# Building Information Modeling (BIM) for Construction and Demolition Waste (CDW) Management: Scientometric and state-of-the-art review

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# Presentation Flow

Introduction and problem statement

Aim and objective

Methodology

Results and discussion

Conclusion and Recommendation

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# Introduction

- CONSTRUCTION AND DEMOLITION WASTE (CDW)

Construction and Demolition Waste (CDW) is a general term used to refer to any material produced as waste from construction, renovation and demolition activities of buildings and other structures (Pacheco-Torgal & Labrincha 2013).

CDW typically includes concrete, wood, steel, glass, gypsum and packing material.

Figure 1: Construction and Demolition Waste (CDW)

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# Introduction

- GLOBAL WASTE STREAMS

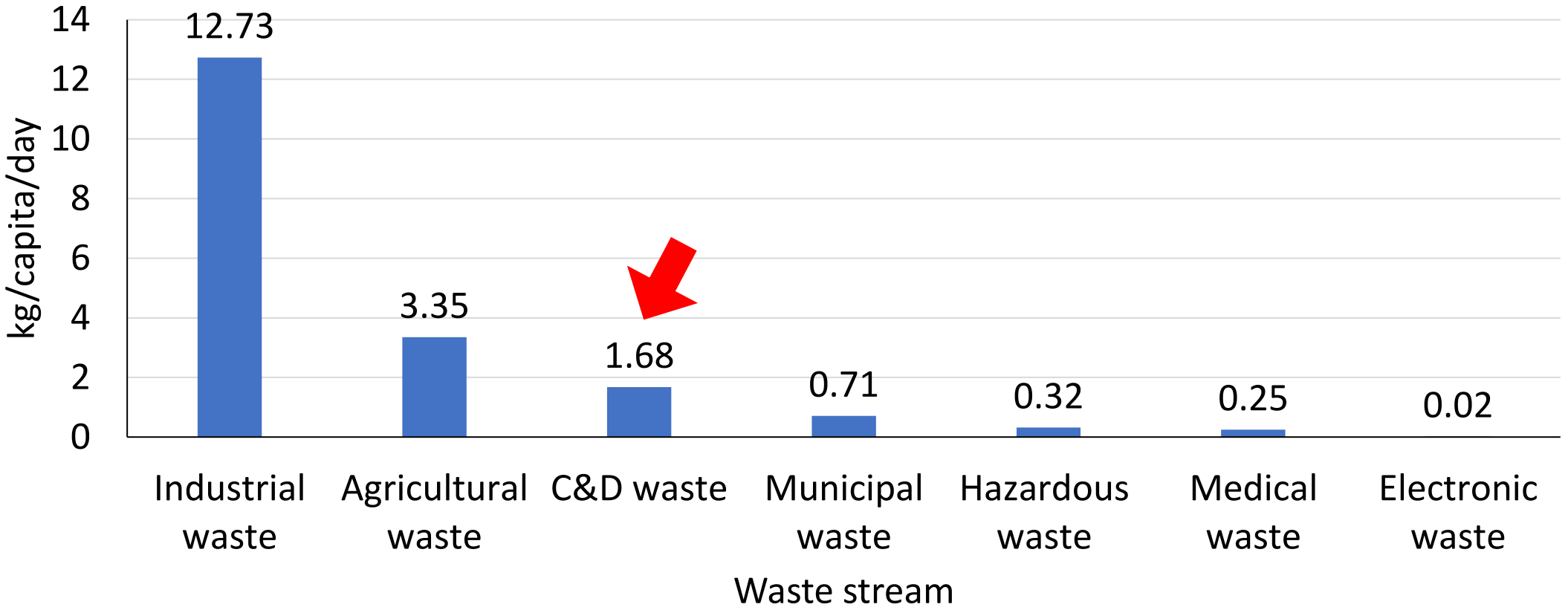



Figure 2: Global average waste generation by streams (Kaza et al. 2018).

