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Assessment of Technology Adoption for Construction Waste Management in Building Projects in Lagos State, Nigeria

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ABSTRACT
The construction industry in Lagos State, Nigeria, faces significant challenges in managing construction waste, a pressing issue due to rapid urbanization and limited waste management infrastructure. This study assesses the adoption of advanced technologies for construction waste management, with a focus on how these innovations can minimize waste and improve sustainability. Through a quantitative research approach, data was gathered from 294 professionals including engineers, architects, builders, and quantity surveyors, to evaluate the primary causes of waste and the effectiveness of technologies like Building Information Modeling (BIM), Geographic Information Systems (GIS), and prefabrication in reducing waste generation.
Key findings reveal that worker skills, inadequate training, design changes during construction, and poor material handling are major contributors to waste. Advanced technologies such as BIM, GIS, and prefabrication were identified as highly effective in improving resource management and reducing on-site waste. The study concludes that integrating these technologies with better training programs, improved documentation, and efficient planning can significantly enhance waste management practices. The findings emphasize the need for collaborative efforts across professional groups to adopt these technologies and foster a culture of sustainability in the construction industry.The research provides valuable insights into waste minimization strategies and highlights the importance of advanced technologies in addressing construction waste challenges in Lagos State. The recommendations aim to guide policy makers and industry professionals towards a more sustainable construction future.

Key words: Construction waste, Building Information Modeling (BIM), Geographic Information Systems (GIS), Prefabrication, Waste Management, Advanced Technologies, Sustainable Construction.

I. INTRODUCTION

The construction industry in Lagos faces significant challenges in managing construction and demolition (C&D) waste, which contributes to a large portion of municipal waste. Effective waste management is crucial for environmental sustainability and improving the efficiency of construction projects. However, the lack of robust waste management systems and policies hinders progress. Olukanni and Oresanya (2018) note that the regulatory framework for waste management in Lagos is still developing, with limited enforcement, leading to non-compliance by construction stakeholders. Rapid urbanization and population growth further strain the system, resulting in illegal dumping and inadequate disposal practices (Ichipi, 2023). This highlights the need for innovative technologies and practices to improve waste management outcomes.

Building Information Modeling (BIM) is one such technology offering transformative potential in waste management. Tang (2019) emphasizes that BIM facilitates the integration of information across all construction stages, supporting better waste recycling management and decision-making processes. BIM's application can improve planning, coordination, and data management, reducing waste generation and enhancing recycling rates. Lean construction principles also offer solutions to minimize waste. Marhani et al. (2022) argue that lean construction tools reduce over-processing and waste by fostering collaboration among project participants. Continuous improvement and efficiency are central to lean construction, making it an effective approach to waste management in Lagos.

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Combining lean principles with advanced technologies allows construction firms to reduce waste and contribute to a more sustainable industry.

Additionally, computational systems like the Solid Construction Waste Management System (SCWMS) provide practical solutions for tracking and managing construction waste. Paz et al. (2022) highlight that SCWMS enhances transparency and accountability by registering waste generators, transporters, and disposal sites. Real-time monitoring of waste generation and disposal can significantly improve waste management in Lagos's dynamic construction environment. Training and capacity building among construction professionals are vital for reducing on-site waste. Ajayi et al. (2017) stress the importance of vocational training in fostering a culture of waste minimization and sustainability. Such training should cover both technical aspects and regulatory compliance, promoting environmental stewardship. Establishing specialized centers for construction waste management could further enhance the efficiency of waste disposal and recycling. Aleksanin (2019) suggests that centralized management can streamline processes, coordinating material and information resources throughout the waste lifecycle.

Moreover, embracing the "3R" principle—reduce, reuse, and recycle—is essential for sustainable waste management. Huang et al. (2018) note that adopting this approach can mitigate the environmental impact of construction waste. In Lagos, where C&D waste forms a significant part of municipal waste, implementing the 3R principle can lead to improved waste management outcomes. The role of government in promoting effective waste management is also critical. Botchway et al. (2023) argue that legislative and fiscal measures are needed to instill sustainable waste management practices within the construction industry. Policymakers must prioritize the development of comprehensive waste management strategies, incentivizing sustainable practices and promoting recycling initiatives. Addressing the construction waste management challenge in Lagos requires a coordinated effort. Integrating BIM, lean construction, computational waste management systems, and the 3R principle provides a pathway for enhancing waste management practices. However, the success of these initiatives depends on the commitment of all stakeholders—government agencies, construction firms, and the workforce—to embrace sustainable practices and foster a culture of waste minimization.

II. LITERATURE REVIEW

2.1 Construction Waste in Nigeria

Because the construction industry generates a significant amount of waste, construction waste in Nigeria is a critical issue. According to Eze et al. (2017), waste from construction materials accounts for 15.32% of garbage on Nigerian construction sites, highlighting the need for efficient waste management techniques. The importance of addressing these particular issues to reduce waste generation is highlighted by Adewuyi & Otali (2013), who identified key factors contributing to construction material waste in Rivers State, Nigeria, including rework contrary to drawings and specifications, design changes, and waste from uneconomical shapes. According to Ibe (2023), Nigeria's construction sector produces over 3 million tons of waste from construction and demolition each year, underscoring the magnitude of the nation's waste management issue. Furthermore, according to Iheukwumere et al. (2020), Nigeria produces a substantial amount of waste—between 0.44 and 0.66 kg per person per day, or up to 25 million tonnes annually—which highlights the severity of the waste management problem in the nation.

Studies like (Oladiran, 2009), which addresses creative waste management through the implementation of waste management plans on construction projects in Nigeria, have examined efforts to address construction waste in that country. According to the study, there is a need for better waste reduction techniques because actual waste on Nigerian projects surpasses estimators' allowances. Additionally, Ogunmakinde et al. (2019) evaluated how trash from construction materials was disposed of in Nigeria, stressing the significance of sustainable disposal methods and the growing difficulty of waste management despite the availability of waste minimization solutions.

