ADOPTING BEST INFRASTRUCTURE ASSET MANAGEMENT PRACTICES IN SOUTH AFRICA: A CASE OF ETHEKWINI METROPOLITAN MUNICIPALITY: A LITERATURE GAP

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Abstract

This research study focuses on evaluating current infrastructure asset management practices within eThekwini Metropolitan Municipality and proposes strategies for improvement. Using a quantitative approach for data collection, analysis, and presentation, the study identified several key challenges. These include aging infrastructure leading to higher maintenance costs and risks, funding constraints impacting effective management, difficulties in integrating new technologies, and challenges in managing risks like resilience against natural disasters. Issues with data management, regulatory compliance, and public engagement were also highlighted. The study emphasises the need for comprehensive strategies to enhance efficiency, sustainability, and resilience in managing infrastructure assets. Recommendations from this research aim to address weaknesses and promote best practices, benefiting policymakers, urban planners, and infrastructure managers locally and globally.

Keywords: Infrastructure Asset Management, Best Practices, Aging Infrastructure, Sustainable Development, Municipalities.

1. INTRODUCTION

Van (2017:55) ; Danylo and Lemer (1998:5); Grigg (1999:115) and Halfawy (2008:2) reported that infrastructure in South Africa's municipalities is aging, necessitating an increasing amount of investment in maintenance and upgrade to maintain current performance levels. Additionally, Construction Industry Development Board (CIDB) discussion document published in 2006, noted that there is abundant evidence indicating a prevalent neglect of infrastructure in South Africa.

Subsequent reports from South African Institute of Civil Engineering (SAICE 2017:9), Department of Water and Sanitation (DWS 2020:24), have also consistently highlighted the inadequate compliance of infrastructure operation and maintenance with the necessary standards.

The aging infrastructure challenges being faced in South Africa have exerted considerable pressure on municipalities in order to improve efficiency of handling their infrastructure assets by embracing more efficient, sustainable, and forward-looking infrastructure asset management approaches (Danylo and Lemer 1998:5; Grigg 1999:115; Halfawy 2008:2 and Van 2017:55. This study intends to support the municipalities in South Africa to adopt best infrastructure asset management practices in order to address issues of proper maintenance and strategic planning to ensure all infrastructure assets have a proper maintenance plan and long-term strategic planning processes.

2. LITERATURE REVIEW AND RESEARCH APPROACH

2.1 Scoping literature review method

The research for this study employs the scoping literature review method. Dijkers (2015:1173) and Peterson et al., (2017:12) noted that this method is frequently utilized for the rapid comparison of variables and critical terms within the review and their primary literature sources.

O'Brien *et al*. (2016:3) highlighted that the scoping literature review method is designed to thoroughly map evidence across various study designs within a specific area, aiming to inform future research practices, programs, and policies. Consequently, scoping reviews are particularly valuable for exploring emerging evidence when it is still unclear what more specific questions can be asked (Munn *et al*. 2018:2).

2.2 Selection Criteria

The search methodology included the following steps: selecting relevant keywords for database searches, conducting searches in the Scopus database, collecting pertinent articles, determining the relevance of each paper, and performing inverse searches using the Web of Science core collection, Research gate and Google Scholar. Definition of Keywords, Online Database Search, and Paper Selection were also done.

First and foremost, keywords pertinent to the subject were defined as follows: "Infrastructure asset management" or "Strategic asset management" or "Asset Management" or "Decision-Making" or "Long term planning" or "Sustainability" or "Infrastructure projects". To retrieve additional relevant papers, keywords were generated by combining those identified for the study. Next, the combined keywords were used to search the databases.

The online database Scopus was systematically investigated to retrieve recent scientific studies that included any of the mentioned keywords in the article titles and had been published from 2010 to 2023. Moreover, further analysis was necessary to determine the relevance of each paper. Each identified article underwent an additional review of its title, abstract, and keywords. If the article seemed pertinent, it was selected for a thorough read and detailed analysis.

This literature research identified a total of 101 publications, including journal and conference papers, books, and reports. After a preliminary review, 60 of these (59%) were deemed relevant and were included in the study, while the remaining 41% were excluded due to irrelevance. Among the publications included, 15 (15%) originated from South Africa, with the other 85% coming from various parts of the world. The key themes and findings derived from this literature research are presented in the next section of the paper.

