



CRITICAL SUCCESS FACTOR FRAMEWORK FOR PUBLIC HOUSING MAINTENANCE IN MALAYSIA: THE MODERATING ROLE OF MAINTENANCE BUDGET

Ong Oi Ling¹, Hasniyati Hamzah^{1,2}, Yasmin Mohd Adnan^{1,2}

¹Centre for Sustainable Urban Planning and Real Estate (SUPRE),

²Department of Real Estate,

FACULTY OF BUILT ENVIRONMENT, UNIVERSITI MALAYA

Abstract

Effective building maintenance is crucial for the sustainability of public housing, but it frequently faces challenges due to budgetary and operational constraints. This study identifies and analyses Critical Success Factors to develop a contextualised framework for optimising maintenance performance (MP) within the People's Housing Programme (PHP). This research redefines the Maintenance Budget (MB) as a dynamic moderating variable rather than a conventional, static input. Following a systematic literature review, factors were validated through a three-round Delphi study involving 15 highly experienced industry experts and ranked using the Relative Importance Index (RII). The structural relationships were subsequently tested using Partial Least Squares Structural Equation Modelling (PLS-SEM) with cross-sectional survey data from 156 practitioners across Peninsular Malaysia. The findings revealed that technology-related factors ($\beta = 0.328$, $p < 0.01$) and operations and management-related factors ($\beta = 0.233$, $p < 0.01$) exert the strongest direct impacts on MP. Furthermore, the empirical data confirm that MB significantly moderates the relationships between organisational, technical, human resource, building user, and operational factors and MP. The framework provides evidence-based guidance for policymakers to prioritise funding allocations within Outcome-Based Budgeting mechanisms.

Keywords: Critical Success Factors, Maintenance Performance, Maintenance Budget, Public Housing, Partial Least Squares Structural Equation Modelling

¹ Corresponding author. Email: ostrad2000@gmail.com

INTRODUCTION

Ensuring adequate, safe, and affordable housing remains a cornerstone of Malaysia's social welfare and urban planning agenda. The People's Housing Programme (PHP) serves as the principal vehicle for delivering housing to the nation's low-income urban population. Despite these efforts, public housing in Malaysia is beset by persistent operational challenges, including progressive deterioration linked to age and material quality, limited stakeholder awareness, vandalism, and chronically low maintenance fee collection rates (Abas et al., 2021; Rabe et al., 2021). Although the National Housing Policy (Dasar Perumahan Negara 2018-2025) provides a comprehensive strategic direction, the maintenance of public housing is critically hampered by financial constraints (Ministry of Housing and Local Government, 2018). Rental rates and maintenance fees have been heavily subsidised and capped at RM124 per month since 1998, whereas actual maintenance expenditures currently average RM450 per unit each month (Fischer, 2006; Shuid, 2016). This substantial deficit dependence necessitates heavy reliance on federal subsidies, which are primarily administered through the Outcome-Based Budgeting (OBB) system (Tuan Mat et al., 2023). However, this mechanism often fails to address the actual operational needs of public housing maintenance.

While a considerable body of research has explored maintenance success factors in commercial and private high-rise settings, there remains a conspicuous gap in empirically validated frameworks that address the statutory, financial, and operational realities unique to Malaysian public housing (Khalid et al., 2017). In response, this study seeks to validate a comprehensive set of Critical Success Factors for Building Maintenance (CSFBM) specifically for the PHP context through the Delphi method, empirically evaluate their direct impact on maintenance performance (MP), and investigate the moderating effect of the maintenance budget (MB) using partial least squares structural equation modelling (PLS-SEM). The primary objective is to develop a CSFBM framework that integrates budgetary moderation to facilitate the effective implementation of national housing policies and local authority mandates

LITERATURE SYNTHESIS AND CONCEPTUAL FRAMEWORK

The theoretical framework underpinning this study integrates the Input-Output Model (Ogunbayo et al., 2022). Within this context, CSFBMs are conceptualised as essential resource inputs to the maintenance management system. It is posited that public housing management is highly dependent on external federal subsidies and statutory fee collections; thus, budget availability dynamically changes the strength of relationships between technical, human, and operational inputs and final performance outcomes.