Omopariola et al. (2022) examined unsustainable behaviors, obstacles, and tactics in the Nigerian construction sector under the heading of sustainable construction practices in Nigeria. They highlighted issues such material waste, negative externalities, and excessive energy use. The study emphasized that in order to improve sustainable construction practices in the nation, collaboration, engagement, and involvement are essential. Additionally, Baba & Suratkon (2017) examined how well building waste minimization strategies worked in Nigeria's Bauchi State, highlighting how crucial it is to reduce construction

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waste in order to support sustainable development. A multifaceted strategy is needed to address construction waste in Nigeria, including the adoption of green practices in the construction sector, sustainable disposal techniques, and efficient waste management systems. Nigeria may strive toward a more ecologically friendly and effective building industry by putting policies in place to lessen waste generation, enhance waste disposal procedures, and increase public knowledge of the significance of sustainable construction.

2.2 Causes of Waste Generation in Building Projects

Numerous variables that lead to inefficiencies and material waste are among the many different sources of waste generation in construction projects. According to Adewuyi & Otali (2013), rework that deviates from plans and specifications, design modifications, and waste from uneconomical shapes are the main causes of construction material waste generation on building sites in Rivers State, Nigeria. In a similar vein, Ibe (2023) lists the reasons why construction materials are wasted in Abuja, Nigeria, such as modifications performed outside of predetermined plans, design revisions and adaptations, and the usage of resources for ineffective forms.

These results highlight the importance of design flaws and specification deviations as major causes of waste production in construction projects. Furthermore, Hashim et al. (2023) stress that improper waste management methods are a major contributor to trash formation and that environmental degradation results from a lack of readiness in handling garbage from building sites. Furthermore, Tongo et al. (2020) note that waste generation during building projects in South-West Nigeria can be greatly impacted by elements including frequent design modifications, low design quality, last-minute client requirements, and the involvement of inexperienced designers. These results emphasize how crucial efficient project planning and design management are to reducing waste in building projects.

Furthermore, traditional materials and procedures frequently result in unacceptable levels of waste creation, according to Mirshekarlou et al. (2018), who analyze the waste-prone materials and reasons in prefabricated steel structure building projects. This implies that the quantity of trash generated during building projects may be influenced by the selection of building materials and techniques. Furthermore, Domingo (2015) highlights the impact of project complexity on waste generation by emphasizing how complicated healthcare elements in construction projects can result in increased waste creation due to variables like poor briefing, erroneous drawing details, and non-standard designs.

Babangida et al. (2017) carried out an empirical investigation of the efficacy of waste minimization in construction in Bauchi State, Nigeria, and found that insufficient waste minimization techniques significantly increased waste generation at various stages of construction. Similarly, Saidu & Shakantu (2016) discovered that a large portion of project cost overruns in Abuja, Nigeria, was caused by building material waste. The financial consequences of trash generation in construction projects are highlighted by these studies, as is the significance of effective waste management techniques in preventing cost overruns.

There are many different reasons why waste is generated in construction projects, including mistakes in design, inadequate waste minimization techniques, poor material management, a lack of readiness for waste management, and project complexity. Proactive steps are needed to address these issues, including better design management, efficient material handling, careful planning, and the use of sustainable construction techniques to reduce waste production and encourage ecologically friendly building procedures.

2.3 Advanced Technologies for Minimizing Construction Waste in Nigeria

In the building business, construction waste management is an essential part of sustainable development. Nigeria, like many other nations, has difficulties in efficiently reducing construction waste. To solve this problem, a number of cutting-edge technologies and approaches have been put forth. To improve construction waste recycling management, one strategy is to employ Building Information Modeling (BIM) technology in cooperative management modes for prefabricated buildings (Tang, 2019). Construction waste recycling may be enhanced by putting into practice a collaborative management model built on BIM technology, which will lower disposal costs and pollution levels while fostering sustainable growth (Tang, 2019).

Accurate waste control and management throughout the construction process can be achieved by integrating technologies such as BIM with Geographic Information System (GIS) to provide intelligent construction waste management

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platforms and real-time monitoring (Wang et al., 2021). Furthermore, a considerable portion of construction waste that would have otherwise been produced in the absence of such technology has been avoided thanks to the optimistic outcomes of using BIM for waste estimation through conflict detection (Hasan et al., 2022). In addition to helping reduce trash, these technical developments also save money and safeguard the environment.Additionally, potential methods to reduce construction waste include the use of waste-driven designs, digital advances in waste management, life-cycle assessment decision-making, and supply chain collaboration (Shen et al., 2004). Effective construction waste management relies heavily on waste management techniques such waste classification, waste avoidance, reduction, reuse, and recycling technologies (Shen et al., 2004). building companies may drastically reduce the quantity of waste produced during building activities by putting these strategies into practice.

It is crucial to concentrate on the elements impacting construction waste management initiatives in emerging nations like Nigeria, where construction activity is increasing, in order to guarantee sustainable practices (Manowong, 2012). Problems like unlawful dumping and the requirement for sustainable waste management emphasize how crucial it is to incorporate efficient waste management techniques into building projects (Rahim et al., 2021). A methodical approach to construction waste management, including raised awareness among construction stakeholders, is necessary to address these issues (Rahim & Kasim, 2017).

In addition to cutting waste, recycling building waste to make aggregates for concrete mixtures promotes sustainable development and environmental preservation (Basha et al., 2020). Countries can address the environmental impact of construction waste and create a sustainable source of building materials by utilizing construction residues as aggregates (Basha et al., 2020). Sustainable construction methods can also be improved by enacting new laws that optimize resource recovery from construction waste (Merino et al., 2009). Reducing construction waste in Nigeria requires utilizing cutting-edge technologies like BIM and GIS as well as creative waste management techniques. Nigeria can transition to more sustainable construction methods and support international initiatives for environmental preservation and sustainable development by incorporating these technologies into building procedures, implementing efficient waste management plans, and encouraging cooperation throughout the supply chain.