3. FINDINGS, ANALYSIS AND DISCUSSION

The study's findings on the adoption of infrastructure asset management best practices in South Africa are crucial. The following section provides an in-depth analysis and discussion of the identified challenges along with the proposed solutions.

3.1 Asset Performance Management and Prediction

The significant volumes of aging infrastructure pose an increasingly complex challenge in understanding their current condition and performance, which in turn affects the ability to predict future developments (Parlikad and Jafari 2016:187). Regulatory-enforced inspections are infrequent and often subjective. Additionally, Parlikad and Jafari (2016:187) noted that the vast scale of infrastructure complicates the identification and location of all assets, compromising the integrity and completeness of the asset register. This issue is further exacerbated by uncertainties in the nature and intensity of asset usage over their long lifespans. Although real-time monitoring of users, their asset usage, the assets themselves, and their operating environments is challenging, novel technologies are increasingly making this possible. Parlikad and Jafari (2016:187) stated that due to the unique design and construction of many infrastructure assets, traditional techniques for deterioration and risk modelling based on historical patterns may not be suitable.

Furthermore, Parlikad and Jafari (2016:187) noted that infrastructure owners must now understand asset performance from previously unconsidered perspectives, such as evaluating the embodied carbon of materials and mitigating the carbon footprint and environmental impact of those materials and processes. Interestingly, Kaganova and Kopanyi (2014:324) added that smart systems can be employed to monitor changing external influences such as demand and climate on infrastructure. Identifying specific data or monitoring strategies that support long-term planning is crucial. It is also important to determine the timescale for these strategies and whether limited and non-contiguous historical data sets can be integrated to provide a head start.

The implementation of an Asset Performance Management System (APMS) offers a comprehensive approach to addressing municipal infrastructure failures and improving performance (Kaganova and Kopanyi, 2014:324). Kaganova and Kopanyi, 2014:324 concluded that to effectively manage asset operations and maintenance in both urban and rural municipalities, the adoption of APMS is recommended. However, the readiness of municipalities to embrace such systems depends on their preparedness and the availability of qualified personnel.

3.2 Data Management

Sharing data and information in an open, semantic format across industry stakeholders to enhance customer experience is a significant challenge (Cooksey et al., 2011:87). In addition, Cooksey et al., (2011:87) also noted that the processes of data capture, sharing, and standardization play crucial roles in improving the overall performance of assets. This, in turn, should increase the overall value for stakeholders involved in delivering services that involve these assets. Furthermore, Parlikad and Jafari (2016:187) noted that effective use of data can also inform decision-making, leading to improved asset performance. For instance, proper data utilization allows organizations to better understand risk and criticality, helping to avoid unexpected issues and failures.

It enables organizations to gauge asset performance, determine if it meets expectations, and take actions to enhance the asset lifecycle cost (Parlikad and Jafari 2016:187). This not only benefits the organizations within the value creation network but also society at large.

The adoption of data sharing standards would theoretically facilitate more willing and effective data exchange between organizations. For example, one organization within the asset-related value creation network might own data that another organization could use to create value. However, the organization owning the data may lack incentive to share or even collect it. Data sharing standards could enforce the sharing of such data. If information-sharing standards are to be implemented, it is essential that they do not compromise commercial standing (Parlikad and Jafari 2016:187).

3.3 Planning and decision making

Vanier (2001: 35) stresses the significance of planning and decision-making in Infrastructure asset management, aligning with the strategic goals of the organisation (Schraven et al., 2011: 63; Arif and Bayraktar, 2012: 2349). Lack of strategic plans and measurable goals can lead to conflicts within the organization (Amekudzi et al., 2002:214). Efficient management processes and consideration of stakeholders' needs are essential (McNeil et al., 2000:21; Hassanain et al., 2003: 52; Poister et al., 2013:305; FHWA, 2007; Schraven et al., 2011: 65; Shiferaw et al., 2012: 58).

