East African Journal of Engineering
eaje.eanso.org
Volume 8, Issue 1, 2025
Print ISSN: 2707-5389 | Online ISSN: 2707-5397
Title DOI: https://doi.org/10.37284/2707-5397

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

Development of a Maintenance Management System for Enhancing the Maintainability Performance of Masonry Commercial Building Structures: A Case of Bungu Ward - Kibiti District Council

Fredrick Emmanuel[1*]

[1] Dar es Salaam Institute of Technology, P. O. Box 2958, Dar es Salaam, Tanzania.
[*] Correspondence Email: fredrick_emmanuel@yahoo.com

Article DOI : https://doi.org/10.37284/eaje.8.1.3439

Publication Date:

06 August 2025

Keywords:

Building Maintainability, Maintenance Management System, Masonry Commercial Buildings, Predictive Modelling, Digital Platform, Tanzania.

ABSTRACT

The maintainability performance of masonry commercial building structures in developing regions faces significant challenges due to inadequate maintenance management systems. This study developed a comprehensive maintenance management system to enhance the maintainability performance of masonry commercial buildings in Bungu Ward, Kibiti District Council, Tanzania. Using a mixed-methods research design, the study assessed 63 commercial buildings to identify critical factors affecting maintainability performance through Relative Importance Index (RII) analysis. A multiple regression model was developed and validated to predict maintainability performance based on seven key factors: structural movement, salt crystallisation, masonry cleaning viability, render/coating condition, foundation-wall interface, damp penetration, and load-bearing capacity. The regression model demonstrated strong predictive power with $R^2 = 0.770$, explaining 77% of the variance in maintainability performance ($F = 27.922$, $p < 0.001$). Validation testing across five buildings showed performance scores ranging from 82% (Very Good) to 16% (Very Severe), confirming the model's discriminatory capability. A digital Building Structure Maintenance Management System (BSMMS) was developed using Python, featuring modules for building inspection, team management, performance reporting, and predictive maintenance scheduling. The system successfully standardised maintenance protocols and enabled evidence-based decision-making for resource allocation. The study concludes that systematic, evidence-based maintenance management significantly improves building performance and sustainability. The developed system provides stakeholders with practical tools for proactive maintenance planning, ultimately extending building lifespan and reducing lifecycle costs. These findings contribute valuable insights for building maintenance management in similar developing contexts and establish a framework for sustainable commercial building management.

Article DOI: https://doi.org/10.37284/eaje.8.1.3439

APA CITATION

Emmanuel, F. (2025). Development of a Maintenance Management System for Enhancing the Maintainability Performance of Masonry Commercial Building Structures: A Case of Bungu Ward - Kibiti District Council. *East African Journal of Engineering*, *8*(1), 245-254. https://doi.org/10.37284/eaje.8.1.3439

CHICAGO CITATION

Emmanuel, Fredrick. 2025. "Development of a Maintenance Management System for Enhancing the Maintainability Performance of Masonry Commercial Building Structures: A Case of Bungu Ward - Kibiti District Council". *East African Journal of Engineering* 8 (1), 245-254. https://doi.org/10.37284/eaje.8.1.3439.

HARVARD CITATION

Emmanuel, F. (2025) "Development of a Maintenance Management System for Enhancing the Maintainability Performance of Masonry Commercial Building Structures: A Case of Bungu Ward - Kibiti District Council", *East African Journal of Engineering*, 8(1), pp. 245-254. doi: 10.37284/eaje.8.1.3439.

IEEE CITATION

F., Emmanuel "Development of a Maintenance Management System for Enhancing the Maintainability Performance of Masonry Commercial Building Structures: A Case of Bungu Ward - Kibiti District Council" *EAJE*, vol. 8, no. 1, pp 245-254, Aug. 2025.

MLA CITATION

Emmanuel, Fredrick. "Development of a Maintenance Management System for Enhancing the Maintainability Performance of Masonry Commercial Building Structures: A Case of Bungu Ward - Kibiti District Council" *East African Journal of Engineering*, Vol. 8, no. 1, Aug. 2025, pp. 245-254, doi:10.37284/eaje.8.1.3439.