III. RESEARCH METHODS

For this study, a quantitative research methodology was adopted. Data was gathered in Lagos State, Nigeria, by distributing questionnaires to registered engineers, architects, builders, and quantity surveyors. The purpose of the questionnaire was to collect demographic information about the respondents, such as their occupation, years of experience, and academic background. This is beneficial for the research study that will serve as the foundation for divergent expert viewpoints regarding the best ways for the Adoption of advanced Technologies for Construction Waste Management in Building Projects in Lagos State, Nigeria. Finding out more about the advanced Technologies for Construction Waste Management in Building Project was the aim of the self-administered survey. The respondents used a Likert-type scale of 5, with Very low being equal to 1, Low being equal to 2, Moderate being equal to 3, High being equal to 4, and very high being equal to 5. The study's target audience is licensed Architects, Quantity Surveyors, Builders, and Engineers in Lagos State, Nigeria. The sample size was calculated using the Yamane (1967) formula; Yamane's theory n = N/1+N (e) ^2. This study requires a minimum sample size of 370 construction industry experts. A total of three hundred and sixty (360) questionnaires were administered using the census technique; two hundred and ninety-four (294) of them were returned and found suitable for analysis. Around 79.5% of the sample size responded to the questionnaire, which is greater than the 20–30% response rate that surveys often receive in management research (Hatamleh et al. 2018). The survey was distributed by hand over the two months of data collecting. Together with descriptive data like mean scores and frequency distribution, the results were displayed in tables and charts. The statistical techniques that were employed were factor analysis and the mean item score. The reliability of the instrument was assessed using the Cronbach's alpha test. SPSS 27, a statistical program for the social sciences, was used to assist with the analysis.

IV. ANALYSIS OF RESULTS AND DISCUSSION OF FINDING

A sample of 294 respondents' demographic and professional profiles are included in the table. Men make up a sizable majority of the sample (72.8%), with women making up 27.2%. With 32.0% of responses, civil engineers make up the largest category in terms of professional practice, closely followed by quantity surveyors (31.3%). Architects comprise 12.9% of the sample, whilst builders comprise 23.8%. The majority of respondents (78.2%) have a bachelor's degree or its equivalent, while 17.0% have a master's degree. Just 4.1% and 0.7%, respectively, have an OND or a PhD. The majority of the group (48.3%) has 11–15 years of professional experience, followed by 1–5 years (25.2%) and 6–10 years (16.3%). Just 0.7% of respondents have more than 20 years of experience, while a smaller percentage (9.5%) have 16–20 years. Furthermore, 89.1% of respondents are married, compared to 10.9% who are not. Regarding the size of the companies they work for, 27.2% are employed by companies with 6–20 employees, and nearly half (49.0%) are employed by companies with 21–50 employees. 10.9% work for companies with 51–100 people, while a lower fraction (12.2%) works for companies with 1–5 employees. In terms of age, the majority of responders (58.5%) are in the 36–45 age range, followed by the 25–35 age group (27.0%) and the 46+ age group (13.6%). Table 4.2 below lists other classes.

Table 1: Background Information of Respondents

Variable	Classification	Frequency	Percent
Gender	Male	214	72.8
	Female	80	27.2
	Total	**294**	100.0
Type of Practice	Architect	38	12.9
	Builder	70	23.8
	Civil Engineer	94	32.0
	Quantity Surveyor	92	31.3
	Total	294	100.0
Highest Academic Qualification	OND	12	4.1
	HND/B.Sc/B.Tech/PGD	230	78.2
	M.Sc	50	17.0
	PhD	2	0.7
	Total	294	100.0
Years of Practising	1-5yrs	74	25.2
	6-10yrs	48	16.3
	11-15yrs	142	48.3
	16-20yrs	28	9.5
	Above 20yrs	2	0.7
	Total	294	100.0
Marital Status	Not married	32	10.9
	Married	262	89.1

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	Total	294	100.0
Size of Organization	1 – 5	36	12.2
	6 – 20	80	27.2
	21 – 50	144	49.0
	51 – 100	32	10.9
	Above 100	2	0.7
	Total	294	100.0
Annual Turnover	N1 - N500,000	30	10.2
	N500,001-N2,000,000	54	18.4
	N2,000,001 - N10,000,000	144	49.0
	N10, 000,001 - N 50,000,000	60	20.4
	Above N50,000,000	6	2.1
	Total	294	100.0
Age range	25 -35yrs	82	27.9
	36-45yrs	172	58.5
	46 and above	40	13.6
	Total	294	100.0

4.1 Primary Factors Contributing to Construction Waste Generation in Building Projects

The main causes of construction waste production are included in the table together with their mean values. With a mean of 2.82 and a standard deviation of 0.866, worker skills and training rank as the most significant component, suggesting that worker abilities and training have a considerable impact on waste generation. With a mean of 2.75 and a standard deviation of 0.851, design modifications made during construction come in second, indicating that they significantly increase waste. With a mean of 2.69 and a greater standard deviation (0.978), lack of documentation comes in third, emphasizing both its significance and its fluctuating effects.

The assembly rate (mean 2.65), which influences waste generation due to the pace at which components are assembled on-site, and the absence of design guidance, which came in fifth place with a mean of 2.61, are other noteworthy aspects. With a mean of 2.60 and a standard deviation of 0.816, inattentive working attitudes and behaviors also play a significant role. Further down the scale, problems with concrete usage, supervision quality, and material handling each have a mean of 2.50, indicating their moderate impact on waste formation, as do poor planning and scheduling (mean 2.52). Concrete work (mean 2.48), the use of timber formwork (mean 2.48), masonry work (mean 2.47), and material storage procedures (mean 2.46), are less important considerations.

Although they are ranked lower in importance, processes such as material handling procedures (mean 2.41) and wet finishing (mean 2.44) are also included as significant factors. Last but not least, steel use has the biggest standard deviation (1.073) and the lowest mean score (2.23), indicating variation in how its use affects waste. According to the data, the main causes of construction waste are worker-related variables, design changes, and poor planning; material-specific problems, such as the use of steel and masonry, are comparatively less significant.

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Table 2: Primary Factors Contributing to Construction Waste Generation in Building Projects

Primary Factors Contributing to Construction Waste Generation	Mean	S. D.	Rank
Worker Skills: The skills and training of construction workers	2.82	0.866	1
Design Changes: Design alterations during construction	2.75	0.851	2
Lack of Documentation: Inadequate documentation practices	2.69	0.978	3
Assembly Rate: The speed at which components are assembled on-site	2.65	0.757	4
Lack of Design Guidance: Insufficient design guidance	2.61	0.848	5
Inattentive Working Attitudes and Behaviors:	2.60	0.816	6
Ineffective Planning and Scheduling: Poor project planning and scheduling	2.52	0.822	7
Concrete Usage: The amount of concrete used in construction projects	2.50	0.887	8
Supervision Quality: The quality of supervision on construction sites	2.50	0.814	9
Material Handling Issues: Problems related to the handling of materials	2.50	0.894	10
Concrete Work	2.48	0.894	11
Timber Formwork Usage	2.48	0.788	12
Masonry Work: The use of masonry materials	2.47	0.939	13
Material Storage Practices: How materials are stored on-site can impact waste generation	2.46	0.805	14
Wet Finishing Processes: Processes involving wet finishing	2.44	0.836	15
Material Handling Procedures: How materials are handled on construction sites	2.41	0.859	16
Steel Usage: The utilization of steel in construction has implications for waste production	2.23	1.073	17

