

Evaluating the Strategic Effectiveness of Road Asset Management Practices for Sustainable Infrastructure Performance in Gauteng, South Africa

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Abstract:

Road infrastructure plays a critical role in economic growth and social mobility, yet many developing regions struggle with ineffective asset management systems. Poor governance fragmentation, low digitization, and patchy application of national frameworks in South Africa hamper sustainable infrastructure performance. This paper will assess the strategic performance of Road Asset Management (RAM) practices in Gauteng Province. Qualitative phenomenological design was taken. The sample was purposely chosen consisting of the ten infrastructure professionals in the municipal and provincial institutions. The semi-structured interview was used to collect data and thematic analysis was used to analyze data. These findings indicate three significant obstacles including broken and responsive governance design, insufficient adoption of digital technologies, and institutional knowledge-operational implementation gap. Despite the availability of policy frameworks and technical skills, lifecycle-based planning is limited by poor coordination and low digital preparedness. There is also a lack of standardized Integrated Asset Management Framework (IAMF), which serves as an additional weakness to strategic alignment. The paper has identified the necessity of integrated governance reform, province-wide digitalization, and active lifecycle management. It adds to the literature because it combines Stakeholder Theory, the Resource-Based View, and the Technology Acceptance Model to identify the reasons behind the performance of RAM in a developing provincial environment.

Keywords:

Road Asset Management, Infrastructure Sustainability, Governance Fragmentation, Digital Transformation

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Introduction

Strategic management of road infrastructure assets has become increasingly critical as governments confront aging networks, rising maintenance costs, and sustainability imperatives. Although most of the developed nations have progressed with integrated system of asset management, predictive maintenance and use of data to make decisions, structural limitations still affect developing environments like South Africa. Disjointed governance, small fiscal capacity and skewed institutional performance limit the successful delivery of sustainable infrastructure models (Pamucar et al., 2021). Since road networks are at the centre of the economic productivity and social mobility, there is need to enhance strategic management of these assets in the long-term development. The national policy tools that have been implemented in South Africa to facilitate the coordinated planning and lifecycle-based maintenance include the National Transport Master Plan (NATMAP) and the Road Infrastructure Strategic Framework of South Africa (RISFSA). But it is not uniformly implemented in all provinces because of differences in the capacity to govern and the institution alignment (Coetzee et al., 2020). This is demonstrated in Gauteng, which is the economic centre of the country. The city is undergoing rapid urbanisation and congestion which puts unending pressure on the road system, but the management of assets is still largely reactive, and insufficiently integrated. Municipal and provincial departments are often using manual registers and non-integrated databases, which lead to the existence of data silos, redundancy, and ineffective maintenance planning (Jacobs et al., 2021; Campbell et al., 2024). The nature of decision-making usually lacks a lifecycle analysis basis and is more heavy on short-term and politically-oriented decisions. The current studies on road asset management (RAM) have largely focused on the technical engineering side of performance, though scarce information has been presented on the institutional, governance, and strategic aspects affecting implementation in the developing provincial settings. This is a sensitive hole that is especially witnessed in Gauteng where there are formal structures that are loosely integrated in terms of operations. The current research is relevant to the body of literature because it covers the institutional and strategic aspects of RAM within a developing provincial setting.

The study pursues the following objectives:

- To evaluate the current strategic effectiveness of RAM practices in Gauteng.
- To identify governance, resource, and technological factors constraining effective implementation.
- To develop recommendations for strengthening lifecycle-based, digitally enabled, and sustainability-oriented RAM systems.

Using the Stakeholder Theory, the Resource-Based View, and the Technology Acceptance Model, the study establishes an analytical perspective on explaining the relationship between governance alignment, resource deployment, and technology adoption and infrastructure performance. The research provides evidence-based information on policy reform and sustainable infrastructure management in Gauteng as well as similar developing areas by putting RAM into a context of wider strategic and institutional analysis.

Literature Review

Theoretical and Conceptual Framework

The Conceptual Framework

The conceptual framework of strategic RAM adopted in this study highlights its multidimensional nature that is informed by governance, alignment of stakeholders, adoption of technology and sustainability. According to the international models (Argyroudis et al., 2020; Pamucar et al., 2021), effective RAM is not absolutely technical but requires coordination of systems, participants, and long-term goals. The policy divisions, old systems and budget limitations are some of the factors that prevent this alignment in Gauteng. The framework has the ability to provide a systematic study of the extent to which the current RAM practices promote sustainable infrastructure performance.