Maintenance Performance (MP) is operationalised through measurable reductions in work backlogs, user complaints, and facility breakdowns. While these indicators represent core operational outcomes, they are highly critical in public housing environments where resource scarcity dictates that functionality (She et al., 2022), cost-effectiveness, and service continuity take precedence. Anchored in strategic objectives, Critical Success Factors (CSFs) provide direction for managerial decision-making, supporting the optimisation of time, cost, and resource allocation to deliver sustainable, high-quality results (Dahal & Dahal, 2020; Zawawi et al., 2011).

A Systematic Literature Review (SLR) was conducted following the PRISMA protocol (Page et al., 2021) to establish a theoretical foundation which justifies the initial pool of CSFs. The initial review identified 32 relevant factors. Foundational models in the literature, notably the widely cited five-factor framework by Hauashdh et al. (2021), were utilised as comparative baselines. This study extends existing models by establishing seven independent CSFBM constructs specifically tailored to the public housing context: Organisational-Related Factors (ORF), Human Resource-Related Factors (HRRF), Technical-Related Factors (TRF), Building User-Related Factors (BURF), Statutory Requirement-Related Factors (SRRF), Operation and Management-Related Factors (OMRF), and Physical Building-Related Factors (PBRF). Historically, building maintenance frameworks have categorised Financial-Related Factors (FRF) as standard independent variables. However, this perspective fails to adequately capture the constraints inherent in public sector building maintenance management. In practice, public building maintenance budgets are rarely determined by actual physical requirements or comprehensive condition surveys; instead, they frequently rely on arbitrary allocations and outdated legacy practices. Consequently, financial constraints act as a rigid boundary that governs and limits the implementation of all other maintenance strategies (Mohd Noor, 2018; Noor & Hamid, 2011). Recent literature corroborates this, demonstrating that even robust organisational policies and technical systems are rendered ineffective without adequate financial resources (Amos et al., 2021).

To resolve this conceptual ambiguity, the present study diverges from conventional models by reconceptualising FRF entirely as a dynamic moderating variable, as the Maintenance Budget (MB). Because public housing management relies heavily on external federal subsidies and statutory fee collections, it is posited that budget availability dynamically amplifies or constrains the effectiveness of the core technical, human, and operational drivers of maintenance performance.