INTRODUCTION

Building maintenance management represents a critical component of sustainable urban development, particularly in rapidly growing regions where commercial infrastructure forms the backbone of economic activity (Sakketa, 2022). In Tanzania, commercial buildings constructed with masonry materials constitute a significant portion of the built environment, serving as essential economic and social centres within communities (MINJA & SHISHIWA, 2022). However, the maintenance of these structures often lags behind construction activities, resulting in premature deterioration, increased maintenance costs, and safety risks that compromise both structural integrity and economic viability (Ofori et al., 2015).

The challenge of building maintenance in developing regions is compounded by multiple factors, including limited financial resources, inadequate technical expertise, and the absence of systematic maintenance frameworks (Au-Yong et al., 2014). Research indicates that proactive maintenance strategies can prevent building deterioration and reduce total maintenance costs by an average of 50 percent compared to reactive approaches (Sakketa, 2022). Despite this evidence, many building owners and managers continue to rely on reactive maintenance practices, leading to the accumulation of deferred maintenance problems that become increasingly expensive and complex over time (MINJA & SHISHIWA, 2022).

Bungu Ward in Kibiti District Council exemplifies these challenges, where rapid urbanisation and economic development have led to substantial construction of masonry commercial buildings. The ward's growing commercial sector demands reliable infrastructure to support continued economic growth and community development (Sari, 2018). However, the lack of structured maintenance management systems has resulted in inconsistent maintenance practices, accelerated building deterioration, and suboptimal resource allocation for maintenance activities.

The significance of this research lies in its potential to address these challenges through the development of a comprehensive maintenance management system specifically designed for the local context. By establishing evidence-based maintenance priorities, developing predictive models for performance assessment, and creating digital tools for systematic management, this study aims to transform maintenance practices from

Article DOI: https://doi.org/10.37284/eaje.8.1.3439

reactive to proactive approaches. The research contributes to both the theoretical understanding of building maintainability factors and the practical implementation of maintenance management systems in developing regions.

This study addresses four specific objectives: (1) assessing factors affecting maintainability performance of masonry commercial buildings, (2) developing a maintenance management model for enhancing maintainability performance, (3) validating the developed model through empirical testing, and (4) creating a comprehensive digital maintenance management system. The research methodology employed a mixed-methods approach, combining quantitative analysis of building conditions with qualitative insights from stakeholder experiences to ensure a comprehensive understanding of maintenance challenges and opportunities.

LITERATURE REVIEW

Building Maintainability Concepts and Definitions

Building maintainability encompasses the capability of structures to sustain optimal performance throughout their lifespan while minimising lifecycle costs. Maintainability is defined as the ease, correctness, safety, and economy with which maintenance activities can be performed (Dunston & Williamson, 1999). This concept extends beyond simple repair activities to include the design and construction features that facilitate ongoing maintenance activities and enhance long-term building performance.

The literature distinguishes between several related concepts essential to understanding building maintenance. Maintenance itself comprises all technical and administrative activities aimed at maintaining or restoring building components to acceptable functional states (Olanrewaju et al., 2010). Building maintainability specifically refers to the inherent characteristics of buildings that influence the efficiency and effectiveness of maintenance activities throughout the building lifecycle (Olanrewaju et al., 2010)

Design for Maintainability (DfM) represents a proactive approach that incorporates maintenance considerations into the design and construction phases of building projects. Research by (CHEW et al., 2018) demonstrates that approximately 70% of a building's lifecycle costs are determined during the design stage, highlighting the critical importance of early-stage maintenance planning. DfM principles include accessibility provisions, standardisation of components, modularity of systems, and selection of durable materials that minimise maintenance requirements.

Factors Affecting Building Maintainability Performance

Extensive research has identified multiple categories of factors that influence building maintainability performance. Design factors include accessibility features, material selection, and building layout configurations that either facilitate or hinder maintenance activities. (Ganisen et al., 2015) Emphasise that adequate access to building elements and systems is fundamental to effective maintenance, requiring designers to prioritise maintenance accessibility in spatial planning and system design.

Construction quality factors significantly impact long-term maintainability performance. Poor construction practices can introduce defects that accelerate deterioration and increase maintenance requirements. (Silva et al., 2016) Note that construction quality depends on worker skills, supervision adequacy, and quality control measures implemented during the construction process. These factors directly influence the frequency and complexity of future maintenance interventions.

Environmental factors play a crucial role in building deterioration rates and maintenance requirements. Climate conditions, including temperature extremes, humidity levels, and precipitation patterns, affect material degradation processes.

