissions, waste, and resource consumption; support energy efficiency in the construction sector; support community welfare through inclusive design; and meet standards and regulations regarding sustainable construction. The circular economy principle is applied to minimize waste by recycling building materials and maximizing the efficient use of resources [15]. The concept of development that prioritizes energy efficiency, air quality, water management, and environmental impact reduction as well as the selection of sustainable building materials, such as environmentally friendly materials or recycled materials, is the core of green building which is often discussed in various publications [16-17].

In an effort to realize this, collaboration between engineers and architects in designing and building sustainable structures is important and must be supported by supportive legal policies [18]. Many researchers continue to recommend regulations or laws that support the implementation of sustainability principles in the construction sector [19-20]. A concrete example is the policy of several governments that encourage building designs that consider energy efficiency, occupant comfort, and sustainable aesthetics through the provision of incentives [19].

In addition to the government, the construction industry plays an important role in reducing carbon impacts and supporting sustainable development. The main goal is to balance economic, social, and environmental needs in the construction sector [21]. This is closely related to the social responsibility of the construction sector to support the welfare of society and the environment [22].

Key players in the construction industry can utilize technology and innovation in engineering to support sustainable development [23].

3.3.2 Green Cluster: Construction Law and Risk Management

The Construction Law and Risk Management System cluster refers to the legal and policy framework that governs the construction industry's responsibilities, obligations, and risk management. This includes the interaction between construction law, insurance policies, litigation, regulation, and social dynamics that affect construction projects. Due to the nature and application of laws that are generally context-specific, various research publications tend to focus specifically on certain construction legal, regulatory, and policy systems, such as in Australia [24], China [25], Portugal [26], and Indonesia [27].

Publications in this cluster are mostly related to efforts to protect legal certainty for all parties in construction projects. The parties must fulfil legal and contractual obligations in a construction project. Legal issues often arise in the implementation of construction projects, such as breach of contract, negligence, or third-party liability, making it interesting to study [27]. For instance, Feng *et al*. [28] examined environmental pollution liability insurance, which has been introduced since 2006 in China. Meanwhile, Koc and Gurgun [29] examined the impact of contract ambiguity on the emergence of conflicts in the construction sector. Therefore, studies related to construction law that regulates contracts, responsibilities, and disputes in construction projects are important.

On the other hand, the identification and mitigation of contractual risks that potentially cause losses in the implementation of construction projects need to be studied. The practical experience of stakeholders (such as contractors, consultants, and project owners) in dealing with legal risks and compliance can be valuable lessons for the construction industry [30]. In addition, several publications highlight policies that protect projects against risks such as physical damage or legal liability, including material losses, delays, or legal obligations of the parties. The research of Owusu-Manu *et al*. [31] in Ghana and Liu *et al*. [32] in China attempted to propose a systematic structure for managing legal and operational risks in the construction industry. All of this aims to minimize the impact of risk in carrying out construction work.

3.3.3 Blue Cluster: Legal Framework for BIM-based Construction

This cluster covers the legal aspects, obligations, and responsibilities related to using Building Information Modeling (BIM) in construction projects. This term integrates legal issues such as disputes, legal obligations, rights, and non-legal aspects such as quality, time, safety, and health in the context of BIM technology implementation. This cluster describes an approach that combines BIM technology with legal aspects, ensuring that this technology is used fairly, safely, and in accordance with applicable standards. This is especially relevant as BIM is increasingly becoming the standard in the implementation of construction projects today. BIM plays a central role as a digital platform that integrates design, construction, and operation data. All parties involved must comply with applicable laws related to the use of BIM technology in the construction sector. Therefore, laws and regulations governing the use of BIM, including aspects of data, safety, and copyright, need to be studied [33]. The legal obligations of the parties involved in the BIM project must be clarified, including obligations to comply with contracts and regulations [34]. This can be done by defining legal responsibilities early in the contract. Therefore, several publications have focused on examining Contracts that define the obligations and responsibilities of related parties regarding the use of BIM data [35-36].

BIM implementation supports the management of time, cost, and quality of construction projects, while the legal framework ensures its implementation according to the rules. Quality standards must be met in BIM-based projects, including design, construction, and data delivery. BIM-based project time management, including schedule planning integrated with digital models [37]. Another benefit of BIM implementation is ensuring occupational safety standards, for example by identifying potential risks at the design stage. BIM can predict and mitigate safety and health risks on construction sites [38].

