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Influence of Circular Economy Practices on Resource Efficiency in Construction Sites in Bauchi State, Nigeria

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Abstract

Despite the construction sector's economic importance in Nigeria, building projects in Bauchi State face resource inefficiencies under conventional linear practices. This study examined how Circular Economy (CE) practices influence resource efficiency on building sites in Bauchi Metropolis, assessing adoption, baseline efficiency, barriers, and predictive effects. A quantitative cross-sectional survey used structured questionnaires administered to 256 built environment professionals (Builders, Quantity Surveyors, Architects, and Civil Engineers). The 204 valid responses represented a 79.7% response rate. Data were analyzed using descriptive statistics, Pearson correlation, and multiple linear regression. CE adoption was low to moderate ($\bar{X}$ = 2.68) and concentrated in cost-saving measures, particularly formwork timber reuse ($\bar{X}$ = 3.98) and accurate material estimation ($\bar{X}$ = 3.82). Recycling ($\bar{X}$ = 2.04) and circular design ($\bar{X}$ = 2.21) were rarely practiced. Resource efficiency was low to moderate ($\bar{X}$ = 2.82). Major barriers were the complete absence of sorting and recycling infrastructure ($\bar{X}$ = 4.62) and the lack of regulatory mandates ($\bar{X}$ = 4.54). Regression analysis showed that CE practices significantly predicted resource efficiency (R^2 = .584, F = 46.062, $p < .001$). Resource reduction (β = .302) and sustainable procurement (β = .274) were the strongest predictors practices, particularly resource reduction and sustainable procurement, are associated with improved resource efficiency in Bauchi Metropolis construction projects. The findings support integrating circular principles into site management and procurement. The study recommends enforcing Site Waste Management Plans and establishing local recycling hubs to address infrastructure and regulatory gaps and strengthen adoption.

Keywords

Bauchi State;
Building Construction;
Circular Economy;
Resource Efficiency;
Waste Management.

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1.0 INTRODUCTION

The construction industry occupies a pivotal position in driving global socio-economic development, delivering the physical infrastructure required to sustain industrial activity, enhance human productivity, and improve quality of life. Across developed and developing nations alike, the sector serves as a fundamental engine of economic growth, with the Nigerian construction sector contributing approximately 9% to the national Gross Domestic Product (GDP) (Adeleke, 2019) and accounting for roughly half of the total stock of fixed capital investment in the economy (Ugwu & Attah, 2016). Despite this economic significance, the sector remains a major contributor to environmental degradation and resource depletion, traditionally operating on a linear economy model characterized by a 'take-make-dispose' approach (Preston, 2012; Afolabi et al., 2018). In Nigeria, building construction projects are frequently marred by substantial waste generation, with an estimated 30–40% of construction materials ending up as waste due to inefficient resource utilization, inaccurate estimation, poor storage, and outdated construction techniques (Olawale & Garba, 2020; Saidu & Shakantu, 2016).

To address these systemic inefficiencies, the Circular Economy (CE) has emerged as a restorative and regenerative paradigm designed to maintain the highest utility and value of products, components, and materials for as long as possible (Kirchherr et al., 2017; Geissdoerfer et al., 2017). Unlike the linear system, circular construction focuses on narrowing, slowing, and closing material loops through targeted strategies including resource reduction, material reuse, recycling, resource recovery, sustainable procurement, and circular design for disassembly (Korhonen et al., 2018; Benachio et al., 2020; Akanbi et al., 2018). A central objective of this transition is resource efficiency achieving required construction outputs with the minimum necessary consumption of materials, energy, and water while maximizing economic value (Faremi et al., 2017; Ertz et al., 2021). Within the Nigerian construction context, effective implementation of CE principles is projected to yield a 25% improvement in material efficiency and a 30% reduction in waste disposal expenditure (Unegbu et al., 2024).