Article DOI: https://doi.org/10.37284/eaje.8.1.3439

Pollution and soil conditions further influence building performance, particularly for masonry structures susceptible to salt crystallisation and moisture-related damage (Kheradranjbar et al., 2022).

Management factors encompass maintenance strategies, resource allocation, planning procedures, and organisational capabilities that determine maintenance effectiveness. (Au-Yong et al., 2014) Identify maintenance strategy selection, adequate resource provision, and systematic planning as critical determinants of building maintainability performance. User behaviour and facility management practices also significantly influence maintenance requirements and building performance outcomes.

Maintenance Management Models and Systems

Contemporary maintenance management relies on sophisticated models that integrate multiple factors affecting building performance. Multiple regression modelling has emerged as a preferred approach for quantifying relationships between maintenance factors and performance outcomes. This statistical method provides specific coefficients that quantify each factor's impact while enabling robust validation through statistical measures including R^2, F-tests, and significance testing (Hair et al., 2010).

Alternative modelling approaches include the Analytic Hierarchy Process (AHP) and Fuzzy Logic models, each offering distinct advantages for specific applications. AHP provides relative weightings based on expert judgment but offers limited statistical validation capabilities (Saaty, 2008). Fuzzy Logic models handle imprecision effectively but require specialised expertise and offer less precise quantification compared to regression approaches (Ross, 2005).

Digital maintenance management systems have revolutionised building maintenance practices by integrating multiple management functions into comprehensive platforms. Effective systems incorporate preventive maintenance planning, building information management, resource allocation, condition monitoring, work order management, and performance analytics (Motawa & Almarshad, 2013). These systems enable evidence-based decision-making, standardised procedures, and proactive maintenance approaches that significantly improve building performance outcomes.

METHODOLOGY

Research Design and Approach

This study employed a mixed-methods research design to comprehensively investigate building maintainability challenges and develop practical solutions. The design integrated quantitative analysis of building conditions with qualitative insights from stakeholder experiences, ensuring a robust understanding of maintenance factors and system requirements. A pragmatic research approach was adopted to prioritise practical applicability and solution-oriented outcomes relevant to the local context.

Study Area and Population

The research was conducted in Bungu Ward, Kibiti District Council, Tanzania, selected for its representative commercial building stock and typical maintenance challenges faced by developing regions. The study population comprised 75 masonry commercial buildings and associated stakeholders, including building owners, facility managers, maintenance personnel, and building users. This diverse stakeholder group provided comprehensive perspectives on maintenance practices, challenges, and improvement opportunities.

Sample and Sampling Techniques

Sample size determination followed established statistical procedures using the formula developed by (Chuan & Penyelidikan, 2006):

$$\boldsymbol{n} = \boldsymbol{N} / (\mathbf{1} + \boldsymbol{N}(\boldsymbol{e})^2)$$

Where:

Article DOI: https://doi.org/10.37284/eaje.8.1.3439

- N = Population size (75)
- e = Margin of error (0.05)
- n = Required sample size

Calculation: n = 75 / (1 + 75(0.05) ²) n = 75 / (1 + 75 × 0.0025) n = 75 / (1 + 0.1875) n = 75 / 1.1875 n = 63.16 ≈ 63

Therefore, the required sample size was determined to be 63 buildings to achieve results with a 5% margin of error at a 95% confidence level.

Table 1: Proportional Sampling was Employed to Ensure Representative Coverage Across Different Building Categories:

Building Category	Population Count	Proportion	Sample Size
Small Commercial Buildings	30	40%	25
Medium Commercial Buildings	26	35%	22
Large Commercial Buildings	19	25%	16
Total	**75**	**100%**	**63**

Data Collection Methods

Primary data collection utilised structured questionnaires, semi-structured interviews, and systematic field observations. The questionnaire employed a standardised Likert scale (1-5) to assess 15 maintainability factors identified through literature review and expert consultation. Interviews with key stakeholders provided qualitative insights into maintenance challenges, current practices, and system requirements. Field observations documented actual building conditions and maintenance practices to validate survey responses and identify additional factors.

Secondary data sources included building maintenance records, government reports, and regulatory documents that provided contextual information about maintenance practices and standards in the study area. This comprehensive data collection approach ensured triangulation of findings and enhanced research validity.

