

Digital Twins: Implications for Construction Material Supply Chain in Sub-Saharan Africa

Adeola Oluwatoyin Osundiran¹

¹University of South Africa, Graduate School of Business Leadership, Department of Sustainable Livelihood, South Africa

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Abstract

Fragmentation, inefficiency, and poor performance are salient matters affecting the building sector. This research explores the role of Digital Twin Technology (DTT) in mitigating inefficiencies in the construction material supply chain. DTT plays a crucial role in improving the efficiency of the construction materials supply chain. This study outlines the critical roles of DTT in the construction supply chain. This exploratory research reveals the significance of DTT in the construction materials value chain and the implications for sub-Saharan Africa. This research adopts a quantitative research design. A Bibliometric-Systematic literature review was conducted by sourcing peer-reviewed articles from selected databases, including Web of Science and Scopus. Relevant themes on the role of DTT in the CMSC were generated. With the use of Vos Viewer, five critical themes (Management, Efficiency, Performance, Digital Transformation, Safety, Systems, Networks) were generated and explored on the pivotal role of DTT in the CMSC. These themes show the importance of the application of DTT in enhancing construction material supply chains. Findings of the research provide the need to expedite the implementation of DTT within Africa, since there is a lag in implementation due to several factors, such as the unawareness of the capabilities of DTT for strategic decisions in the construction sector. This study is significant because it shows how DTT can improve the construction supply chain management and enhance digital transformation.

Key Words: Construction Supply Chain, Digital Twin Technologies, Sub-Saharan Africa, Bibliometric Analysis, and VOSviewer

1. Introduction

DTT originated in 2002, when the white paper authored by Grieves (2016) was published. Grieves (2016) elucidated that DTT is a “digital informational construct of an actual and existing structure, which is based on the information derived. This digital information would be a 'twin or the duplicate' of the information that was embedded within the physical system itself. This information can be linked to that physical system throughout the system's lifecycle (Grieves, 2016). Although the concept of Digital Twin has been in existence since 2002, it began to gain traction at the beginning of the 21st Century (Grieves, 2023). Hence, the digital twin is still an emerging technology whose application has extended beyond manufacturing to various sectors of the economy. This research explores the capabilities of DTT in the Construction Supply Chain.

In the construction industry, even though building projects occur serially, it is discovered that relevant stakeholders continue to work in silos (Riazi et al., 2020). This segmented circumstance has prevented the industry from performing efficiently (Riazi et al., 2020; Liet al., 2026). Delayed information and even the lack of the correct and relevant information at the right time

along the construction supply chain impedes efficiency. DTT transforms business functionality and operations (Attaran and Celik 2023). Based on several studies, the following are some of the challenges that emanate in the building sector: resilience, risks, and performance failure (Ding and Jie 2025). Fragmentation and operational silos in the Construction supply chain necessitate the need to probe the implications of DTT in the construction space (Riazi et al., 2020). The main objective of this research is to explore the potential of DTT in the construction material supply chain, specifically in mitigating inefficiencies. The main research question is, what is the role of Digital Twin Technology (DTT) in mitigating inefficiencies in the construction material supply chain?

Databases such as the Web of Science, Scopus, and Google Scholar were used to search for peer-reviewed articles, book chapters, and conference proceedings that included words such as "Digital Twin" or "Construction Supply Chain" in the title and abstract. These literary resources were explored due to the wideness of their scope. Section 2 discusses the review of the literature. Section 3 explains the methodology, while the findings and discussion are discussed in Section 4. The conclusion and further research are outlined in Section 5

¹ Corresponding Author

Email address: osundo@unisa.ac.za; niyot31@gmail.com

2. Review of Literature

DTT has transformed the process of monitoring, simulating, and optimizing the construction value chain (Bhatia and Khumar, 2026). Riazi et al. (2020) are of the view that the building value chain has generally been confronted with issues such as delays, cost overruns, and several others. Ineptitude surrounds some functions in the construction value chain (Riazi et al., 2020). Ahmadi et al. (2026) state that digital twin (DT) technologies streamline data management via virtual representations and real-time updates across the supply chain. Therefore, creating alerts wherever there might be hitches or delays in the value chain. DTT continuously updated with real-time data has the capability for dual interaction and engagement (Zhang et al., 2026). Fuller et al (2019) further describe DTT as the unification of data between reality and cyberspace. Over time, there has been an increase in the application of DTT in different industry fields (Hu et al., 2021). Companies in any sector, including construction, are quick to detect and solve physical problems, design and build better products, and realize value and benefits faster than previously possible (Attaran and Celik 2023). DTT allows companies, irrespective of their industry, to have a twin of their product in their full lifecycle, respond expeditiously to physical issues sooner, prognosticate situations before it occurs, and better serve their customers (Hu et al., 2021). Despite the several benefits of DTT, there is still a lag in its implementation in sub-Saharan Africa. The critical issue with the application of DTT is that it has not been implemented extensively in sub-Saharan Africa. One of the several reasons for the lack of implementation in Sub-Saharan Africa could be a lack of awareness (Awodele et al., 2025). This study, therefore, delves into the potential of DTT in CMSC, hence contributing to the body of knowledge on the pivotal role of DTT in CMSC.

