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(RESEARCH ARTICLE)

WASTE CONTROL MEASURES IN THE NIGERIAN CONSTRUCTION INDUSTRY: A LEAN PROJECT MANAGEMENT PERSPECTIVE

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ABSTRACT

Construction material waste raises project costs, contributes to project abandonment and degrades the environment, yet in Nigeria waste is still routinely priced into estimates rather than controlled. This paper evaluates measures for reducing material waste in the Nigerian construction industry through the lens of lean project management. It combines an integrative review of the construction waste, project management and lean construction literature with a secondary analysis of survey data from two Nigerian studies: one on site waste management practice and one on the awareness, adoption, benefits and barriers of lean construction. The analysis shows that materials account for more than half of total project cost for 66% of respondents, that site storage (40%), transport and delivery (38%), wrong specification (31%) and intra-site transit (30%) are the leading waste sources, and that 35% of firms gave no information on how they record inventory. Lean practices are widely known (mean awareness scores of 3.36 to 4.22 on a five-point scale) but consistently less adopted, with the largest gaps in employee training and in tracking plan completion. Lack of enlightenment, lack of exposure and lack of training are the strongest barriers. The paper recommends cloud-based material tracking, performance-linked incentives, mechanised intra-site handling, secure storage and the integration of lean thinking into professional education and training.

Keywords: Construction Waste; Material Waste; Lean Construction; Lean Project Management; Waste Minimisation; Nigeria

1 INTRODUCTION

Sustainable development depends on coordinated progress across social, economic and environmental goals (Lu et al., 2015). Sustainable Development Goal 11 commits countries to reducing the per capita environmental impact of cities by 2030, including through better municipal and other waste management (UN, 2015). Rapid urbanisation and population growth have increased construction activity worldwide, and with it the volume of construction waste sent to landfill (Hwang and Bao Yeo, 2011).

Construction waste has both economic and environmental effects (Kralj, 2011). Economically, it appears as cost and time overruns; environmentally, it degrades land and harms nearby communities. Waste is commonly divided into physical waste, chiefly materials lost during construction, and non-physical waste, which covers time and cost overruns caused by poor estimation or inefficient management (Figure 1). The scale can be large: Llatas (2011) reports that waste in some contexts reaches 40% of the materials used in construction.

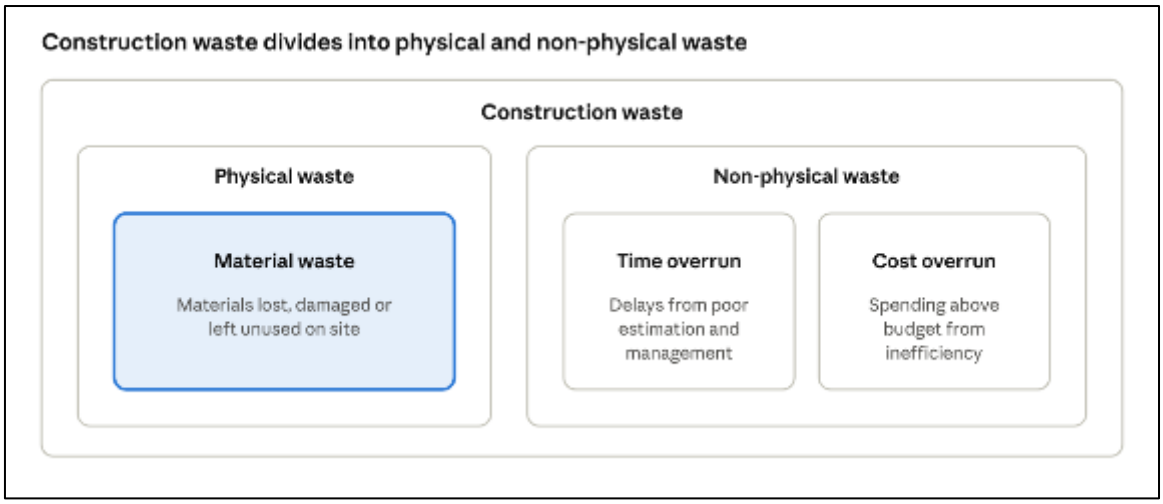

Figure 1: Classification of waste in the construction industry. Adapted from the physical/non-physical classification in the construction waste literature.