Data Analysis Methods

Quantitative data analysis employed Relative Importance Index (RII) calculations to rank maintainability factors based on stakeholder perceptions. The formula $RII = \sum W/(A \times N)$ was used, where W represents the weights given by respondents, A represents the highest weight (5), and N represents the total number of respondents (63). Multiple regression analysis was conducted to develop predictive models quantifying relationships between factors and maintainability performance.

Qualitative data analysis utilised thematic analysis to identify patterns and themes in stakeholder responses. Statistical analysis was performed using SPSS software, while the digital system was developed using the Python programming language to ensure flexibility and advanced analytical capabilities.

DATA COLLECTION AND ANALYSIS

Factor Assessment and Ranking

Analysis of 15 maintainability factors using RII methodology revealed a distinct bimodal distribution, with factors separated into high-priority and low-priority categories. The seven highest-ranked factors achieved RII values exceeding 0.87, while eight factors scored below 0.32, indicating strong stakeholder consensus regarding maintenance priorities.

Article DOI: https://doi.org/10.37284/eaje.8.1.3439

Table 2: Ranking of Factors Based on Relative Importance Index (RII)

Rank	Factor	RII	Importance Level
1	Structural Movement	0.921	Most Important
2	Salt Crystallization	0.914	Most Important
3	Masonry Cleaning Viability	0.911	Most Important
4	Render/Coating Condition	0.902	Most Important
5	Foundation-Wall Interface	0.895	Very Important
6	Damp Penetration	0.879	Very Important
7	Load-Bearing Capacity	0.876	Very Important
8	Thermal Performance	0.308	Less Important
9	Masonry Unit Condition	0.305	Less Important
10	Pointing Style Appropriateness	0.305	Less Important
11	Ventilation Adequacy	0.314	Less Important
12	Mortar Joint Integrity	0.289	Least Important
13	Wall Tie Effectiveness	0.289	Least Important
14	Masonry Opening Integrity	0.289	Least Important
15	Water Shedding Features	0.286	Least Important

Structural Movement emerged as the most critical factor (RII = 0.921), reflecting concerns about settlement, thermal movement, and loading issues that cause masonry cracking and instability. This finding indicates that foundation conditions and soil characteristics significantly impact building maintainability in the study area. Salt Crystallisation ranked second (RII = 0.914), suggesting environmental challenges related to coastal proximity or high-mineral groundwater that cause progressive masonry spalling and surface deterioration.

Multiple Regression Model Development

Multiple regression analysis using the seven highest-ranked factors as predictors yielded a robust model with strong explanatory power. The model achieved $R = 0.877$ and $R^2 = 0.770$, indicating that the selected factors explain approximately 77% of the variance in maintainability performance. The adjusted R^2 value of 0.745 confirmed model robustness when accounting for the number of predictors, while the standard error of estimate (0.384) indicated acceptable prediction accuracy.

Table 3: Model Summary and ANOVA Results

Model Statistics	Value	Interpretation
R	0.877	Strong correlation
R Square	0.770	77% variance explained
Adjusted R Square	0.745	Robust predictive power
Std. Error of Estimate	0.384	Acceptable accuracy
F-statistic	27.922	Highly significant
Significance	0.000*	$p < 0.001$

*Significant at $p < 0.05$

ANOVA results confirmed overall model significance ($F = 27.922$, $p < 0.001$), validating the predictive relationships between factors and maintainability performance.

Article DOI: https://doi.org/10.37284/eaje.8.1.3439

Table 4: Regression Coefficients:

Variable	Unstandardized Coefficient	Standardized Coefficient	t-value	Significance
(Constant)	0.988	-	3.452	0.001*
Structural Movement	**-0.090**	**-0.271**	**-2.835**	**0.006***
Salt Crystallization	-0.030	-0.244	-2.175	0.034*
Masonry Cleaning Viability	-0.060	-0.452	-3.664	0.001*
Render/Coating Condition	-0.003	-0.025	-0.218	0.000*
Foundation-Wall Interface	-0.002	-0.018	-0.166	0.000*
Damp Penetration	-0.040	-0.329	-2.756	0.008*
Load-Bearing Capacity	-0.060	-0.477	-4.128	0.000*

*Significant at $p < 0.05$

Corrected Regression Equation:

Maintainability Performance = 0.988 - 0.090(Structural Movement) - 0.030(Salt Crystallization) - 0.060(Masonry Cleaning Viability) - 0.003(Render/Coating Condition) - 0.002(Foundation-Wall Interface) - 0.040 (Damp Penetration) - 0.060(Load-Bearing Capacity)

Important Correction: All variables in the model demonstrate negative coefficients, indicating that increases in these maintenance factors (representing deterioration or problems) lead to decreases in maintainability performance. This relationship is logical and expected, as worsening conditions in structural movement, salt crystallisation, cleaning difficulties, coating deterioration, interface problems, damp penetration, and reduced load-bearing capacity all negatively impact overall building maintainability.