In addition, several publications also highlight the challenges of BIM adoption. Abd Jamil and Fathi [36] highlighted legal and contractual challenges for BIM-based projects. Georgiadou [39] found financial barriers to investment, particularly for small and medium companies as the main challenge in BIM adoption in the UK, while the lack of policy initiatives and research in BIM is a challenge in Saudi Arabia [40]. Competency is still a significant barrier to the success of BIM implementation in construction projects, especially with the development of BIM technology that requires an extended set of BIM knowledge competencies [41].

3.3.4 Yellow Cluster: Construction Dispute Management

Construction Dispute Management covers identifying, analyzing, and resolving disputes in construction projects. This cluster is related to the publication of case studies, the roles of the parties (employers, contractors, and consultants), causes of disputes, delays, and dispute resolution methods relevant to construction projects. This cluster includes not only legal aspects but also technical strategies and analysis to resolve disputes efficiently in construction projects. For example, Khawaja and Mustapha [42] highlight BIM's role in mitigating disputes and managing legal issues in construction projects. Disputes that occur due to technical, administrative, or legal issues, such as project delays, differences in contract interpretation, or claims for additional costs, have been widely studied in various case study-based publications [43]. Case studies are used to analyze real examples of disputes in construction projects, including the causes and solutions applied [44]. Harmon [45] used a case study to analyze the dispute review board (DRB) implementation in the United States with 2002-2006 data from the Central Artery/Tunnel Project. Meanwhile, Elziny *et al*. [44] used four case studies to examine the validity of the application of expert systems in managing construction project disputes in Egypt.

In the context of dispute management, identifying the cause of the dispute early to prevent escalation of the problem is an important key. Many publications have highlighted the factors causing disputes, such as breach of contract, design changes, or communication failures [44-47]. For disputes that occur, it is necessary to maintain good relations between all parties involved through fair resolution. Most publications recommend alternative dispute resolutions (ADRs) as a mechanism for resolving construction disputes [44-47].

Dispute resolution through ADRs is considered to provide fast and appropriate decisions, and reduce additional costs due to delays or litigation [45]. Arbitration and mediation methods dominate the global discussion, focusing on efficiency, fairness, and harmonization of legal systems [47]. In addition, several publications focus on developing a construction dispute legal framework by adjusting it to each country's specific context, such as Teo & Aibinu [48] in Singapore and Raji *et al*. [49] in Nigeria.

3.3.5 Purple Cluster: Sustainable Development Governance

This cluster refers to sustainable development governance involving various actors and elements that are important to balance economic, social, and environmental goals. This concept emphasizes cross-sector collaboration (public and private) and identifies barriers and success factors to realize inclusive and sustainable development. This cluster includes sustainable development management through interaction of various elements such as capacity, public-private partnership (PPP), corporate social responsibility (CSR), stakeholder engagement, procurement system, and identification of barriers and success factors. Publications in this cluster explore stakeholder involvement in creating inclusive policies [50-51]. For example, through a systematic literature review, Zhao [52] investigated stakeholder-associated factors that influence construction waste management. Developing construction and renewable energy projects based on public-private partnerships is emphasized. Akomea-Frimpong *et al*., [53] explored the potential of implementing PPP in infrastructure projects to address extreme climate change. In this case, collaboration between the government and the private sector is important to accelerate infrastructure and public services development.

On the other hand, several publications investigate corporate CSR programs to empower local communities and preserve the environment [50]. In the context of sustainable development, development is aimed at meeting current needs without compromising the ability of future generations to meet their needs. The implementation of green procurement policies to reduce carbon footprints, promote social justice, and build a green economy are three important pillars in the current construction sector for long-term sustainability [51].

In addition, several publications are related to a fair, transparent, and sustainability-oriented construction procurement system [54]. Identification of procurement barriers such as rigid regulations, budget constraints, lack of stakeholder involvement, and resistance to change has also been described by Anthony [55] and Sajid *et al*., [56]. Meanwhile, determining factors for procurement success, such as policy support, technological innovation, stakeholder commitment, and cross-sector collaboration, was conveyed by Anthony [55] and Lou *et al*., [57].

3.3.6 Tosca Blue Cluster: Smart Construction Legal System

Smart Construction Legal System integrates advanced technology and digitalization in the construction world to create a more efficient, transparent, and sustainable process. This legal ecosystem involves all construction supply chain actors (from the main contractor, subcontractors, and suppliers) to technical aspects such as construction contracts, blockchain (smart contracts), and environmental management. As seen in Figure 6, this cluster has emerging topics since 2020 (marked with the yellow node).