2.1. Theoretical Framework

This section examines the underlying theoretical framework that governs this research. The digital transformation theory relates strongly to this research as it describes how the combination of technology, people, and process transforms organisations (Elia et al., 2024). The application of this theory is that DTT can be used as a tool to transform and enhance the CMSC processes and procedures. This theory implies that it mitigates the underlying risk that emanates from supply chain failure.

3. Research Methodology: Bibliometric Systematic Literature Review

The bibliometric systematic review (B-SLR) adopts the pillars of critical analysis and proffers the need for relevant theoretical contributions (Marzia et al, 2025). Lame (2019) attests that systematic literature reviews (SRs) include the process of applying empirical

answers to respond to research questions. Furthermore, De Sousa et al. (2024) define bibliometrics as a procedure that enables the quantitative mapping of scientific information found in scientific literature. According to Marzia et al (2025), there are 10 steps involved in the B-SLR process. This is captured in Table 1 (Appendix 1). This study applies the Bibliometric-Systematic Literature Review (B-SLR) framework

The entire research process is captured in Table 1. Step 1 includes selecting a Research Topic; Step 2 involves Formulating Research Questions; Step 3 includes establishing the Study Boundaries. Steps 4 and 5 are data collection and cleaning, respectively. Step 6 involves the application of bibliometric methods, in this case, Vosviewer. Vos Viewer is a bibliometric mapping computer software that enhances the ability to examine the trends in DTT. Vos Viewer reveals the author, publication, keyword, journal, country, and citation variables (Van Eck and Altman, 2009). Van Eck and Altman (2009) further reiterate that VOSviewer builds maps of authors or journals based on co-citation data, or constructs maps of keywords based on co-occurrence data. Figure 1 shows the mapping of keywords on DTT. The data set was synthesized in step 7 to generate themes and clusters. The themes are outlined in Table 2. The themes generated aligned with the theoretical framework. Steps 8 and 9 deal with alignment to the theoretical framework. This is discussed in section 4. Section 10 is the last step that deals with the report findings. In this final stage, the themes were systematically generated and coalesced into categories. The final stage of the systematic content analysis was discussed in Section 4.

3.1. Intense use of Databases

This section outlines the Journal sourced from the database. The 95 Journals examined are reflected in Table 2 (Appendix 1). The Journal on Buildings had the most publications.

3.2. Bibliometric Mapping

VOSViewer is adapted for bibliometric mapping, and the search was conducted on the Scopus databases. Keywords with ("Construction industry" OR "Construction Supply Chain") AND ("Digital Twin Technology"), AND ("Implications for Future"), for 2018-2026 were searched for on 19th February 2026. Peer-reviewed articles were sourced from the selected document type "article" or "review". 1107 papers. The network analysis is depicted in Figure 1. The set of items included in the map is referred to as the cluster (Van Eck and Altman, 2009). The bibliometric mapping network has 5 clusters with 64 items. This is a map of terms related to DTT. These clusters are depicted with colors such as purple, yellow, green, red, and blue. Cluster red has the most keywords. The following keywords emerge from the mapping of DTT's role in the construction supply chain:

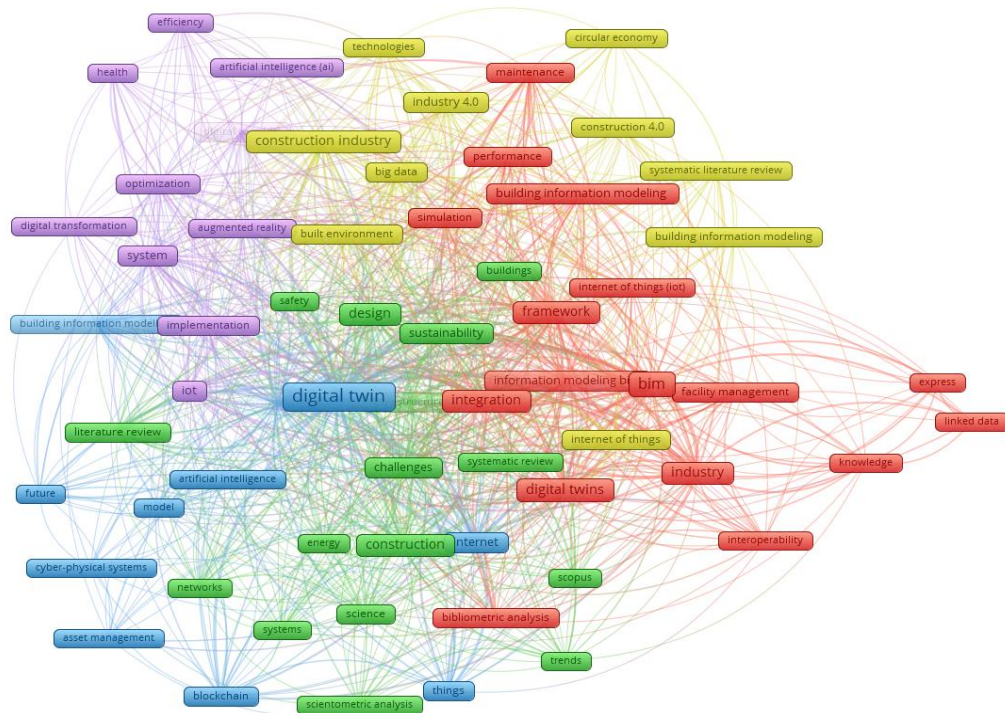


Figure 1: Map of Key Words on DTT
Source: Osundiran, 2026

Management, Efficiency, Performance, Digital Transformation, Safety, Systems, Networks. For instance, performance is a key term that emphasises the importance of DTT in improving the construction supply chain (Omrany et al., 2023; Hu et al., 2022; Qi et al., 2021). Managing the construction supply chain involves planning, controlling, and monitoring the entire process. DTT provides the manager the opportunity to identify possible gaps or problems that can emanate, therefore ensuring that the necessary action is taken to forestall the gap. DTT enhances efficiency in the process by reducing waste and delays. Performance is quickened when the manager can assess the value chain and prevent any situation that can lead to lags or hindrances. Digital transformation occurs when there is a shift from traditional procedures to digital, as DTT streamlines data management via virtual representations and real-time updates across the supply chain. Integrating these tools presents significant opportunities to support circular strategies in the building sector (Ahmadi et al., 2026).

4. Findings and Discussion

Five clusters are generated. These are named as Cluster 1 (Red) with 17 items, Cluster 2 (Green) with 16 items, Cluster 3 (Blue) with 11 items, Cluster 4 (Purple) with 10 items, and Cluster 5 (Yellow) with 10 items. The clusters explain the roles of DTT in the CMSC, as supported by the literature. Please refer to Table 3. Table 3 indicates the themes and the supporting literature. The first theme is facility management; DTT improves the efficiency of existing systems and

structures (Wang et al., 2024). Efficiency borders on cost reduction and the ability to reduce waste in terms of time and resource allocation. Efficiency is another dominant theme in the role of DTT because it simulates and tests structures even before they are built (Wang et al., 2024).

For instance, when potential problematic situations are identified before they occur, improvements are enabled, hence leading to higher efficiency and higher delivery time (Wang et al., 2024). Performance is critical in construction. Non-performance affects buildings and, therefore, can lead to the demise of people. DTT is capable of predictive maintenance, which allows for early detection of faults, thereby promoting safety. DTT creates dynamic, evolving digital replicas of physical assets (Badenko et al., 2024). DTT enables just-in-time information (Preut et al., 2021). The themes generated align with the Digital Transformation theory because it shows how technology, in this case, a digital twin, can transform the construction material supply chain.

4.1. Implication of DTT for the Construction Supply Chain in Sub-Saharan Africa

The implication of the lack of adoption and slow implementation of DTT in Sub-Saharan Africa is that there will continually be delays in the overall supply chain. DTT provides the opportunity for transformation in the CSC. Nevertheless, many sub-Saharan African nations are yet to adopt DTT (Awodele et al., 2025).