In Nigeria, abandoned projects are a serious economic waste that raises unemployment and lowers living standards (Aluko, 2008). Material waste is one contributor: Adewuyi and Odesola (2015) analysed 74 waste factors and found rework, uneconomical cutting, weak on-site material control and design changes to be the most significant. Sustainable construction requires the industry to cut resource use and minimise such waste (Hill and Bowen, 1997; Pearce and Ahn, 2012). Lean project management offers a structured way to do so, because it removes non-value-adding activity while protecting value-adding work (Koskela, 2000). Its just-in-time variants, including kanban, production levelling and set-up reduction, treat unnecessary inventory as waste (Chaouiya, Liberopoulos and Dallery, 2000; Miltenburg, 2002; Salem et al., 2006).

The aim of this paper is to evaluate measures that can reduce material waste in the Nigerian construction industry. The objectives are to:

- analyse the causes and sources of material waste on Nigerian construction sites;
- compare the measures currently used to control construction material waste;
- assess the awareness, adoption, benefits and barriers of lean project management in Nigerian construction; and
- recommend measures for minimising material waste in the sector.

2 LITERATURE REVIEW

2.1 Material waste in Nigerian construction

The Nigerian construction sector contributes significantly to output and employment but performs below its potential, as its many abandoned projects show (Akindoyeni, 2012; Aluko, 2008). Material waste is the difference between the materials bought for a project and those actually incorporated into the finished work (Akinkurolere and Franklin, 2005). Nigerian practice tends to institutionalise it: estimators typically allow at least 5% for wastage, which is often insufficient (Obiegbu, 2002). Budgeting for waste in this way accepts it rather than reducing it.

The literature identifies a range of causes (Table 1). Olomolaiye, Wahab and Price (1987) found that 43% of time on Nigerian sites was unproductive, and Oladiran (2009) reports that 36.7% of Nigerian professionals rarely use waste management plans while 13.3% never do.

Table 1: Principal causes of construction material waste in the literature

Cause	Mechanism	Source
Rework and uneconomical cutting	Rejected work redone; offcuts cannot be reused	Adewuyi and Odesola (2015)
Design changes	Materials ordered for an earlier design discarded	Alwi et al. (2002); Ekanayake and Ofori (2004)
Weak on-site material control	No process for recording and issuing materials	Adewuyi and Odesola (2015)
Improper planning	Inaccurate estimates of materials, labour and time	Olomolaiye (1991)
Manual handling	Fragile materials damaged when carried by hand	Akinkurolere and Franklin (2005)

Waste drives cost overrun. Tam, Shen and Tam (2007) link overruns to material wastage, and Bossink and Brouwers (1996) attribute 20% to 30% of overruns to it. Where materials exceed half of total building cost (Akinkurolere and Franklin, 2005), even modest waste rates erode a large share of project value. Because government is the largest client in Nigeria, much of this loss falls on public funds.

2.2 Project management and the TFV theory

Project management applies knowledge, skills, tools and techniques to project activities to meet project requirements (PMI, 2017). Koskela's (2000) transformation-flow-value (TFV) theory extends the traditional view of production as the transformation of inputs into outputs. It adds flow, in which waiting, moving and inspection are waste, and value, in which the aim is to meet customer requirements as fully as possible (Table 2).

Table 2: The TFV theory of production (adapted from Koskela, 2000)

Indicator	Transformation	Flow	Value generation
Production seen as	Inputs transformed into outputs	Flow of material through transformation, inspection, moving and waiting	Creation of value by meeting customer requirements
Main principle	Efficient production	Eliminating non-value-adding activity	Eliminating value loss
Methods	Work breakdown structure, MRP	Continuous flow, pull control, continuous improvement	Requirement capture, quality function deployment
Application	Task management	Flow management	Value management

Koskela (2000) classes waiting, material handling, over-production, excess inventory, rework and unnecessary movement as non-value-adding. All are common on construction sites, and several generate material waste directly.