Nevertheless, practical adoption of circular construction practices in Nigeria remains uneven due to regulatory weaknesses, inadequate waste-processing infrastructure, financial constraints, and limited technical capacity (Okafor & Ibrahim, 2022; Suleman et al., 2023; Ubayi, 2024). In Bauchi State, rapid urban expansion has intensified residential, commercial, and public institutional building activities, placing mounting pressure on primary resources such as cement, aggregates, timber, and reinforcement steel (Baba & Suratkon, 2017; Dangana et al., 2020). However, existing empirical research in Nigeria has concentrated predominantly on major commercial hubs such as Lagos, Abuja, and Port Harcourt, leaving a pronounced geographical and empirical gap regarding the Bauchi construction environment (Onamade et al., 2022; Benshak & Dabuahat, 2021). Without localized quantitative evidence linking specific CE practices to measurable resource efficiency outcomes, practitioners and policymakers lack an empirical basis for prioritizing circular interventions. Grounded in Institutional Theory, Ecological Modernization Theory, and the Closed-Loop Material Cycle framework (Sassi, 2008; Alyahya et al., 2022), this study empirically assesses the level of adoption of Circular Economy practices, evaluates baseline resource efficiency, identifies critical barriers, and determines the predictive influence of CE practices on resource efficiency across building construction sites in Bauchi State, Nigeria.

2.0 MATERIALS AND METHODS

2.1 Research Design and Approach

This study adopted a quantitative cross-sectional survey research design to systematically evaluate Circular Economy adoption, baseline resource efficiency, implementation barriers, and the predictive relationship between CE practices and resource efficiency within Bauchi Metropolis, Bauchi State, Nigeria. A quantitative approach was selected to obtain standardized, measurable empirical data from active built environment

practitioners and test statistical relationships among study variables (Boudah, 2019; Naoum, 2007). The study focused specifically on building construction projects spanning residential, commercial, public/institutional, and mixed-use developments while excluding heavy civil engineering works such as highways, bridges, and dams.

2.2 Study Population, Sampling Frame and Sample Size

The target population comprised active, certified built environment professionals directly responsible for design specification, material procurement, cost control, and on-site construction management within Bauchi Metropolis, specifically Builders, Quantity Surveyors, Architects, and Civil Engineers (Oladapo, 2007; Gyadu-Asiedu, 2009). Based on professional institutional registers and active project records in the study area, a total sampling frame of 720 professionals was established. Applying Krejcie and Morgan's (1970) sample size determination model for a population of 720 yielded a baseline sample size of 251, which was adjusted to 256 respondents to ensure proportionate representation across the four professional strata and accommodate potential non-response. Proportionate stratified random sampling was employed using the allocation formula $n_i = (N_i / N) \times n$, where n_i is the allocated stratum sample, N_i is the stratum population, N is the total sampling frame (720), and n is the total target sample size (256), as detailed in Table 1.

Table 1: Sampling Frame and Proportionate Sample Size Distribution

S/N	Professional Category	Sampling Frame (N_i)	Proportion (%)	Allocated Sample (n_i)
1	Builders	220	30.56	78
2	Quantity Surveyors	185	25.69	66
3	Architects	101	14.03	36
4	Civil Engineers	214	29.72	76
	Total	720	100.00	256

2.3 Data Collection Instrument and Analytical Techniques

Primary data were collected through a structured, self-administered questionnaire designed on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The instrument comprised four core sections: demographic profile of respondents; level of adoption of six Circular Economy sub-dimensions (Resource Reduction, Material Reuse, Recycling, Resource Recovery, Sustainable Procurement, and Circular Design/Design for Disassembly); level of Resource Efficiency across four dimensions (Material, Economic, Water, and Energy Efficiency); and 14 structural, regulatory, financial, and technical barriers constraining CE adoption. Data were screened, coded, and analysed using IBM SPSS Statistics. Descriptive statistics (frequencies, percentages, mean scores, standard deviations, and mean rankings) were used to establish baseline adoption, efficiency levels, and barrier severity. Inferential statistics specifically Pearson product-moment correlation (r) and multiple linear regression analysis were performed at the 5% significance level ($p < .05$) to test the magnitude and statistical significance of the influence of CE practices on resource efficiency.