Table 3: The Role of DTT in the Construction Supply Chain

The Dominant Theme	Clusters				
	1 Red	2 Green	3 Blue	4 Purple	5 Yellow
Facility Management	Facility Management Bhatia, and Kumar (2026) Badenko et al., (2024)	Infrastructure Broo et al., (2022)	Asset Management Attaran and Celik (2023)	Built Environment Wang et al (2024)	Digital Transformation Zhang et al., (2026)
Efficiency	Integration (Moshood et al., 2024)	Sustainability (Badenko et al., 2024 Moshood et al., 2024)	Building Information Management Wang et al (2024)	Construction Industry (Hu et al., 2021). Liet al., 2026	Efficiency (Hu et al., 2021). Liet al., 2026
Performance	Performance (Omrany et al., 2023)	Construction (Moshood et al., 2024)	Future Wang et al (2024)	Technologies Ahmadi et al. (2026)	Optimization Ahamadi et al., (2026)
Digital Transformation	Interoperability Mia and Haque, 2023)	Buildings Wang et al (2024) Avireneni et al., 2023)	Cyber Physical Systems Omrany et al., 2023	Digital Transformation Avireneni et al., 2023)	Implementation Fuller et al, (2019
Safety	Simulation Ahmadi et al. (2026) Agnusdei et al., 2025)	Safety Luo et al., (2025)	Management Ahmadi et al. (2026)	Circular Economy (Preut et al., 2021)	Artificial Intelligence Avireneni et al., 2023)
Systems	Predictive Maintenance (Hu et al., 2021). Wang et al (2024)	Systems Iliuță et al. (2024)	Artificial Intelligence Avireneni et al ., 2023)	Building Information Management (Mia and Haque, 2023)	System Avireneni et al., 2023)
Networks	Building Information Management Badenko et al (2024)	Networks Mashaly et al., (2021)	Model (Mashaly et al., 2021)	Construction 4.0 (Moshood et al, 2024)	Augmented Reality Wang et al (2024)

(Source: Osundiran, 2026)

There are many barriers to the adoption of DTT, hence, explaining why the adoption of DTT in the construction environment has not been smoothly implemented (Ibrahim et al., 2026). Some of the barriers include costs, lack of relevant skill set, infrastructure etc. Meanwhile, the construction industry is in dire need of a change due to the inherent challenges such as waste, delays, safety etc.

The implication of DTT for the construction supply chain in sub-Saharan Africa is that DTT can produce the change that is critical to ensure efficiency and accelerate performance. Therefore, there is an urgent need for stakeholders in the construction sector to be deliberate in transitioning from the traditional way of doing things to Industry 4.0(Moshood et al., 2024). The transformation is slow; however, there is an urgent need for stakeholders in the construction sector to continue conversations on how the processes and procedures can

be improved. The potentials and benefits of DTT should be harnessed to accelerate the transformation to construction 4.0.

5. Conclusion and Further Research

The construction material supply chain sector is in dire need of an effective and efficient supply chain. This research advocates for the adoption of DTT in the construction sector. This research contributes to the body of knowledge by examining the pivotal role of DTT in enhancing the construction material supply chain.

This research focused on the role of digital twin technology in enhancing the construction supply chain. Even though the postulation of DTT has existed for over three decades, it has great significance in the

construction sector. A systematic literature review was done, and several themes emerged. The dominant themes included Facility Management, Efficiency, Performance, Digital Transformation, Safety, Systems, and Networks. These themes were threshed and discussed. The implementation of DTT in the sub-Saharan Africa construction industry should be examined since it has been successfully adopted in developed nations. Moshood et al al (2024) attest that

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- DTT enhances efficiency and productivity in construction through increased innovation and improved collaboration, ultimately reducing information gaps and data discrepancies. The pivotal motivation of this research is to throw more light on the significance of DTT in the construction sector. Further research can be done on how the adoption of DTT can be enhanced in sub-Saharan Africa.
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Appendix 1**Table 1:** Bibliometric Systematic Literature Review: The 10 Steps

