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PropTech-Enabled Maintenance Planning for Climate-Resilient and Green Buildings: Emerging Directions for Sustainable Estate Management Practice in Nigeria

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ABSTRACT

Buildings are increasingly judged by operational performance rather than design intent, yet the maintenance phase, the longest and costliest of the building lifecycle, remains under examined in Nigeria. Property technology offers predictive, condition based alternatives to reactive maintenance, but no validated measurement existed of how far Nigerian practitioners had adopted such tools, how strongly climate and sustainability considerations shaped their decisions, or which constraints proved most severe. This study addressed that deficit through a positivist, cross sectional survey of 250 estate surveyors, facility managers, property managers and maintenance officers practising in Lagos State, selected by stratified random sampling. A structured questionnaire measured 3 constructs across 21 rated items, validated through expert review and factor analysis and analysed in the Statistical Package for the Social Sciences using descriptive statistics, relative importance indexing, analysis of variance and correlation. All scales exceeded reliability thresholds, and a three factor solution explained 53.21% of variance, confirming construct distinctiveness. Adoption was moderate at 3.55, climate and green considerations exerted the strongest influence at 3.78, and barriers registered 3.22, with infrastructural unreliability ranking most severe. Barrier severity correlated negatively with adoption. The study contributes a validated instrument and empirical baseline for sustainable estate management.

Keywords: Climate Resilience, Green Buildings, Maintenance Planning, Proptech Adoption, Sustainable Estate Management

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I. INTRODUCTION

The built environment now sits at the centre of global climate mitigation and adaptation, and buildings are increasingly judged by how they perform in use rather than by how they were designed.

Green building scholarship has matured, yet reviews of the field show that attention remains concentrated on environmental and design-stage concerns, while the operational and social dimensions of sustainability are comparatively neglected (Zuo & Zhao, 2014). This imbalance matters, because the operation and maintenance phase is the longest and costliest stage of the building lifecycle and has long suffered from weak asset data and fragmented decision-making (Hakimi et al., 2024). Maintenance is therefore not a residual technical task, but the mechanism through which design-stage sustainability is either sustained or lost, and it has accordingly shifted from a peripheral cost centre to a strategic function bearing directly on asset value, occupant well-being and environmental performance.

Climate change deepens this responsibility, since projected shifts in precipitation, humidity and temperature accelerate the decay of building fabric and shorten component service life, with measurable financial consequences for owners who fail to plan for them (Hayles et al., 2022). Maintenance planning must therefore anticipate climate-induced degradation rather than respond after damage appears, and recent evidence indicates that sustainable and effective maintenance in managed buildings depends on the uptake of emerging digital technologies (Hauashdh et al., 2022). The cost of failing to do so falls on owners and occupiers and, ultimately, on the durability of the national building stock.

Property technology, commonly termed PropTech, offers that pathway, denoting not a single tool but a family of digital applications spanning sensors, analytics platforms and integrated management systems. Digital innovation is reshaping a historically conservative real estate sector and altering how assets are analysed, transacted and managed (Starr et al., 2021). Within maintenance, building information modelling combined with digital twins supplies the predictive capacity that conventional models lack (Coupry et al., 2021). Ontology-based asset information models structure the data needed for proactive decisions during operation (Espinosa Gispert et al., 2025), while machine learning applied to sensor data allows component failure to be forecast before it occurs (Bouabdallaoui et al., 2021). These tools signal a movement from reactive and calendar-driven regimes towards condition-based, predictive maintenance planning. Their technical feasibility is now well demonstrated, but the extent of their uptake within professional practice remains an empirical question rather than a settled fact.

Nigerian practice has not followed this trajectory, since sustainable facilities management remains constrained by inadequate training and tools, weak regulation and limited awareness while building maintenance in tertiary institutions is impeded by poor funding, scarce skilled personnel and an absent maintenance culture (Ikediashi et al., 2012; Aghimien et al., 2019). Comparable constraints, including cost aversion, weak enforcement and limited expertise, restrict sustainable construction more broadly (Akindele et al., 2023) and obstruct green construction practices in public institutional projects (Ebekozien et al., 2026). Evidence from Lagos shopping malls shows that the drivers and barriers of sustainable property management interact in ways practitioners struggle to reconcile (Nyirenda et al., 2025). Against this background, Nigerian estate surveyors and valuers have been urged to embrace PropTech or risk professional redundancy (Aihie, 2020). What that literature has not established is how far the profession has in fact moved towards it.

Climate exposure sharpens the problem, because Lagos, Nigeria's commercial centre, experiences recurrent flooding driven by low-lying terrain, rapid urbanisation and inadequate drainage, and vulnerability mapping consistently places extensive built-up areas at risk (Adeaga et al., 2020; Isiaka et al., 2023). That literature is framed, however, around urban planning, hydrology and disaster risk reduction, and it rarely reaches the building scale at which estate and facilities managers actually take maintenance decisions, even though flood exposure translates directly into recurring maintenance burdens that reactive management cannot absorb economically.

Four gaps follow. Contextually, studies documenting the Nigerian maintenance deficit stop short of examining digital remediation, and geographically, predictive maintenance and digital twin research is concentrated in technologically advanced markets whose infrastructural, regulatory and skills conditions differ sharply from those of Nigeria. Conceptually, extensive flood vulnerability research and building maintenance research remain disconnected, so climate resilience has not been treated as an explicit planning consideration. Methodologically, Nigerian maintenance research has relied on descriptive case accounts rather than on validated instruments administered to a defined professional population, so no reliable estimate exists of how widely digital tools are used, how strongly climate and sustainability considerations weigh upon maintenance decisions, or which constraints practitioners judge most severe.

