Maponga, K. & Emuze, F. (2024). “A Case for Lean-Based Guidelines for Construction and Demolition Waste Minimization in Zimbabwe”. In D. B. Costa, F. Drevland & L. Florez-Perez (Eds.), *Proceedings of the 32nd Annual Conference of the International Group for Lean Construction* (IGLC32) (pp. 940–941). doi.org/10.24928/2024/0101

A CASE FOR LEAN-BASED GUIDELINES FOR CONSTRUCTION AND DEMOLITION WASTE MINIMIZATION IN ZIMBABWE

Kurauwone Maponga[1] and Fidelis Emuze[2]

ABSTRACT

Construction and Demolition Waste (CDW) significantly costs Zimbabwe, as most waste is directed to landfills, riverbanks, and open spaces. This has made construction practitioners call for efficient strategies such as lean construction (LC). LC could help minimize construction waste in on-site operations. It could reduce land and water pollution and the blockage of watercourses caused by CDW. Minimizing CDW creates cost savings and value for the construction project clients. Although LC has addressed CDW minimization in varying countries, this is not the case in Zimbabwe, where a pressing need for resource efficiency is urgent. Thus, this paper proposes a conceptual framework for evolving LC-based guidelines for minimizing CDW in Zimbabwe. A critical review of relevant literature was conducted to observe how LC tools are utilized to minimize CDW. Given that such a framework could limit the pollution of land and open spaces with CDW, which affects people and the built environment in general, the next phase of the doctoral study would be to test and modify it through mixed methods research empirically.

KEYWORDS

Lean construction, Demolition, Lean, Waste, Pollution, Construction projects, Zimbabwe

INTRODUCTION

According to the Lean Construction Institute (LCI) (2012), Lean Construction (LC) is a manufacturing and production management system that focuses on the elimination of all forms of waste and the creation of value for the client. The focus on LC is on both physical and process waste. The paper concerns physical waste, which is a harmful dilemma because construction and demolition activities are considered the highest waste generators globally (Karaz et al., 2021). The development of lean strategies to minimize CDW is a priority for some countries in the European Union (EU) (Karaz et al., 2021). According to Gálvez-Martos and Istrate (2020), the proper management of CDW is usually associated with high costs due to logistics and the relatively low benefit from its recovery and recycling. The EU has released incentives such as Directive Number 2008 /63/EC to reduce CO2 emissions, encourage recycling, and urge contractors and other professionals in construction to minimize the overuse of materials and the disposal of CDW to open areas and landfill and challenges are being addressed on how to incentivize contractors who comply (Karaz et al., 2021). However, Zimbabwe is lagging in

1 PhD Candidate, Department of Construction Management, Nelson Mandela University, Gqeberha, South Africa, kmaponga@gmail.com, orcid.org/0000-0002-5286-9635

2 Professor, Department of Built Environment, Central University of Technology, Free State, Private Bag X20539, Bloemfontein, 9301, South Africa, Tel: (051) 507 3089, Email: femuze@cut.ac.za. ORCID.org/0000-0001-7714-4457

CDW minimization techniques; hence, the guidelines provided by this study will act as an essential foundation for embracing lean construction.

According to Coşgun, Arslan, and Salgin (2012: 313), "the huge amount of construction waste streams in different countries has revealed the importance of local actions to manage, recycle and re-use the wastes generated through the lifecycle of buildings." Although the application of LC tools for the minimization of CDW has been investigated by several scholars who highlighted their potential (Gomez et al., 2018; Gutiérrez, 2020; Erazo-Rondinel & Huaman-Orosco, 2021; Orihuela et al., 2019; Erazo et al., 2020; Suarez et al., 2020; Ballard et al., 2009 and Ballard, Kim, Jang and Liu, 2007), in Zimbabwe such study is lacking. The construction sector worldwide faces severe challenges due to vast amounts of waste. Accordingly, the call for lean-based guidelines to minimize CDW cannot be overstated. The adoption of lean-based interventions has been shown to offer several benefits. According to Hamzeh and Albanna (2019: 179), "to reap the benefits of Lean Construction, construction companies should integrate, empower, and enable all personnel involved in the construction process whether on or off-site." Thus, in Peru, adopting lean-based guidelines achieved the following benefits: generating and adding value for the client, increasing productivity, reducing CDW, delivering the project on time, and improving communication (Erazo-Rondinel & Huaman-Orosco, 2021).

Despite the potential of lean-based interventions to minimize CDW, Zimbabwe still lags in embracing CDW minimization techniques. Accordingly, this study sought to develop guidelines to promote the adoption of lean-based interventions to improve construction and demolition waste minimization. The paper is part of a doctoral study that aims to develop guidelines for minimizing CDW in the Zimbabwean construction industry.