Steps	Action Taken
Step 1: Selecting a Research Topic	The researcher scrutinized the existing literature on ‘Digital Twins: Implications for Construction Material Supply Chain in Sub-Saharan Africa’, to build an overview of the research stream. Key words such as: (“Construction Industry” OR “Construction Supply Chain”) AND (“Digital Twin Technology”), AND (“Implications for Future”), from 2010 to 2026 were used. The search was conducted on 19 th February 2026. Peer-reviewed articles were sourced from the selected document type “article” or “review”.
Step 2: Formulating Research Questions	The main research question is, what is the role of Digital Twin Technology (DTT) in mitigating inefficiencies in the construction material supply chain? How can DTT enhance the construction material supply chain?
Step 3: Establishing Study Boundaries	The search query is defined as follows: (“Construction Industry” OR “Construction Supply Chain”) AND (“Digital Twin Technology”), AND (“Implications for Future”), between 2010 and 2026. We ran the search query in the Web of Science. The literary publications were limited to those published in English and included Journal articles and Conference proceedings.
Step 4: Data Collection	The query generated 175 results with 77 Conference Proceedings and 98 Journal articles published in Web of Science. Three journal articles were removed because they were not in English. This means a total of 172 pieces of literature.
Step 5: Data Cleaning	Duplicates and ineligible documents were removed This has resulted in a final dataset of 172 literary pieces
Step 6: Applying Bibliometric Methods	Next, we moved to bibliometric analysis in VOSviewer version 1.6.20. (van Eck & Waltman, 2010). Section 3.2 captures the Bibliometric mapping
Step 7: Synthesizing Data	After independently reading the extracted documents, five clusters were identified with 64 items
Step 8: Alignment to theoretical framework	The following themes were generated: Efficiency, Management, Performance, Digital transformation, systems, safety and networks. This aligns with the digital transformation theory.
Step 9: Theoretical Findings/ Development	The clusters have been reviewed, and the keywords have been mapped in Figure 1.
Step 10: Report Findings	Based on the themes generated, DTT can enhance and improve the construction supply chain

Source: B-LS Framework adapted by Osundiran, 2026

Table 2: Journals Examined

Journals	Number of Selected Publications	References
Advanced Engineering Informatics	4	Su, SM; Zhong, RY; Jiang, YS; Song, JD; Fu, Y; Cao, HR Liu, Y; Feng, J; Lu, JM; Zhou, SY Jung, S; Jeoung, J; Kong, M; Jung, D; Hong, T Zhang, C; Wang, ZH; Zhou, GH; Chang, FT; Ma, DX; Jing, YZ; Cheng, W; Ding, K; Zhao, D
Advances in Civil in Engineering	2	Hosamo, HH; Imran, A; Cardenas-Cartagena, J; Svennevig, PR; Svidt, K; Nielsen, HK Hosamo, HH; Hosamo, MH

Journals	Number of Selected Publications	References
Architectural Engineering And Design Management Architecture-Switzerland	2	Jin, ST Chatsuwan, M; Moriwaki, A; Ichinose, M; Alkhalaf, H
Automation in Construction	12	Tuhaise, VV; Tah, JHM; Abanda, FH Jiang, F; Ma, L; Broyd, T; Chen, K Zhong, BT; Pan, X; Ding, LY; Chen, Q; Hu, XW Saif, W; Razavialavi, S; Kassem, M Bakhshi, S; Ghaffarianhoseini, A; Ghaffarianhoseini, A; Najafi, M; Rahimian, F; Park, C; Lee, D Li, T; Li, XJ; Rui, Y; Ling, JX; Zhao, SC; Zhu, HH Mai, TG; Nguyen, M; Ghobakhlou, A; Yan, WQ; Chhun, Nguyen, H Naderi, H; Shojaei, A XW; Liu, YP; Huang, LZ; Onstein, E; Merschbrock, C Marocco, M; Garofolo, I
Buildings	33	Zhang, ZC; Wei, ZK; Court, S; Yang, LC; Wang, SZ; Thirunavukarasu, A; Zhao, YF Shishehgharkhaneh, MB; Keivani, A; Moehler, RC; Jelodari, N; Laleh, SR Hu, W; Lim, KYH; Cai, YY Zahedi, F; Alavi, H; Sardroud, JM; Dang, HT Mêda, P; Calvetti, D; Hjelseth, E; Sousa, H Liu, WH; Lv, YH; Wang, Q; Sun, B; Han, DC Lauria, M; Azzalin, M Sepasgozar, SME Keles, C; Rios, FC; Hoque, S Peng, H; Wang, XL; Wu, H; Huang, B Sokic, D; Dolacek-Alduk, Z; Galic, M Alnajjar, O; Atencio, E; Turmo, J Cheng, FC; Bier, H; Wang, NZ; Andrasek, A Zohourian, M; Pamidimukkala, A; Kermanshachi, S; Almaskati, D Olimat, H; Alwashah, Z; Abudayyeh, O; Liu, HX Hauer, M; Hammes, S; Zech, P; Geisler-Moroder, D; Plörrer, D; Miller, J; van Karsbergen, V; Pfluger, R de Souza, ASC; Debs, L Yan, JK; Zheng, Z; Zhou, YC; Lin, JR; Deng, YC; Lu, XZ Wang, J; Ma, YC; Li, R; Zhang, SX Li, YN; Li, YC; Ding, ZK Siccardi, S; Villa, V Adewale, BA; Ene, VO; Ogunbayo, BF; Aigbavboa, CO Ali, KN; Alhajlah, HH; Kassem, MA
Built Environment Project and Asset Management	1	Aklashie, S; Agyekum, K; Tachao, ET; Adinyira, E; Nani, G
Construction Innovation England	3	Radzi, AR; Azmi, NF; Kamaruzzaman, SN; Rahman, RA; Papadonikolaki, E Ghansah, FA; Lu, WS Gondak, MD; Hluszko, C; Moretti, V; Zeni, GLF; de Francisco, AC
Energy and Buildings	2	Liew, EFY; Ong, DEL; Peerun, MI Geng, LN; Li, SP; Farsangi, EN; Xu, XX; Tam, VWY