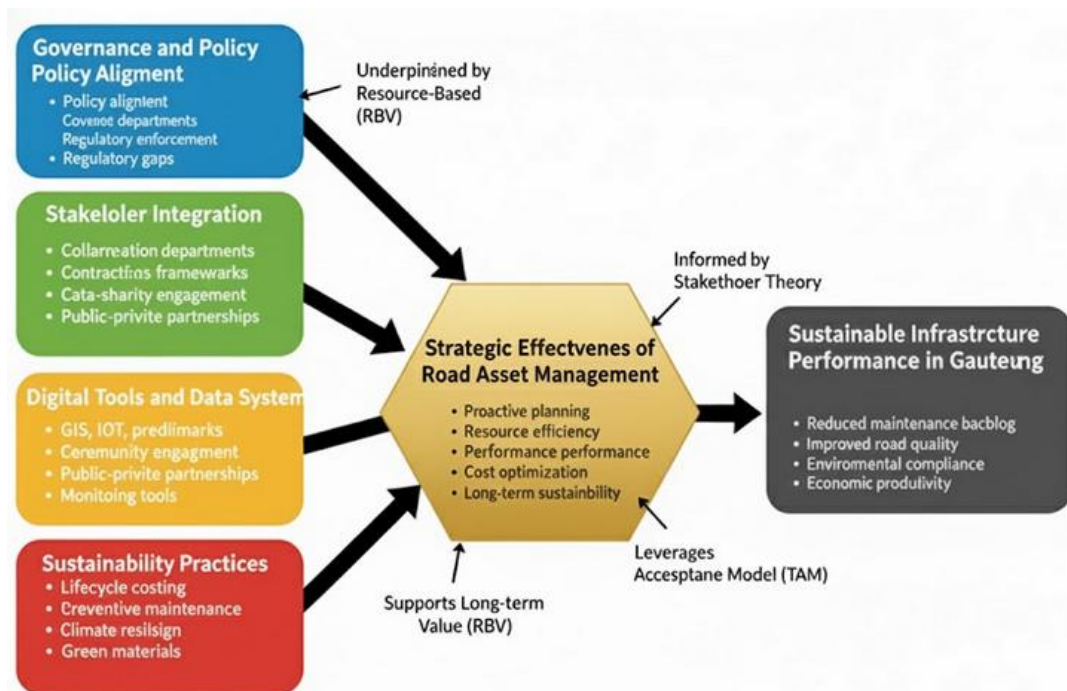


Figure 1: Conceptual framework for the study

Governance and Policy Alignment

Governance is an important element of RAM because it defines the allocation of duties, resources, and control. The lack of the uniformity of national frameworks is weakened by the inconsistent application of RISFSA by the provinces in South Africa (Watermeyer and Phillips, 2020). Independent municipal systems in the Gauteng jurisdiction generate overlapping efforts, incompatible budget priorities, and disjointed reaction to the decline of assets (Coetzee et al., 2020). Strategic RAM will not work without a unified or imposed policy fit.

Stakeholder Integration

Successful RAM involves coordination of stakeholders; the government departments, contractors, communities, and road users. Insufficient coordination between these teams results in timely or repeated maintenance, the absence of accountability, or reduced innovation (Jacobs et al., 2021). The stakeholder engagement must not be limited to consultation and instead seek to co-decide on the matters with the objective of adopting lifecycle performance as opposed to political expediency. Nevertheless, stakeholder strategies have not been fully exploited in Gauteng and this hinders development.

Technology Integration and Digital Tools

Advocates of GIS, IoT, and predictive analytics utilize those tools to gain control over infrastructure more efficiently on the global scale (Kazancoglu et al., 2021). Conversely, Gauteng municipalities use spreadsheets and paper records extensively (Mhlanga, 2021), which form data silos, duplication, and poor institutional memory. Implementation of an effective IAMF requires the use of digital tools. Piryonesi and El-Diraby (2020) posit that digitalization is not an upgrading option available but a strategic need, and its implementation in Gauteng is very little, partly because of opposition and a training shortage.