STATEMENT OF THE PROBLEM

CDW costs contractors and clients' money in Zimbabwe as most of the waste is directed to landfills, riverbanks, roads, and open spaces. In the country, 76% of the CDW produced is disposed of by open dumping, 7% is disposed of by burning, 10% is disposed of by a combination of open dumping and burning, 1% is disposed of by landfilling, and 5% is disposed of using other methods (Jerie, 2018). Limited or no recycling, reuse, or recovering techniques are employed to manage CDW. Figure 1 shows that CDW is often transported to landfills and dumped on roadsides, open spaces, and riverbanks. This leads to the pollution of watercourses and fertile lands. The lack of CDW minimization causes social, environmental, and economic problems. For instance, African countries are keen to overcome these challenges to meet their development and infrastructure needs for the 21st century. It is not news that Africa faces various problems in the construction industry that marginalize its ability to realize sustainable development goals (SDGs). Magadzire and Maseva (2006) suggest that Section 70(3) of the Environmental Management Act (2007) of Zimbabwe encourages the use of sustainable techniques for CDW management. The major hindrance is that the technology and knowledge needed to employ the techniques are unavailable. The Public Health Act (1996) of Zimbabwe stresses that the producers of waste should manage all forms of waste. The Act prohibits waste production and dumping on lands that the waste producers do not control. Waste producers are expected to transport and manage the waste; however, the Act is silent on the 3Rs: recycling, recovery and reuse, and lean construction techniques.

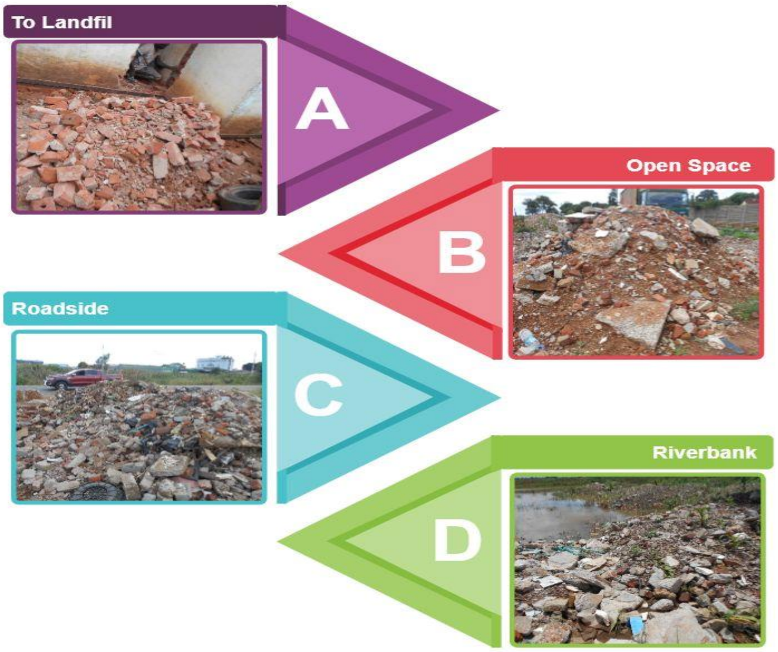

Figure 1: Disposal of construction and demolition wastes in Zimbabwe (Source: 2023 field survey of doctoral researcher)

According to the Environmental Management Act (2007) of Zimbabwe, a permit is supposed to be acquired for CDW disposal, fines are paid for illegal CDW disposal, and companies disposing hazardous waste into any waters or on the environment are made to remove their toxic waste and pay for environmental restoration. The Act also stipulated that a license should be acquired for transporting toxic waste, and construction sites generating CDW must minimize the CDW through treatment, reclamation, and recycling. Although some statutory instruments such as the Harare Waste Management by-law (SI 127 of 1981), Waste Management by-law (SI 477 of 1979) and (SI 185 of 1981) and other policies such as the Sustainable Strategy Policy and the Environmental Impact Policy exist, poor waste management of CDW in Zimbabwe persists because of lack of enforcement, lack of equipment and lack of expertise (Magadzire & Maseva, 2006).

The management of CDW in Zimbabwe can be improved by embracing several changes in design, communication, cost, scope, safety, and quality. Design aspects require changes to include more standardization, modularization, and modeling. The design must be done for CDW minimization to minimize offcuts, reworks, and defects. The design must include recyclable and reusable materials. Cost and scope aspects need to change to include more local and sustainable materials. The storage and transportation of CDW can cause cost aspects. Construction processes need to minimize the use of energy and environmental degradation. Safety and quality changes will help improve health and safety and reduce waste in materials, time, overproduction, delays, and unnecessary inventory. Legal and environmental constraints also come in, as CDW can cause pollution, and the Environmental Management Authority (EMA) can impose lawsuits. Communication and coordination will help minimize the time constraints for sorting and transporting CDW.