4.2 Adoption of Advanced Technologies Helps in Minimizing Construction Waste

The table rates advanced construction technologies according to how well they can improve efficiency and waste management. With a mean of 2.78 and a standard deviation of 0.660, Building Information Modeling (BIM) comes in first, emphasizing its function in enhancing planning and collaboration to cut waste. Next, with a mean of 2.76, are Geographic Information Systems (GIS), which reduce waste by streamlining material delivery routes and site architecture. With a mean score of 2.73, prefabrication and modular construction also contribute significantly by lowering waste on-site through off-site assembly. By providing immersive project previews, augmented reality (AR) and virtual reality (VR) technologies—ranked fourth with a mean of 2.67—help to reduce errors and rework; nevertheless, their standard deviation of 2.748 suggests significant application heterogeneity. 3D printing (mean 2.54) enables sophisticated designs without using too much material, whereas advanced demolition techniques (mean 2.59) concentrate on selective deconstruction to rescue useful materials.

Drones and UAVs (mean 2.42) enhance site surveys and material usage accuracy, while lean construction practices (mean 2.47) seek to minimize waste throughout the project lifespan. Tracking the production and disposal of garbage is made possible by waste management software, which comes in tenth place with a mean score of 2.40. While robotics and automation (mean 2.36) guarantee accurate material handling, technologies such as artificial intelligence (AI) and machine learning (mean 2.38) spot trends that lead to waste and offer solutions. Down the list, Internet of Things (IoT) sensors (mean 2.33) track material consumption and environmental conditions in real-time, while sustainable design software (mean 2.34) helps choose low-waste methods.

Digital twin technology (mean 2.21) detects possible waste sources during planning, whereas concrete recycling technologies (mean 2.32) turn demolition waste into useable aggregates. Last but not least, smart construction equipment (mean 2.02) is ranked lowest, indicating that its current application in reducing material spillage and overuse is limited. Though promising, technologies like robotics, artificial intelligence, and digital twins are not as frequently used or adopted in the construction sector as BIM, GIS, and prefabrication.

Table 3: Adoption of Advanced Technologies Helps in Minimizing Construction Waste

Advanced Technologies	Mean	S. D.	Rank
Building Information Modeling (BIM): Enhances collaboration and planning	2.78	0.660	1
Geographic Information Systems (GIS): Minimizes waste by improving site layout and material delivery routes	2.76	1.042	2
Prefabrication and Modular Construction: Off-site construction reduces on-site waste	2.73	0.764	3
Augmented Reality (AR) and Virtual Reality (VR): Reduces errors and rework by providing immersive project previews	2.67	2.748	4
Advanced Demolition Techniques: Implements selective dismantling to preserve reusable components	2.59	1.084	5
3D Printing: Allows for complex designs without excess material use	2.54	0.733	6
Lean Construction Techniques: Focuses on waste reduction throughout the project lifecycle	2.47	0.813	7
Drones and UAVs: Improve site surveys and monitoring and enhance precision in material placement and usage	2.42	0.802	8
Waste Management Software: Tracks and manages waste generation and disposal	2.40	0.825	9
Artificial Intelligence (AI) and Machine Learning: Identifies patterns that lead to waste and suggests improvements	2.38	0.894	10
Robotics and Automation: ensures precise cutting and placement of materials	2.36	0.860	11
Sustainable Design Software: Facilitates the selection of low-waste construction techniques	2.34	0.807	12
Internet of Things (IoT) Sensors: Monitors material usage and environmental conditions in real-time	2.33	0.878	13

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Concrete Recycling Technologies: Processes demolition waste into usable aggregate for new concrete	2.32	0.785	14
Digital Twin Technology: Helps in identifying potential waste generation points and mitigating them.	2.21	0.908	15
Smart Construction Equipment: Minimizes material overuse and spillage	2.02	0.940	16

4.2.1 Test of Hypothesis 2

In order to determine whether there were statistically significant variations between the opinions of quantity surveyors, architects, builders, and civil engineers regarding the employment of sophisticated technology to help minimize construction waste based on occupation, the Kruskal-Wallis test was employed. The study focuses on the Asymptotic Significance (p-value) to ascertain whether the variations in the professionals' mean ratings for each technology are statistically significant. According to a 95% confidence level, a significant result above 0.05 indicates that respondents' opinions are identical, whilst a significant value below 0.05 indicates that respondents' opinions of their preferences differ.

The p-values are higher than 0.05 for every sophisticated technology that is being reviewed, including "Robotics and Automation," "Drones and UAVs," "Prefabrication and Modular Construction," "Building Information Modeling (BIM)," "3D Printing," and others. This suggests that there are no statistically significant differences in the perspectives or usage of these technologies among various professional groups. Specifically, the p-values, which range from 0.265 to 0.958, show that quantity surveyors, architects, builders, and civil engineers generally concur. According to the Kruskal-Wallis test results, architects, builders, civil engineers, and quantity surveyors all view and use advanced technologies to help in minimizing construction waste based on the profession in essentially the same ways. This implies that there are no significant differences in the ways that different professional groups embrace or perceive these technologies.

