
RISK-BASED PRIVATIZATION OF MAINTENANCE ACTIVITIES FOR HIGH-RISE BUILDINGS USING MCDM: A COMPREHENSIVE REVIEW

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Abstract

Maintenance is a major part of managing a high-rise building because building services have to work safely and continuously. As buildings become larger and more complex, owners often consider outsourcing some maintenance work to private agencies. This can reduce the management burden and give access to specialist skills, but it also brings risks related to cost, quality, safety, time, contractor performance and contracts. For this reason, the decision to privatize a maintenance activity should not be based on cost alone. Multi-Criteria Decision-Making (MCDM) methods can help compare different maintenance activities using several criteria at the same time. This review brings together studies on high-rise maintenance, maintenance outsourcing, risk assessment and MCDM. The review shows that AHP and TOPSIS are widely used for maintenance and contractor selection, while fuzzy and grey techniques are useful when expert judgments are uncertain. The literature also shows a growing interest in performance-based contracts, life-cycle thinking and data-based maintenance. A clear research gap remains in combining maintenance privatization, risk assessment and MCDM specifically for high-rise buildings. A simple risk-based decision approach can help identify activities that are suitable for private outsourcing and activities that are better managed in-house.

Keywords: *High-rise building, building maintenance, privatization, outsourcing, risk management, MCDM, contractor selection, maintenance decision*

1. INTRODUCTION

High-rise buildings depend on many technical and service systems such as lifts, HVAC, electrical installations, fire protection, pumps, plumbing, generators, security and façade systems. Because these systems work together, maintenance is not only a repair activity; it is a continuous management task. Poor maintenance can increase downtime, reduce service quality and create safety problems. Research on high-rise buildings also points out that maintenance becomes more difficult when the building has many systems, heavy occupancy and difficult working conditions ^[1].

To manage this workload, many organizations use private contractors for selected maintenance activities. Contracting out can provide specialist workers, equipment and technical experience, and it may also allow the owner to focus on core management work ^[2], ^[11]. At the same time, outsourcing changes who carries out the work and how risk is controlled. Problems can arise when the contractor performs poorly, reporting is weak, responsibilities are unclear or safety requirements are not followed ^[13].

A maintenance privatization decision therefore has several sides. The owner must consider cost, technical complexity, risk, safety, reliability, quality, response time and contractor capability. MCDM methods are useful in such situations because they allow several criteria to be considered together instead of using one factor only ^[3], ^[19].

This review examines the existing work on risk-based maintenance privatization for high-rise buildings and studies how MCDM methods can support such decisions. The purpose is not to propose a physical or software model, but to organize the existing knowledge and identify a practical direction for future research.

2. OBJECTIVES OF THE REVIEW

The review was prepared with the following objectives:

- (i) To understand the main maintenance problems and risks in high-rise buildings
- (ii) To examine the reasons for privatizing or outsourcing maintenance activities
- (iii) To identify the main criteria used for contractor and maintenance decisions
- (iv) To compare the MCDM methods used in related studies
- (v) To identify gaps in the existing literature

3. REVIEW APPROACH

The review is based on the 40 studies supplied for this work. The papers cover building maintenance, maintenance outsourcing, risk assessment, contractor selection and MCDM applications. The studies were grouped into five themes: high-rise maintenance risks, privatization and outsourcing, MCDM methods, risk-based maintenance planning, and research gaps. This thematic approach is used to compare findings from studies that do not all deal with the exact same building type or decision problem.

Table 1. Summary of Review Themes and Main Focus Areas

Review theme	Main focus
High-rise maintenance	Structural, technical, safety and operational issues ^[1] ^[5]
Outsourcing and privatization	Contracting out, contractor selection and performance ^[2] ^[6]
MCDM methods	AHP, TOPSIS, fuzzy, grey and other ranking methods ^[3] ^[4]
Risk-based maintenance	Risk prioritization, RAMS and life-cycle thinking ^[17] ^[18]
Digital and future tools	BIM, 3D, data quality and predictive approaches ^[35] ^[36]

4. RISKS IN HIGH-RISE BUILDING MAINTENANCE

High-rise maintenance has a different risk profile from routine building maintenance. Work at height, complex mechanical and electrical services, limited access, heavy occupancy and the need for continuous operation can increase the consequences of failure. The literature

points to four broad groups of risk: technical and structural, safety, management and operational, and economic and environmental.

Technical and Structural Risks

Technical risk is linked to the condition and failure of building components or services. Benítez et al. ^[1] showed that corrosion in reinforced concrete structures can require planned intervention at the right time. Their work supports the idea that maintenance decisions should consider both condition and timing rather than waiting for failure. Similar risk-based maintenance ideas have been applied to unique technological structures where limited resources have to be used carefully ^[8]. In high-rise residential buildings, even supporting systems such as sewage treatment can create technical and compliance risks when maintenance is poor ^[5].