Tackling the poor handling and proliferation of CDW is one way to close this gap. The study thus sought responses to the following research questions:

- How will lean tools and techniques enhance CDW minimization practices in Zimbabwe?
- What lean-based guidelines would minimize the negative impacts of CDW in Zimbabwe?

Although exhaustive responses to these questions are beyond the scope of this conceptual paper, an attempt is made to present a framework that could aid the effort. The theoretical background of the framework is presented in the next section of the paper.

LEAN CONSTRUCTION AND CDW MINIMIZATION

According to Forbes and Ahmed (2020), LC is a technique used to design production and construction systems to minimize waste of time, materials, and effort to generate value for the client. Tommelein and Ballard (2016) define LC as applying lean thinking to the design and construction of construction projects. This means that effectively implementing LC tools and techniques will help minimize the materials used and save time. Salem et al. (2006) pointed out that the lean construction principles for the construction industry are transparency, process variability, continuous improvement, and flow variability.

Pedo et al. (2021) say that LC can enhance CDW minimization through early identification of requirements for process standardization and systematic waste analysis and offer accurate information regarding the materials and building systems, which allows stakeholders to decide on design early to provide reduced reworks, design iterations, and product visualization. Lean tools can help minimize CDW generation by allowing stakeholders to make critical decisions early, which helps minimize work variations, and reworks can be a source of CDW. According to Mawed et al. (2020), poor communication leads to project reworks, which generate CDW. Erazo-Rondinel and Huaman-Orosco (2021: 547), say "Even the construction industry in Peru is still working in silos, focusing objectively only on the project stage they oversee; however, client value mapping is still minimal." Employing lean-based CDW minimization techniques can help provide value for the client and reduce the amount of CDW produced on a construction site.

Najafpoor et al. (2014) stated that, in developed countries, 35 to 50% of the waste produced is CDW. Azmy and El-Gohry (2017) posit that one-third of domestic waste in Egypt is CDW. Elshaboury and Marzouk (2020) reported that CDW generated in the United States (US) amounts to 569 million tonnes, in Europe 330 million tonnes; in Germany 324.38 million tonnes; in Lebanon 9.6 million tonnes; and in Egypt 3.65 million tonnes. According to Huang et al. (2018), China produces an estimated CDW of 30-40% of the total waste. Ballard and Howell (2003) confirmed that 50% of construction waste goes to landfills, only 18% is recycled, and about 32% is reused. A case example will help to illustrate the CDW challenge in developing countries. In the example, Bajjou and Chafi (2018) note that poor project management and delivery in Egypt has caused CDW to proliferate, although there is a low level of use of LC in the sector. The use of LC would improve processes, project planning, inventory, time savings, health and safety, risk management, quality, and productivity, apart from customer value, improved decision-making, employee satisfaction, and better energy consumption (Shaqour, 2022). Reworks due to defects, material transportation, and overproduction caused a lot of CDW in the Egyptian construction industry, and the benefits of lean construction included reduced reworks and overproduction (Shaqour, 2022).

THEORY OF PLANNED BEHAVIOUR

The theory of planned behavior (TPB) was developed by social psychologists (Ajzen, 1991). The theory captures motivational factors influencing behavior. TPB expresses how hard people are willing to try to perform the behavior (Ajzen, 1991). In TPB, norms, attitudes, and perceived behavior control will have a physiological effect on workers' intended behavior in terms of the reuse, recovery, reduction, and recycling of materials (Ajzen, 2015 and 1991). The TPB postulates that project stakeholders' attitudes, CDW regulatory frameworks, CDW minimization techniques, and CDW project life cycle can lead to effective CDW management (Kabirifar et al., 2020). The most widely utilized CDW management technique encompasses reducing, reusing, and recycling strategies (Huang et al., 2018). CDW techniques involving reduce, reuse, and recycle strategies have been considered the most effective way to manage CDW (Kabirifar et al., 2020). Therefore, reducing, reusing, and recycling techniques will be a part of the Zimbabwean lean-based guidelines.

The application of lean-based CDW minimization is discussed based on best industrial practices from various countries. Kabirifar et al. (2020) developed a framework based on the TPB in Australia. The authors added that the regulatory frameworks involving rewards, incentive mechanisms, taxes on waste disposal and landfilling, and sustainable CDW management hierarchy are effective ways to manage CDW. According to Jahan et al. (2022), nearly 30% to 40% of total solid waste is generated globally, and in Australia, the amount of CDW increased by 61% from 2006 to 2017. They added that some Australian states achieved better CDW management from 2018–2019, where the State of Victoria and South Australia achieved 87% and 91.4% CDW recycling, respectively. Even with such efforts, 6.7 million tons of CDW went to landfills. Jahan et al. (2022) assert that prioritizing waste minimization and management are crucial to building a circular economy. The authors added that subjective attitudes and personal reluctance of designers and material suppliers to exercise waste mitigation techniques are crucial. Another effective CDW minimization strategy involves the designing out of the CDW; design for CDW minimization is also a practical approach to CDW minimization (Baldwin et al., 2009). The Australian government is emphasizing the use of BIM (Jahan et al., 2022). The industry lacks the utilization of BIM, CAD, and prefabrication because the effective utilization of prefabricated components could significantly minimize about 84.7% of construction waste (Jaillon et al., 2022).