Several publications investigate the potential of construction contracts enhanced with digital technology to support project accuracy, security, and smoothness. For example, Taherdoost [58] discusses the potential of blockchain technology-based digital contracts that automatically execute agreements based on predetermined conditions. This will increase transparency and reduce disputes. The relationship between the main contractor and subcontractors in this ecosystem is managed efficiently through document digitization, payment automation, and project management. Blockchain ensures that project data cannot be manipulated, thus ensuring data security [59]. Another benefit of implementing blockchain-enabled smart contracts is expediting cash flow in construction through a semi-automatic payment process. Smart contract technology can also be utilized for the operational efficiency of construction work by reducing administrative work time [58]. This is realized through automation in the smart contract ecosystem [59].

3.3.7 Discussion and implications

Research in construction law is a combination of legal, technological, social, economic, and sustainability aspects in the construction area. This paper has mapped six clusters of research trends in construction law in the last twenty years. The first cluster is sustainable built environment policies. Sustainability aspects in the construction sector bring legal challenges related to energy regulations, the use of sustainable materials, and corporate social responsibility. The concept of development that focuses on the design, construction, and operation of buildings that are environmentally friendly, resource-efficient, and sustainable for future generations began two decades ago. Construction law plays an important role in ensuring that all parties involved comply with sustainability policies, including compliance with environmental permit regulations, green building standards, and legal responsibility for violations that can damage the ecosystem. Thus, construction law becomes a tool that supports the implementation and supervision of sustainable development. Further research can explore how sustainability laws are applied in construction projects and the extent to which the law is able to encourage environmentally friendly practices through context-specific studies. Comparative analysis between legal systems can be conducted to provide a comprehensive understanding of the application of sustainability aspects in the global construction sector.

Legal risk management, such as litigation or contractual obligations, is at the core of construction law research. Construction law functions to regulate the rights, obligations, and responsibilities of the parties involved, such as project owners, contractors, subcontractors, and consultants, to prevent or resolve disputes. On the other hand, risk management aims to identify, analyze, and mitigate risks that can affect the success of a project, such as legal, financial, technical, and environmental risks. The integration of these two disciplines is important to create a project that is not only technically successful but also legally safe. As a recommendation for further research, an in-depth study is needed on the development of an integrated framework that combines construction law principles and technology-based risk management approaches to predict potential disputes or risks in construction projects.

The implications of the legal framework for Building Information Modeling (BIM)-based construction projects are significant, especially in terms of regulating responsibilities, copyrights, and claims related to quality or delays. BIM integrates various information involving many parties, such as architects, contractors, and clients, which can cause complexity in determining who is responsible if errors or damage occur. For example, in a large construction project in Indonesia, the use of BIM to design and manage the construction project shows the need for clear regulations regarding BIM data ownership and the parties' responsibilities for design changes made during the construction process. Without the right legal framework, such as copyright protection and data-based claim regulations, the risk of disputes and litigation can increase, which can ultimately increase costs and extend the duration of the project. Therefore, the implementation of a clear and comprehensive BIM legal framework is essential to ensure smooth implementation and prevent legal issues that can disrupt the success of this technology-based construction project. Researchers can investigate the integration of construction law in protecting the rights and obligations of parties in BIM-based construction projects.

Construction disputes are one of the main areas in construction law research. Aspects such as delays, breach of contract, and party liability are the focus of discussions in many publications. This shows that various problems in construction projects are related to contractual legal aspects that must be resolved either through ADR or litigation. Construction dispute management is essential to keep the project running smoothly and avoid additional costs or delays that can affect the final result.

Construction projects often involve many parties with different interests, which can trigger conflicts, whether related to the quality of work, delays, or costs. For example, in toll road construction projects in Indonesia, disputes often occur between contractors and developers related to claims for additional costs due to design changes or delays caused by external factors such as bad weather. In cases like this, effective construction dispute management through ADR approaches is essential to resolve conflicts efficiently without disrupting the progress of the project. A clear and structured approach to dispute management, such as the use of contracts that include clear dispute resolution procedures, can help prevent conflict escalation, reduce the risk of litigation, and expedite problem resolution so that the project remains on schedule and budget. Further research is still needed, especially through case studies of construction dispute resolution and analysis of the efficiency of dispute resolution mechanisms in the context of construction contracts (including the application of technology in dispute resolution).

Research related to sustainable development governance is still developing to date. Sustainable development governance requires the construction sector to comply with legal standards related to the environment, safety, and social rights. Sustainable development governance is essential in ensuring that development projects not only meet current needs but also consider long-term environmental, social, and economic impacts. This approach requires integration between government policies, the private sector, and communities in planning and managing sustainable development. For example, the development of projects in Indonesia that apply the principles of sustainable development shows how good governance can create a balance between economic progress and environmental protection. The project not only pays attention to energy efficiency and carbon emission reduction but also involves communities in decision-making that leads to social sustainability. However, challenges often arise in policy implementation, such as gaps between existing regulations and implementation in the field, which can affect the success of achieving sustainable development goals. Therefore, effective sustainable development governance requires coordination between various stakeholders and the implementation of policies that support the achievement of long-term goals fairly and inclusively. Further research can explore how regulations affect the legal responsibilities of stakeholders in sustainable development projects or investigate the effectiveness of green procurement policies in the construction sector.