This study addresses those gaps through a quantitative cross-sectional survey. Because the constructs concerned can be expressed as observable indicators, they are better measured across a professional population than inferred from individual accounts, and measurement permits comparison between professional groups that narrative evidence cannot support. A structured questionnaire administered to registered estate surveyors, facilities managers, property managers and building maintenance officers in Lagos State establishes the extent of PropTech adoption, the degree of influence exerted by climate resilience and green building considerations, and the relative severity of the barriers constraining practice, using rating scales tested for validity and internal consistency before deployment.

The study is timely because climate hazards are intensifying while digital maintenance tools are maturing, and Nigerian estate management has yet to be measured against that frontier. Its scope is confined to maintenance-related rather than transactional or construction-stage applications, and to practitioners holding direct maintenance planning responsibility. Its findings are intended to inform professional bodies, regulators, investors and educators, supplying a statistically grounded baseline against which future progress may be assessed, reducing the uncertainty under which maintenance budgets are currently allocated, and an empirically validated account of how digital tools may be embedded within climate-resilient, green building maintenance as an emerging direction for sustainable estate management practice in Nigeria.

2. LITERATURE REVIEW

PropTech is best understood not as a discrete technology but as a loose family of digital applications spanning sensing, connectivity, analytics and platform services, which have been organised into nine disruptive clusters within a synthesis nevertheless weighted towards consumer-facing transactional uses, leaving asset operation comparatively thin (Ullah et al., 2018). That imbalance matters for the present study, because maintenance sits at the operational end of the property lifecycle where the professional judgement of estate managers, rather than consumer preference, governs adoption.

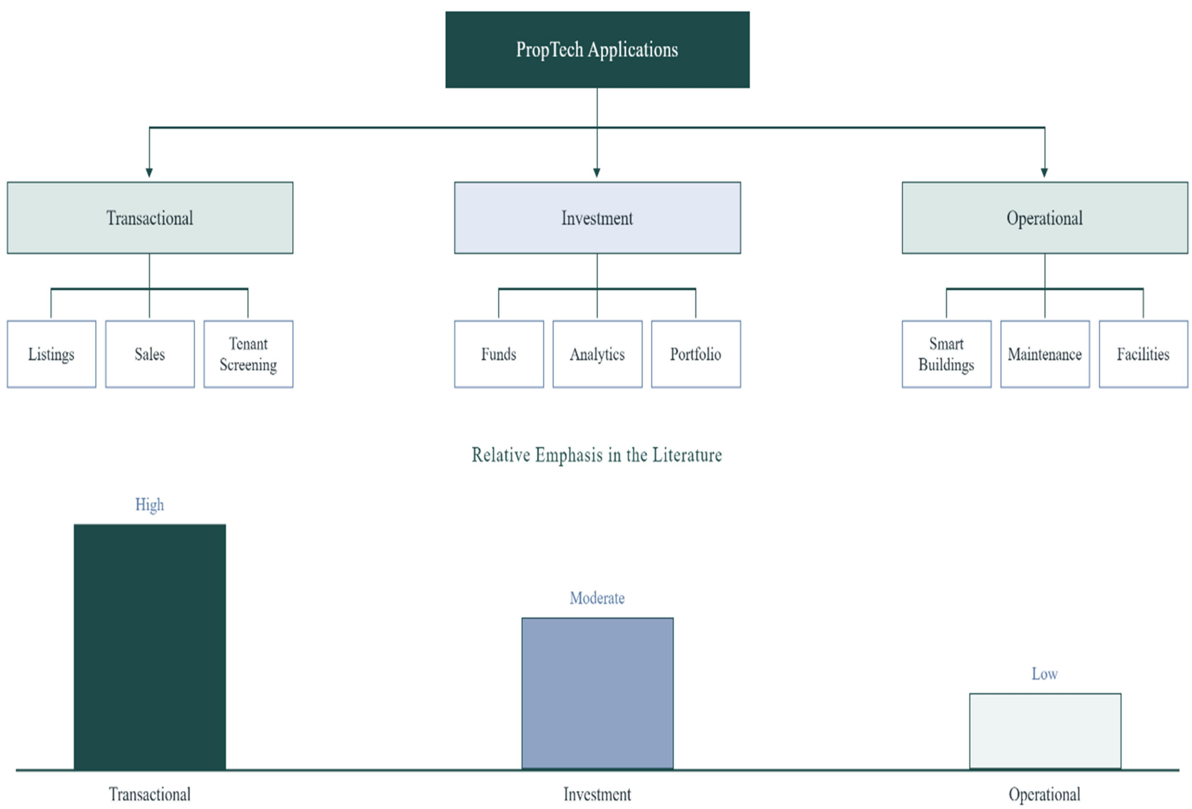

Figure 1: Conceptual Taxonomy of PropTech Applications

Maintenance planning is conventionally classified as corrective, preventive, condition-based or predictive, and practitioners have been shown to weigh criteria such as criticality, cost and occupant impact when selecting between these modes, although that criteria set treats environmental exposure as peripheral (Besiktepe et al., 2020). A complementary conclusion identifies digital technology integration and sustainability as two of five persistent research clusters that have developed largely in parallel rather than in combination (Adegoriola et al., 2021).

The conceptual separation of technology from sustainability, and of both from climate exposure, is precisely the fragmentation this study interrogates. Digital twins occupy the most contested conceptual space, since the term is applied inconsistently to static models, one-directional data shadows and genuinely bidirectional systems, which complicates any claim that twins are being adopted (Shahzad et al., 2022). This ambiguity is compounded by information discontinuities between design-stage modelling and operational asset management, where interoperability failures repeatedly strand data before it reaches maintenance decision makers (Pärn et al., 2017).