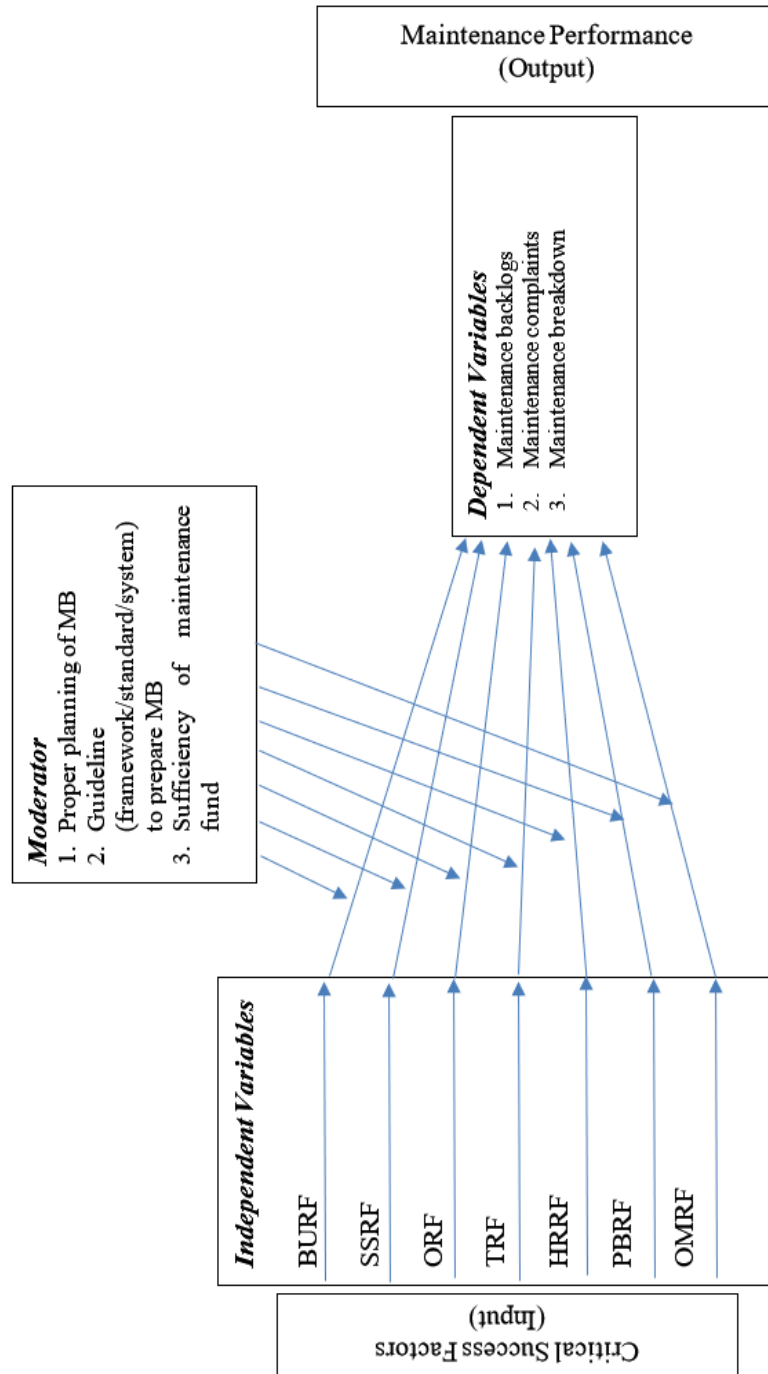
Grounded in this conceptual framework, the following hypotheses are proposed:

- **H1–H7:** ORF, HRRF, TRF, BURF, SRRF, OMRF, and PBRF have a significant positive direct effect on Maintenance Performance (MP).
- **H8–H14:** MB significantly moderates the relationships between the seven CSFBM constructs and MP.

METHODOLOGY

A quantitative research design was implemented, comprising three primary phases: systematic literature review (SLR), the Delphi technique, and empirical validation using PLS-SEM. The CSFBM identified through the SLR was validated using a three-round Delphi technique. A purposive panel of 15 subject matter experts was engaged. The selection criteria required experts to possess over ten years of professional experience specifically within property management, budgeting, and public housing operations. A rigorous 70% consensus threshold was established to determine indicator retention across the three rounds, achieving a 100% participant retention rate. Indicators deemed overly generic or incompatible with the socio-legal realities of PHP (e.g., highly advanced but impractical software integration) were removed, while context-specific indicators (e.g., strategies for managing hardcore defaulters) were incorporated. This culminated in a finalised framework comprising 36 CSFs distributed across the seven constructs. Data were analysed using Smart-PLS 4. Contemporary reporting standards were adhered to by evaluating the measurement model's reliability and validity. Internal consistency was confirmed with Cronbach's Alpha and Composite Reliability (CR) values exceeding the 0.70 threshold across all constructs. Convergent validity was established, as the Average Variance Extracted (AVE) values for all constructs surpassed 0.50, and indicator outer loadings exceeded 0.70. Discriminant validity was rigorously verified using the Heterotrait-Monotrait Ratio (HTMT), with all values falling below the conservative threshold of 0.85, ensuring that the constructs are empirically distinct.

Structural model diagnostics indicated an absence of multicollinearity (Inner VIF values < 3.0) and confirmed the model's predictive relevance ($Q^2 > 0$) alongside a robust coefficient of determination (R^2). The significance of the path coefficients (β) was assessed using a 5,000-subsample bootstrapping procedure.