# Introduction

- QUANTIFICATION OF C&D WASTE

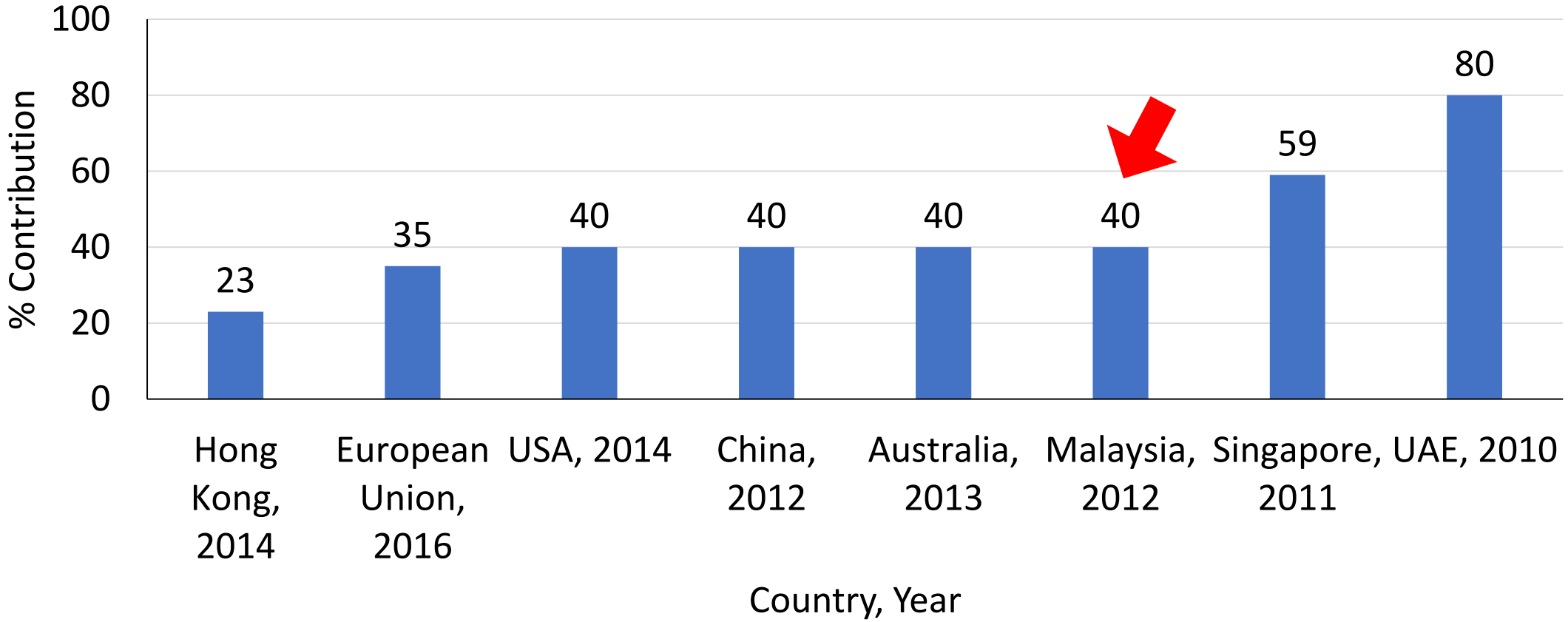
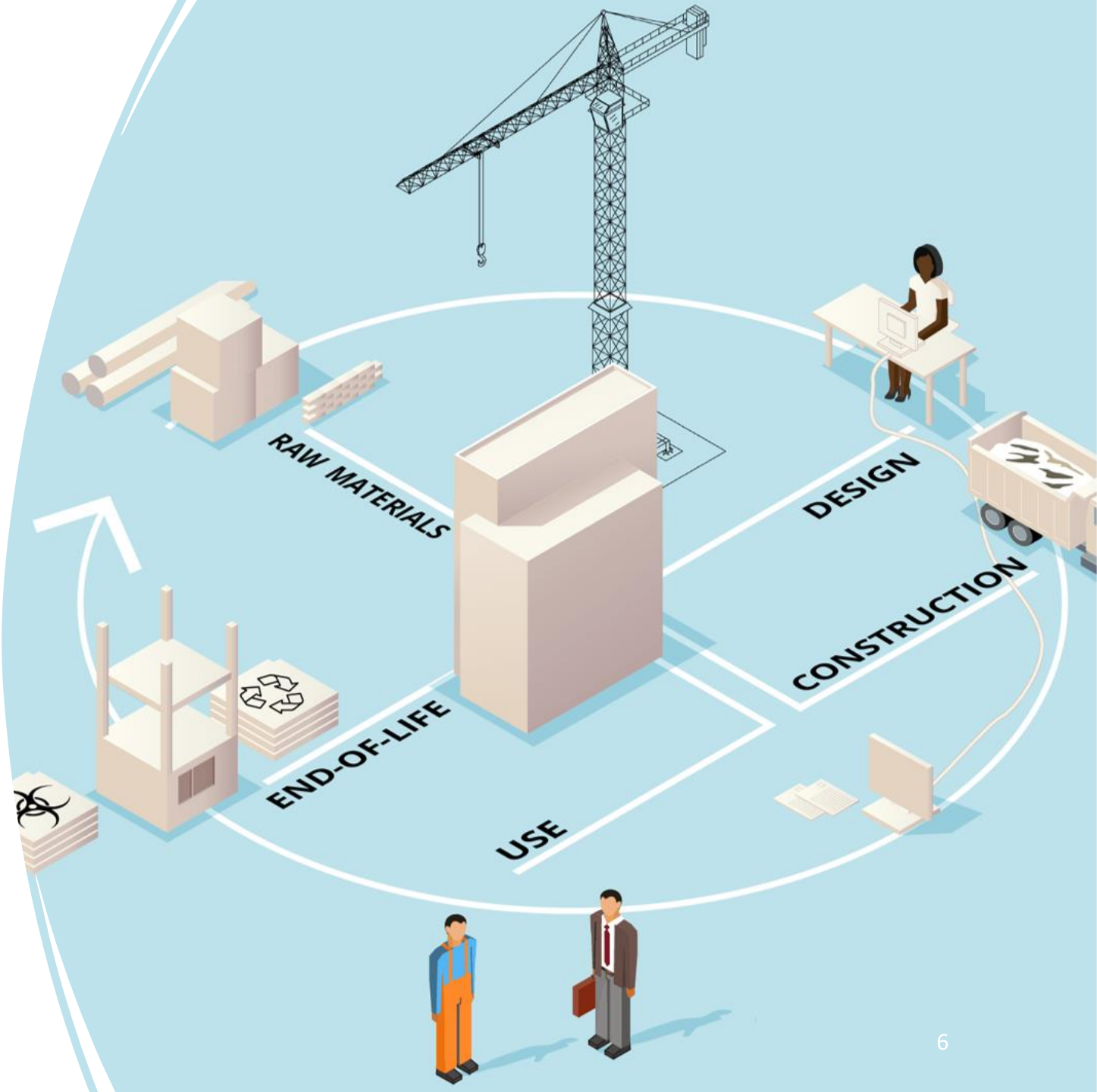



Figure 3: Contribution of C&D waste to total waste generated by various countries (Turkyilmaz et al. 2019)

# CAUSES OF C&D WASTE

- Poor design quality
- Poor material handling
- Improper procurement and planning
- Making inappropriate decisions during design
- Unexpected design changes