2.3 Lean construction

Lean construction applies these principles to construction, raising productivity by eliminating the activities that generate waste (Abdullah et al., 2009). Ballard and Howell (2004) present it as a new paradigm that challenges traditional construction management. Howell (1999) summarises its practice as delivering customer value, organising work as continuous flow, pulling materials and information only when needed, and pursuing perfection. Mossman (2009) adds that it delivers more with less effort, equipment, time and space.

Chesworth, London and Gajendran (2011) identify three primary principles: reducing waste in the value stream, synchronising processes and making planning transparent. Kempton (2006) adds right-first-time quality, solving problems at source and long-term supplier relationships. Across these sources, lean pursues three goals: lower cost, greater client satisfaction and the elimination of waste.

Evidence from Nigeria is limited. Olatunji (2008) found awareness to be very low, with only two in ten respondents having heard of lean, and Dania, Kehinde and Bala (2007) observed that Nigerian practitioners understand

sustainability differently from peers elsewhere. Studies of site waste and of lean adoption have mostly been reported separately; this paper brings the two strands together.

3 METHODOLOGY

The study uses a qualitative, desk-based design that combines an integrative literature review with secondary analysis of published Nigerian survey data. Peer-reviewed articles, conference papers, theses and professional texts on construction waste, project management and lean construction were selected for their relevance to developing countries, and to Nigeria in particular. The review supplied the conceptual framework against which the survey data were interpreted.

Two Nigerian empirical studies were then selected because together they cover the four objectives (Table 3). Both used structured questionnaires administered to construction firms and professionals.

Table 3: Secondary data sources analysed

Study	Focus	Variables used	Measures
Akinkurolere and Franklin (2005)	Site waste management, south-western Nigeria	Material cost share, record keeping, waste sources, minimisation methods, incentives, transit damage, plant use	Counts, percentages, ranks
Adegbembo, Bamisaye and Aghimien (2016)	Lean construction practice in Nigeria	Awareness and adoption of 17 lean approaches; 14 benefits; 19 barriers	Mean item score (MIS), five-point scale

Frequency data were analysed using percentages and ordinal ranks. For each lean approach, an adoption gap was calculated as awareness MIS minus adoption MIS, to show where knowledge is not turned into practice. Results were then analysed thematically and compared with the literature to derive recommendations. Because the data are secondary, the analysis is limited to the variables and samples chosen by the original authors, and some items allowed multiple responses. The findings are therefore indicative of Nigerian practice rather than statistically representative.

4 RESULTS

4.1 Material cost and inventory management

Materials dominate project cost. Two-thirds of respondents (66%) put materials above 50% of total project cost, and a further 22% put them at 41% to 50% (Figure 2). Only 6% of respondents placed the share at 30% or below.

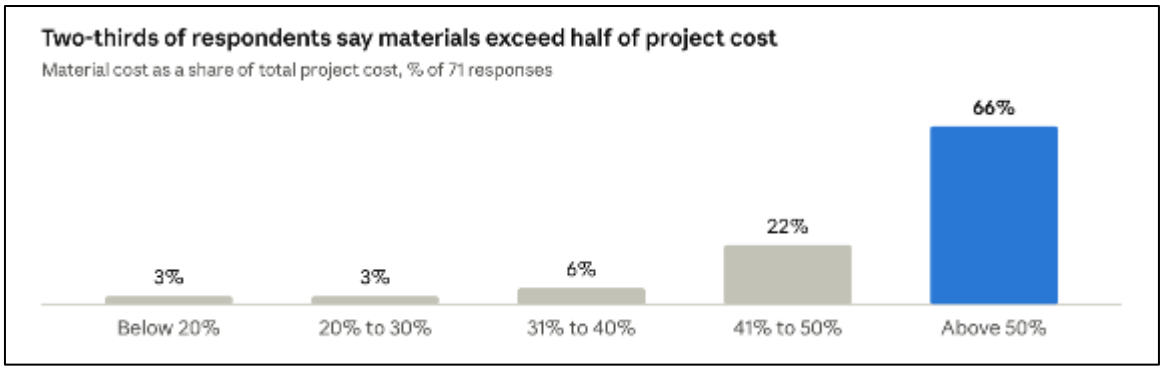

Figure 2: Material cost relative to total project cost. Source: Akinkurolere and Franklin (2005).