Safety and Occupational Risks

Safety is one of the strongest reasons for careful contractor and maintenance selection. High-rise maintenance includes work at height, electrical work, mechanical equipment and fire protection systems. Ansari et al. ^[7] found that falling from height was a major safety risk, followed by injuries from manual tools. Training, supervision and monitoring were important risk-control factors. Fire safety is also a major concern in large and high-rise buildings, where Fuzzy AHP has been used to prioritize fire risk criteria ^[26].

Management and Operational Risks

Outsourcing creates management risks because the owner no longer controls every maintenance activity directly. Contractor experience, past performance, communication and reporting become important. Studies on maintenance contractor selection show that these factors are not always easy to verify in practice ^[6], ^[15]. Data quality is another issue. Madhikermi et al. reported that poor or inconsistent maintenance reporting can weaken decision making. This matters because a privatization decision based on incomplete maintenance data may lead to the wrong choice. ^[36]

Economic and Environmental Risks

Cost remains an important factor, but maintenance cost is affected by several building and service characteristics. Building age, occupancy and service quality have been linked to maintenance cost differences ^[28]. Privatized contracts may also face cost escalation, variation claims or poor cost control. Environmental conditions can add another layer of risk. Studies on tropical high-rise buildings, flood risk and sustainable maintenance show that environmental performance and operating conditions can influence maintenance decisions ^[29].

Risk group	Typical examples	Why it matters for privatization
Technical	Equipment failure, corrosion, service breakdown	Poor technical control can reduce reliability and increase repair cost ^[1] , ^[8]
Safety	Falls from height, fire, electrical	Wrong contractor or weak

	hazards	supervision can increase serious incidents ^{[7], [26]}
Management	Weak reporting, poor coordination, lack of experience	Owner may lose control over service quality and information ^{[6], [36]}
Economic / environmental	Cost variation, building age, climate exposure	May change the real long-term value of outsourcing ^{[24], [28]}

5. PRIVATIZATION AND OUTSOURCING OF MAINTENANCE

Maintenance outsourcing is not a simple decision between “in-house” and “private contractor”. Different activities can have different levels of strategic importance, technical difficulty and risk. Martin^[2] discussed contracting out maintenance as an important management issue, while Hassanain et al.^[15] developed a multi-criteria approach for outsourcing maintenance services. These studies suggest that outsourcing should be treated as a structured selection problem.

Reasons for Outsourcing

Common reasons include access to specialist skills, flexible staffing, lower internal workload, specialist equipment and the ability to focus on core activities^{[2], [11]}. In some cases, outsourcing may also improve service quality when the private contractor has better technical experience. However, the expected benefit depends on how the contract is designed and monitored.

Contractor Selection

Contractor selection is a key part of privatization. Research commonly considers cost, technical experience, previous performance, quality systems and management capability^[6]. Zavadskas et al.^[14] and Hassanain et al.^[15] show how multi-criteria methods can be used to avoid choosing a contractor only because it submitted the lowest price.

Performance-Based Contracts

A related development is performance-based maintenance, where the contractor is paid and evaluated against service outcomes rather than only completed tasks. Recent work on critical infrastructure shows the value of linking maintenance and operation to measurable performance^[33]. Risk identification is especially important in such contracts because poor risk allocation can reduce the expected benefit of outsourcing^{[13], [24]}.

Broader Privatization Models

BOT and PPP arrangements show a wider form of privatization in which private partners may take a larger share of lifecycle responsibility. Risk assessment and risk allocation are central in these arrangements^[20]. Hybrid fuzzy MCDM methods have also been used for contractor and risk prioritization in PPP infrastructure projects^[32]. These studies are useful as supporting evidence, although they are broader than routine high-rise building maintenance.

6. MCDM METHODS USED IN RELATED STUDIES

MCDM methods are useful when several criteria must be considered together. In maintenance decisions, one criterion can easily conflict with another. For example, a contractor may offer low cost but have less experience, while another may offer stronger technical capability at a higher price. MCDM helps make such trade-offs more transparent.