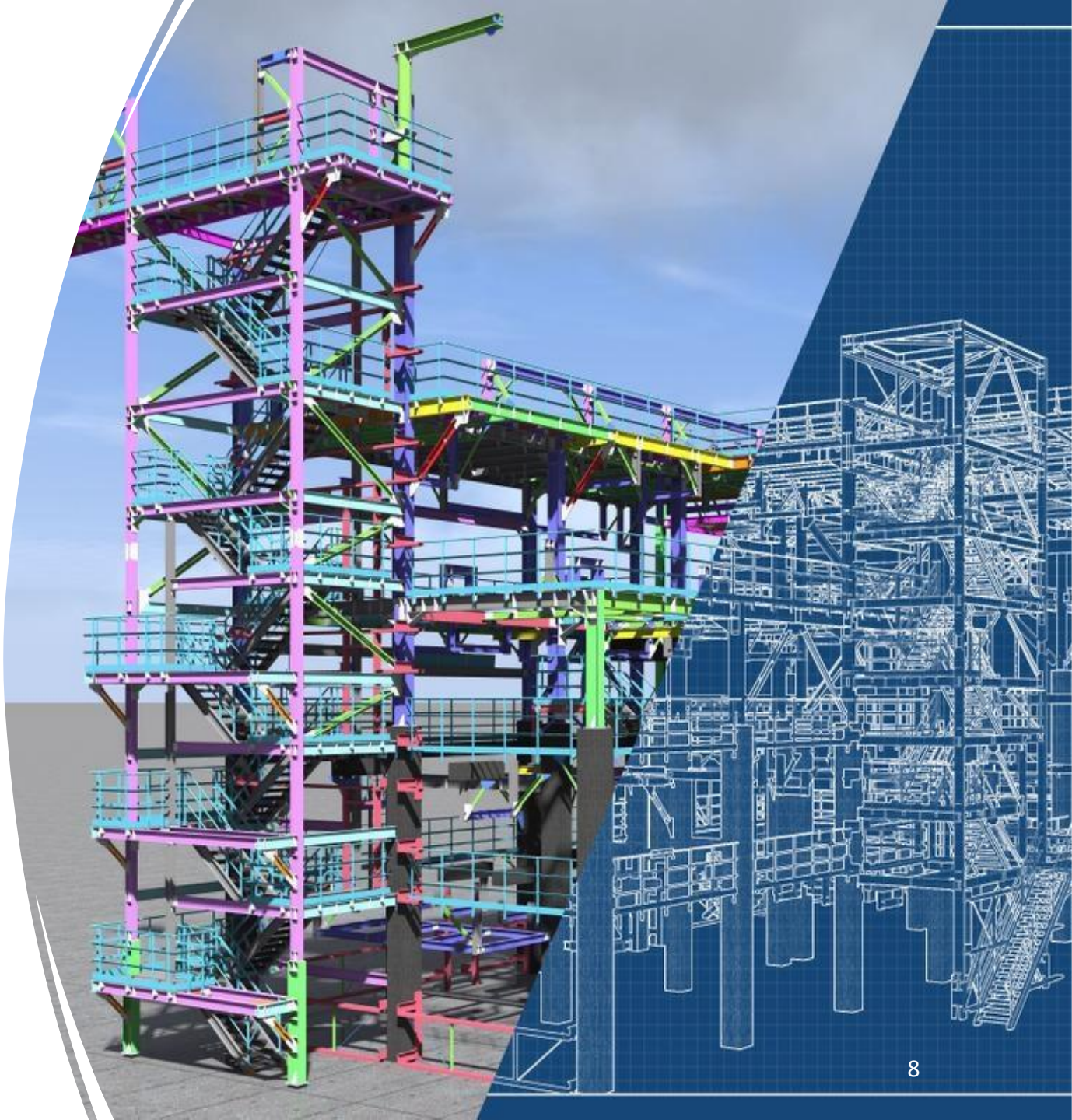


# ADVERSE IMPACTS OF C&D WASTE

- 40-50% of the global output of GHG
- Diminishes landfill space (85% of global waste is landfilled)
- Material waste (On average 4%-30% )
- Increase construction cost by 30%-35%

# BUILDING INFORMATION MODELLING (BIM)

- With such background, the research on CDW Management has attracted major attention worldwide.
- Newly emerging technologies like Building Information Modelling (BIM), Geographic Information System (GIS) and Big Data (BD) have also been gradually adopted to improve the efficiency of CDW Management.
- Among these technologies, BIM has received considerable attention from researchers in CDW Management field (Li et al. 2020).



# Introduction

- Why BIM?

| BIM Dimensions | BIM-based application | Benefits to CDW Management |
|---|---|---|
| 3D | • 3D-Visualisation<br>• Design validation (Clash detection and design review) | Minimize design error and change orders thus reducing rework |
| | • Material quantification | Accurate procurement and CDW quantification |
| 4D | Phase planning | • Improves material handling<br>• Improve efficiency of onsite waste collection |
| 5D | Cost benefit analysis | Comparing between different Waste treatment alternatives |
| 6D | • Recycling and reuse planning<br>• Sustainability analysis | • Identifying onsite reuse opportunities<br>• Reducing Environmental impacts |

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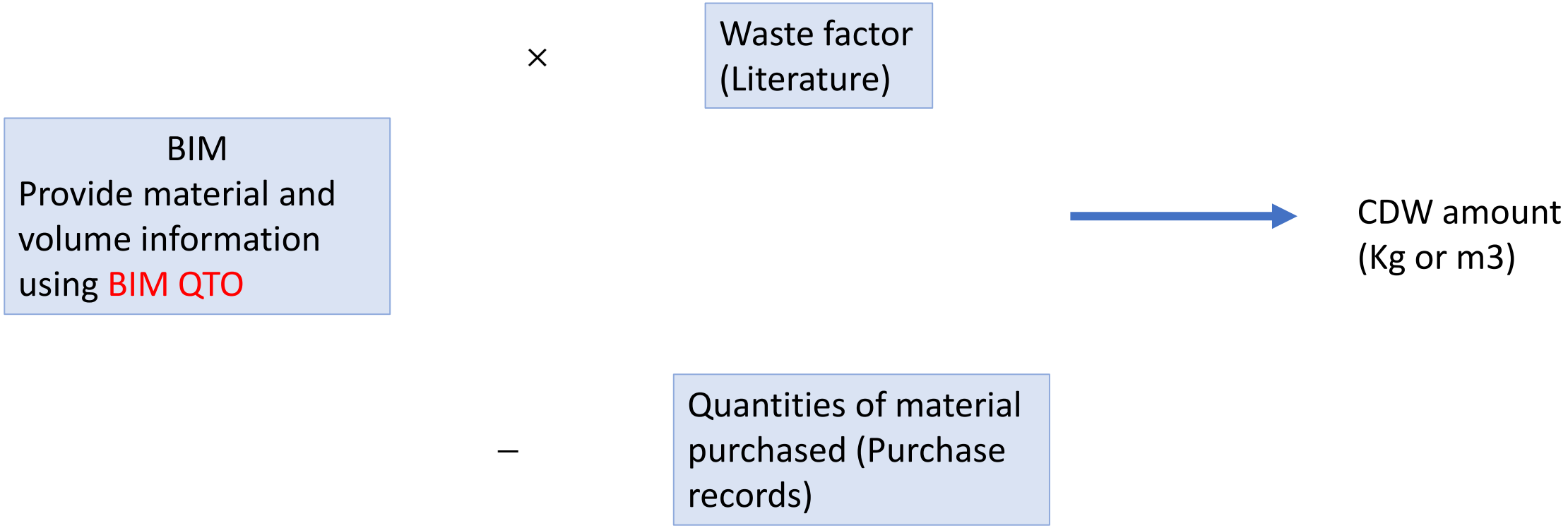
# Introduction

- How BIM estimates CDW amount?