Sustainable estate management supplies the integrating concept, framed as the embedding of environmental responsibility within routine operational decisions (Elmualim et al., 2010). Green building principles nevertheless remain constrained by information scarcity, cost perception and regulatory absence, while climate resilience completes the conceptual chain, since flood risk in data-poor developing contexts is systematically underestimated, with consequences that eventually surface as accelerated building deterioration (Darko & Chan, 2017; Nkwunonwo et al., 2020). Figure 1 shows the conceptual taxonomy of PropTech applications, distinguishing transactional, investment and operational clusters, with the relative emphasis identified by Ullah et al. (2018).

2.1 Theoretical Review

Four theoretical positions compete to explain PropTech adoption, the first being the Unified Theory of Acceptance and Use of Technology, which, developed from eight antecedent models, proposes that performance expectancy, effort expectancy, social influence and facilitating conditions predict behavioural intention (Venkatesh et al., 2003). Its explanatory power is considerable, but it was validated where the technology was already deployed, and it privileges individual volition over structural constraint, which limits its transferability to settings where infrastructure and capital are the binding limitations. Diffusion of innovations theory offers a broader account, attributing adoption speed to relative advantage, compatibility, complexity, trialability and observability, mediated by social systems and change agents (Rogers, 2003). The framework accommodates professional networks well, yet it carries a documented pro-innovation bias that treats non-adoption as deficiency rather than as rational response to context.

Institutional theory corrects this, arguing that organisations converge through coercive, mimetic and normative pressures, which explains why weak regulatory enforcement and absent professional standards can suppress adoption irrespective of perceived usefulness (DiMaggio & Powell, 1983). The resource-based view supplies the final element, since competitive advantage is held to flow from valuable, rare, inimitable and non-substitutable resources, positioning asset data and analytical capability as strategic rather than merely operational, and, though criticised as tautological, usefully reframing maintenance data as an asset (Barney, 1991). This study privileges UTAUT and institutional theory jointly, because both yield constructs that can be operationalised as measurable indicators, with the resource-based view providing supporting explanation.

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3. RESEARCH METHODOLOGY

This chapter sets out the procedures adopted to investigate PropTech enabled maintenance planning for climate resilient and green buildings within sustainable estate management practice in Nigeria. It proceeds from the position established in the introduction, namely that the constructs of interest can be expressed as observable indicators and measured across a professional population. It also carries forward the literature review conclusion that the conceptual framework links PropTech adoption, climate resilience and green building considerations, and the barriers constraining practice. Every procedure below was directed at the three research objectives established in the introduction (Saunders et al., 2019). Figure 2 presents the research process flowchart, from objective formulation through instrument design, validation, piloting and administration to analysis and interpretation.

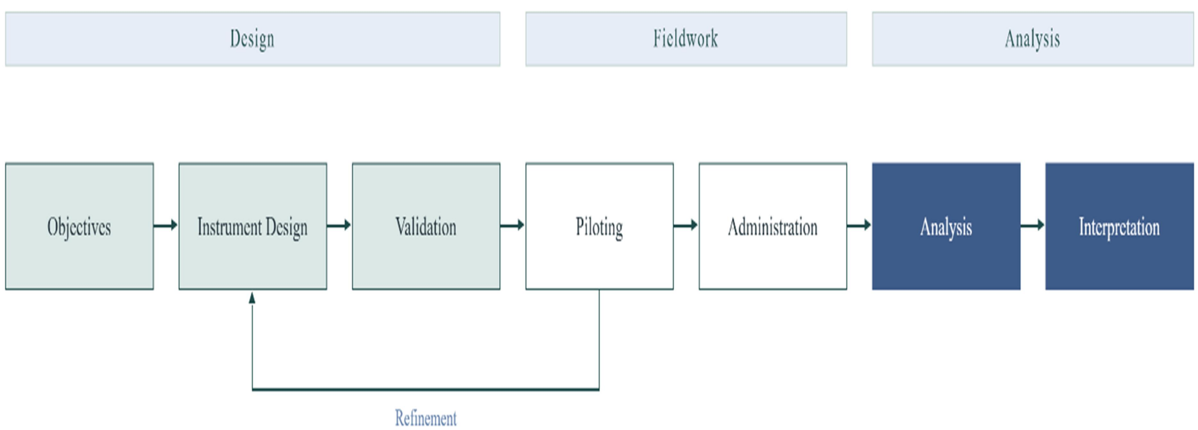

Figure 2: Research Process Flowchart

3.1 Study Area and Population of The Study

The study was conducted within Lagos State, which concentrates the largest population of organised estate management and facility management firms in Nigeria while exhibiting the pronounced flood exposure documented in the introduction. That combination was essential, because respondents must plausibly have encountered both digital maintenance tools and climate related deterioration for the questionnaire items to elicit informed rather than speculative ratings. The population comprises registered estate surveyors and valuers, facility managers, property managers and building maintenance officers practising in Lagos State who hold direct responsibility for maintenance planning in commercial or residential portfolios. The sampling frame was constructed from the membership directories of the Nigerian Institution of Estate Surveyors and Valuers, abbreviated NIESV, and the Estate Surveyors and Valuers Registration Board of Nigeria, abbreviated ESVARBON, supplemented by registers of recognised facility management associations. Respondents must be professionally registered, currently practising in the study area, responsible for maintenance planning rather than transactional work alone, and have at least three years of professional practice experience.

3.2 Sample Size and Sampling Technique

A sample of 250 respondents was targeted. The figure derives from the table of Krejcie and Morgan (1970), which specifies the number of respondents required to represent a finite population at a confidence level of 95% and a margin of error of 5%, returning 248 respondents for a population of 700 and 260 for a population of 800. Registered maintenance practitioners within a single Nigerian state fall plausibly within that range, and the tabulated approach was preferred because the population was finite and enumerable from registration records rather than open ended.