RESEARCH METHODOLOGY

The paper is based on a literature review of LC principles. The conceptual framework was developed from working ideas in other countries. The literature was sourced from, Science Direct, LC textbooks, and the International Group of Lean Construction IGLC) conference papers. The keywords for the search included “lean construction”, “lean-based CDW management”, “lean tools”, and “lean-based CDW case studies”. An attempt was made to utilize the latest articles. Content analyses were utilized for conceptual framework development.

CONCEPTUAL FRAMEWORK

Figure 2 shows the proposed framework for the lean-based guidelines for minimizing CDW in Zimbabwe. The guidelines are hinged on CDW recycling, recovery and reuse, proper lean construction training, just-in-time deliveries, standardization of a worker rewards system, and proper regulatory frameworks. Achieving this helps come up with guidelines that can be utilized to minimize CDW on construction sites. The guidelines can aid in identifying further CDW issues as many huddle meetings, brainstorming, and planner systems will be used to gather feedback from workers; this can aid with continuous improvement.

The lean tools are implemented by the TPB stages of CDW stakeholders' attitude buy-in, CDW regulatory framework, utilized CDW tools, and CDW project life cycle standardization. The utilized CDW management lean tools will include the Last Planner System (LPS), Just-in-time (JIT), Continuous Improvement, 5S, and Flow Systems. The selected lean tools can be taught and adapted for utilization in developing countries. Stakeholders' buy-in and human resources training can be done through seminars, huddle meetings, and webinars. Stakeholders are essential because CDW minimization is a collective effort focused on reuse, reduce, and recycle techniques (Lu et al., 2015). CDW regulatory frameworks can be created by having rewards and incentives and lobbying for reduced taxes. The utilized on-site CDW minimization strategies will include reducing, recovering, reusing, and recycling. Last planner decisions on what to recycle will be used, the material will be delivered just in time (JIT), and there should be clear communication. The last stage of CDW project life cycle standardization will be standardizing a CDW process and rewarding practice. Lean CDW minimization should include all stakeholders because contractors and sub-contractors also affect the generation, recycling, reduction, and reuse of CDW through their attitudes (Saunders and Wynn, 2004).

The second column of the framework (Figure 2) shows the lean tools and activities utilized. The first stage of worker training uses seminars, huddle meetings, improved visualization, communication, and continuous improvement procedures. Training has benefits in column three, including improved communication, standardization, and reduced variability. The second stage of regulatory frameworks uses rewards, incentives, and lobbying for clear CDW policies on-site and in the country. Regulatory frameworks have the intended benefits of stakeholder buy-in, worker compliance, and waste stream identification. The utilized lean tools for CDW minimization in the next stage of the CDW minimization hierarchy include the LPS, which gives workers the autonomy to make decisions on CDW continual process improvements, reduced pollution, and reduced inventory. This helps minimize lawsuits caused by illegal CDW dumping. The last stage of the environmental life cycle will utilize 5S for site sorting, storage, and transfer of CDW. Information from the literature thus informed the proposed Lean CDW conceptual framework for Zimbabwe, as illustrated in Figure 2. Bajjou et al. (2018) stated that developing a lean-based conceptual framework helps show good practice and procedure. Figure 2 involves three main strands: TPB components, lean tools and activities, and client focus and benefits.

Theory of Planned Behaviour Components	LEAN TOOLS AND ACTIVITIES		CLIENT FOCUS AND BENEFITS
Norms and Worker Attitudes Stakeholder Engagement and buy-in 1	- Training	-Persuade management -Seminars, Improve CDW awareness -Webinars	• No variability • No miscommunication • Simplify CDW process • Simplify the training • Compress cycle times • Change acceptance
	- Improved communication	-Involve employees and open communication flow	
	- Huddle meetings - Weekly kaizen meetings	-Worker feedback -Educate all subcontractors	
Sustainability Frameworks Circular Economy 2	- JIT deliveries	-Procurement plan	• No inventories • Stakeholder buy-in • CDW quantification • Supplies done on time • Identification of CDW-producing streams
	- Value Stream Mapping	-Identify, understand current waste minimisation strategy	
	- Define-Measure-Analyse-Improve-Control (DMAIC)	-Define, Measure, Analyse, Improve and Control noting CDW problems	
CDW Hierarchy and Techniques Circular Economy 3	- Continuous improvement	-Brainstorm and refine procedures	• Last planner decisions by workers • Regulatory frameworks • Design for waste management
	- LPS	-Involve all workers	
	- BIM	-Build from BIM models	
	- 4Rs	-Recycle, Reduce, Reuse and Recover	
CDW Environmental Impact Life Cycle Assessment 4	- Standardisation of procedure	-Select on site CDW storage area -Select team, CDW sorting. Transfer. -CDW collection and transport -Rewards, incentives, taxes on waste disposal -Create continuous flow of work, refine procedure	• Increase customer value • Results analysis of recorded processes • Knowledge consolidation • Rewards and appraisals of workers who did well