# Problem Statement

- Reviews in BIM for CDW Management field are limited to assessing the potential of BIM for CDW Management and assessment of current BIM for CDW Management tools.
- Due to the current increase in the use of BIM in the Construction Industry (CI) and the rising worldwide awareness of the enormous amount of CDW generated by CI.
- There is a need to look at the gaps and future research direction in BIM for CDW research to aid in reducing Environmental Impacts of CI.

# Aim and Objectives

**Aim**

To identify the gaps and future research direction in BIM for CDW Management field through a scientometric analysis and a qualitative discussion.

**Objectives**

1) To analyze the main research topics and trends within BIM for CDW management field.

2) To identify the current research gaps in BIM for CDW management field.

3) To propose a framework to guide future research directions.

# Methodology

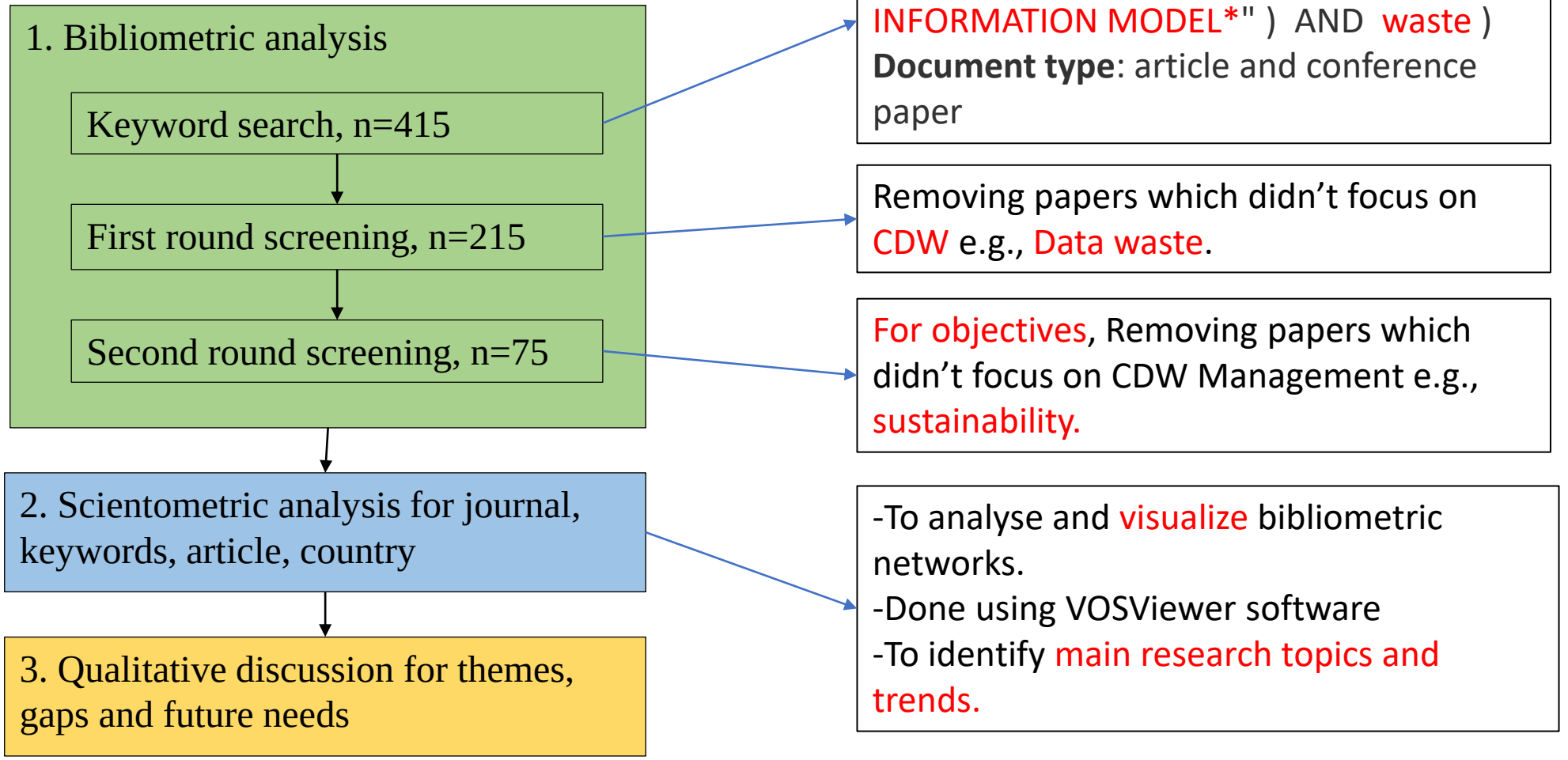



Figure 4: Shows the three-step workflow of the methodology adopted in this research