Strategic Effectiveness of RAM

Strategic effectiveness indicates the level of alignment between RAM and long-term objectives such as sustainability, service delivery, and cost and lifecycle. RAM in Gauteng is frequently responsive and politicized, with political decisions being focused on short-term interests (Campbell et al., 2024). Lack of coordination in budgeting and fragmented systems are degrading to cost-efficiency. RAM needs to be instilled into data-driven, proactive, and institutionally aligned structures in order to transition to strategic effectiveness.

Sustainability in Road Infrastructure Management

Sustainable road asset management balances the economic viability, environmental impact and social equity. Recycled materials and low-carbon construction are among the best practices to use

(Priyatiningih and Sutrisno, 2020). In South Africa, structural frameworks, such as NATMAP and RISFSA, sustainability is theoretically supported but it fails to work in practice due to deficits and misaligned priorities in the budget (Christophers, 2024). The reactive maintenance model currently in place at Gauteng generates backlogs on a long-term basis and restricts the infrastructural resilience.

Challenges in Implementing Road Asset Management

Inadequate Data Systems: Most of the municipalities in Gauteng still operate with old systems that are paper based and therefore they cannot monitor and predict maintenance real time. The consequence of this is low institutional memory and ineffective planning (Mhlanga, 2021). RAM is reactive and fragmented without incorporated digital means, such as GIS and IoT.

Funding Constraints: Road asset management requires long term investment but most of the municipalities are run on erratic and inadequate budgets. This compels urgent choices that postpone vital repairs and make it impossible to invest in digital tools or the development of skills (Christophers, 2024).

Skills and Capacity Gaps: Although Gauteng has technical knowledge, most departments are not trained in the skills of advanced analytics, digital platforms, and lifecycle costing. This skills gap weakens the process of implementing evidence-based maintenance (Ametepey et al., 2023).

Governance and Accountability: There is duplication of efforts and lack of accountability because of overlapping of responsibilities among provincial and municipal departments. Poor adoption of RISFSA and lack of performance monitoring systems also undermine accountability (Watermeyer and Phillips, 2020).

Strategic Road Asset Management Practices

RAM must be life cycle-driven, digitally enabled, and proactive to work. As it stands, the practises in Gauteng are still very disjointed and municipalities go about their business independently with ancient tools. According to Coetzee, Cooper, and Katumba (2020), the fact that the application of IAMF principles is inconsistent results in the inefficient use of resources and ineffective infrastructure. An intergovernmental coordination and sustainable-oriented planning would be encouraged by a province-wide, standardized IAMF.

Factors Influencing Strategic Effectiveness

The effectiveness of RAM is predetermined by the quality of governance, the involvement of stakeholders, the digitization of the organization, and a stable financial state. Argyroudis et al. (2020) stress the necessity of combined governance, monitoring of the performance, and data-driven

judgments. These are not the case in Gauteng. The priorities of maintenance are more concerned with political reasons and data systems are fragmented which hinders long-term infrastructure objectives.

Sustainable Infrastructure Performance

Sustainable performance is the capacity of road systems to be functional, safe and environmental-responsible at their life cycle. Although frameworks such as NATMAP spread this vision, its execution is poor because there is fragmented planning and insufficient application of green technologies (Priyatningsih and Sutrisno, 2020). The road networks in Gauteng are facing the danger of constant deterioration unless predictive maintenance and climate-sensitive designs are incorporated.

External Factors Affecting RAM Performance

Policy and Regulation: National policies such as RISFSA offer a basis, although they do not enforce and coordinate at the local level (Watermeyer and Phillips, 2020). This has led to failure to plan uniformly among the municipalities.

Political Commitment: The infrastructure decisions are commonly biased in favour of short-term visibility, which minimizes continuity and compromises maintenance initiatives (Aghimien et al., 2020). Long-lasting RAM strategies require long-term political will.

Economic Constraints: Fiscal strains and austerity programs restrict the capacity of the municipalities to finance contemporary systems or training. New financing (e.g., public-private partnerships) is needed to bridging the funding gaps (Christophers, 2024).