Source :Adapted from Ogunbayo, Ohiis Aigbavboa, et al. (2022) Input-Output Model

Figure 1: The Conceptual Framework of CSFBM of PHP

ANALYSIS AND RESULTS

Delphi Validation for CSFBM

In the three rounds of the Delphi technique, experts systematically excluded concepts that, while academically endorsed, were deemed impractical for real-world implementation (e.g., BIM integration). Conversely, the panel incorporated socio-legal complexities with direct operational relevance, such as strategies for managing persistent defaulters. This iterative process culminated in a finalised measurement framework comprising 36 CSFs distributed across seven constructs. The indicators are shown in Table 1.

Table 1: List of CSFBM indicators

Organisational-related Factor (ORF)		
1	ORF1	Clear organisation structure and job description
2	ORF2	Collaboration among maintenance stakeholders
3	ORF3	Verification and assessment of maintenance work quality
4	ORF4	Implementing preventive maintenance
Human Resources-related Factor (HRRF)		
5	HRRF1	Employ skilled and experienced manpower
6	HRRF2	Job training for maintenance staffs
7	HRRF3	Courses and workshops to improve staffs' skills
8	HRRF4	Employ experts of building maintenance professionals
9	HRRF5	Monitoring of maintenance staff performance
Technical-related Factor (TRF)		
10	TRF1	Proper maintenance planning at the building design stage and design of building maintenance work accessibility
11	TRF2	Record of accurate data and information about the maintenance work
12	TRF3	Application of advanced technology to detect or evaluate building defects - Adopting building information modelling (BIM)
13	TRF4	Usage of Information and Communications Technology (ICT) - system, software in maintenance work
14	TRF5	Prioritise maintenance activities based on criticality, risk assessment, and the impact on operations.
Financial-related Factor (FRF)		
15	FRF1	Proper planning of maintenance budget
16	FRF2	Sufficiency of maintenance fund
17	FRF3	Guideline (framework/standard/system) to prepare maintenance budget
Building User-related Factor (BURF)		
18	BURF1	Awareness to maintain the building and facility among the building users

19	BURF2	Understanding the usage of building facilities
20	BURF4	Commitment to report building defects by the building users
Statutory requirements-related Factor (SRRF)		
21	SRRF1	Application of prescribed method in the procurement of maintenance contractors
22	SRRF 2	Compliance to Strata Management Act
23	SRRF 4	Inspection of building safety and health – lift and building
24	SRRF 5	Guideline to deal with hardcore defaulters
25	SRRF 6	Property management company with proper standard operating procedures (SOPs) and good headquarters (HQ) support
26	SRRF 7	Active involvement and surveillance by the authorities on the service performance carried out by the Property Management (PM) team (appointed)
Operation and Management-related Factor (OMRF)		
27	OMRF1	The quality of spare parts, components and materials being used
28	OMRF2	Performance of the maintenance group
29	OMRF 3	Availability of operation and maintenance manuals
30	OMRF 4	Response to maintenance request
31	OMRF 5	Outsourcing maintenance work
Physical Building-related Factor (PBRF)		
32	PBRF1	Existing building condition
33	PBRF2	Building age
34	PBRF3	Facilities services - lift systems, water supply systems, power supply systems; security system and fire protection system
35	PBRF4	Design of the building
36	PBRF5	Number of units in the development

PLS-SEM: Measurement Model Assessment

Following the validation of CSFBM, the structural model was evaluated using PLS-SEM to test the hypothesised direct relationships (H1–H7) and the moderating effects of the MB (H8–H14) on MP. The significance of the path coefficients (β) was assessed using a bootstrapping procedure.

Direct Effects of CSFs on Maintenance Performance (H1–H7)

The path analysis produced compelling empirical evidence for the structural influence of five key operational and tactical constructs on maintenance performance in public housing. Table 2 shows the results of the direct effects on MP.