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# Results and Discussion

- **SCIENTOMETRIC ANALYSIS**

1. Overview of literature sample

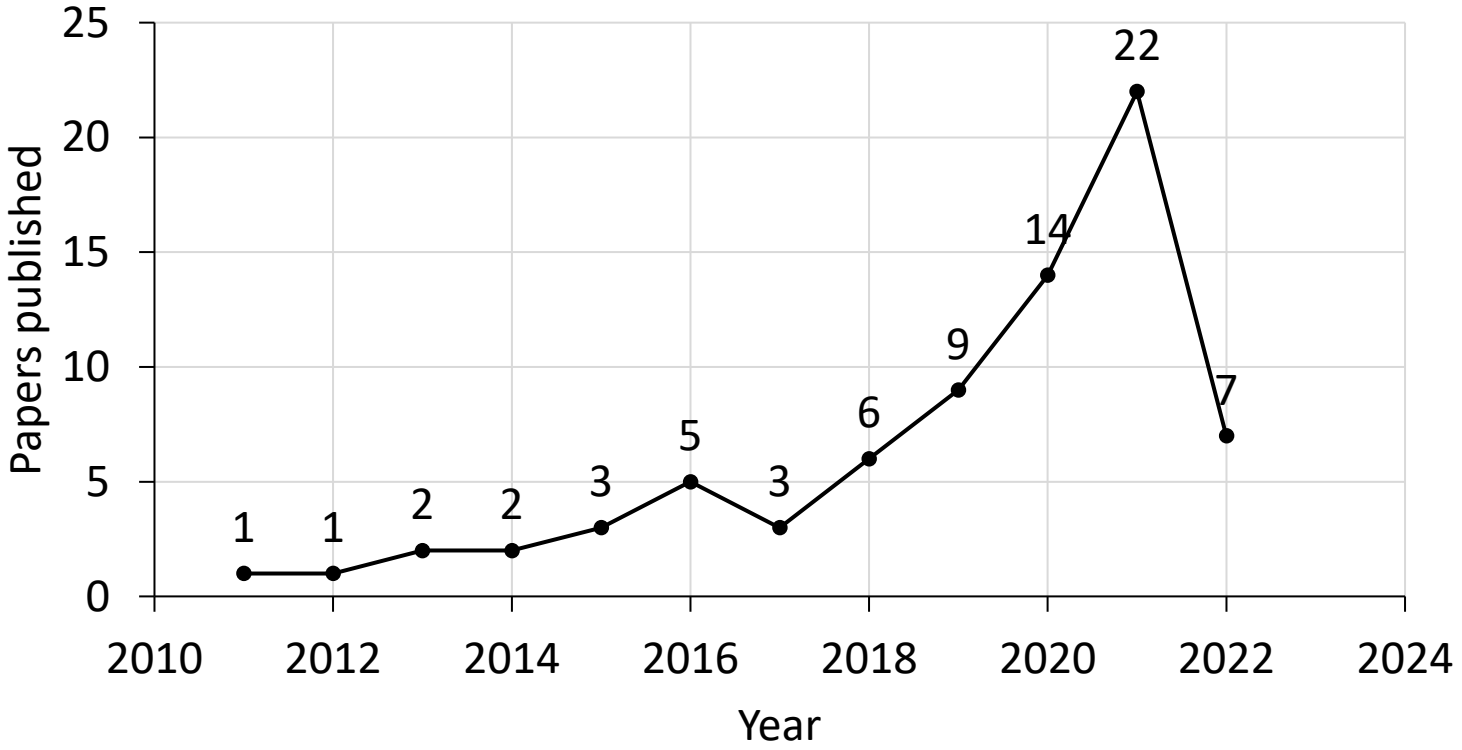


Figure 5: Shows yearly publications of BIM for CDW Management research (Scopus).

- Increase in yearly publication indicating increase research interest in BIM for CDW Management research.

# Results and Discussion

- **SCIENTOMETRIC ANALYSIS**

2. Science mapping of Journal sources

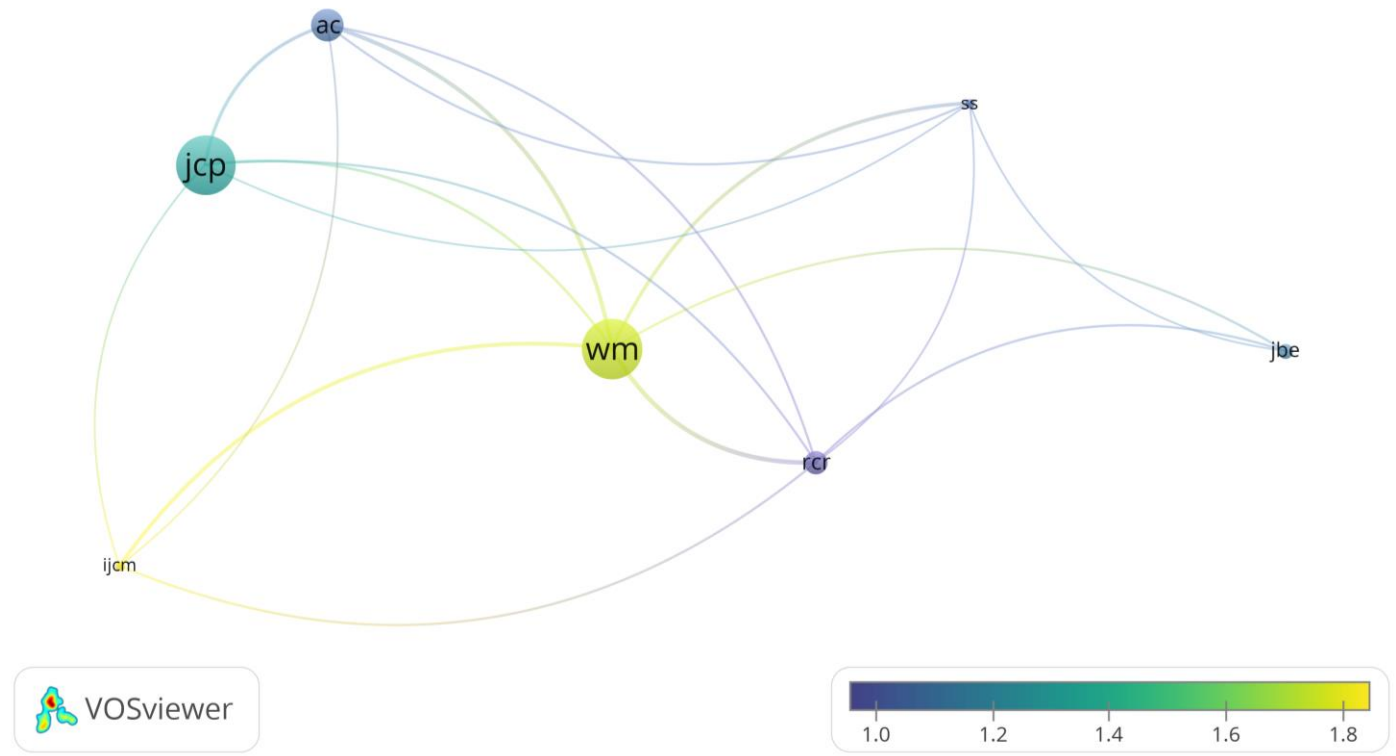


Figure 6: Mapping of journal sources (VOSviewer)