3.0 RESULTS AND DISCUSSION

3.1 Questionnaire Distribution and Demographic Profile of Respondents

Out of the 256 questionnaires administered across the four professional strata in Bauchi Metropolis, 204 valid questionnaires were retrieved and found suitable for analysis, representing a robust overall response rate of 79.7% (Table 2). Builders recorded the highest retrieval rate (83.3%), followed by Quantity Surveyors (78.8%), Architects (77.8%), and Civil Engineers (77.6%).

Table 2: Questionnaire Administration and Response Rates

Professional Category	Number Administered	Number Retrieved	Response Rate (%)
Builders	78	65	83.3
Quantity Surveyors	66	52	78.8
Architects	36	28	77.8
Civil Engineers	76	59	77.6
Total	**256**	**204**	**79.7**

The demographic profile of the 204 respondents (Table 3) shows that Builders constituted the largest professional group (31.9%), followed by Civil Engineers (28.9%), Quantity Surveyors (25.5%), and Architects (13.7%). Regarding industry experience, 37.3% possessed 10–14 years of experience, 23.5% had 15 years and above, 23.5% had 5–9 years, and 15.7% had 0–4 years. Thus, 84.3% of respondents had at least five years of active industry experience. Furthermore, respondents handled residential (48.0%), commercial (22.5%), public/institutional (20.6%), and mixed-use (8.9%) building projects, confirming that the sample possessed sufficient operational exposure to provide reliable empirical assessments.

Table 3: Demographic Characteristics of Respondents (n = 204)

Demographic Variable	Category	Frequency	Percentage (%)
Professional Designation	Builders	65	31.9
	Civil Engineers	59	28.9
	Quantity Surveyors	52	25.5
	Architects	28	13.7
	Total	204	100.0
Years of Experience	0–4 years	32	15.7
	5–9 years	48	23.5
	10–14 years	76	37.3
	15 years and above	48	23.5
	Total	204	100.0
Primary Project Type	Residential	98	48.0
	Commercial	46	22.5
	Public/Institutional	42	20.6
	Mixed-use	18	8.9
	Total	204	100.0

3.2 Level of Adoption of Circular Economy Practices

Table 4 presents the descriptive statistics evaluating the adoption of Circular Economy practices across six sub-dimensions in Bauchi Metropolis. The overall grand mean score of $\bar{X}$ = 2.68 indicates a low-to-moderate baseline adoption of CE principles, demonstrating that site operations remain predominantly anchored to the traditional linear 'take-make-dispose' model.

Table 4: Level of Adoption of Circular Economy Practices in Bauchi Metropolis

Circular Economy Dimension / Practice Statement	Mean ($\bar{X}$)	Std. Dev.	Rank
A. Resource Reduction (Sub-dimension Mean)	**3.45**	**0.88**	**1st**
Material quantities are accurately estimated before procurement	3.82	0.81	1st
Materials are properly stored and handled to prevent damage and loss	3.65	0.84	2nd
Work is supervised to minimise errors, rework, and material waste	3.44	0.89	3rd
Project drawings/specifications are reviewed to minimise material use	3.38	0.90	4th
Materials ordered in quantities that avoid over-ordering	3.25	0.92	5th
Water and energy use monitored on site	3.17	0.94	6th
B. Material Reuse (Sub-dimension Mean)	**2.94**	**1.02**	**2nd**
Timber formwork is reused on multiple construction activities	3.98	0.82	1st
Reusable materials recovered from site are stored for subsequent use	3.10	0.98	2nd
Surplus materials are transferred to other work activities	2.85	1.04	3rd
Materials are inspected to confirm suitability before reuse	2.52	1.10	4th
Doors, windows, or roofing components reused where suitable	2.25	1.15	5th
C. Sustainable Procurement (Sub-dimension Mean)	**2.56**	**1.05**	**3rd**
Procurement decisions consider material durability and service life	3.12	0.95	1st
Locally available materials are prioritized	2.95	1.01	2nd
Maintenance, replacement, and disposal costs considered (LCC)	2.40	1.08	3rd
Suppliers assessed on packaging and environmental considerations	2.22	1.09	4th
Materials with recycled content considered during purchasing	2.11	1.12	5th
D. Resource Recovery (Sub-dimension Mean)	**2.38**	**1.10**	**4th**
Site personnel identify materials with resale or recovery value	2.75	1.04	1st
Usable materials are recovered from site waste before disposal	2.58	1.08	2nd