Journals	Number of Selected Publications	References
Engineering Application and Artificial Intelligence	1	Zhang, LM; Li, YS; Pan, Y; Ding, LY
Engineering Construction and Architectural Management	5	Omrany, H; Al-Obaidi, KM; Ghaffarianhoseini, A; Chang, RD; Park, C; Rahimian, F Lu, MQ; Antwi-Afari, MF Luo, QM; Sun, CS; Li, Y; Qi, ZQ; Zhang, GZ Yao, YL Ohene, E; Nani, G; Antwi-Afari, MF; Darko, A; Addai, LA; Horvey, E
Frontiers in Built Environment	1	Hosamo, HH; Nielsen, HK; Alnmr, AN; Svennevig, PR; Svidt, K
Infrastructures	2	Oditallah, M; Alam, M; Ekambaram, P; Ranjha, S Wangchuk, J; Banihashemi, S; Abbasianjahromi, H; Antwi-Afari, MF
Intelligent Buildings International	1	Krishna, USR; Kumar, NVP; Tadi, C; Badiger, MH
Journal of Building Engineering	7	Opoku, DJ; Perera, S; Osei-Kyei, R; Rashidi, M Zhang, AS; Yang, J; Wang, FL Arsecularatne, BP; Rodrigo, N; Chang, RD Osadcha, I; Jurelionis, A; Fokaides, P Alhadi, A; Tom, B; Yacine, R Khan, H; Bin Zahid, Z; Malik, UJ; Ahmad, J Wang, X; Wang, SQ; Xiao, F; Luo, XW
Journal of Computing in Civil Engineering	1	Davletshina, D; Reja, VK; Brilakis, I
Journal of Construction Engineering and Management	5	Manzoor, B; Antwi-Afari, MF; Alotaibi, KS; Edwards, DJ; Posillico, JJ Ahmadi, L; Bilal, M; Olumo, A; Mollaei, A; Jalaei, F; Ebrahimi, N; Mozaffari, H; Kim, J; Haas, C Yue, HZ; Wang, Q; Zhao, MR; Yang, ZZ; Lu, L Liu, HX; Han, S; Zhu, ZH Assaf, M; Al-Hussein, M; Li, XM
Journal of Construction Innovation and Management	1	Yildirim, M; Giran, O
Journal of Information Technology in Construction	5	Madubuike, OC; Anumba, CJ; Khallaf, R Paliakkara, AD; Osorio-Sandoval, CA; Tizani, W Getuli, V; D'Ascenzi, E; Fiesoli, I Deng, M; Menassa, CC; Kamat, VR Begic, H; Galic, M; Dolacek-Alduk, Z
Journal Of Science And Technology Policy Management	1	Dhamak, P; Aital, P; Daftardar, A
Nordic Concrete Research	1	Saback, V; Popescu, C; Blanksvärd, T; Täljsten, B
Smart And Sustainable Built Environment	1	Sarigul, FH; Gunaydin, HM
Sustainable Cities And Society	1	Xia, HS; Liu, ZS; Efremochkina, M; Liu, XT; Lin, CX
Transportation Geotechnics	1	Tan, J; Koohmishi, M; Jing, GQ; Kaewunruen, S; Guo, YL