According to Issa, Georges and Dragan (2021:70) the strategy and planning theme is crucial for aligning Infrastructure Asset Management (IAM) activities with the organization's mission and goals. It involves developing a comprehensive policy that serves as a framework for IAM practices, ensuring consistency and alignment with organizational values. Additionally, it translates the diverse expectations of stakeholders, including employees, customers, investors, and regulatory bodies, into specific IAM objectives and strategies, thereby fostering trust and satisfaction (Issa, Georges and Dragan 2021:71).

Issa, Georges and Dragan (2021:71) added that effective planning and coordination are essential for managing infrastructure assets across their entire lifecycle, from acquisition to disposal, by detailing tasks, timelines, resources, and responsibilities. This structured approach ensures that IAM activities are integrated and aligned, minimizing risks and maximizing asset performance and value in support of the organization's mission.

3.4 Organisational culture change

Smith (2020) reported that implementing a robust asset management system signifies a significant organizational and cultural transformation. This shift involves overhauling existing processes, methods, techniques, and sometimes even organizational structures. Additionally, Smith (2020) reported that transformation requires breaking down entrenched organizational silos, which have developed over many years, and this dismantling effort necessitates strong support and motivation from top management.

One of the major challenges organizations faces is the inherent resistance to change, often struggling to justify the need for such a transformation. Smith (2020) and Johnson (2021) also

indicated that while some organizations have argued that maintaining the status quo is inadequate, business leaders increasingly demand more robust justifications for adopting asset management practices. Consequently, practitioners in the field are calling for the development of methodologies and tools that can help build a compelling business case for asset management.

According to Smith (2020) a fundamental shift introduced by effective asset management is the focus on whole-life considerations rather than immediate expenditure. For instance, evaluating Design and Build tenders for construction projects on a whole-life cost (WLC) and value basis, rather than just the lowest initial price, can be particularly challenging (Smith 2020).

Conventional evaluation methods typically encourage a lowest-price mentality, whereas WLC-based designs emphasize durability and longevity, often resulting in higher initial costs. To address this, Smith (2020) and Johnson (2021) indicated that organizations need not only the tools, techniques, and methodologies for calculating whole-life costs and value but also a shift in mindset. Organizations must embrace long-term thinking and move away from the short-sighted views that often dominate investment decision-making. Adopting this long-term perspective is essential for maximizing the value and performance of assets throughout their lifecycle (Smith, 2020; Johnson, 2021).

More interestingly, Parlikad et al., (2016:188) states that organizations need to foster a culture that values sustainability and long-term planning. This cultural shift can be facilitated through continuous education and training, ensuring that all stakeholders understand the benefits of whole-life cost considerations. Johnson (2021) noted that implementing asset management systems also involves aligning these systems with the organization's strategic objectives, ensuring that every infrastructure asset management decision supports broader business goals. This alignment helps in gaining buy-in from various departments and creating a unified approach to asset management.

Moreover, organizations should consider leveraging technology and data analytics to support whole-life cost evaluations (Parlikad et al., 2016:188). Advanced software tools can provide accurate and comprehensive analyses of asset performance over time, helping organizations make informed decisions that balance initial costs with long-term value. By integrating these tools into the asset management process, organizations can enhance their ability to predict future asset performance and plan accordingly (Johnson, 2021).

3.5 Budget Constraints

According to Tafazzoli (2017:3) while the need to improve infrastructure is clear, there are significant obstacles to doing so. One major challenge is the substantial cost involved, which is especially daunting for developing nations. Furthermore, the environmental impact of constructing new infrastructure or expanding existing ones runs counter to the principles of sustainable development, especially when adequate measures to control and mitigate these

The needs for additional infrastructure are summarised below as follows:

- The necessity to accommodate ongoing growth to support the economic and social advancements of the nation (Steven et al., 2006:259; Kessided, 2004).

- Significant portions of infrastructure are aging and approaching the end of their economically viable lifespan (Hardwicke, 2005:8).

- Current funding commitments are either insufficient or yet to be determined to support the considerable costs of renewal and replacement (Hardwicke, 2005:8).

- Existing planning and political processes lack the necessary long-term focus (Hardwicke, 2005:8).

- Only limited infrastructure information is available in certain crucial areas (Hardwicke, 2005:8).