Table 2: Result of Direct Effects on Maintenance Performance (MP)

Factor	Path Coefficient (β)	t-value	p-value
Technical-Related Factors (TRF)	0.328	5.912	< 0.001
Operation and Management-Related Factors (OMRF)	0.233	3.265	0.001
Organisational-Related Factors (ORF)	0.209	3.520	< 0.001
Human Resource-Related Factors (HRRF)	0.182	3.140	0.002
Building User-Related Factors (BURF)	0.174	2.898	0.004

TRF emerged as the most substantial direct predictor of maintenance performance, highlighting the importance of technical systems and rigorous risk assessment protocols. OMRF also contributed significantly, demonstrating the value of effective tactical execution. The results confirm the necessity of robust strategic governance, as ORF had a meaningful impact on maintenance outcomes. The analysis further underscores the critical role of human capital, with HRRF exerting a significant direct effect, and BURF illustrating the influence of tenant engagement and defect reporting on sustained performance. Collectively, these findings support hypotheses H1 through H4 and H6, underscoring the multifaceted drivers of maintenance success in the public sector. In contrast, the empirical analysis did not reveal statistically significant direct effects of SRRF ($\beta = -0.016$, $p = 0.811$) or PBRF ($\beta = 0.069$, $p = 0.185$) on daily maintenance metrics. Consequently, hypotheses H5 and H7 were not supported, indicating that these constructs do not exert a direct structural influence within the tested model.

Moderating Effects of the Maintenance Budget (H8–H14)

An interaction-moderation analysis examined the moderating effect of Maintenance Budget (MB) on relationships between key operational constructs and Maintenance Performance (MP) in public housing. Findings confirmed MB is a highly significant and positive moderator across all five tested pathways. The strongest moderating effect was between MB and Organisational-Related Factors (ORF), with a notable effect size ($\beta = 0.303$, $f^2 = 0.294$, $p < 0.001$). Significant moderating effects were also found for Building User-Related Factors (BURF), Technical-Related Factors (TRF), Operation and Management-Related Factors (OMRF), and Human Resource-Related Factors (HRRF), each showing statistically robust coefficients and p-values.

These findings offer strong empirical support for the hypothesis that the influence of strategic and operational drivers on maintenance performance is significantly enhanced when adequate budgetary resources are available. This underscores the importance of aligning financial planning with operational priorities to achieve effective and sustainable maintenance outcomes in public housing. Table 3 presents the results of the test of the moderation hypothesis.

Table 3: Results of Moderation Hypothesis Testing

Hypothesis	Interaction Path	Path Coefficient (β)	t-value	p-value	Effect size (f^2)	Decision
H8	MB X ORF $\rightarrow$ MP	0.303	5.457	0.000***	0.294	Supported
H11	MB X BURF $\rightarrow$ MP	0.280	4.643	0.000***	0.227	Supported
H10	MB X TRF $\rightarrow$ MP	0.244	4.133	0.000***	0.147	Supported
H13	MB X OMRF $\rightarrow$ MP	0.201	2.917	0.004**	0.129	Supported
H9	MB X HRRF $\rightarrow$ MP	0.136	2.496	0.013*	0.055	Supported
H12	MB $\times$ SRRF $\rightarrow$ MP	0.034	0.561	0.575	0.003	Not Supported
H14	MB $\times$ PBRF $\rightarrow$ MP	0.034	0.613	0.540	0.003	Not Supported

DISCUSSION

The PLS-SEM analysis reveals that the maintenance budget (MB) serves as a critical multiplier, significantly enhancing the influence of Organisational-Related (ORF), Operation and Management-Related (OMRF), Technical-Related (TRF), Human Resource-Related (HRRF), and Building User-Related Factors (BURF) on maintenance performance. Robust organisational frameworks, such as scheduled preventive maintenance and rigorous contractor coordination, are foundational but remain insufficient without adequate financial backing. Specifically, implementing advanced technical solutions, including Building Information Modelling (BIM) and ICT-based defect tracking systems, requires substantial initial and ongoing capital. Similarly, continuous professional development for the maintenance workforce relies heavily on consistent financial support. When adequately funded, these technical and human resource investments can drastically reduce lifecycle costs and system downtime. Furthermore, the budget directly shapes the efficacy of building user engagement; translating tenant awareness into tangible outcomes through clear signage, educational initiatives, and responsive defect-reporting systems fundamentally depends on the management body's financial capacity to execute prompt repairs. A key finding of this study is the lack of significant direct and moderating effects for Statutory Requirement-Related Factors (SRRF) and Physical Building-Related Factors (PBRF). The analysis indicates that legal compliance mandates (e.g., the Strata Management Act and occupational safety inspections) and physical building characteristics (e.g., structural age and mechanical complexity) establish a consistent baseline across all public housing schemes. Because these institutional and physical characteristics are fixed and uniformly mandated, they do not function as daily, fluctuating drivers that alleviate immediate maintenance backlogs or complaints. Furthermore, the budgets analysed in this context are