Despite this, inventory control is informal. The largest group of firms (35%) gave no answer on how they record materials. The rest relied mainly on stock cards (21%), log books (13%), bin cards (10%) and daily stock taking (10%). Only 4% used computers, and 3% relied on trusted individuals.

4.2 Sources of waste and minimisation methods

Waste arises mostly from how materials are stored and moved (Figure 3). Site storage (40%) and transport and delivery to site (38%) lead, followed by wrong specification (31%) and intra-site transit (30%). Negligence, fixing, pilfering and conversion each affect a fifth to a quarter of firms.

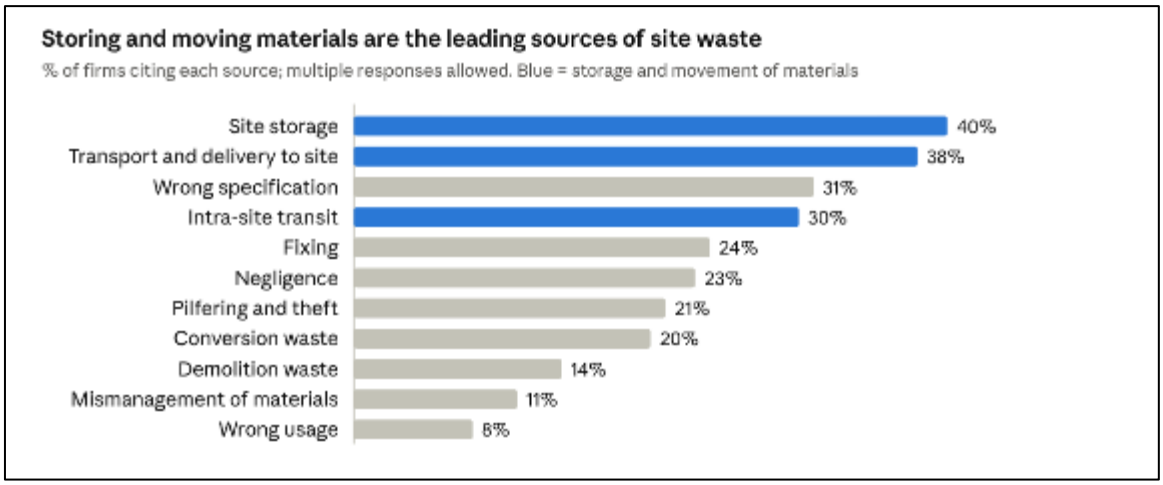

Figure 3: Sources of material waste on building sites. Source: Akinkurolere and Franklin (2005).

Firms rely mainly on supervision and accounting to minimise waste: supervision by engineers and trained personnel (35%), proper site accounting (34.5%) and locating stores close to the work (26%). Capacity development of staff was cited by only 4% of firms. In addition, 41% of firms reported rewarding staff who reduce waste, through cash or in-kind commendation, bonuses, salary increases, promotion and closer supervision.

4.3 Responsibility for damage and plant use

Most firms (75%) held suppliers responsible for materials damaged in transit; 14% said responsibility was shared and 11% placed it on the client. On site, materials are still moved largely by hand. Wheelbarrows accounted for 43% of reported plant use, against 19% for dumpers, 16% for cranes, 10% for hoists, 8% for forklifts and 5% for conveyors.

4.4 Awareness and adoption of lean approaches

All 17 lean approaches are better known than practised (Figure 4). Awareness scores range from 3.36 to 4.22 and adoption scores from 2.89 to 3.84. Identifying clients' needs is the best-known approach, while giving attention to projects that need it most is the most adopted. The widest gaps are in employee training (0.85), measuring the percentage of plan completed (0.54) and identifying clients' needs (0.52). Foremen's involvement in decision-making has the lowest adoption of all (2.89).