Table 4: Test on theAdoption of Advanced Technologies to Help in Minimizing Construction Waste

Advanced Technologies	Mean item score				KruskalWallis Test	
	Architect	**Builder**	**Civil Engineer**	**Quantity Surveyor**	**Chi-square**	**Asymp. Sig.**
Building Information Modeling (BIM)	2.63	2.77	2.86	2.83	3.183	**0.528**
Prefabrication and Modular Construction	2.63	2.69	2.82	2.80	2.112	**0.715**
3D Printing	2.47	2.63	2.64	2.52	1.702	**0.790**
Drones and UAVs	2.37	2.49	2.41	2.46	0.788	**0.940**
Robotics and Automation	2.32	2.46	2.36	2.37	1.328	**0.857**
Waste Management Software	2.42	2.37	2.5	2.35	0.703	**0.951**
Lean Construction Techniques	2.47	2.57	2.36	2.35	3.599	**0.463**
Internet of Things (IoT) Sensors	2.26	2.43	2.14	2.41	2.783	**0.595**
Augmented Reality (AR) and Virtual Reality (VR)	2.26	2.34	2.50	2.57	3.281	**0.512**
Artificial Intelligence	2.32	2.40	2.27	2.43	0.643	**0.958**

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(AI) and Machine Learning						
Digital Twin Technology	2.11	2.06	2.27	2.22	2.426	**0.658**
Sustainable Design Software	2.47	2.23	2.36	2.33	1.170	**0.883**
Concrete Recycling Technologies	2.37	2.37	2.27	2.24	1.012	**0.908**
Smart Construction Equipment	2.00	2.03	2.36	1.83	5.220	**0.265**
Geographic Information Systems (GIS)	2.53	2.80	2.77	2.80	1.211	**0.876**
Advanced Demolition Techniques	2.63	2.51	2.68	2.46	2.166	**0.705**

4.3 Discussion of Findings

4.3.1Primary Factors Contributing to Construction Waste Generation in Building Projects

In order to reduce construction waste, worker skills and training are essential because insufficient training frequently results in mistakes and rework, both of which greatly increase waste production on construction sites (Eze et al., 2021). According to research, strengthening worker competences through focused training can successfully minimize waste by limiting errors during building operations and improving material handling (Kolaventi et al., 2020). According to research, design modifications made during construction can contribute up to 33% of the total trash generated on building sites, making them a major source of construction waste (Luangcharoenrat et al., 2019). This waste results from a number of sources, such as direct changes made by owners and designers as well as modifications required by site circumstances or mistakes made during construction. This emphasizes how important it is to have efficient design management in order to reduce waste.

Because improper documentation frequently results in design and execution problems that need rework and material waste, it is a major contributor to the development of construction waste. Inadequate planning and site management make waste problems worse, according to Moeis et al. (2023), underscoring the necessity of better documentation procedures to reduce waste in building projects. Since studies show that about 33% of construction waste results from design decisions and adjustments made throughout the construction process, the absence of design guidance greatly adds to the development of construction waste (Mohammed et al., 2021). Because poor craftsmanship and a lack of knowledge about waste management procedures result in increased material waste, construction workers' inattentive working attitudes and behaviors greatly contribute to the development of waste in building projects (Eze et al., 2021). According to Bajjou & Chafi (2021), poor planning and scheduling cause delays, rework, and improper resource allocation, which in turn exacerbate material waste on site and greatly contribute to construction waste generation in building projects.

Key elements in the production of construction waste include the use of concrete, the caliber of supervision, and material management. According to studies showing that insufficient supervision increases errors and rework, which exacerbates waste generation, ineffective material management and poor handling techniques frequently result in substantial waste (Khaleel & Al-Zubaidy, 2018). Furthermore, excessive dimensions and unpredictability in material consumption might result in overproduction of concrete, which highlights the need for better management procedures (Kaliannan et al., 2018). The use of timber formwork, masonry, concrete, and material storage techniques are important but frequently disregarded sources of building waste. Because inadequate material handling and storage enhance waste production on building sites, ineffective management of these factors can result in significant waste (Na et al., 2021). Additionally, the selection of formwork systems, which contribute significantly to project expenses, might affect the total amount of trash produced, underscoring the necessity of cautious selection and management to reduce environmental effect (Bakırhan & Kayili, 2023).

Because of poor handling and storage techniques that result in material degradation and inefficiencies on-site, wet finishing and material handling procedures are important contributors to

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the creation of construction waste (Nadarason et al., 2023). The necessity for better training and methodical approaches to material logistics is highlighted by the fact that inefficient management of these operations not only increases waste but also affects project costs and schedules (Widhiawati et al., 2019). When compared to other materials like concrete, steel's high recyclability and effective application greatly reduce waste, making it one of the materials that contributes to the lowest factors of construction waste formation in building projects (Meng et al., 2024).

4.3.2 Adoption of Advanced Technologies Helps in Minimizing Construction Waste

By promoting stakeholder engagement and optimizing resource utilization, Building Information Modeling (BIM) greatly improves building project management and, eventually, reduces construction waste (Wang et al., 2015). By integrating BIM technology, waste creation can be reduced through better data management and visualization, which facilitates more effective planning and building process execution (Olugboyega & Windapo, 2019). By facilitating accurate site selection for waste disposal and improving decision-making processes through spatial analysis, Geographic Information Systems (GIS) are crucial for optimizing construction waste management (Ertunç et al., 2019). The effective management of waste flows made possible by the incorporation of GIS technology eventually helps to lessen the environmental effects of construction-related activities (Asefa et al., 2022).

By facilitating off-site production, prefabrication and modular building greatly reduce construction waste. This reduces material waste and increases construction process efficiency (Chauhan et al., 2022). These cutting-edge methods promote a circular economy through efficient resource management in addition to improving sustainability by reducing CO_2 emissions (Zighan & Abualqumboz, 2021). In order to reduce construction waste, the construction industry has adopted Augmented Reality (AR) and Virtual Reality (VR) technologies, which greatly improve project visualization and decision-making. Stakeholders can detect possible design errors and inefficiencies early in the process by combining these immersive technologies with Building Information Modeling (BIM). This reduces material waste and increases project efficiency overall (Monla et al., 2023).

By enhancing material recovery and encouraging sustainable practices in the construction industry, advanced demolition techniques—especially those made possible by digital technologies like Building Information Modeling (BIM) and robotic sorting systems—significantly reduce construction waste (Rodrigo et al., 2024). These developments support improved waste management techniques and the effective disassembly of structures, both of which are consistent with the circular economy's tenets (Ratnasabapathy et al., 2019). By enabling accurate, layer-by-layer production without the need of conventional molds, 3D printing technology greatly lowers material waste and improves efficiency in the construction industry, resulting in waste savings of up to 30–60% (Bumanis et al., 2023). By tackling the environmental issues related to traditional construction processes, this creative approach not only reduces labor costs and construction time but also encourages sustainable behaviors within the business (Hossain et al., 2020).