primarily allocated for routine Operation and Maintenance (O&M). Consequently, augmenting routine O&M budgets does not alter a building's inherent physical age, nor does it affect the efficacy of statutory compliance, which is more closely tied to procurement integrity, contract duration, and regulatory enforcement than to routine financial allocations.

In the context of Malaysia's People's Housing Programme (PHP), these findings expose a significant vulnerability in current building maintenance management models: robust technical and organisational frameworks cannot offset the detrimental effects of persistent underfunding. To enhance maintenance performance and preserve the liveability of public housing, policymakers must transition away from flat-rate or historically constrained subsidy models. Rather than broadly advocating for increased funding, this study recommends that the Ministry of Housing and Local Government (KPKT) and local authorities integrate risk-based budgeting within the federal Outcome-Based Budgeting (OBB) framework. Financial allocations must be strategically aligned with active operational drivers, linking funding directly to performance metrics. Priority should be given to preventive maintenance reserves and digital management systems over reactive interventions. Concurrently, local authorities must strengthen the statutory enforcement of maintenance fee collections to curb operational deficits and secure long-term financial sustainability.

While this study provides valuable empirical insights, it acknowledges several methodological limitations. The reliance on a cross-sectional design and self-reported survey data captures perceptions at a single point in time, thereby limiting the ability to establish strict causal relationships. Additionally, the sample was geographically confined to Peninsular Malaysia, which may restrict the generalisability of the CSFBM framework to other regional contexts or distinct housing systems. Future research should prioritise longitudinal studies to evaluate maintenance performance over time, ideally incorporating objective maintenance logs and cost-effectiveness analyses to complement perceptual data. Cross-country comparative studies within Southeast Asia, as well as comparative analyses across different housing typologies (e.g., public versus private strata developments), are also recommended to broaden the framework's applicability and refine its contextual nuances.

CONCLUSION AND POLICY IMPLICATIONS

Achieving long-term sustainability and functional efficiency in Malaysia's Public Housing Programmes (PHP) requires a shift from reactive maintenance to a proactive, performance-oriented framework. To support this transition, the present research systematically identified 36 Critical Success Factors of Building Maintenance (CSFBM) tailored to the public housing sector. Empirical analysis using Partial Least Squares Structural Equation Modelling (PLS-SEM) indicates

that Technical-Related Factors (TRF) and Operation and Management-Related Factors (OMRF) have the most significant direct effects on maintenance performance. These operational drivers are underpinned by strong organisational governance, skilled human resources, and active tenant engagement. Notably, this study advances maintenance management models by conceptualising the Maintenance Budget (MB) as a dynamic moderator rather than a static input, challenging the traditional view that financial resources function independently of managerial strategies. Additionally, by incorporating context-specific dimensions such as Statutory Requirement, Operation and Management, and Physical Building-Related Factors, this research disputes the assumption that public-sector facilities are exempt from the rigorous physical and statutory scrutiny applied to private developments.

Practically, the contextualised CSFBM framework serves as a critical decision-support tool, bridging the gap between federal funding allocations and local, real-time operational requirements. By empirically demonstrating that the effective implementation of organisational and technical frameworks depends on sufficient financial resources, this study supports a move away from uniform, flat-rate budget distributions. The framework provides housing authorities and budgeting officers with evidence to direct funds toward validated, high-impact initiatives. This strategic approach aligns local maintenance practices with the Federal Government's Outcome-Based Budgeting (OBB) system, thereby optimising the allocation of public funds to foster safer and more sustainable public housing environments.

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