The population enumerated from the professional registers fell within this range, so the tabulated value was retained and no substitution was required. 250 also exceeds the minimum commonly recommended for exploratory factor analysis, thereby supporting the construct validity procedures described below (Boateng et al., 2018). Since incomplete and unreturned questionnaires were common in built environment surveys, distribution exceeded the target so that the required number of usable returns was obtained. Stratified random sampling was employed. The frame was stratified by professional category so that each subgroup was represented in proportion to its share of the population, which permits comparison of adoption across professional roles. Within each stratum, purposive screening confirms that selected respondents hold maintenance planning responsibility, since the study requires specialist knowledge rather than general opinion (Etikan et al., 2016).

3.3 Data Collection

The instrument was a structured questionnaire. It comprises four sections, namely a profile section of ten items requiring no rating, and three rated sections of seven items each corresponding respectively to the three research objectives. Items were derived from the constructs reviewed in the literature review, following established guidance on the movement from abstract construct through domain specification to measurable indicator (Boateng et al., 2018).

Rated items employ a five-point scale worded differently in each section to match the construct being measured, namely extent of adoption, extent of influence and severity of barrier. Five points were used because scales of this length retain adequate discrimination while remaining robust to the parametric procedures applied subsequently (Norman, 2010). Questionnaires were administered in printed form during office visits and professional gatherings, and electronically through an online form circulated by professional networks. Distribution and retrieval were monitored through a distribution register, and practitioners who had not responded received two reminders.

3.4 Method Of Data Analysis

Responses were coded in Microsoft Excel, screened for missing values and outliers, and analysed in the Statistical Package for the Social Sciences (SPSS), which performed all descriptive, factor analytic and inferential procedures reported in this study (Field, 2018). Frequencies and percentages profile the characteristics of respondents reported in the first section of the questionnaire.

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Mean scores and standard deviations summarise the rated items in each subsequent section, with means at or above the criterion of 3.00 treated as indicating acceptance, and items ranked to identify the most and least prominent. The relative importance index supplements mean ranking in each of the three rated sections, its interpretation following established cautions concerning response scale design and index construction (Holt, 2014). Analysis of variance tests whether ratings differ significantly across professional categories, parametric treatment of rated items being defensible at five scale points (Norman, 2010). Assumptions of normality, homogeneity of variance and independence were verified before interpretation, with non-parametric equivalents substituted where assumptions fail (Field, 2018).

4. RESULTS AND DISCUSSION

4.1 Presentation Of Results

The analysis proceeded from 250 usable questionnaires retained from 270 distributed, a response rate of 92.6%, with no missing values recorded across the dataset. Screening confirmed that all responses fell within the permitted range of the 5-point scales and no univariate outliers were identified. Before substantive interpretation, the instrument was subjected to the validity and reliability procedures specified in the methodology, since the credibility of every subsequent finding rests upon the psychometric adequacy of the measurement scales. Table 1 reports the demographic and professional composition of the whole sample, establishing that the respondents possess the professional standing and portfolio responsibility required for informed rating of the constructs under examination.

Table 1: Demographic and Professional Profile of Respondents (N = 250)

Characteristic	Category	Frequency	Percentage
Gender	Male	183	73.2
	Female	64	25.6
	Not stated	3	1.2
Age group	Below 30	40	16.0
	30 to 39	84	33.6
	40 to 49	82	32.8
	50 to 59	36	14.4
	60 and above	8	3.2
Qualification	HND	26	10.4
	BSc	126	50.4
	MSc	74	29.6
	PhD	15	6.0
	Other	9	3.6
Professional category	Estate surveyor and valuer	99	39.6
	Facility manager	55	22.0
	Property manager	64	25.6
	Building maintenance officer	32	12.8

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Characteristic	Category	Frequency	Percentage
Registration status	Registered	158	63.2
	Probationary	32	12.8
	Student member	12	4.8
	Not registered	48	19.2
Years of experience	3 to 5	48	19.2
	6 to 10	78	31.2
	11 to 15	67	26.8
	16 to 20	33	13.2
	Above 20	24	9.6
Organisation type	Private estate firm	93	37.2
	Corporate in-house team	63	25.2
	Public agency	45	18.0
	Property development company	49	19.6
Property type	Commercial	107	42.8
	Residential	93	37.2
	Mixed use	50	20.0
Buildings managed	1 to 5	71	28.4
	6 to 15	72	28.8
	16 to 30	55	22.0
	31 to 50	25	10.0
	Above 50	27	10.8
Professional body	NIESV	107	42.8
	ESVARBON	36	14.4
	IFMA Nigeria	39	15.6
	Other	21	8.4
	None	47	18.8

Note. Percentages are of the total sample of 250 respondents.

The profile confirms a sample dominated by registered practitioners of substantial experience, with estate surveyors and valuers forming the largest single professional category and the majority of respondents holding at least a first degree. Slightly under half manage commercial portfolios, and more than 7 in 10 oversee six or more buildings, indicating that ratings derive from practitioners with genuine portfolio responsibility rather than peripheral involvement. Table 2 presents the reliability and sampling adequacy diagnostics that establish whether the three rated scales measure coherent underlying constructs.