Table 1: Journal sources with their citations

| Source | Number of publications | Total citations | Average Norm. Citation |
|---|---|---|---|
| Waste Management (WM) | 6 | 365 | 1.7 |
| Journal Of Cleaner Production (JCP) | 7 | 363 | 1.3 |
| Automation In Construction (AC) | 6 | 199 | 1.1 |
| Resources, Conservation and Recycling (RCR) | 5 | 140 | 0.95 |
| Journal Of Building Engineering (JBE) | 3 | 93 | 1.14 |
| Sustainability (Switzerland) (SS) | 6 | 51 | 1.08 |
| International Journal of Construction Management (IJCM) | 4 | 41 | 2.02 |

# Results And Discussion

- **SCIENTOMETRIC ANALYSIS**

3. Co-occurrence of keywords

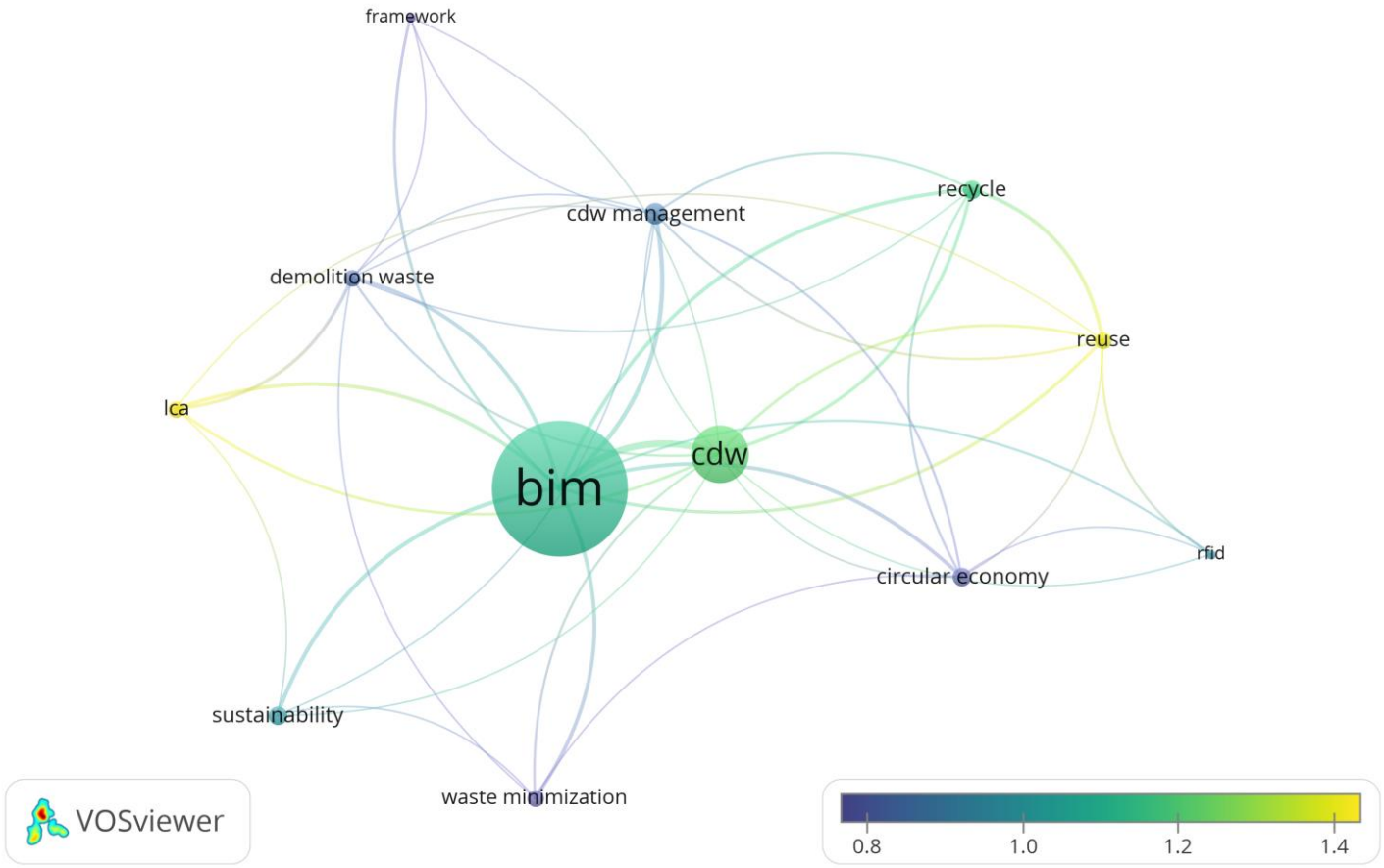


Table 2: Keyword occurrences

| Keyword | Occurrences | Average year published | Average citations | Ave. Norm. Citation |
|---|---|---|---|---|
| BIM | 56 | 2019 | 25 | 1.1 |
| CDW | 24 | 2019 | 24 | 1.2 |
| CDW Management | 9 | 2019 | 20 | 0.9 |
| Circular Economy | 8 | 2021 | 11 | 0.8 |
| Demolition Waste | 7 | 2020 | 17 | 0.9 |
| Framework | 3 | 2018 | 24 | 0.8 |
| LCA | 7 | 2020 | 17 | 1.5 |
| Recycle | 8 | 2020 | 12 | 1.2 |
| Reuse | 7 | 2020 | 21 | 1.4 |
| RFID | 3 | 2019 | 20 | 1.0 |
| Sustainability | 8 | 2019 | 27 | 1.0 |
| Waste Minimization | 7 | 2020 | 12 | 0.8 |

Figure 7: Co-occurrence of author keywords in BIM for CDW Management field.