Technological Access: Despite global advances in predictive analytics and GIS, Gauteng's adoption remains low due to institutional inertia and lack of digital infrastructure (Piryonesi & El-Diraby, 2020). Tools alone are insufficient—user training and cultural readiness are critical.

Linking Asset Management and Sustainable Performance

Individual and Generalized Insights: The examples of the UK and Botswana show that infrastructure failure can be mitigated by planning and centralized digital platforms and enhance the investment (Argyroudis et al., 2020). Gauteng is lagging in this aspect as its systems are fragmented such that they hamper performance in lifecycle.

Strategic Asset Management (SAM): SAM assists in maintaining sustainability in terms of cost-benefit analysis, lifecycle costing, and proactive maintenance (Pamucar, Ecer & Deveci, 2021). In Gauteng, the implementation of SAM principles will have a great impact on the results as it will be possible to transition to prevention instead of reaction.

Innovation and Digital Tools: GIS, IoT, and AI can be used to facilitate evidence-based decision-making and long-term decision-making. However, their institutional obstacles rather than cost are limiting their adoption in Gauteng. Digital leadership, training, and system integration are necessary to achieve success (Piryonesi & El-Diraby, 2020).

Theoretical Framework for the Study

Stakeholder Theory

Stakeholder Theory, formulated by Freeman (1984), holds that organisations should consider the interests of all entities affected by their decisions. The stakeholders in the context of road infrastructure in Gauteng are the government departments, municipalities, contractors, engineers, communities, and road users. According to Watermeyer and Phillips (2020), the inability to deliver road projects is often due to poor coordination among these actors. Divided governance, political interference, and low engagement procedures do not allow maintenance activities to align with the broader infrastructure goals. Thus, the current research will apply stakeholder theory to identify the impact of mismatched roles, ineffective communication, and the absence of shared responsibility on the strategic performance of road asset management practices. It acknowledges that road infrastructure needs a more integrated, multi-stakeholder approach to enhance lifecycle performance and service delivery.

Resource-Based View (RBV) Theory

The Resource-Based View (RBV), formulated by Wernerfelt (1984) and further developed by Barney (1991), holds that an organization's ability to sustain competitive advantage depends on its efficient use of internal resources, such as human resources, technology, financing, and institutional knowledge. The accessibility and strategic deployment of resources in road asset management are direct influences on the potential for responsible infrastructure maintenance at a cost-effective level. As Campbell et al. (2024) note, mismanagement of resources, such as underfunding and inadequate lifecycle planning, is one factor contributing to the deterioration of roads in Gauteng. It is this framework that justifies the ineffectiveness of institutional memory and talented professionals if they are not accompanied by financial investment and modern management systems. RBV assists this study in analyzing how Gauteng departments utilize their internal resources and whether their deployment aligns with strategic and sustainable outcomes.

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is a framework that was developed by Davis (1989) and was used to explain how users accept and adopt a technology. It proposes two main factors that determine user adoption: perceived usefulness and perceived ease of use. TAM applies to road asset management

practices in Gauteng due to the underutilization of GIS, predictive maintenance tools, and data analytics, which could be beneficial to these practices. Aghimien et al. (2020) identify the lack of training, institutional inertia, and an unclear digital strategy as the reasons why group members do not embrace Fourth Industrial Revolution technologies in South African construction. Mhlanga (2021) has also noted that manual systems remain in place due to fear of complexity and a lack of digital culture. TAM will be used in this research to evaluate the reasons why departments are likely to resist or slow down the implementation of digital asset management tools, as well as how such attitudes impact the achievement of strategic results.

Linking the Theory to the Research Objectives

This study applies an integrated theoretical framework combining Stakeholder Theory, the Resource-Based View (RBV), and the Technology Acceptance Model (TAM) to evaluate the strategic effectiveness of road asset management (RAM) in Gauteng. These theories have been chosen because they are relevant in combination for covering the institutional, operational, and technological aspects of RAM practices. The Stakeholder Theory helps Objective 1 by explaining how fragmented governance and inadequate interdepartmental coordination undermine the implementation of strategic RAM frameworks. The theory emphasizes inclusive governance, role clarity, and collective accountability among municipalities, provincial departments, and communities (Freeman, 1984). These play critical roles in diagnosing the reasons behind the reactive, politically motivated nature of the RAM structures in Gauteng, rather than a strategically planned structure.