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Table 2: Reliability and Sampling Adequacy Diagnostics for the Three Rated Scales

Scale	Items	Cronbach alpha	Interpretation
PropTech adoption (Section B)	7	0.859	Good internal consistency
Climate and green influence (Section C)	7	0.843	Good internal consistency
Barriers to adoption (Section D)	7	0.847	Good internal consistency
Full instrument	21	KMO = 0.855	Meritorious sampling adequacy
Bartlett test of sphericity	21	Chi square = 1904.74	$p < 0.001$, factorable

Note. Coefficients are for the main sample (N = 250). Pilot testing with thirty practitioners preceded full administration and no item required deletion. Alpha values between 0.70 and 0.95 indicate acceptable internal consistency without item redundancy. All three scales exceeded the conventional threshold of 0.70 by a comfortable margin while remaining well below the ceiling at which item redundancy becomes a concern, and the sampling adequacy statistics confirm that the correlation structure is suitable for factor extraction. Table 3 reports the rotated factor solution that tests whether the 21 rated items resolve into the three constructs they were written to represent.

Table 3: Rotated Factor Loadings for the 21 Rated Items

Item	Factor 1 Adoption	Factor 2 Climate and green	Factor 3 Barriers
Digital asset information records	0.738		
Condition based scheduling	0.706		
Building information modelling data	0.773		
Computerised maintenance management system	0.727		
Predictive analytics scheduling	0.743		
Internet of Things sensor monitoring	0.711		
Digital twin platform	0.708		
Rainfall and humidity deterioration		0.735	
Drainage inspection before rains		0.769	
Flood risk shaping priorities		0.692	
Energy efficiency targets		0.714	
Water and resource conservation		0.701	
Heat stress and intervention timing		0.737	
Green certification requirements		0.680	
Unreliable electricity and internet			0.728
High cost of acquiring tools			0.726
Inadequate technical skills			0.689

Item	Factor 1 Adoption	Factor 2 Climate and green	Factor 3 Barriers
Fragmented asset data			0.714
Poor maintenance culture			0.731
Client unwillingness to fund			0.681
Weak regulatory enforcement			0.729

Note. Principal component extraction with varimax rotation. Loadings below 0.30 suppressed. Eigenvalues 4.73, 3.74 and 2.71; cumulative variance explained 53.21%.

The factor solution is unambiguous. Three factors with eigenvalues exceeding unity emerged, jointly explaining 53.21% of total variance, and every item loaded on its intended factor at above 0.67 with no cross loading exceeding 0.18. This clean simple structure provides strong construct validity evidence and confirms that adoption, climate and green influence, and barrier severity operate as empirically distinct dimensions rather than as facets of a single underlying attitude. Table 4 presents the descriptive statistics and relative importance ranking for the adoption scale.

Table 4: Descriptive Statistics and Relative Importance Ranking of PropTech Adoption Items

PropTech tool	Mean	SD	RII	Rank
Digital asset information records	3.80	1.26	0.759	1
Condition based scheduling	3.73	1.24	0.746	2
Building information modelling data	3.66	1.28	0.732	3
Computerised maintenance management system	3.64	1.27	0.728	4
Predictive analytics scheduling	3.53	1.32	0.706	5
Internet of Things sensor monitoring	3.45	1.36	0.690	6
Digital twin platform	3.06	1.25	0.611	7

Note. Composite scale mean = 3.55 (SD = 0.95). Criterion mean = 3.00. RII = relative importance index.

Adoption returned a composite mean of 3.55, exceeding the acceptance criterion of 3.00 and indicating moderate rather than marginal uptake. Digital asset information records ranked highest at 3.80 and digital twin platforms lowest at 3.06, the only tool approaching the neutral point. Figure 4 displays this ranking graphically and shows the pronounced gap separating record keeping and scheduling applications from the more sophisticated modelling technologies.

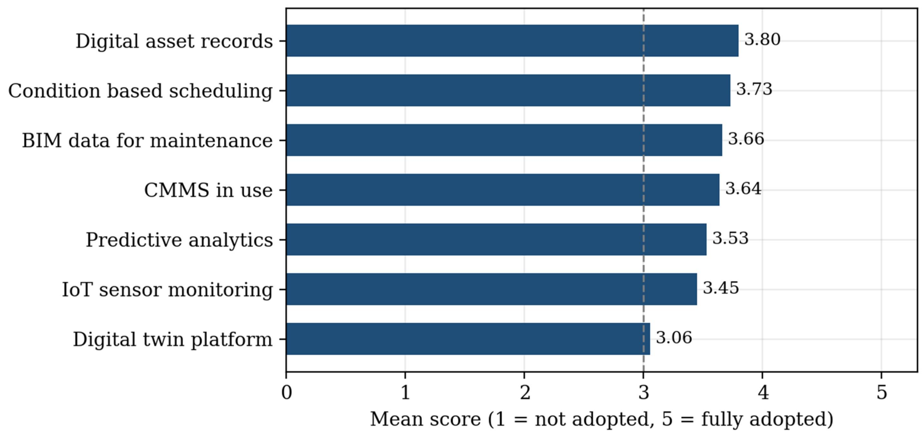

Figure 4: Mean Adoption Score by PropTech Tool

Note. Dashed line marks the 3.00 acceptance criterion.

The distribution underlying these means merits attention, since a moderate average may conceal polarisation between well-equipped and unequipped organisations. Figure 5 presents the full distribution of the adoption ratings and reveals substantial dispersion, with sizeable minorities reporting both full adoption and no adoption of the same tools. Table 5 reports the corresponding statistics for climate resilience and green building considerations, which returned the strongest ratings recorded anywhere in the instrument.