By optimizing resource usage and improving process efficiency, lean construction strategies greatly reduce construction waste when combined with cutting-edge technology like automation and Building Information Modeling (BIM) (Abkar et al., 2023). These developments improve overall project sustainability by streamlining processes and promoting the use of prefabricated and modular building techniques, which further minimize material waste (Liu et al., 2022). By facilitating precise data gathering and real-time monitoring, the integration of drones and UAVs in construction improves waste management and drastically lowers material waste over the course of the project (Chen et al., 2021).

By enhancing data integration and enabling efficient decision-making processes, the use of cutting-edge waste management software greatly improves construction waste minimization, which in turn reduces material waste and its negative effects on the environment (Sudarsan et al., 2023). By automating waste management procedures and improving trash categorization accuracy, the incorporation of artificial intelligence (AI) and machine learning (ML) into building practices greatly reduces construction waste (Na et al., 2022). Furthermore, throughout the building lifespan, better resource allocation and waste reduction techniques are made possible by predictive models that use machine learning (ML) to forecast waste formation trends (Utku & Kaya, 2022)

By improving efficiency and accuracy in material utilization, especially through technologies

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like Building Information Modeling (BIM) and prefabrication, the construction industry's adoption of robotics and automation greatly reduces waste (Pan et al., 2018). By decreasing waste on-site and enhancing resource management, these cutting-edge solutions not only expedite the building process but also encourage sustainable behaviors. By facilitating improved material management and waste reduction techniques throughout the design phase, the use of sustainable design software, such as Building Information Modeling (BIM), greatly reduces building waste (Lee et al., 2021).

By providing real-time monitoring and data analytics, the incorporation of Internet of Things (IoT) sensors into construction processes improves waste management efficiency, resulting in a considerable decrease in waste generation and an optimization of resource allocation (Qureshi et al., 2023). By improving resource management and encouraging sustainability, digital twin and concrete recycling technologies are crucial for reducing construction waste. When paired with concrete recycling techniques, digital twins allow for real-time monitoring and decision-making, which in turn helps to convert waste materials into reused resources and promote a circular economy in the building industry (Chen & Huang, 2020). By improving resource management accuracy and streamlining prefabrication procedures, the use of smart construction equipment—which is distinguished by cutting-edge technologies like automation and Building Information Modeling (BIM)—significantly reduces construction waste (Gürgün et al., 2024).

The test to establish if there is no significant difference in the responses of architects, builders, civil engineers, and quantity surveyors based on their profession was largely accepted as the asymptotic value is above 0.05 for all components analyzed, according to the hypothesis. It is most appropriate to implement collaborative training programs and unified guidelines to encourage the widespread adoption of advanced technologies across all construction professional groups.

V. CONCLUSION AND RECOMMENDATIONS

The study has assessed Adoption of advanced Technologies for Construction Waste Management in Building Projects in Lagos State, Nigeria. It evaluates the primary factors contributing to construction waste generation in building projects, and evaluate how the adoption of advanced technologies helps in minimizing construction waste. In this closing chapter, the study summarizes the research findings, posited appropriate recommendations and suggested areas for further studies.

The results showed that improving worker skills and training, efficient design management, appropriate documentation practices, and effective material handling are all closely related to reducing construction waste. This emphasizes the need for a comprehensive strategy that takes into account these many variables in order to reduce waste production and advance sustainability in the construction sector. In order to improve construction project management, maximize resource utilization, and ultimately reduce construction waste across different professional groups within the industry, it was found that the integration of cutting-edge technologies like Building Information Modeling (BIM), Geographic Information Systems (GIS), and automation, along with cooperative training and unified guidelines, is crucial.

Therefore, it is advised that in order to successfully reduce construction waste, it is crucial to adopt cutting-edge waste management strategies like Building Information Modeling (BIM) and lean construction methodologies, as well as to improve documentation practices, implement strong design management strategies, and improve worker training. The implementation of cooperative training programs and the establishment of uniform guidelines that stress the integration of cutting-edge technologies, ongoing education, and best practices in waste management across all professional groups within the construction sector are also advised in order to encourage the broad adoption of advanced technologies in the industry and successfully reduce waste generation.

REFERENCES:

[1]. Abkar, M. M. A., Yunus, R., Al-Shameri, A. S. A. S., Harouache, A., & Gamil, Y. (2023). An empirical investigation of automation technology as material waste mitigation measure at Johor construction sites. Frontiers in Built Environment, 9, 1232195.

[2]. Adewuyi, T. O., & Otali, M. (2013). Evaluation of causes of construction material waste: Case of River State, Nigeria. Ethiopian Journal of Environmental Studies and Management, 6(6), 746-753.

[3]. Ajayi, S. O., Oyedele, L. O., Bilal, M., Akinade, O. O., Alaka, H. A., & Owolabi,