Figure 2: Conceptual framework for lean-based guidelines for construction and demolition waste minimization in Zimbabwe (Source: Researcher's construct)

DISCUSSION

The guidelines target construction companies registered with the Construction Industry Federation of Zimbabwe. The construction project manager will spearhead implementing and managing the guides on the construction site. The skilled and semi-skilled workers will then implement the guidelines practically. Thus, an essential user guide is proposed to ensure effective implementation of the developed conceptual framework.

STEP 1: CONDITIONING OF WORKER NORMS AND BEHAVIOUR BY TRAINING

In step 1, training, huddle meetings, and improved communication will be utilized. Training employees in the organization and hiring new workers ensures the availability of the skills and expertise needed in the lean implementation phase (Watfa, and Sawalha, 2021). The project operation phase provides data and analysis, which creates a valuable database, which enhances learning capability (Moradi and Sormunen 2022). It is essential to document Lean guidelines, which specify the plan and scope of implementation (Watfa, and Sawalha, 2021). The conceptual framework provides a construction project lifecycle-based application of LC tools and techniques, which makes it easy to understand for project practitioners (Moradi and Sormunen 2022).

STEP 2: SUSTAINABILITY AND REGULATORY FRAMEWORKS

In step 2, the lean tools JIT, VSM, and DMAIC will be used to define and understand CDW generating streams. The second stage of regulatory frameworks uses rewards, incentives, and lobbying for clear CDW policies on-site and in the country. Regulatory frameworks have the intended benefits of stakeholder buy-in, worker compliance, and waste stream identification. A conceptual framework with sustainability frameworks has the advantage of mixing sustainability and LC for client value and delivery (Moradi and Sormunen 2022).

STEP 3: CDW MINIMIZATION HIERARCHY, TECHNIQUES

In step 3, CI, LPS, BIM, and 4Rs will be utilized as these tools can help with brainstorming, involving workers, modeling, and recycling of CDW. Engagement of all employees is a key element that supports and encourages management of resistance to change (Watfa, and Sawalha, 2021). Individual application of LC tools has fewer benefits and is more effective when integrated and used together (Moradi and Sormunen 2022). Karaz et al. (2021) defined LPS as collaboratively planning and controlling work processes. Supervisors and operatives are the last planners, as they are also involved in CDW minimization.

STEP 4: CDW ENVIRONMENTAL IMPACT LIFE CYCLE MANAGEMENT

Step 4 will involve mainly concretizing and standardizing perfect procedure. JIT is producing and delivering the right items at the right time in the right amounts and is used to reduce variation and waste (Ballard, 1995). Continuous Improvement (CI) is a procedure done by clearly documenting and constantly checking back to look for causes of CDW and find solutions (Marzouk et al., 2019). CI is an incremental, ongoing procedure to improve products, processes, and services (Imai, 1986). It is practically impossible to utilize all the discussed LC tools in this study as the resources required to do so may not be accessible. Table 1 gives the important lean implementation steps.

Studies by Bansal and Sing (2013), Akhtar and Ahmar (2018), Jin et al. (2019), Xing and Hao (2019), Shooshtarian et al. (2019), and Ghosh et al. (2020) have shown that standardization of 3D visualization and the 3Rs are the most common lean tools in CDW minimization cases. The cases given by the authors showed that LPS, GPS, GIS, BIM, CAD, daily huddle meetings, in-time inspections, incentives, and penalties utilized lean CDW minimization strategies. Clear policies, research, action cards, 5S system, clear communication, and pull planning were the third most effective techniques for CDW minimization. The last techniques that can be utilized are constraint analysis, prefabrication, clash detection, field software, and 5 WHYS.