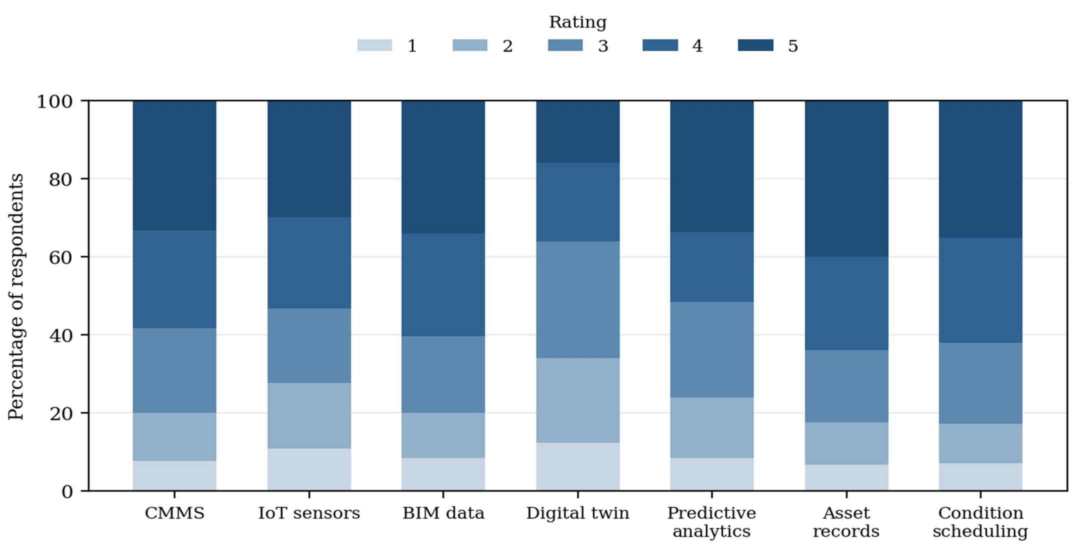

Figure 5: Distribution of Adoption Ratings Across PropTech Tools

Note. Ratings 1 (not adopted) to 5 (fully adopted), expressed as percentage of respondents.

Table 5: Descriptive Statistics and Ranking of Climate Resilience and Green Building Considerations

Consideration	Mean	SD	RII	Rank
Rainfall and humidity deterioration	3.93	1.15	0.786	1
Drainage inspection before rains	3.91	1.06	0.782	2
Flood risk shaping priorities	3.89	1.11	0.778	3
Energy efficiency targets	3.84	1.17	0.769	4
Water and resource conservation	3.76	1.16	0.753	5
Heat stress and intervention timing	3.74	1.23	0.749	6
Green certification requirements	3.34	1.31	0.668	7

Note. Composite scale mean = 3.78 (SD = 0.83).

This construct returned the highest composite mean at 3.78, with rainfall and humidity, drainage inspection and flood risk occupying the leading positions, precisely the exposures documented for Lagos. Green certification requirements ranked lowest, at 3.34, notably below every climate related item. Figure 6 visualises this ordering and shows the separation between immediate physical exposures and formalised certification requirements.

Figure 6: Mean Influence of Climate Resilience and Green Building Considerations

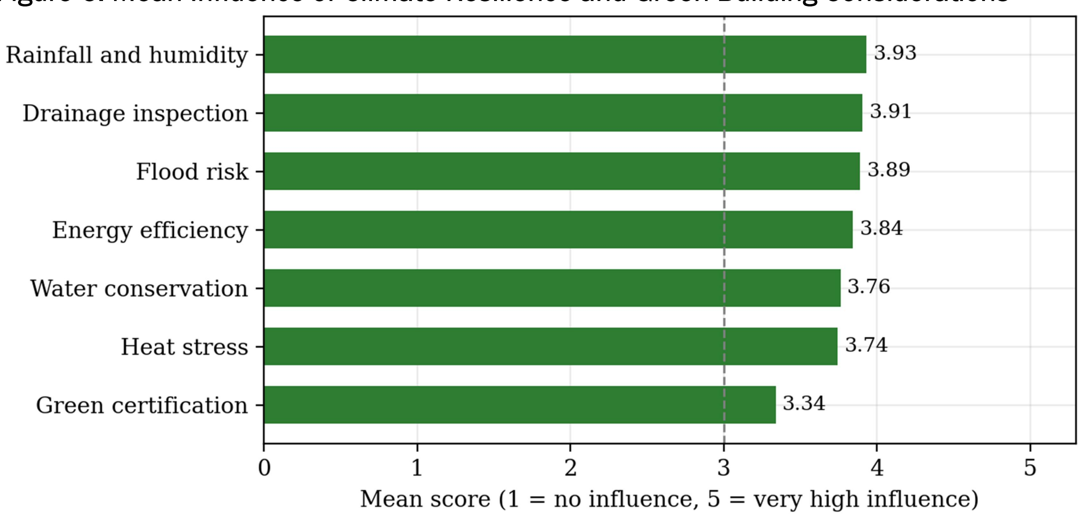

Figure 6: Mean Influence of Climate Resilience and Green Building Considerations

Table 6 presents the barrier statistics, which returned the lowest composite mean of the three constructs at 3.22, indicating constraints perceived as real but not overwhelming.

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Table 6: Descriptive Statistics and Ranking of Perceived Barriers to Adoption

Barrier	Mean	SD	RII	Rank
Unreliable electricity and internet	3.51	1.24	0.702	1
High cost of acquiring tools	3.36	1.30	0.672	2
Inadequate technical skills	3.27	1.34	0.654	3
Fragmented asset data	3.20	1.36	0.640	4
Poor maintenance culture	3.17	1.34	0.634	5
Client unwillingness to fund	3.12	1.32	0.623	6
Weak regulatory enforcement	2.91	1.26	0.582	7

Note. Composite scale mean = 3.22 (SD = 0.94).