H. A. (2017). Critical management practices influencing on-site waste minimization in construction projects. Waste management, 59, 330-339.
[4]. Aleksanin, A. (2019). Development of construction waste management. In E3S Web of Conferences (Vol. 97, p. 06040). EDP Sciences.
[5]. Asefa, E. M., Barasa, K. B., & Mengistu, D. A. (2022). Application of geographic information system in solid waste management. In Geographic information systems and applications in coastal studies. IntechOpen.
[6]. Baba, B., & Suratkon, A. B. (2017). A Review of Effectiveness of Construction Waste Minimization Practices in Bauchi State, Nigeria. Traektoriâ Nauki= Path of Science, 3(11), 2012-2015.
[7]. Babangida, B., Suratkon, A., Abdullahi, S., & Yakubu, B. (2017). Empirical study of the effectiveness of construction waste minimization in Bauchi state. International Journal of Scientific Research and Management, 5(12), 7584-7589.
[8]. Bajjou, M. S., & Chafi, A. (2022). Exploring the critical waste factors affecting construction projects. Engineering, Construction and Architectural Management, 29(6), 2268-2299.
[9]. Bakırhan, E. K., &Kayili, M. T. (2023). Evaluation of the Environmental Impact of Formwork Systems Depending on the Service Life and Cost Analysis.FOCSCI, 9(2), 1-10.
[10]. Basha, E., Al-Tarhouni, A., & Basha, A. (2020). Recycling of construction waste in the production of aggregates for use in the manufacture of concrete mixtures and for environment protection. International Journal of Engineering Technology and Scientific Innovation, 5(1), 23-43.
[11]. Botchway, E. A., Asare, S. S., Agyekum, K., Salgin, B., Pittri, H., Kumah, V. M. A., & Dompey, A. M. A. (2023). Competencies driving waste minimization during the construction phase of buildings. Buildings, 13(4), 971.
[12]. Bumanis, G., Sapata, A., Sinka, M., Spurina, E., & Bajare, D. (2023). Additive Manufacturing of Lightweight Gypsum and Expanded Polystyrene Granulate Composite. Journal of Composites Science, 7(10), 425.
[13]. Chauhan, K., Peltokorpi, A., Lavikka, R., & Seppänen, O. (2022). The monetary and non-monetary impacts of prefabrication on construction: the effects of product modularity. Buildings, 12(4), 459.
[14]. Chen, Q., Li, Y. Y., Jia, Z. Y., & Cheng, Q. H. (2021). 3D Change Detection of Urban Construction Waste Accumulations Using Unmanned Aerial Vehicle Photogrammetry. Sensors & Materials, 33.
[15]. Chen, Z., & Huang, L. (2020, November). Digital twin in circular economy: Remanufacturing in construction. In IOP Conference Series: Earth and Environmental Science (Vol. 588, No. 3, p. 032014). IOP Publishing.
[16]. Domingo, N. (2015). Assessment of the impact of complex healthcare features on construction waste generation. Buildings, 5(3), 860-879.
[17]. Ertunç, E., Bozdağ, A., & Gökçek, Ö. B. (2019). Investigation of Solid Waste Storage Site Selection in Niğde City with the Help of Geographic Information System. Konya Journal of Engineering Sciences, 7(4), 822-838.
[18]. EZE, E. C., AWODELE, I. A., & EGWUNATUM, S. I. (2021). Labour–specific factors influencing the volume of construction waste generation in the construction industry. Journal Of Project Management Practice (JPMP), 1(2), 1-16.
[19]. Eze, E. C., Seghosime, R., Eyong, O. P., & Loya, O. S. (2017). Assessment of materials waste in the construction industry: A view of Construction Operatives, Tradesmen and Artisans in Nigeria. The International Journal of Engineering and Science, 6(4), 32-47.
[20]. Gurgun, A. P., Koc, K., & Kunkcu, H. (2024). Exploring the adoption of technology against delays in construction projects. Engineering, Construction and Architectural Management, 31(3), 1222-1253.
[21]. Hasan, R., Rakib, M., & Rahman, M. (2022). Quantification of Construction Waste through BIM. Journal of Technology Management and Business, 9(1), 62-77.
[22]. Hashim, M. Z., Othman, I., Bakar, N. A., Hassan, S. H., & Musa, M. K. (2023). Relationship of Construction Waste Causes and BIM-IBS Practices in Reducing Waste through Project Design

Stage. International Journal of Academic Research in Business and Social Sciences, 13(2), 342-352.
[23]. Hatamleh, M.T., Hiyassat, M., Sweis, G.J. and Sweis, R.J., 2018. Factors affecting the accuracy of cost estimate: case of Jordan. Engineering, Construction and Architectural Management, 25(1), 113-131.
[24]. Hossain, M. A., Zhumabekova, A., Paul, S. C., & Kim, J. R. (2020). A review of 3D printing in construction and its impact on the labor market. Sustainability, 12(20), 8492.
[25]. Huang, B., Wang, X., Kua, H., Geng, Y., Bleischwitz, R., & Ren, J. (2018). Construction and demolition waste management in China through the 3R principle. Resources, Conservation and Recycling, 129, 36-44.
[26]. Ibe, C. N. (2023, March). Construction material waste causes and their contribution levels: A case study of construction projects in Abuja, Nigeria. In Proceedings of the International Conference on Industrial Engineering and Operations Management (pp. 637-644). IEOM Society International.
[27]. Ichipi, E. B., & Senekane, M. F. (2023). An Evaluation of the Impact of Illegal Dumping of Solid Waste on Public Health in Nigeria: A Case Study of Lagos State. International journal of environmental research and public health, 20(22), 7069.
[28]. Iheukwumere, S., Nkwocha, K., & Nwabudike, C. (2020). Schematic modelling of sustainable solid waste management in Nigeria. International Journal of Sustainable Energy and Environmental Research, 9(2), 98-109.
[29]. Kaliannan, S., Nagapan, S., Sohu, S., & Jhatial, A. A. (2018). Determining root cause of construction waste generation: A global context. Civil Engineering Journal, 4(11), 2539-2547.
[30]. Khaleel, T., & Al-Zubaidy, A. (2018). Major factors contributing to the construction waste generation in building projects of Iraq. In MATEC web of conferences (Vol. 162, p. 02034). EDP Sciences.
[31]. Kolaventi, S. S., Tezeswi, T. P., & Siva Kumar, M. V. N. (2020). An assessment of construction waste management in India: A statistical approach. Waste Management & Research, 38(4), 444-459.
[32]. Lee, B. X. Y., Ponraj, M., Widyasamratri, H., & Wang, J. (2021). Green building practices on waste minimization in China construction industry. Industrial and Domestic Waste Management, 1(1), 12-25.
[33]. Liu, K., Meng, Q., Kong, Q., & Zhang, X. (2022). Review on the Developments of Structure, Construction Automation, and Monitoring of Intelligent Construction. Buildings, 12(11), 1890.
[34]. Luangcharoenrat, C., Intrachooto, S., Peansupap, V., & Sutthinarakorn, W. (2019). Factors influencing construction waste generation in building construction: Thailand's perspective. Sustainability, 11(13), 3638.
[35]. Manowong, E. (2012). Investigating factors influencing construction waste management efforts in developing countries: An experience from Thailand. Waste Management & Research, 30(1), 56-71.
[36]. Marhani, M. A., Jaapar, A., Bari, N. A., & Shaari, S. M. (2022, October). Reducing over-processing construction waste by using lean construction tools in the Malaysian construction industry. In IOP Conference Series: Earth and Environmental Science (Vol. 1067, No. 1, p. 012048). IOP Publishing.
[37]. Meng, T., Shan, X., Ren, Z., & Deng, Q. (2024). Analysis of Influencing Factors on Solid Waste Generation of Public Buildings in Tropical Monsoon Climate Region. Buildings, 14(2), 513.
[38]. Merino, M., Izquierdo Gracia, P., & Weis Azevedo, I. S. (2009). Sustainable construction: construction and demolition waste reconsidered. Waste management & research, 28(2), 118-129.
[39]. Mirshekarlou, B. R., Dikmen Toker, İ., & Birgönül, M. T. (2018). An investigation of the most waste-prone materials and waste causes in prefabricated steel structure building projects.
[40]. Moeis, A. A. A., Ahmad, A. C., Tharim, A. H. A., & Othman, N. (2023, March). Design and documentation as attributes to waste generation at construction sites. In IOP Conference Series: Earth and Environmental Science (Vol. 1151, No. 1, p. 012047). IOP Publishing.