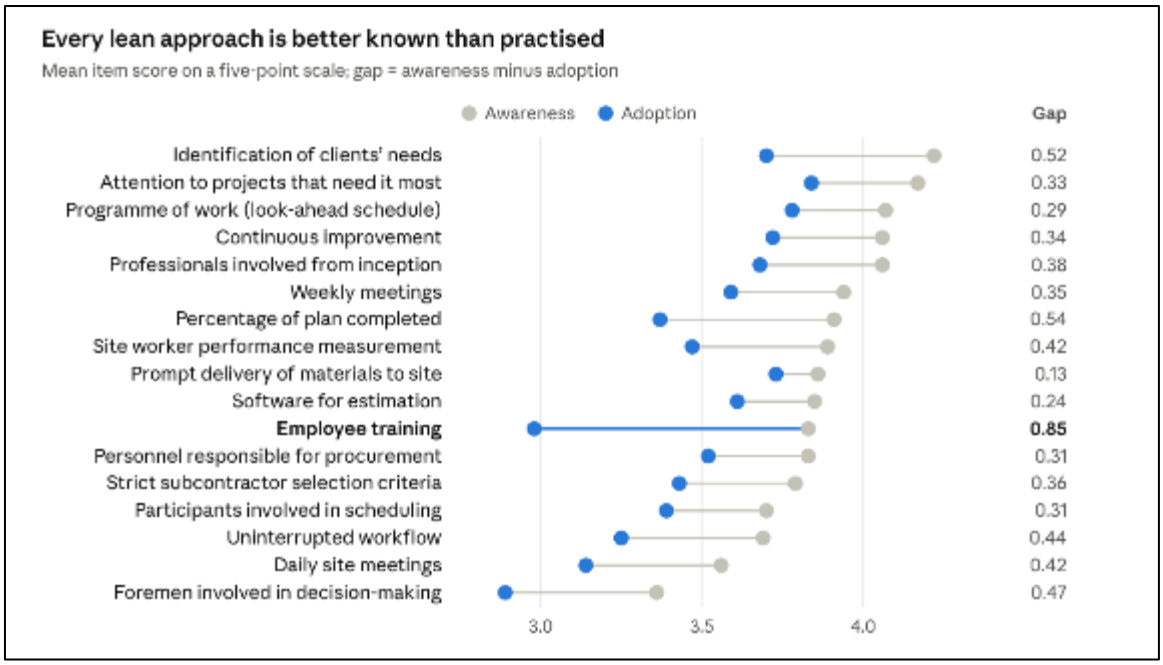

Figure 4: Awareness and adoption of lean approaches in Nigerian construction. Source: Adegbembo, Bamisaye and Aghimien (2016).

4.5 Benefits and barriers of lean construction

Respondents rated all 14 listed benefits above 3.4. Improved project delivery methods (4.40), more satisfied clients (4.07), products that meet client goals (4.00) and continuous improvement (3.99) ranked highest. Benefits tied directly to waste, such as less rework (3.86) and lower direct costs (3.85), sat mid-table. Worker motivation (3.49) and reduced idle time (3.56) ranked lowest.

The strongest barriers concern knowledge rather than resources (Table 4). The 19 barriers ranged from 4.27 down to 3.32 for lack of long-term supplier relationships.

Table 4: Most significant barriers to lean construction in Nigeria

Barrier	MIS	Rank
Lack of enlightenment	4.27	1
Lack of exposure to lean management	4.27	1
Lack of proper training	4.11	2
Difficulty understanding lean construction	3.94	3
Poor communication among clients, consultants and contractors	3.90	4
Waste accepted as inevitable	3.90	5

Source: Adegbembo, Bamisaye and Aghimien (2016).

5 DISCUSSION

5.1 Inventory management

With materials above half of project cost for most firms, the 20% to 30% overrun attributed to wastage (Bossink and Brouwers, 1996) is a large loss of public and private funds, and helps explain the abandoned projects reported by Aluko (2008). Yet most firms manage this largest cost item with paper records, and over a third would not describe their method. Manual records cannot give the real-time visibility that lean flow management requires (Koskela, 2000). Cloud-hosted records would let site managers, quantity surveyors and clients see stock levels at once, applying the lean principle of transparent planning (Chesworth, London and Gajendran, 2011). They would also support just-in-time ordering, cutting the stock exposed to storage losses.