Method	Typical use in literature	Main strength	Main concern
AHP	Criteria weighting and maintenance/contractor selection	Easy to structure a complex decision	Depends on expert judgments ^[1] , ^[11]
TOPSIS	Ranking contractors or maintenance alternatives	Clear comparison with ideal and worst solutions	Results depend on weights and normalization ^[19] , ^[21]
Fuzzy AHP / Fuzzy TOPSIS	Decisions with uncertain expert opinions	Handles linguistic or uncertain judgments	More complex than traditional methods ^[3]
DEMATEL / Grey	Risk interaction and factor prioritization	Useful when risks influence one another	Requires careful interpretation of relationships ^[4]
VIKOR / PROMETHEE / COPRAS / ARAS	Alternative ranking in specialized problems	Provides additional ranking options	Less directly focused on high-rise maintenance privatization ^[7] , ^[9]

AHP

AHP is one of the most common methods in the reviewed literature. It breaks the decision into levels and uses pairwise comparisons to calculate the relative importance of criteria. It has been used for maintenance strategy selection, outsourcing and contractor evaluation ^[1], ^[11]. Its main weakness is that the results depend on expert judgment. Mathew et al. ^[3] and other studies therefore use fuzzy or interval-based approaches when uncertainty is high.

TOPSIS

TOPSIS ranks alternatives by measuring how close each option is to an ideal solution and how far it is from a poor solution. It is often combined with AHP so that AHP provides criterion weights and TOPSIS produces the final ranking ^[19], ^[21]. This combination is useful when the study needs a clear ranking of maintenance activities or contractors.

Fuzzy, Grey and Other Methods

Fuzzy MCDM is useful when experts cannot provide precise numerical values and prefer terms such as “high risk” or “moderate importance”. Interval Type-2 Fuzzy AHP-TOPSIS has been proposed for uncertain group decision making ^[3]. Grey theory and DEMATEL have also been used where expert preferences and risk interactions are uncertain

[4]. Other methods such as VIKOR, PROMETHEE, COPRAS and ARAS appear in specialized maintenance and risk studies^{[7], [9], [31]}.

7. RISK-BASED MAINTENANCE AND SUPPORTING APPROACHES

The literature increasingly moves from simple time-based maintenance towards risk-based maintenance. The main idea is to spend maintenance effort where failure consequences and likelihood are higher. RAMS frameworks consider reliability, availability, maintainability and safety and can support maintenance decision making for civil structures^[22]. Risk-based models have also been used for ageing structures and limited maintenance budgets^[18].

Life-cycle cost is another useful consideration. Privatization decisions can look attractive in the short term but become less attractive when long-term risks, contract changes and lifecycle costs are included. Osman^[24] highlighted the importance of risk-based life-cycle cost analysis for privatized infrastructure. Sustainability is also being added to MCDM studies, including maintenance and material selection for buildings^{[21], [23]}.

Digital approaches are developing alongside these methods. BIM and 3D spatio-temporal models can connect maintenance information with location and time, which may improve planning and reporting^{[35], [38]}. Research on building data quality also shows that good digital information is necessary before advanced decision tools can work reliably^[36]. These tools are promising, but they are not a requirement for a basic risk-based privatization study.

8. RESEARCH GAPS

The literature provides strong support for maintenance planning, outsourcing and MCDM as separate research areas. However, fewer studies directly combine all three for high-rise building maintenance privatization. Existing work often focuses on contractor selection, general outsourcing, structural maintenance, fire safety or infrastructure PPPs rather than the specific activity-level decision faced by a high-rise building owner^{[6], [15]}.

A second gap is the balance between cost and risk. Many decision studies include cost, but the practical consequences of safety, criticality, contractor dependency and service failure may not receive the same weight. A third gap is data quality. Maintenance records are often incomplete or inconsistent, which can weaken both risk assessment and MCDM results^[36]. A fourth gap is the limited use of design-for-maintainability thinking when future outsourcing risk is considered^[39].

The literature also shows a growing use of BIM, 3D models, sensors, predictive maintenance and artificial intelligence^{[25], [34]}. These are useful future directions, but they can make a project unnecessarily complex when the main research question is simply to rank maintenance activities for privatization. A practical M.Tech study can remain focused on expert-based risk assessment and a transparent MCDM procedure.

9. CONCLUSION

Maintenance of high-rise buildings involves many important activities, and outsourcing them can provide skilled manpower, technical support, and operational flexibility. However, it can also create risks related to cost, quality, safety, time, and contractor performance. The reviewed studies show that privatization should not be decided only on the basis of cost. Different technical, financial, safety, and operational factors should be considered together. Risk assessment helps to identify the major risks involved, while MCDM methods help compare and rank maintenance activities in a systematic way. Among the available methods, AHP and TOPSIS are useful for assigning importance to different criteria and obtaining a clear ranking.

Overall, combining risk assessment with MCDM can provide a practical basis for deciding which maintenance activities are suitable for privatization and which are better managed in-house. This can help building owners improve maintenance decisions while maintaining safety, quality, and overall building performance.

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