RBV also complies with the two aims, but Objective 2, since the problem addressed is the underutilization of the internal resources the province possesses in terms of technical expertise, institutional skills, and the funding available. According to Barney (1991), organizations generate strategic advantage by successfully marshalling valuable and inimitable resources. The lack of fit between potential skills and implementation in the Gauteng context indicates the failure of this strategy principle. TAM will be especially pertinent to Objective 2, where strategic suggestions to enhance RAM practice are to be developed. The framework describes the influence of behavioural aspects such as resistance to change, lower levels of digital literacy, and perceived complexity on the use of digital asset management tools (Davis, 1989). These factors are critical to developing effective digital integration strategies that municipalities can realistically adopt. The combination of these three theories can explain the current fragmentation, unsustainability, and under-optimization of RAM practices in Gauteng. The point is more important: they are the guiding force behind recommendations whose importance is rooted in context, are institutionally viable, and can deliver long-term infrastructure performance.

Methods and Data

Research Design

The research design used in this study was a qualitative phenomenological research design to understand the lived experiences of the professionals who are engaged in managing the assets of road infrastructure in Gauteng. According to Adedoyin (2020) and Brennen (2021), phenomenology helps the researcher to reveal the subjective realities, practices, and institutional dynamics of the complex environments. The choice of this design was to understand both the existing practices and the institutional elements that impact the introduction, delay, or distortion of RAM initiatives particularly in the lack of formalized systems. It is appropriate to the road infrastructure sector in Gauteng due to its focus on meaning-making, which is applicable in the analysis of fragmented governance, roles of stakeholders, and digital adoption.

Research Philosophy

The research took the (interpretivist) philosophy, which dwelled on the subjective experiences of the stakeholders in their institutional and social settings. The interpretivism approach focuses on the meanings of participants, and not on testing pre-conceived hypotheses (Kirango and Odoyo, 2020). This philosophy advocates the qualitative inquiry to unravel the experience and interpretation in relation to RAM by infrastructure professionals in different departments in Gauteng.

Research Strategy

The search of the experiences of stakeholders regarding the asset planning, maintenance, and management was carried out in a qualitative and inductive approach. The case study technique enabled detailed, situational knowledge of the broken RAM environment in Gauteng. According to Camic (2021), qualitative approaches are appropriate in the context of open-ended investigation of institutional and governance phenomena, in which the patterns and themes are not predetermined but receive their emergence out of the data.

Target Population and Sampling.

The research aimed at professionals involved in the road infrastructure industry in Gauteng namely engineers, municipal and provincial authorities, consultants and project managers. With the help of purposive sampling, a sample of 10 participants was chosen because of the relevancy of their expertise and strategic interest in road asset management. Allan (2020) notes that purposive sampling is guaranteed to have in-depth insights based on experience. The process of sampling went on until thematic saturation was achieved and no new themes that came up when collecting data.

Data Collection Procedures

The main data collection method was semi-structured interviews conducted under the open-ended questions that covered the digital adoption, governance, and sustainability. The interviews (face-to-face or via the Internet) took up 45-60 minutes each and were audio-recorded and transcribed. According to Gephart and Saylor (2020), such an approach can be explored flexibly and focused. Such secondary data as RISFSA, NATMAP, and official reports were also examined, which favored triangulation and increased the validity of findings.

Data Analysis

Thematic analysis was employed in the analysis of the data, which is one of the most popular qualitative approaches to determining patterns in narratives. This method contributed to an inductive, participant-grounded analysis, as familiarization, coding, theme development, review, definition, and reporting steps were based on the six-step process provided by Braun and Clarke (2006). According to Busetto et al. (2020), thematic analysis allows integrating emergent themes with theoretical constructs, which is why it is best suited to this study.

Trustworthiness

In order to prove research trustworthiness, the study used the criterion of credibility, transferability, dependability, and confirmability. The process of member checking enhanced credibility as the participants were reviewing the summaries of the interviews. Fine contextual details were given that would facilitate extrapolation to other related contexts of the provinces. The open research process increased the level of dependability, whereas bracketing was used to reduce researcher bias and increase the level of confirmability (Mishra and Alok, 2022).