Table 1: Application of the lean tools in the proposed framework

Lean Tools Applied	Important Implementation Steps	Source	Targeted Challenges
Value stream mapping (VSM)	Uses flow charts to depict every work process. Identify and monitor CDW-generating work areas.	Hamzeh and Albanna (2019)	Quality, Site organization, environmental and legal
Just-In-Time (JIT)	Procurement plan. Producing and delivering the right items at the right time in the right amounts	Karaz et al., (2021)	Reduced inventory
Six Sigma	Split smaller work processes and reduce the changeover of tasks.	Al-Aomar (2012)	Cost, legal, and environmental
Kanban	Card systems devised by the automotive industry produce or procure only parts needed at a particular time.	Marzouk et al., (2019)	Time and quality
Last Planner System, clear visualization, and 5S	Planning work collaboratively. Rules for workplace housekeeping. Include (Sort), (Set in order), (Shine), (Standardize), and (Sustain).	Enshassi and Zaiter (2014)	Clear communication, environmental sustainability
Continuous Improvement	Documenting and always checking back work for improvement.	Marzouk et al., (2019)	Communication, Time, and cost
BIM	Digital representation of the building. Models could be utilized.	Steel et al. (2012);Marte et al. (2012)	Scope design for CDW minimization.
Daily huddle meetings	Short everyday meetings focus on CDW-specific issues.	Memon et al. (2018).	Feedback meetings

CONCLUSION

The minimization of CDW in Zimbabwe has been an issue, as most of them are dumped on roadsides, watercourses, open spaces, and landfills. Some of the CDW is used for filing road potholes and as low-cost building hard cores, just improvisations of materials not intended for them. By applying lean-based CDW minimization guidelines, the contractors can minimize the environmental and health impacts of CDW, which are dumped everywhere. The guidelines can help minimize project reworks and work variability and increase customer value. In addition, Zimbabwean contractors can find the causes of CDW and develop more effective waste minimization techniques. The study, therefore, is just a preliminary step of a doctoral thesis; the study will provide further guidelines and recommendations from practicing construction industry professionals as more and more professionals will be consulted.

REFERENCES

Ajzen, I. (1991). The theory of planned behavior. In: Journal of Organizational Behavior and Human decision processes 50(2) 179-211. https://doi.org/10.1016/0749-5978(91)90020-T.

Al-Aomar, R. (2012). Analysis of lean construction practices in Abu Dhabi construction Industry. Lean Construction Journal, pp.105-121.

Ahmed, S., Hossain, M, M. and Haq, I. (2020). Implementation of lean construction in the construction industry in Bangladesh: awareness, benefits, and challenges. International Journal of Building Pathology and Adaptation. 2020;39 (2):368–406. doi: https://doi.org/10.1108/IJBPA-04-2019-0037.

Akhtar, A. and Sarmah, A. K. (2018). Construction and demolition waste generation and properties of recycled aggregate concrete: A global perspective. In: Journal of Cleaner Production. 186: 262-281. https://doi.org/10.1016/j.jclepro.2018.03.085.

Azmy, A., and El-Gohary. R. (2017). Environmental and sustainable guidelines for integrated municipal solid waste management in Egypt. Sage Journals. 38(4): 371–382. https://doi.org/10.1177/0734242X20901568.

Bajjou, M. S. and Chafi, A. (2018). Lean construction implementation in the Moroccan industry: Awareness, benefits and barriers. Journal of Engineering, Design and Technology, 16(4): 533-556. https://doi.org/10.1108/JEDT-02-2018-0031.

Baldwin, A., Poon, C. S., Shen, L. Y., Austin, S. & Wong, I. (2009). Designing out waste in High-rise residential buildings: Analysis of precasting methods and traditional construction. In: Renewable Energy Journal, 34(9) 2067–2073. https://doi.org/10.1016/j.renene.2009.02.008.

Ballard, G. and Tommelein, I. (2016). Current Process Benchmark for the Last Planner System. http://p2sl.berkeley.edu/wp-content/uploads/2016/10/Ballard_Tommelein-2016- Current-Process-Benchmark-for-the-Last-Planner-System.

Ballard, G., Kim, Y.W., Jang, J.W. and Liu, M. (2007). Road Map for Lean Implementation at the Project Level, Research Report 234-11, Construction Industry Institute, The University of Texas at Austin, Texas, USA, 426. https://www.academia.edu/18828914/Roadmap_for_Lean_Implementation_at_the_Project_Level.

Ballard, G., Hammond, J. and Nickerson, R. (2009) Production control principles. In: Proceedings of International Group for Lean Construction (IGLC-17) International Conference, Taipei, Taiwan, 15-17 July 2009. https://iglc.net/papers/Conference/19.

Ballard, G. (1995). Towards construction JIT. https://www.academia.edu/811455/Toward_.

Ballard, G. & Howell, G. A. (2003). An Update on Last Planner. In: Proceedings of the 11th Annual Conference of the International Group for Lean Construction. Virginia, USA. 22-24 July 2003. Pp. 1–13. https://iglc.net/Papers/Details/227.

Coşgun, N., Arslan, H. and Salgin, B. (2012). Construction and demolition waste management in Turkey. Department of Architecture, College of Engineering, Technology and Architecture, Hartford University, West Hartford. https://doi.org/10.5772/46110.