[41]. Mohammed, M., Shafiq, N., Elmansoury, A., & Muhammad, A. (2021). A confirmatory framework PLS-SEM for construction waste reduction as part of achieving sustainable development goals of a building.
[42]. Monla, Z., Assila, A., Beladjine, D., & Zghal, M. (2023). Maturity evaluation methods for BIM-based AR/VR in construction industry: a literature review. IEEE Access, 11, 101134-101154.
[43]. Na, S., Heo, S. J., & Han, S. (2021). Construction waste reduction through application of different structural systems for the slab in a commercial building: A south Korean case. Applied Sciences, 11(13), 5870.
[44]. Na, S., Heo, S., Han, S., Shin, Y., & Lee, M. (2022). Development of an artificial intelligence model to recognise construction waste by applying image data augmentation and transfer learning. Buildings, 12(2), 175.
[45]. Nadarason, K., Nagapan, S., & Arumugam, N. (2023, September). Preliminary survey on the root causes of mishandling materials occurrence at construction sites in central region Malaysia. In IOP Conference Series: Earth and Environmental Science (Vol. 1238, No. 1, p. 012031). IOP Publishing.
[46]. Ogunmakinde, O. E., Sher, W., & Maund, K. (2019). An assessment of material waste disposal methods in the Nigerian construction industry. Recycling, 4(1), 13.
[47]. Oladiran, O. J. (2009). Innovative waste management through the use of waste management plans on construction projects in Nigeria. Architectural Engineering and Design Management, 5(3), 165-176.
[48]. Olugboyega, O., & Windapo, A. (2019). Model of information sharing and exchange in a building information modelling supply chain. WIT Transactions on the Built Environment, 192, 117-129.
[49]. Olukanni, D. O., & Oresanya, O. O. (2018). Progression in waste management processes in Lagos State, Nigeria. International Journal of Engineering Research in Africa, 35, 11-23.
[50]. Omopariola, E. D., Olanrewaju, O. I., Albert, I., Oke, A. E., & Ibiyemi, S. B. (2024). Sustainable construction in the Nigerian construction industry: unsustainable practices, barriers and strategies. Journal of Engineering, Design and Technology, 22(4), 1158-1184.
[51]. Pan, M., Linner, T., Pan, W., Cheng, H., & Bock, T. (2018). A framework of indicators for assessing construction automation and robotics in the sustainability context. Journal of Cleaner Production, 182, 82-95.
[52]. Paz, D. H. F. D., Lafayette, K. P. V., & Sobral, M. D. C. M. (2022). Computational system for the integrated management of construction and demolition waste. Ambiente Construído, 22, 255-273.
[53]. Qureshi, K. N., Khan, A., Jamil, S. U. U., Sharma, B., & Jeon, G. (2023). Internet of Things enables smart solid waste bin management system for a sustainable environment. Environmental Science and Pollution Research, 30(60), 125188-125196.
[54]. Rahim, M. H. I., & Kasim, N. (2017). Conceptual model for systematic construction waste management. In MATEC Web of Conferences (Vol. 87, p. 01008). EDP Sciences.
[55]. Rahim, M. H. I., Mohamed, S., Kasim, N., Rahmat, M., & Azmi, N. (2021). Challenges Towards Reducing Illegal Dumping Activities in the Construction Industry. Journal of Social Transformation and Regional Development, 3(2), 75-84.
[56]. Ratnasabapathy, S., Perera, S., & Alashwal, A. (2019). A review of smart technology usage in construction and demolition waste management.
[57]. Rodrigo, N., Omrany, H., Chang, R., & Zuo, J. (2024). Leveraging digital technologies for circular economy in construction industry: a way forward. Smart and Sustainable Built Environment, 13(1), 85-116.
[58]. Saidu, I., & Shakantu, W. (2016). The contributions of construction material waste to project cost overruns in Abuja, Nigeria. Acta Structilia: Journal for the Physical and Development Sciences, 23(1), 99-113.
[59]. Shen, L. Y., Tam, V. W., Tam, C. M., & Drew, D. (2004). Mapping approach for examining waste management on construction sites. Journal of construction engineering and management, 130(4), 472-481.

[60]. Sudarsan, J. S., Katare, V., & Gavali, H. (2023). Enhancing Construction and Demolition Waste Management through BIM Implementation: A Pathway to Circular Economy.
[61]. Tang, Q. (2019, December). The Role of Cooperative Management Mode of Prefabricated Buildings According to Building Information Modeling in the Recycle Management of Construction Waste. In 2nd International Symposium on Social Science and Management Innovation (SSMI 2019) (pp. 129-135). Atlantis Press.
[62]. Tongo, S. O., Oluwatayo, A. A., & Adeboye, B. A. (2020). Factors influencing waste generation in buildings project in South-West, Nigeria. International Journal of Waste Resources, 9(371), 1-4.
[63]. Utku, A., & Kaya, S. K. (2022). Deep learning based a comprehensive analysis for waste prediction. Operational Research in Engineering Sciences: Theory and Applications, 5(2), 176-189.
[64]. Wang, A., Wang, N., Li, K., & Ren, F. (2021). Preliminary study on the integration control platform of construction waste based on “BIM+ GIS” technology. In E3S Web of Conferences (Vol. 237, p. 01034). EDP Sciences.
[65]. Wang, C., Adetola, S. H., & Abdul-Rahman, H. (2015). Assessment of BIM implementation among MEP firms in Nigeria. International Journal of Advances in Applied Sciences, 4(3), 73-81.
[66]. Widhiawati, I. A. R., Astana, I. N. Y., & Indrayani, N. L. A. (2019). An analysis of building construction waste in Badung, Bali. In MATEC Web of Conferences (Vol. 276, p. 02010). EDP Sciences.
[67]. Zighan, S., & Abualqumboz, M. (2021). A project life-cycle readiness approach to manage construction waste in Jordan. Construction Economics and Building, 21(3), 58-79.