Circular Economy Dimension / Practice Statement	Mean ($\bar{X}$)	Std. Dev.	Rank
Construction waste sorted to make material recovery easier	2.30	1.12	3rd
Recovered materials cleaned, repaired, or prepared for reuse	2.20	1.14	4th
Formulated channels for transferring recovered materials to buyers	2.07	1.15	5th
E. Circular Design & Design for Disassembly (Sub-dimension Mean)	**2.21**	**1.14**	**5th**
Standardised/modular components considered to reduce off-cuts	2.62	1.08	1st
Building components selected for durability and adaptability	2.35	1.12	2nd
Design decisions consider how materials may be reused in future	2.10	1.16	3rd
Reversible/mechanical connections preferred over wet trades	2.02	1.17	4th
Future recovery or recycling considered during design detailing	1.96	1.18	5th
F. Recycling (Sub-dimension Mean)	**2.04**	**1.16**	**6th**
Scrap metals separated and channelled to informal scrap dealers	2.88	1.02	1st
Concrete, block, or masonry waste crushed for backfill/hardcore	2.15	1.15	2nd
Construction waste separated into categories for recycling	1.88	1.18	3rd
Recycled or secondary materials specified in building projects	1.72	1.20	4th
Timber, plastics, glass, or packaging collected for processing	1.57	1.22	5th
Overall Circular Economy Adoption Grand Mean	**2.68**	**1.06**	

As shown in Table 4, adoption is heavily skewed toward basic, cost-driven operational practices rather than systemic circularity. Resource Reduction ranked highest among the six dimensions ($\bar{X}$ = 3.45, SD = 0.88), led by accurate pre-procurement material estimation ($\bar{X}$ = 3.82) and proper material storage and handling ($\bar{X}$ = 3.65). Material Reuse ranked second ($\bar{X}$ = 2.94, SD = 1.02), driven almost entirely by routine multi-cycle reuse of timber formwork ($\bar{X}$ = 3.98), whereas structural or architectural component reuse remained low ($\bar{X}$ = 2.25). Conversely, upstream and downstream circular strategies exhibited widespread non-adoption: Sustainable Procurement recorded $\bar{X}$ = 2.56, Resource Recovery recorded $\bar{X}$ = 2.38, Circular Design and Design for Disassembly recorded $\bar{X}$ = 2.21, and Recycling ranked lowest at $\bar{X}$ = 2.04. Aside from informal scrap metal recovery ($\bar{X}$ = 2.88), formal waste segregation ($\bar{X}$ = 1.88), specification of recycled-content materials ($\bar{X}$ = 1.72), and collection of timber, plastics, or packaging for processing ($\bar{X}$ = 1.57) were virtually absent. These findings corroborate Agunbiade and Adeyemi (2020), Onyeka et al. (2024), and Dania et al. (2007), confirming that contractors in regional Nigerian cities prioritize short-term cost containment over formal lifecycle circularity.

3.3 Baseline Level of Resource Efficiency Achieved

Reflecting the limited integration of circular economy principles, the overall baseline level of resource efficiency achieved on construction sites in Bauchi Metropolis was low-to-moderate, with a grand mean of $\bar{X}$ = 2.82 (Table 5).