Emuze, F. & Mpembe, W. 2021. A Case-Based Study of Lean Culture Among South African Contractors, Proc. 29th Annual Conference of the International Group for Lean Construction (IGLC) , 353-362. doi.org/10.24928/2021/0104

Elshaboury, N. & Marzouk, M. M. (2020). Optimizing construction and demolition waste transportation for sustainable construction projects. Engineering Construction and Architectural Management,28(9):2411–2425.https://doi.org/10.1108/ECAM-08-2020-0636.

Enshassi, A. and Zaiter, M, A. (2014). Implementation of Lean Tools on Safety in Construction Projects in Palestine. In: Proceedings of the Annual 22nd Conference of International Green Lean Construction. Oslo, Norway, June 2014. pp 1205-1218.

Erazo-Rondinel, A. A. & Huaman-Orosco, C. 2021. Exploratory Study of the Main Lean Tools in Construction Projects in Peru, Proc. 29th Annual Conference of the International Group for Lean Construction (IGLC) , 542-551. doi.org/10.24928/2021/0213

Forbes & Ahmed (2020). Morden Construction: Lean Project Delivery and Integrated Practices. 2nd Edition. New York, NY: Routledge.

Gálvez-Martos, J. L. and Istrate, I. R. (2020). Construction and demolition waste management. In: Pacheco-Torgal, F., Ding, Y., Colangelo, F., Tuladhar, R. and Koutamanis, A. (eds). Advances in construction and demolition waste recycling. Woodhead Publishing, Berlin, pp. 51–68. Available at: https://doi.org/10.1016/B978-0-12-819055-5.00004-8.

Gomez, S. , Ballard, G. , Naderpajouh, N. & Ruiz, S. 2018. Integrated Project Delivery for Infrastructure Projects in Peru, 26th Annual Conference of the International Group for Lean Construction , 452-462. doi.org/10.24928/2018/0506

Ghosh, S., Bhattacharjee, S., Bozorgi, P. P. and Ganapathy, R. (2020). A case study to examine environmental benefits of lean construction. In: Proceedings of the 22nd Annual Conference of the International Group for Lean Construction. Oslo, Norway, 13-21 June. https://iglcstorage.blob.core.windows.net/papers/attachment-f9b0342f-8961-4f93- 93ec-1bae441c2888.pdf.

Lazarte, F. M. G. 2020. Influence of Integrated Teams and Co-Location to Achieve the Target Cost in Building Projects, Proc. 28th Annual Conference of the International Group for Lean Construction (IGLC) , 733-744. doi.org/10.24928/2020/0109

Hamzeh, F. & Albanna, R. 2019. Developing a Tool to Assess Workers' Understanding of Lean Concepts in Construction, Proc. 27th Annual Conference of the International Group for Lean Construction (IGLC) , 179-190. doi.org/10.24928/2019/0241

Huang, B., Wang, X., Kua, H., Geng, Y., Bleischwitz, R., Ren, J. (2018). Construction and Demolition waste management in China through the 3R principle. In: Journal of Resources, Conservation, and Recycling, 129 (2018) 36-44.https://doi.org/10.1016/j.resconrec.2017.09.029.

Imai, M. (1986). Kaizen: The Key to Japan's Competitive Success. McGraw-Hill Education, New York.

Jahan, I., Zhang, G., Bhuiyan, M., Navaratnam, S. and Shi, L. (2022). Experts' Perceptions of the Management and Minimisation of Waste in the Australian Construction Industry. In: Sustainability Journal 2022, 14 (11319): 34-46. https://doi.org/10.3390/ su141811319.

Jaillon, L., Poon, C.S. and Chiang, Y.H. (2009). Quantifying the waste reduction potential of Using prefabrication in building construction in Hong Kong. In: Waste Management Journal. 29, (1): 309–320. Doi: 10.1016/j.wasman.2008.02.015.Epub 2008 Apr 22.

Jerie, S. (2018). The role of informal sector solid waste management practices to climate change abatement: A focus on Harare and Mutate, Zimbabwe. Journal of Environmental Waste Management and Recycling, 1(2):57–67.

Jin, R., Yuan, H. and Chen, Q. (2019). Science mapping approach to assisting the review of construction and demolition waste management research published between 2009 and 2018. Resources Conservation Recycling Journal, 140(029): 175–188. http://dx.doi.org/10.1016/j.resconrec.2018.09.029.

Kabirifar, K., Mojtahedi, M., Wang, C. C. and Tam, W. Y. V. (2020). A Conceptual Foundation For Effective Construction and Demolition Waste Management. In: Journal of Cleaner Engineering and Technology, 1(100019) 1-24. http://doi.org/10.1016/j.clet.2020.100019.

Karaz, M., Teixeira, J.C. and Rahla, K.M. (2021). Construction and demolition waste—A Shift toward lean construction and building information models. In: Rodrigues H., Gaspar F., Fernandes, P. Mateus, A. (Eds.). (2018). Sustainability and automation in intelligent constructions. In: Proceedings of the International Conference on Automation Innovation in Construction (CIAC-2019), Leiria, Portugal, November 7-8, pp. 51–58.