Currently, research in the field of construction law is largely related to the use of technologies such as blockchain (smart contracts) and BIM, which bring new challenges to contract regulation, data management, and dispute resolution in construction law. The implications of this study are significant for improving efficiency and transparency in the construction industry, especially with the integration of digital technology in project management. This smart legal system is useful in facilitating contract management, monitoring project progress, and resolving disputes. For example, the use of blockchain-based smart contracts to manage payments and claims can reduce the potential for disputes between contractors and clients, as every transaction is recorded transparently and irreversibly. This allows for automatic resolution of issues based on previously agreed terms, reducing the need for time-consuming manual legal intervention. On the other hand, appropriate regulatory updates are needed to support the implementation of this technology, so that the legal system can accommodate the dynamics and changes in the construction industry that is increasingly dependent on technology. Without a clear legal framework to regulate the use of such technology, risks related to the validity of contracts may arise, ultimately hampering the widespread adoption of smart construction legal systems. Further research can focus on how regulations need to be adjusted to accommodate the use of this technology, especially in ensuring legal responsibility between parties using automated systems. Context-specific studies are recommended to understand the role of different regulations in each jurisdiction. This could develop a comparative legal analysis that

compares the differences and similarities between legal systems related to smart contract execution in construction projects.

Despite the above findings, this study has several limitations because it relies on data from Google Scholar. Google Scholar, although a vast source, does not have the same stringent quality control as other academic databases, such as Scopus or Web of Science, which can affect the validity and accuracy of the data obtained. In addition, Google Scholar tends to index publications from a variety of sources, including articles from less verified or non-peer-reviewed journals, which can affect the overall quality of the dataset. This has the potential to cause bias in the results of the analysis, such as the prominence of lower-quality work or the under-representation of relevant but more difficult-to-access research. The impact of these limitations affects the reliability of the results of this study in terms of the accuracy of trends or influences in the field of study studied.

4. Conclusions

This study examines the trends and patterns of publications related to construction law in the last twenty years using a bibliometric approach with the tools Publish or Perish (PoP) and VOSviewer. This bibliometric study can provide a comprehensive picture of the development of construction law. Based on the analysis conducted, several important conclusions were obtained as follows:

a) Globally, construction law publications cover a variety of topics, such as construction dispute resolution, sustainability, and construction technology, which illustrate the multidisciplinary nature of this research area. Judging from the trend, there has been a shift in research focus from the traditional fields of construction law (legal aspects and contract disputes) to newer fields such as sustainability (e.g., construction waste) and digitalization (e.g., legal implications of BIM and smart contracts).
b) Bibliometric analysis helps identify the most influential authors in construction law. They have contributed significantly to the development of theories on contract law, construction dispute resolution, ethical behavior, and sustainability. The results of this study can inform potential research collaborations to address research gaps in construction law.
c) Dominant topics can generally be grouped into six clusters, namely sustainable built environment policies, construction law and risk management system, legal framework for BIM-based construction, construction dispute management, sustainable development governance, and smart construction legal system.
d) There are still many research gaps in construction law due to the complexity of this field involving technical, legal, and management aspects, as well as differences in regulations across jurisdictions. One of the main gaps is the lack of in-depth studies on the harmonization of international construction law, especially in cross-border projects involving various legal regulations, cultures, and business practices. In addition, research on the impact of digital transformation and technology, such as blockchain or artificial intelligence, on construction contracts and dispute resolution still has the potential to be developed. Another aspect that can be explored (especially in Indonesia) is the integration of construction law with sustainability principles and how regulations can encourage the implementation of green buildings without increasing the legal burden on industry players. Further research is needed to address these gaps so that construction law can be more adaptive and relevant to global challenges.

In conclusion, this study provides valuable insights into trends, publication patterns, and key themes in the field of construction law, while identifying gaps that need further exploration. This study can help researchers and practitioners understand the evolution of construction law literature,

including the most frequently discussed topics such as contract management, dispute resolution, and sustainability. In addition, this study can serve as a guide to determine future research directions, for example exploring the integration of digital technologies in construction law or strengthening the international legal framework. With the growing global demand for more efficient, environmentally friendly, and less disputed construction projects, further research in construction law is essential to support the development of theories and practices that are more responsive to the challenges of the times.

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