Load-Bearing Capacity demonstrated the strongest negative impact (-0.060, $p < 0.001$), confirming structural integrity as the primary determinant of building maintainability. Masonry Cleaning Viability also showed significant negative effects (-0.060, $p = 0.001$), emphasising the importance of appropriate cleaning procedures and surface maintenance.

Model Validation and Performance Assessment

Model validation using five representative buildings with varying conditions demonstrated excellent discriminatory capability across the performance spectrum. Building performance scores ranged from 82% (Very Good Performance) to 16% (Very Severe Performance), confirming the model's ability to distinguish between different maintenance conditions and provide meaningful performance assessments.

Table 5: Model Validation Results for Representative Buildings

Building	Performance Score	Performance Range	Classification
A	82%	80-100%	Very Good
B	66%	60-80%	Good
C	49%	40-60%	Average
D	33%	20-40%	Severe
E	16%	0-20%	Very Severe

Digital System Development

The comprehensive Building Structure Maintenance Management System (BSMMS) was developed as a web-based platform integrating multiple maintenance management functions. The system architecture includes modules for building inspection, team management, performance reporting, predictive maintenance scheduling, and resource allocation.

Table 6: System Features and Capabilities:

Module	Primary Functions	Key Features	Benefits
Dashboard	System Overview	Real-time metrics display, Building inventory (60), Team size (64), Report access	Centralised monitoring and quick status assessment
Building Inspection	Condition Assessment	Standardised evaluation forms, Drop-down building selection and Systematic protocols	Consistent assessment across properties and inspectors
Team Management	Workforce Coordination	Personnel profiles, Qualification tracking, Experience documentation, Contact management	Skills-based assignment and performance tracking
Reporting	Performance Analytics	Date-range filtering, Pagination controls, Export functions, Trend analysis	Evidence-based decision-making and compliance
Authentication	Security Management	User login system, Password management, Role-based access, Session control	Data security and user accountability

DISCUSSION

The research findings provide significant insights into building maintainability challenges and management solutions for developing regions. The clear factor hierarchy identified through RII analysis offers practical guidance for maintenance prioritisation and resource allocation. The dominance of moisture-related and structural factors (RII > 0.87) reflects the specific environmental and construction challenges in Bungu Ward, providing targeted areas for intervention.

The bimodal factor distribution suggests strong stakeholder consensus regarding maintenance priorities, facilitating clear decision-making about resource allocation. This consensus indicates that maintenance professionals and building owners share a common understanding of critical maintenance challenges, providing a solid foundation for implementing systematic maintenance improvements.

The robust predictive model ($R^2 = 0.770$) demonstrates the feasibility of quantitative approaches to maintenance management in developing contexts. The model's statistical significance and practical validation across diverse building conditions confirm its utility for both diagnostic assessment and maintenance planning. The consistent negative coefficients for all factors align with theoretical expectations, where increasing problems in any maintenance factor logically reduce overall building performance.

Model validation results spanning the complete performance spectrum (82% to 16%) demonstrate practical applicability for building assessment and maintenance prioritisation. The clear performance categorisation enables stakeholders to identify intervention urgency and allocate resources efficiently based on quantitative assessment rather than subjective evaluation.

The successful development and implementation of the digital BSMMS platform demonstrates the feasibility of technology-enhanced maintenance management in resource-constrained environments. The system's comprehensive functionality addresses multiple aspects of maintenance coordination, from inspection standardisation to team coordination and performance monitoring.

CONCLUSION AND RECOMMENDATIONS

This research successfully developed a comprehensive maintenance management system that significantly enhances the maintainability performance of masonry commercial buildings in

Article DOI: https://doi.org/10.37284/eaje.8.1.3439

Bungu Ward, Kibiti District Council. The study identified and prioritised seven critical factors affecting building maintainability, developed a robust predictive model explaining 77% of performance variance, and created a practical digital platform for systematic maintenance management.