# Results And Discussion

- **SCIENTOMETRIC ANALYSIS**

4. Citation of articles

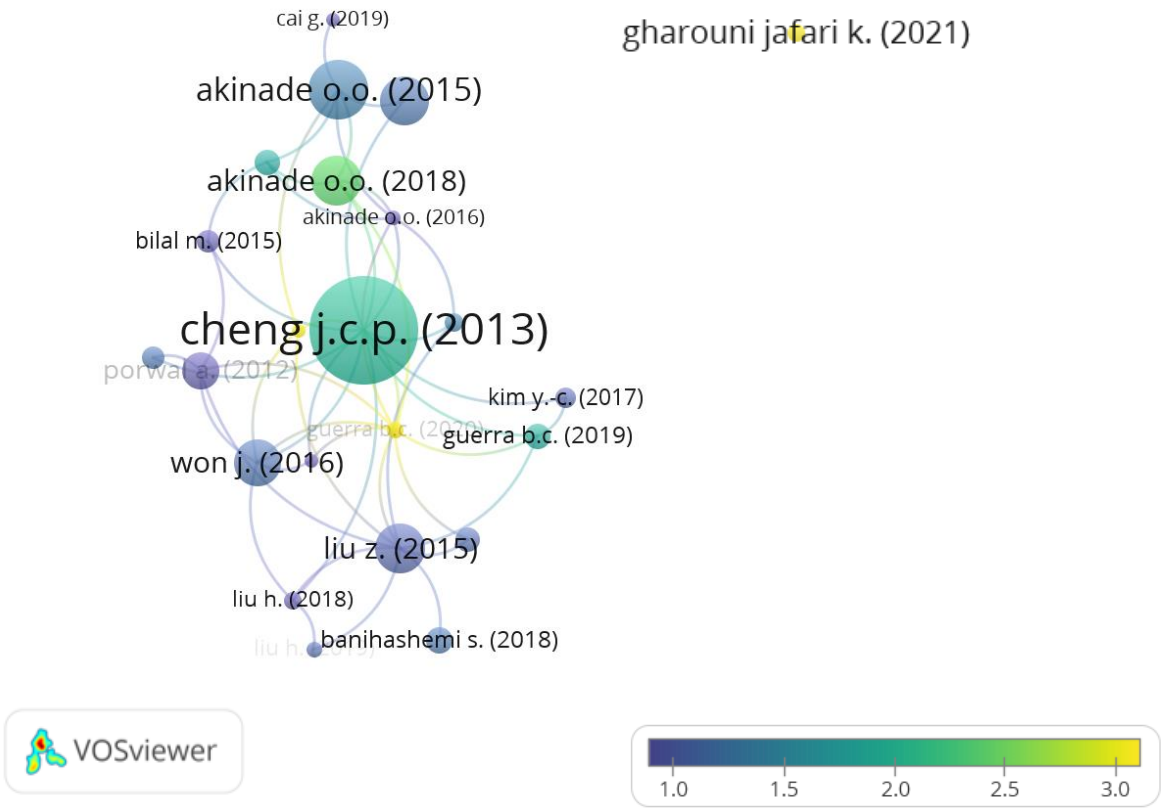


Figure 8: Science mapping of most influential publications in BIM for CDW management research.

Table 3: List of publications with the highest impact in BIM for CDW management research.

| Author | Title | Citations | Average Norm. Citation |
|---|---|---|---|
| Cheng and Ma (2013) | A BIM-based system for demolition and renovation waste estimation and planning | 197 | 1.99 |
| Akinade et al. (2015) | Waste minimisation through deconstruction: A BIM based Deconstructability Assessment Score (BIM-DAS) | 109 | 1.36 |
| Akinade et al. (2018) | Designing out construction waste using BIM technology: Stakeholders' expectations for industry deployment | 91 | 2.37 |
| Guerra, Leite & Faust (2020) | 4D-BIM to enhance construction waste reuse and recycle planning: Case studies on concrete and drywall waste streams | 31 | 3.34 |
| Jalaei, Zoghi and Khoshand (2021) | Life cycle environmental impact assessment to manage and optimize construction waste using Building Information Modeling (BIM) | 26 | 6.22 |
| Gharouni Jafari, Ghazi Sharyatpanahi & Noorzai (2021) | BIM-based integrated solution for analysis and management of mismatches during construction | 21 | 5.02 |