Results

This section presents the study's results in alignment with the research objectives. Thematic analysis was used to generate key themes from interview data, guided by the theoretical framework. This section begins with the presentation of demographic data, followed by thematic findings and critical discussions.

Participant Demographic Profile

The study included 10 purposively selected participants from the Gauteng province, drawn from municipal and provincial departments involved in road asset management. The composition of the sample was as follows:

Participant ID	Position	Department/Institution	Experience (Years)	Gender
P1	Senior Engineer	Provincial Roads Agency	18	Male
P2	Infrastructure Planning Officer	Local Municipality	12	Female
P3	Roads Maintenance Manager	Department of Transport	15	Male
P4	Asset Management Consultant	Private Firm	10	Female
P5	GIS and Systems Analyst	Metropolitan Municipality	8	Male
P6	Operations Executive	Municipal Infrastructure Dept	20	Male
P7	Roads Inspector	District Municipality	6	Female
P8	Infrastructure Finance Officer	Treasury Unit	14	Female
P9	Civil Engineer	Roads Planning Office	7	Male
P10	Digital Transformation Lead	Infrastructure Innovation Hub	9	Female

Table 1: Participant Demographics by Role, Institution, Experience, and Gender

Participants were selected for their relevant experience and strategic involvement in road infrastructure development, maintenance, planning, or asset digitization.

Occupations of the Participants

The study sample consisted of individuals occupying 10 unique professional roles relevant to road asset management. These included engineering, planning, financial oversight, digital transformation, and executive management. The table below shows the diversity of roles held by participants:

Position	Count
Senior Engineer	1
Infrastructure Planning Officer	1
Roads Maintenance Manager	1
Asset Management Consultant	1
GIS and Systems Analyst	1
Operations Executive	1
Roads Inspector	1
Infrastructure Finance Officer	1
Civil Engineer	1
Digital Transformation Lead	1

Table 2: Occupations of the Participants

This broad scope of functions makes the study capture views on the technical, managerial, digital, and financial aspects of asset management. Despite all roles being represented by only one each, the diversity adds reliability to the findings by incorporating the perspectives of both strategic leadership and operational execution at the asset management ecosystem level.

Years of Work Experience of the Participants

The participants in this study had varying levels of professional experience, ranging from 6 to 20 years. The table below summarizes this range:

Metric	Years
Minimum Experience	6
Maximum Experience	20
Average Experience	11.9

Table 3: Participants' work experience

The average of 11.9 years of experience demonstrates that the participants are seasoned professionals with a solid understanding of the infrastructure landscape. The individuals with 15 years or more of experience provided strategic and policy-level support, whereas those with less experience provided new insights and on-the-ground issues. Such a combination promotes a solid thematic analysis grounded in institutional memory and the development of field practices.

Gender of Participants

The study achieved a balanced gender distribution among the participants, as shown in the table below:

Gender	Number	Percentage
male	5	50%
Female	5	50%
Total	10	100%

Table 4: Gender of Participants

Gender equality enhances data representativeness by ensuring that male and female professionals are represented equally in the data collected. This balance is indicative of the rising participation of women in leadership, planning, and technical work in the infrastructure industry in Gauteng, despite the sector being dominated by men, particularly in engineering and transport. It also provides a more refined understanding of issues and the likelihood of having multiset gendered experiences in managing road assets.

Discussion

Theme 1: Fragmented and Reactive Road Asset Management

The first major theme that emerged from the interviews was the fragmented and reactive nature of road asset management (RAM) practices in Gauteng. The lack of a coherent Integrated Asset Management Framework (IAMF) was mentioned as the key concern among the participants, and resulted in uncoordinated planning among various departments. Maintenance was characterised as short-term like, project-based and not in line with long-term infrastructure objectives:

“We follow a mix of asset registers and ad hoc logs. No unified IAMF. Too reactive.” – P1

“There is no clear long-term strategy; each municipality does what it can afford in the moment.” – P3

This fragmentation leads to the duplication of maintenance works, resources waste, and increased long-term expenses (Campbell et al., 2024). This problem can be described with the help of the Stakeholder

Theory (Freeman, 1984): the lack of coordination between the actors on a provincial, municipal, and national level destroys the joint responsibility and lifecycle planning.