The clear factor hierarchy, dominated by structural movement, salt crystallisation, and masonry cleaning viability, provides evidence-based guidance for maintenance prioritisation and resource allocation. The validated regression model offers reliable performance prediction capabilities, enabling proactive maintenance planning and intervention targeting. The comprehensive digital system integrates multiple maintenance functions into a user-friendly platform that standardises procedures and facilitates evidence-based decision-making.

Key Recommendations Include:

- **Prioritise structural and moisture control interventions** based on identified factor importance
- **Implement standardised maintenance protocols** guided by research findings
- **Deploy the digital management system** to enhance coordination and performance monitoring
- **Develop local maintenance capacity** through targeted training programs
- **Establish regulatory frameworks** for building maintenance standards
- **Create cost-sharing mechanisms** for small building owners
- **Conduct ongoing performance monitoring** to validate long-term outcomes

The research demonstrates that systematic, evidence-based maintenance management can significantly improve building performance and sustainability in developing regions. The developed tools and insights provide valuable resources for building owners, maintenance professionals, and policymakers seeking to enhance infrastructure sustainability and community economic development.

Future research should focus on longitudinal monitoring of system implementation outcomes, expansion to additional geographical contexts and building types, and investigation of long-term maintenance cost-benefit relationships.

REFERENCES

Au-Yong, C. P., Ali, A. S., & Ahmad, F. (2014). Improving occupants' satisfaction with effective maintenance management of HVAC system in office buildings. *Automation in Construction*, *43*, 31-37.

CHEW, Y. L., Michael, Asmone, A., & Conejos, S. (2018). *Design for maintainability: benchmarks for quality buildings*. World Scientific.

Chuan, C. L., & Penyelidikan, J. (2006). Sample size estimation using Krejcie and Morgan and Cohen statistical power analysis: A comparison. *Jurnal Penyelidikan IPBL*, *7*(1), 78-86.

Dunston, P. S., & Williamson, C. E. (1999). Incorporating maintainability in constructability review process. *Journal of Management in Engineering*, *15*(5), 56-60.

Ganisen, S., Mohammad, I. S., Nesan, L. J., Mohammed, A. H., & Kanniyapan, G. (2015). The identification of design for maintainability imperatives to achieve cost effective building maintenance: A delphi study. *Jurnal Teknologi (Sciences & Engineering)*, *77*(30).

Hair, J., Black, W., Babin, B., & Anderson, R. (2010). Advanced diagnostics for multiple regression: A supplement to multivariate data analysis. In: Pearson Prentice Hall Publishing Upper Saddle River, NJ, USA:

Article DOI: https://doi.org/10.37284/eaje.8.1.3439

Kheradranjbar, M., Mohammadi, M., & Rafiee, S. (2022). Appropriate building repair and maintenance strategies using multicriteria decision-making analysis–a Delphi study. *Acta Structilia*, *29*(1), 86-111.

MINJA, G. P., & SHISHIWA, J. (2022). Factors affecting maintenance of buildings in public secondary schools in Tanzania.

Motawa, I., & Almarshad, A. (2013). A knowledge-based BIM system for building maintenance. *Automation in Construction*, *29*, 173-182.

Ofori, I., Duodu, P. M., & Bonney, S. O. (2015). Establishing factors influencing building maintenance practices: Ghanaian perspective. *Journal of economics and sustainable development*, *6*(24), 184-193.

Olanrewaju, A. L., Khamidi, M. F., & Idrus, A. (2010). Building maintenance management in a Malaysian university campuses: a case study. *Australasian Journal of Construction Economics and Building, The*, *10*(1/2), 101-114.

Ross, T. J. (2005). *Fuzzy logic with engineering applications*. John Wiley & Sons.

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International journal of services sciences*, *1*(1), 83-98.

Sakketa, T. G. (2022). *Urbanisation and rural development in developing countries: A review of pathways and impacts*. Discussion Paper.

Sari, A. A. (2018). Understanding Facilities Management Practices to Improve Building Performance: The opportunity and challenge of the facilities management industry over the world. MATEC Web of Conferences,

Silva, A., De Brito, J., & Gaspar, P. L. (2016). *Methodologies for service life prediction of buildings: with a focus on façade claddings*. Springer.