Table 5: Level of Resource Efficiency Achieved in Bauchi Metropolis

Resource Efficiency Dimension / Indicator	Mean ($\bar{X}$)	Std. Dev.	Rank
A. Material Efficiency (Sub-dimension Mean)	**3.01**	**0.95**	**1st**
Recovered/reused materials reduce procurement of new items	3.25	0.91	1st
Actual material consumption kept close to estimated quantities	3.12	0.94	2nd
Material losses from breakage and handling kept to a minimum	2.95	0.97	3rd
Surplus materials are measured/monitored rather than discarded	2.88	0.98	4th
Construction waste is diverted from disposal via circular pathways	2.85	0.96	5th
B. Economic Efficiency (Sub-dimension Mean)	**2.92**	**0.98**	**2nd**
Effective material control helps reduce secondary re-procurement	3.18	0.92	1st
Resource management practices reduce avoidable rework expenses	2.98	0.98	2nd
Reuse and recovery of materials contribute to lower project costs	2.90	1.00	3rd
Efficient use of resources contributes to overall project cost control	**2.82**	**0.99**	**4th**
Reduced site waste minimizes haulage and disposal expenditure	2.72	1.01	5th
C. Water Efficiency (Sub-dimension Mean)	**2.74**	**1.02**	**3rd**
Water used carefully during curing, plastering, and cleaning	3.05	0.96	1st
Water wastage from leakage or careless handling is minimized	2.78	1.03	2nd
Water use on site is actively monitored or controlled	2.62	1.05	3rd
Wastewater or runoff reused for suitable site activities	2.51	1.06	4th
D. Energy Efficiency (Sub-dimension Mean)	**2.61**	**1.05**	**4th**
Transport and delivery activities planned to minimise trip numbers	2.96	0.98	1st
Construction activities coordinated to avoid machinery idling	2.60	1.06	2nd
Equipment operated in ways to prevent excessive fuel consumption	2.52	1.07	3rd
Energy/fuel consumption of site equipment tracked and logged	2.36	1.08	4th
Overall Resource Efficiency Grand Mean	**2.82**	**1.00**	

Material Efficiency ranked highest ($\bar{X}$ = 3.01, SD = 0.95), supported by partial reduction of new material purchases through basic reuse ($\bar{X}$ = 3.25) and adherence to estimated quantities ($\bar{X}$ = 3.12), followed by Economic Efficiency ($\bar{X}$ = 2.92, SD = 0.98). However, Water Efficiency ($\bar{X}$ = 2.74, SD =

1.02) and Energy Efficiency ($\bar{X}$ = 2.61, SD = 1.05) recorded poor performance. Specifically, site teams rarely tracked or logged equipment fuel and electricity consumption ($\bar{X}$ = 2.36) or reused site wastewater ($\bar{X}$ = 2.51). These results align with Dangana et al. (2020) and Saidu and Shakantu (2016), illustrating that unmonitored utility consumption and weak waste-diversion mechanisms constrain overall resource productivity on Bauchi building sites.

3.4 Barriers Militating Against Circular Economy Adoption

Fourteen constraining factors were ranked to diagnose the structural and institutional impediments limiting circular adoption in Bauchi State (Table 6). The most severe barriers were structural and regulatory: complete lack of sorting, processing, and recycling infrastructure in Bauchi ranked first ($\bar{X}$ = 4.62, SD = 0.62), followed by lack of clear government policies, building regulations, and circular mandates ($\bar{X}$ = 4.54, SD = 0.68), high initial investment costs for circular construction methods and tools ($\bar{X}$ = 4.42, SD = 0.73), and insufficient technical knowledge and training among professionals and site labour ($\bar{X}$ = 4.35, SD = 0.77).

Table 6: Factors Militating Against Circular Economy Adoption in Bauchi State

Rank	Militating Factor	Mean ($\bar{X}$)	Std. Dev.
1	Complete lack of sorting, processing, and recycling infrastructure in Bauchi	4.62	0.62
2	Lack of clear government policies, building regulations, and circular mandates	4.54	0.68
3	High initial investment costs for circular construction methods and tools	4.42	0.73
4	Insufficient technical knowledge and training among professionals and site labor	4.35	0.77
5	Client preference for new/virgin materials and stigma against recycled components	4.28	0.81
6	Absence of formal secondary construction material markets and supply chains	4.21	0.84
7	Weak monitoring and non-enforcement of site waste management rules	4.15	0.86
8	Concerns regarding structural strength, quality, and durability of reused materials	4.08	0.89
9	Additional time, labor, and costs associated with manual site sorting and salvaging	3.92	0.91
10	Entrenched reliance on traditional linear construction methods ('take-make-dispose')	3.85	0.93
11	Inadequate space on urban sites for storing and segregating reusable materials	3.68	0.96