# Results And Discussion

- **SCIENTOMETRIC ANALYSIS**

5. Countries active in BIM for CDW Management research

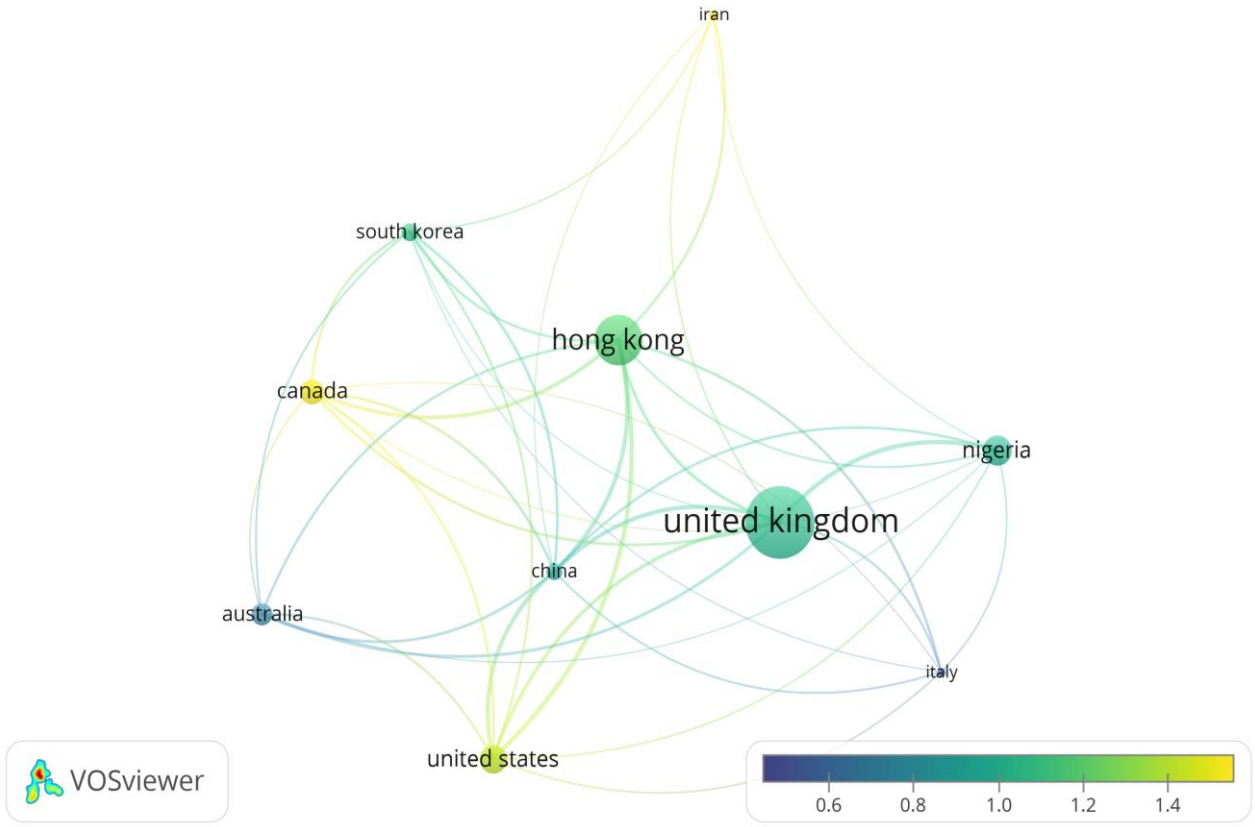


Figure 9: Science Mapping of countries active in CDW management research.

Table 4: Countries active in BIM for CDW Management research.

| Country | Documents | Citations | Average publication year | Ave. Norm. Citation |
|---|---|---|---|---|
| United Kingdom | 10 | 540 | 2018 | 1.0 |
| Hong Kong | 7 | 377 | 2019 | 1.2 |
| Nigeria | 4 | 224 | 2017 | 1.0 |
| United States | 10 | 214 | 2019 | 1.4 |
| Canada | 10 | 185 | 2019 | 1.7 |
| Australia | 8 | 166 | 2019 | 0.7 |
| South Korea | 3 | 137 | 2016 | 1.1 |
| China | 13 | 127 | 2021 | 0.9 |
| Italy | 6 | 72 | 2020 | 0.6 |
| Iran | 3 | 64 | 2021 | 4.4 |

# Results And Discussion

- **QUALITATIVE DISCUSSION**

1. Waste quantification and estimation

| Current research areas | Gaps | Future research direction |
|---|---|---|
| **1) Demolition Waste estimation**<br>**2) Construction Waste estimation** | 1) Little research on use phase waste estimation (e.g., waste due to renovation). | 1) Estimation of renovation waste. |
| | 2) Lack of regional waste volume change factors in most countries. | 2) Research on Volume change factor to aid in accurate waste estimation. |
| | 3) Little research on formwork waste | 3)Estimation of formwork waste. |
| | 4) No clear framework for the use of material schedule generated by 3D modeling software like Revit for CDW estimation. | 4)Investigating universal methods that ensure accurate calculations when using material schedules. |

# Results And Discussion

- **QUALITATIVE DISCUSSION**

2. CDW Environmental Impact Assessment (EIA)

| Current research areas | Gaps | Future research direction |
|---|---|---|
| **End of Life EIA** | 1)Lack of fully automated (dynamic) CDW EIA tools | 1)Development of fully automated tools that can automatically evaluate EI of CDW |
| | 2)Lack of LCA modelling parameters like Building material replacement factor in Use phase and type of treatment in EoL stage. | 2) Refinement of each parameter with the use of statistical estimation and uncertainty analysis. |
| | 3)Lack of trade-off analysis between environment and economy | 3)Conducting trade-off analysis between environment and economy |
| | 4)Landfill charging based on mass/volume alone | 4) Revisiting the landfill charging fee system and taking into consideration Environmental impacts. |
| | 5)Lack of full life cycle EIA of CDW | 5) Conducting full life cycle EIA of CDW |

# Results And Discussion

- **QUALITATIVE DISCUSSION**

3. CDW minimization

| Current research areas | Gaps | Future research direction |
|---|---|---|
| **1)Minimizing CDW due to Poor design quality, inappropriate decisions during design and unexpected design changes.**<br><br>**2)Minimizing CDW due Improper procurement and planning,** | 1) Lack of research on quantification of CDW due to change orders and mismatches in design and as-built drawings. | 1) The use of system dynamics model to comprehensively quantify CDW due to change orders<br>2)Use of machine learning to manage mismatches |

# Results And Discussion

- **QUALITATIVE DISCUSSION**

4. CDW reuse and recycle

| Current research areas | Gaps | Future research direction |
|---|---|---|
| **1) Planning and simulation** | 1)Little research on formwork reuse since formwork make up a large portion of CW. | 1)Further exploration on formwork layout planning, processing, and onsite storage is also encouraged for future work |
| **2)Information technology (i.e., material and component bank, material passport, GIS)** | 2)Little research on concepts like Digital urban mining platform, which would enable a direct use of the demolished materials within new construction projects. | 2)Digital urban mining platform development research |
| **3) Radio frequency identification (RFID) technology.** | 3)RFID technical limitation. Technical operability and recycling of RFID tags seem to currently hinder its uptake for structural components' lifecycle management. | 3)Future technological innovations could provide solutions that would enable RFID to become a mainstream practice. |

# Conclusion

The following can be concluded on BIM for CDWM research area.

1) The BIM for CDW Management field is divided into four areas: CDW quantification and estimation, CDW Environmental Impact Assessment (EIA), CDW minimization and CDW reuse and recycle.

2) The main research gaps include ;-

- Lack of regional dataset of waste volume change factors in most countries
- Lack of trade-off analysis between environment and economy.

3) Future research direction include ;-

- Research on regional volume change factors
- Conducting trade-off analysis between environment and economy.

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# THANK YOU
# FOR YOUR ATTENTION

# Q&A

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