5.2 Waste generation and minimisation

The two leading waste sources, storage and delivery, are flow problems in Koskela's (2000) terms: materials waiting and being moved. Locating stores close to the work reduces handling but increases exposure to weather and theft unless storage is secured with CCTV, controlled access and issue records. Wrong specification reflects the design-change and rework problems identified by Adewuyi and Odesola (2015) and points to the value view: capturing requirements accurately before materials are ordered.

Firms favour supervision and accounting over training, with only 4% investing in capacity building. Supervision catches waste after it occurs, whereas training reduces the negligence and mismanagement that cause it. The 41% of firms already rewarding waste reduction show that incentives are accepted. Formalising them through targets, scoring and team rewards (gamification) would extend their reach and address worker motivation, the lowest-rated lean benefit.

5.3 Responsibility and handling equipment

Holding suppliers responsible for transit damage is reasonable where contracts specify delivery condition, but the result reflects only contractors' views. Lean thinking treats such damage as a shared supply chain problem, solved through long-term supplier relationships and clear specifications (Kempton, 2006). On site, reliance on wheelbarrows confirms that manual handling damages fragile materials (Akinkurolere and Franklin, 2005). Greater use of forklifts, hoists and conveyors would reduce intra-site damage, the fourth-largest waste source.

5.4 Lean awareness, adoption, benefits and barriers

Awareness of lean has grown considerably since Olatunji (2008) found that only two in ten respondents had heard of it. The consistent gap between awareness and adoption, however, shows that knowledge has not yet changed site practice. The largest gap, in employee training, matters because training is also a top-three barrier and the least-used minimisation method. Low adoption of foremen's involvement in decisions is also a concern, since foremen supervise materials directly and know where waste occurs.

Respondents value lean mainly for better delivery and client satisfaction, matching the lean goals identified in Section 2.3. The lowest-rated benefits concern the workforce, suggesting lean is seen as a management tool rather than a way of organising site work. All top barriers concern knowledge, and acceptance of waste as inevitable mirrors the habit of pricing a wastage allowance into estimates (Obiegbu, 2002). Education is therefore the main lever for wider adoption, ahead of investment in technology or plant.

6 CONCLUSION

This paper evaluated measures for reducing material waste in the Nigerian construction industry. Materials are the largest cost item on most projects, yet they are tracked mainly with manual records, so poor stock visibility is a root cause of waste. Most waste arises from storing and moving materials, compounded by wrong specification; these are the flow and value losses lean methods are designed to remove. Firms rely on supervision and accounting after the fact and invest little in training, although many already reward staff who reduce waste. Lean approaches are now widely known and their benefits recognised, but adoption lags awareness for every approach, held back mainly by gaps in enlightenment, exposure and training. Lean project management is therefore a practical framework for Nigerian contractors, but its gains depend on education and changed site practice, not awareness alone.

6.1 Recommendations

Recommended measures, each linked to the finding it addresses and the lean principle it applies.

Recommended measures for minimising material waste

Measure	Finding addressed	Lean principle	Lead party
Cloud-based software to record, issue and reorder materials	35% gave no record method; 4% use computers	Transparency; just-in-time supply	Contractors
Rewards tied to measured waste reduction (gamification)	41% already reward staff; motivation rated lowest	Continuous improvement	Contractors
Forklifts, hoists and conveyors for intra-site movement	43% wheelbarrow use; transit waste 30%	Flow	Project managers

Secure stores with CCTV, access control and issue logs	Site storage the leading source (40%)	Flow; inventory control	Site managers
Fix specifications before procurement; involve foremen in planning	Wrong specification (31%); low foremen involvement	Value; right first time	Designers, project managers
Lean construction in university curricula and CPD	Knowledge barriers ranked highest	Building capability	Universities, professional bodies

Future research should collect primary data on actual waste quantities on Nigerian sites before and after lean measures are introduced. Surveys of suppliers would also test the contractors' view of who is responsible for transit damage.

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