Rank	Militating Factor	Mean ($\bar{X}$)	Std. Dev.
12	Lack of cooperation among clients, design consultants, and site contractors	3.55	0.97
13	Lack of verifiable cost-benefit data proving financial savings from CE	3.48	1.01
14	Uncertainty over long-term financial returns on circular investments	3.32	1.04

Client preference for virgin materials ($\bar{X}$ = 4.28), absence of formal secondary material markets ($\bar{X}$ = 4.21), weak enforcement of waste management rules ($\bar{X}$ = 4.15), and structural quality concerns regarding reused components ($\bar{X}$ = 4.08) also registered high severity. These empirical patterns strongly validate Institutional Theory (Alyahya et al., 2022; Unegbu & Yawas, 2024): without coercive regulatory mandates and physical recycling infrastructure, contractors face structural lock-in that discourages site-level waste segregation.

3.5 Relationship and Predictive Influence of CE Practices on Resource Efficiency

Pearson product-moment correlation analysis was conducted to examine the bivariate associations between the six CE sub-dimensions and overall Resource Efficiency (Table 7). All six CE dimensions exhibited statistically significant positive correlations with Overall Resource Efficiency at $p < .01$: Sustainable Procurement ($r = .635$), Resource Reduction ($r = .614$), Material Reuse ($r = .582$), Resource Recovery ($r = .542$), Circular Design ($r = .510$), and Recycling ($r = .468$).

Table 7: Pearson Correlation Matrix Between CE Practices and Resource Efficiency (n = 204)

Variables	1	2	3	4	5	6	7
1. Resource Reduction	1.000						
2. Material Reuse	.425**	1.000					
3. Recycling	.312**	.504**	1.000				
4. Resource Recovery	.388**	.561**	.612**	1.000			
5. Sustainable Procurement	.495**	.438**	.390**	.472**	1.000		
6. Circular Design	.362**	.412**	.485**	.520**	.518**	1.000	
7. Overall Resource Efficiency	**.614****	**.582****	**.468****	**.542****	**.635****	**.510****	**1.000**

***Correlation is significant at the 0.01 level (2-tailed).*

To determine the combined predictive power and individual contributions of the six CE practices on Resource Efficiency, a multiple linear regression analysis was performed (Tables 8 and 9). Diagnostic checks confirmed the absence of multicollinearity, with Tolerance values ranging from .588 to .725 (all > .10) and Variance Inflation Factor (VIF) values ranging from 1.379 to 1.701 (all < 10), alongside a Durbin-Watson statistic of 1.892 indicating independence of residuals.

Table 8: Multiple Regression Model Summary and ANOVA Results

Model Source	Sum of Squares	df	Mean Square	F	Sig. (p)	Model Fit Statistics
Regression	22.384	6	3.731	46.062	.000	R = .764; R^2 = .584
Residual	15.957	197	0.081			Adjusted R^2 = .571
Total	**38.341**	**203**				**SEE = .2845; DW = 1.892**

Predictors: (Constant), Resource Reduction, Material Reuse, Recycling, Resource Recovery, Sustainable Procurement, Circular Design. Dependent Variable: Overall Resource Efficiency.

Table 9: Multiple Regression Coefficients for Predictors of Resource Efficiency

Model Predictors	Unstd. B	Std. Error	Std. Beta (β)	t-value	Sig. (p)	Tolerance	VIF
(Constant)	0.412	0.185		2.227	.027*		
Resource Reduction (X1)	0.285	0.054	0.302	5.278	.000*	0.684	1.462
Sustainable Procurement (X5)	0.248	0.051	0.274	4.863	.000*	0.698	1.433
Material Reuse (X2)	0.184	0.048	0.211	3.833	.000*	0.725	1.379
Resource Recovery (X4)	0.132	0.045	0.156	2.933	.004*	0.624	1.603
Circular Design (X6)	0.108	0.044	0.125	2.455	.015*	0.650	1.538
Recycling (X3)	0.062	0.042	0.074	1.476	.142 (NS)	0.588	1.701