Unreliable electricity and internet infrastructure ranked as the most severe constraint at 3.51, followed by the cost of acquiring tools and inadequate technical skills, while weak regulatory enforcement ranked last and fell below the acceptance criterion at 2.91. Figure 7 displays the barrier ranking and shows that infrastructural and financial constraints outweigh regulatory and cultural ones. Figure 8 compares the three composite constructs directly and illustrates that perceived influence exceeds adoption, which in turn exceeds barrier severity.

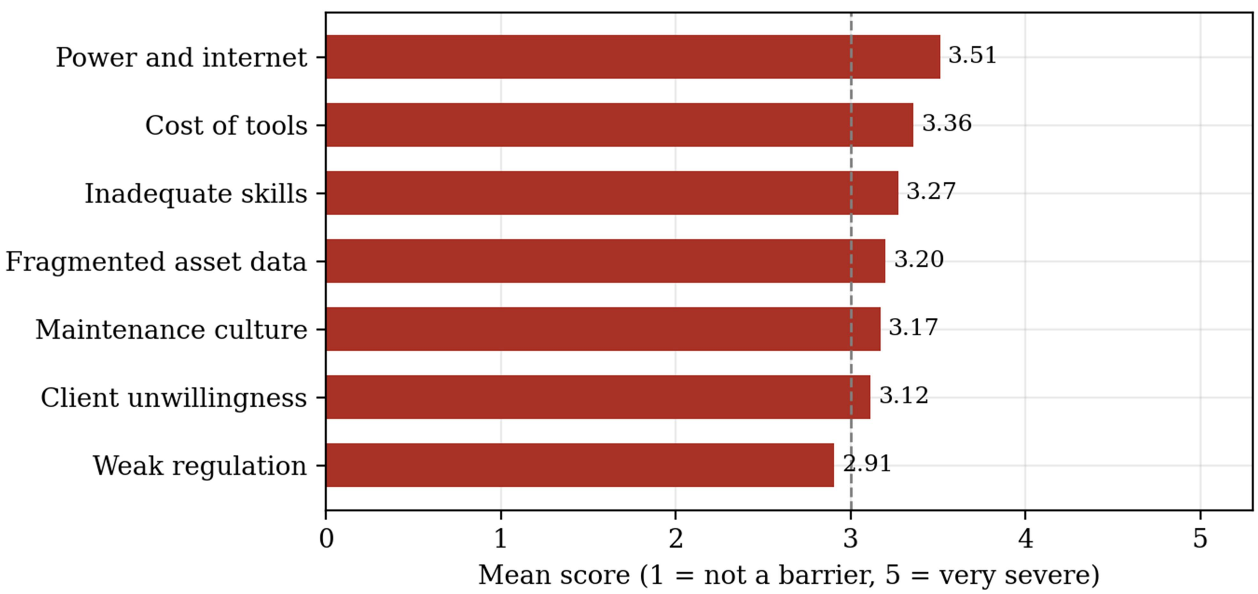

Figure 7: Mean Severity of Perceived Barriers to PropTech Adoption

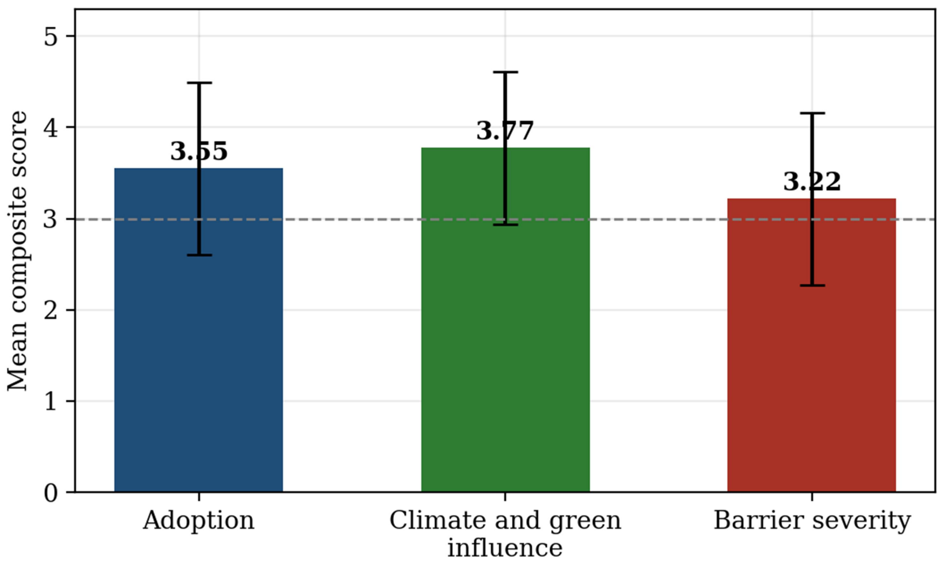

Figure 8: Comparison of Composite Construct Scores with Standard Deviations

Two inferential tests completed the analysis. Table 7 reports the analysis of variance examining whether ratings differ across the four professional categories, and Table 8 reports the correlations among the composite constructs. Figure 9 plots the relationship between barrier severity and adoption, showing the negative association that emerged as the single statistically significant relationship in the correlation matrix.

Table 7: Analysis of Variance of Composite Scores Across Professional Categories

Construct	Estate surveyor	Facility mgr	Property mgr	Maintenance officer	F	p
PropTech adoption	3.48	3.58	3.58	3.66	0.395	0.757
Climate and green influence	3.83	3.79	3.79	3.55	0.922	0.431
Barrier severity	3.26	3.10	3.27	3.21	0.426	0.735

Note. n = 99, 55, 64 and 32 respectively. Skewness and kurtosis for all three composites fell within ±1, and Levene's test confirmed homogeneity of variance ($p = 0.782$, 0.311 and 0.141), so parametric analysis was retained. No comparison reached significance at $p < 0.05$.