Lu, W., Peng, Y., Webster, C. and Zuo, J. (2015). Stakeholders' willingness to pay for Enhanced construction waste management: A Hong Kong study. In: Journal of Renewable and Sustainable Energy Reviews, 47(2015) 233-240. https://doi.org/10.1016/j.rser.2015.03.008.

Magadzire, F. R. and Maseva, C. (2006). Policy and legislative environment governing waste management in Zimbabwe, American Journal of Science, 8(4): 692-706. http.www.americanscience.org.93.

Marte Gómez, J. A. , Daniel, E. I. , Fang, Y. , Oloke, D. & Gyoh, L. 2021. Implementation of BIM and Lean Construction in Offsite Housing Construction: Evidence From the UK, Proc.

29th Annual Conference of the International Group for Lean Construction (IGLC) , 955-964. doi.org/10.24928/2021/0122

Elmaraghy, A. , Voordijk, H. & Marzouk, M. 2018. An Exploration of BIM and Lean Interaction in Optimizing Demolition Projects, 26th Annual Conference of the International Group for Lean Construction , 112-122. doi.org/10.24928/2018/0474

Mawed. M., Nuaimi. M. and Kashawni, G. (2020). Construction and demolition waste management in the UAE: Application and obstacles. International Journal of GEOMATE, June 2020, 18(70): 235 – 245. DOI: https://doi.org/10.21660/2020.70.45101.

Memon, A. H., Akhund, M. A., Laghari, A.A.N., Imad, H.U. and Bhangwar, S. N. (2018). Adaptability of lean construction techniques in Pakistan's construction industry. Civil Engineering Journal, 4(10): 5-10.

Moradi, S. and Sormunen, P. (2022). Lean and Sustainable Project Delivery in Building Construction: Development of a Conceptual Framework. In: Journal of Buildings, 12(10): 1757. [Online]. Available at: https://doi.org/10.3390/ buildings12101757. [Accessed 19 March 2024].

Najafpoor, A., Zarei, A., Jamali-Behnam, F., Vahedian-Shahroudi, M. and Zarei, A. (2014). A study identifying causes of construction waste production and applying safety management on construction sites. Iranian Journal of Health Sciences, 2(3): 49-54. http://jhs.mazums.ac.ir/article-1-201-.pdf.

Pedo, B. , Tezel, A. , Koskela, L. , Whitelock-Wainwright, A. , Lenagan, D. & Nguyen, Q. A. 2021. Lean Contributions to BIM Processes: The Case of Clash Management in Highways Design, Proc. 29th Annual Conference of the International Group for Lean Construction (IGLC29) , 116-125. doi.org/10.24928/2021/0164 S

alem, J. O., Solomon, Genaidy, A. & Minkarah, I. (2006). Lean construction: From theory to implementation. Journal of Management and Engineering, 22 (2006): 168–175.

Saunders, J. & Wynn, P. (2004). Attitudes towards waste minimization amongst labour-only sub-contractors. Structural Survey, 22(3), 148–155. https://doi.org/10.1108/02630800410549044.

Shaqour, E. N. (2022). The impact of adopting lean construction in Egypt: Level of knowledge, application, and benefits. In: Ain Shams Engineering Journal. 13(2022): 101551 pp 1–11. https://doi.org/10.1016/j.asej.2021.07.005.

Shooshtarian, S., Maqsood, T., Wong, P. S. P. and Khalfan, M. R. J.Y. (2019). Review of energy recovery from construction and demolition waste in Australia. Journal of Construction, Engineering Management and Innovation, 2 (3) 112–130. http://dx.doi.org/10.31462/jcemi.2019.03112130.

Steel, J., Drogemuller, R. and Toth, B. (2012). Model interoperability in building information modeling. Software Systems Modelling, 11(1): 99-109.

Suarez, J. C. , Zapata, J. & Brioso, X. 2020. Using 5D Models and Cba for Planning the Foundations and Concrete Structure Stages of a Complex Office Building , Proc. 28th Annual Conference of the International Group for Lean Construction (IGLC) , 913-924. doi.org/10.24928/2020/0131

The Government of Zimbabwe. (2017). The Environmental Management Act. Harare: Government Printer.

Watfa, M and Sawalha, M. (2021) Critical Success Factors for Lean Construction: An Empirical Study in the UAE. In: The Lean Construction Journal, 2021(2021): 01-17. https://leanconstruction.org/resources/lean-construction-journal/2021-issue/.

Xing, W. and Hao, J. (2019). Lean construction application: A case study in Suzhou, China. In: 2nd International Conference on Sustainable Buildings and Structures (ICSBS 2019). Suzhou, China, 10 October 2019, pp 25-27. https://doi.org/10.1016/j.jclepro.2020.124944.