**Significant at p < .05. NS = Not Significant.*

As shown in Table 8, the regression model is highly statistically significant ($F(6, 197) = 46.062$, $p < .001$) and yields a coefficient of determination of $R^2 = .584$ (Adjusted $R^2 = .571$), demonstrating that Circular Economy practices collectively account for 58.4% of the variance in resource efficiency on Bauchi construction sites. Based on the regression coefficients in Table 9, the predictive equation is expressed in Eq. (1):

$$Y = 0.412 + 0.285X_1 + 0.184X_2 + 0.062X_3 + 0.132X_4 + 0.248X_5 + 0.108X_6 \quad (1)$$

where; Y represents Overall Resource Efficiency, X_1 represents Resource Reduction, X_2 represents Material Reuse, X_3 represents Recycling, X_4 represents Resource Recovery, X_5 represents Sustainable Procurement, and X_6 represents Circular Design.

Evaluation of standardized beta weights (Table 9) reveals that Resource Reduction (β = .302, t = 5.278, p < .001) and Sustainable Procurement (β = .274, t = 4.863, p < .001) exert the strongest positive influence on resource efficiency, followed by Material Reuse (β = .211, t = 3.833, p < .001), Resource Recovery (β = .156, t = 2.933, p = .004), and Circular Design (β = .125, t = 2.455, p = .015). This confirms that upstream waste prevention, accurate specification, and lifecycle-oriented procurement deliver the highest immediate resource savings. Notably, Recycling (β = .074, t = 1.476, p = .142) was statistically non-significant in the multivariate model. This outcome reflects the

empirical reality captured in Table 6: because Bauchi State lacks commercial waste-sorting and crushing facilities ($\bar{X}$ = 4.62) and secondary material markets ($\bar{X}$ = 4.21), isolated on-site recycling efforts cannot yet translate into measurable project-wide efficiency gains. Overall, these findings validate Ecological Modernization Theory and the Closed-Loop Material Cycle framework (Sassi, 2008; Ghaffar et al., 2020), establishing that systematic CE adoption substantially improves material, economic, water, and energy performance.

4.0 CONCLUSION AND RECOMMENDATIONS

This study investigated the influence of Circular Economy practices on resource efficiency in building construction sites across Bauchi State, Nigeria. The empirical evidence establishes that baseline CE adoption in Bauchi Metropolis is low-to-moderate ($\bar{X}$ = 2.68) and remains confined to conventional cost-saving routines such as formwork timber reuse and pre-procurement estimation, while formal recycling, resource recovery, and design for disassembly are largely absent. Correspondingly, baseline resource efficiency is low-to-moderate ($\bar{X}$ = 2.82), characterized by weak monitoring of site energy and water consumption. These deficits are driven primarily by structural and institutional bottlenecks, notably the absence of regional waste-processing infrastructure ($\bar{X}$ = 4.62), lack of regulatory mandates ($\bar{X}$ = 4.54), high initial transition costs ($\bar{X}$ = 4.42), and technical skill gaps ($\bar{X}$ = 4.35). Crucially, multiple linear regression demonstrated that CE practices explain 58.4% of the variance in project resource efficiency (R^2 = .584, $p < .001$), with Resource Reduction, Sustainable Procurement, Material Reuse, Resource Recovery, and Circular Design acting as statistically significant positive drivers.

To accelerate the transition toward circular, resource-efficient building construction in Bauchi State, the following targeted recommendations are proposed: (i) the Bauchi State Government, in collaboration with the Council of Registered Builders of Nigeria (CORBON) and relevant urban development agencies, should formulate and enforce policies mandating Site Waste Management Plans (SWMP) and enforcing National Building Code provisions on material auditing; (ii) public-private partnerships should invest in establishing centralized construction waste collection, sorting, and aggregate-crushing hubs in Bauchi Metropolis to unlock secondary material markets; (iii) professional regulatory bodies (CORBON, NIOB, NIA, COREN, and QSRBN) should organize continuous professional development (CPD) workshops and site-level training on Design for Disassembly (DfD), accurate material estimation, and waste recovery protocols; and (iv) clients and design consultants should embed Life Cycle Costing (LCC) and sustainable procurement specifications during early project planning to prioritize durable, modular, and locally recoverable building components.

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