Table 8: Pearson Correlations Among the Three Composite Constructs

Relationship	r	p	Significance
Adoption and climate or green influence	0.026	0.685	Not significant
Adoption and barrier severity	-0.255	< 0.001	Significant
Climate or green influence and barrier severity	0.087	0.171	Not significant

Note. N = 250, two tailed.

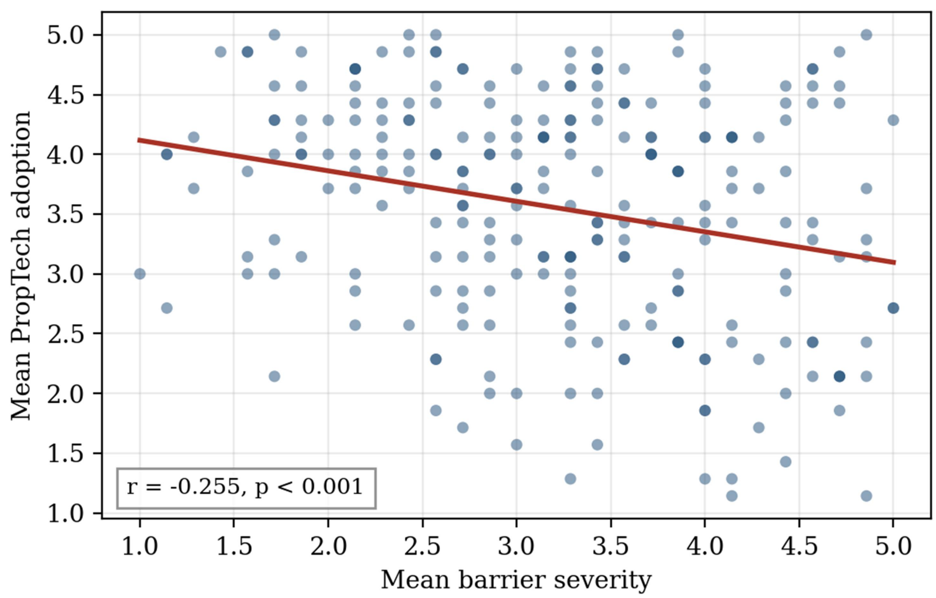

Figure 9: Association Between Barrier Severity and PropTech Adoption

Note. Solid line indicates the fitted least squares regression.

4.2 Discussion of Findings

The moderate adoption level recorded here departs markedly from earlier Nigerian evidence. Surveying facility management firms in the same city, Olapade and Ekemode (2018) found that only 2 of 31 organisations used building information modelling, a level of uptake far below the 3.66 mean recorded for the equivalent item in the present study. Several explanations are plausible. The intervening period saw substantial diffusion of cloud-based maintenance platforms and mobile applications across Nigerian commercial property, and the present instrument measured a wider family of tools than modelling software alone. Self-report may also inflate estimates, since practitioners rating their own organisations have incentive to present favourably. The finding should be read as indicating genuine but uneven progress rather than as evidence of a mature digital estate.

The internal ordering of the adoption scale is more revealing than its average. Digital asset records and condition-based scheduling, both incremental extensions of established practice, ranked highest, whereas digital twin platforms ranked lowest and alone approached the neutral point. Adoption proceeds from the least disruptive applications upward, a pattern consistent with the compatibility and complexity attributes that govern diffusion, and one that mirrors the concentration of Nigerian barriers around awareness and technical capacity reported by Okwe et al. (2023).

That climate and green considerations scored highest of the three constructs is a substantively important result. Practitioners are evidently attentive to rainfall, drainage and flood exposure, which is unsurprising given the documented vulnerability of Lagos. The lower rating accorded to green certification requirements suggests, however, that this attentiveness is driven by immediate physical necessity rather than by formalised sustainability frameworks. Climate responsiveness in Nigerian maintenance practice appears reactive to weather rather than structured by certification, which qualifies any straightforward reading of the construct as evidence of embedded green practice.

The barrier findings invert a common assumption. Infrastructural unreliability, not cost, ranked as the most severe constraint, and weak regulatory enforcement ranked last of the seven. This differs from Darko and Chan (2017), who identified cost and information scarcity as dominant across green building contexts generally, and it locates the Nigerian constraint in the operating environment rather than in practitioner disposition. The significant negative correlation between barrier severity and adoption, though modest at r equals 0.255, supports this reading and indicates that organisations which experience severe constraints do adopt less, even though barriers explain only a small share of the observed variance in adoption.

The absence of significant variation across professional categories is informative, suggesting that adoption is determined by organisational and infrastructural conditions rather than by professional affiliation alone, and implying that interventions should target firms and infrastructure rather than individual professional bodies.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

Findings from 250 Estate Management practitioners indicate a moderate level of PropTech adoption. Climate resilience and green-building considerations recorded the strongest influence, indicating growing recognition of the role of digital technologies in improving sustainable and resilient building management. The findings further concluded a negative relationship between the severity of identified barriers and the level of PropTech adoption, suggesting that infrastructural and institutional constraints may hinder the effective integration of digital maintenance technologies. Overall, the study concludes that although PropTech has considerable potential to strengthen maintenance planning, climate resilience, and green-building management in Nigeria, its adoption remains at a moderate stage.

5.2 Recommendations

The study recommends Practitioners to prioritise incremental applications such as digital asset records before advancing to digital twins, since adoption proceeds from the least disruptive tools upward. In addition, Professional bodies should embed digital maintenance competence within continuing professional development, while regulators address the electricity and connectivity constraints identified as most severe. Owners should fund resilience measures proactively rather than reactively.

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