- There is a growing sense of societal vulnerability and economic structure due to the perceived increase in terrorism (Steven et al., 2006:259).

- The ongoing integration of economies and systems, such as the growing globalization and trade in goods, services, and information (Steven et al., 2006:261).

5. CONCLUSION AND FURTHER RESEARCH

Infrastructure asset management is crucial for maintaining and enhancing the efficiency, safety, and longevity of public and private assets. However, several challenges hinder the effectiveness of asset management practices, including asset performance and prediction, data management, planning and decision-making, organizational culture change, and budget constraints. Effective asset management requires accurate performance assessment and reliable prediction models, but the complexity and variability of infrastructure assets make it difficult to develop models that can accommodate all influencing factors. Ensuring continuous monitoring and leveraging advanced technologies, such as IoT and machine learning, can enhance predictive accuracy. High-quality data is the backbone of effective asset management, yet challenges lie in collecting, storing, and analysing vast amounts of data from various sources. Implementing robust data management systems and standardizing data collection processes are critical steps toward better data utilization.

Strategic planning and informed decision-making are vital for optimizing asset lifecycle costs and performance, but integrating diverse data sources and stakeholder inputs into a coherent decision-making framework is challenging. Advanced decision support systems and collaborative platforms can help streamline this process. Adapting to new asset management practices often requires a significant cultural shift within organizations. Resistance to change, lack of training, and insufficient communication can impede the adoption of best practices. Fostering a culture of continuous improvement and providing adequate training and resources are essential for successful implementation. Financial limitations often restrict the ability to maintain and upgrade infrastructure assets, making prioritizing investments and optimizing

resource allocation crucial. Innovative financing mechanisms, public-private partnerships, and cost-benefit analysis can help address these challenges.

To effectively address these challenges, further research is necessary in several key areas: developing more sophisticated predictive models that incorporate a wider range of variables and scenarios; investigating the integration of emerging technologies, such as IoT, blockchain, and big data analytics; developing standardized protocols and frameworks for data collection, storage, and analysis; enhancing decision support systems with advanced algorithms and user-friendly interfaces; understanding the human factors involved in organizational change; and exploring alternative financing models, such as performance-based contracts, value capture financing, and green bonds. By addressing these areas through targeted research and development, the challenges of infrastructure asset management can be mitigated, leading to more sustainable and efficient infrastructure systems.

The study has provided the following specific recommendations to tackle the challenges of existing infrastructure assets and to promote the adoption of best practices in infrastructure asset management in South Africa:

- Comprehensive Assessment and Inventory:

Conduct detailed assessments of existing infrastructure to evaluate their current condition. Create a comprehensive inventory of all infrastructure assets, including age, maintenance history, and expected lifespan.

- Prioritization and Strategic Planning:

Develop a prioritization framework to identify critical infrastructure that requires immediate attention. Implement long-term strategic planning to ensure sustainable management and timely upgrades or replacements.

- Enhanced Funding and Investment:

Increase funding for maintenance and rehabilitation of aging infrastructure through government budgets, public-private partnerships, and international aid. Explore innovative financing options such as infrastructure bonds or dedicated infrastructure funds.

- Adoption of Advanced Technologies:

Utilize modern technologies like Geographic Information Systems (GIS), Building Information Modeling (BIM), and Internet of Things (IoT) for real-time monitoring and management. Implement predictive maintenance technologies to anticipate and address issues before they become critical.

- Capacity Building and Training:

Invest in training programs to build the capacity of local engineers, technicians, and maintenance staff. Encourage knowledge transfer and collaboration with international experts and organizations.

- Public Awareness and Community Involvement:

Increase public awareness about the importance of infrastructure maintenance and the challenges of aging infrastructure. Involve communities in decision-making processes to ensure that infrastructure development aligns with local needs.

The study highlights the importance of ongoing and expanded research into the adoption of best practices for infrastructure asset management in South Africa. This research is crucial to addressing the current infrastructure challenges and strategic planning issues faced by municipalities. The study identifies several key research topics and recommendations that can be explored and published to meet the specific needs of successful infrastructure asset management for South African municipalities. The goal is to enhance efficiency and promote the development of sustainable cities for the future.

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