Comparatively, centralized, predictive systems of maintenance in Botswana indicate the worth of coordinated RAM structures in enhancing infrastructure performance (Privatiningsih and Sutrisno, 2020). Although recent researchers such as Watermeyer and Phillips (2020) point to the lack of resources as the cause of the problem instead of coordination difficulties, the results of this study indicate that the problem is not solved by resources-rich departments, and it cannot be solved without strategic alignment. Fragmentation, therefore, is a structural and governance challenge which needs institutional reform and political will of the Gauteng.

Theme 2: Lack of Digital Integration and Technology Use

The second theme was the low application of digital tools in assets management. The respondents talked about the use of spreadsheets and manual records, resulting in inconsistency, significance duplication, and a lack of foresight:

“Each municipality has its own spreadsheet – no one sees what the other is doing.” – P5

“Some roads are repaved twice in a year, while others are ignored.” – P8

This theme is largely associated with the Technology Acceptance Model (TAM) (Davis, 1989) implying that the factors of resistance are based on the perception of complexity and insufficiency in the training. This is further supported by the Resource-Based View (RBV) that emphasizes the fact that internal resources, including digital infrastructure, should be put to an appropriate use in order to facilitate performance.

The adoption of technologies such as GIS, AI, and IoT is changing RAM world over through the concept of predictive maintenance and cost optimization (Kazancoglu et al., 2021). In Gauteng, however, these tools are not well used or loosely connected. The national asset register in the UK is a good example of how centralized and monitored systems based on digital technologies can enhance visibility, decision-making, and collaboration (Peraka & Biligiri, 2020). Although Pirayonesi and El-Diraby (2020) observe that digital transformation needs to be invested in, the results indicate that institutional inertia, the absence of a strategy, and the low level of digital literacy are more important obstacles to change than funding.

The human and organization factors should be not left out and the technological procurement needs to be taken to create an integrated and progressive RAM system.

Theme 3: Institutional Knowledge with Weak Execution

The third theme discloses a paradox in that the road agencies of Gauteng are not able to implement strategic asset management even in the presence of experienced professionals and institutional knowledge. Respondents observed that competent personnel tend to work without instruments or structures to apply knowledge into practice:

“There is institutional wisdom, but no operational systems to act on it.” – P6

“We have experience, but we lack power, systems, and leadership to implement anything.” – P2

This is one of the major observations of the RBV: knowledge is not enough without the effective structures and strategies (Barney, 1991). This is due to poor execution caused by the absence of integrative dashboards, performance-monitoring systems, and coordination across departments (Coetzee et al., 2020). The example of Kenya with its centralized training, strategic digital platforms, and unified systems can be used as a helpful comparative example (Ametepey et al., 2023). They demonstrate the use of institutional knowledge by the means of organizational support, strategic planning and leadership commitment. Lack of these enablers means that the human capital of Gauteng is not well used.

Thematic Synthesis

Across all three themes, the findings highlight critical weaknesses in Gauteng’s RAM system:

- **Fragmentation** and short-termism undermine strategic planning and coordination.
- **Digital underuse** leads to inefficiency, data silos, and missed opportunities for predictive maintenance.
- **Execution gaps** waste valuable human capital due to the absence of operational frameworks.

These problems are closely connected with Stakeholder Theory, RBV, and TAM, which combined serve as the explanations of the systemic misalignment of people, processes, and technologies. Gauteng has no integrated structure, incentives, and digital frameworks to execute the policies and expertise they have. To determine that digital transformation, stakeholder alignment and institutional reform are not just possible but long term infrastructure performance, comparative models with Botswana and the UK reveal that digital transformation is necessary and can be achieved through institutional reforms and alignment of stakeholders. Gauteng needs to move towards an active, information-based, and coordinated asset management culture to create sustainability and resilience.

Conclusion

This study evaluated the strategic effectiveness of road asset management (RAM) practices in Gauteng, South Africa, in relation to sustainable infrastructure performance. Through a qualitative phenomenological method, three themes were identified as paramount challenges which include fragmented and reactive governance structures, lack of digital integration, and the continuing gap between what is known in institutions and what actually happens. Despite the presence of policy frameworks and technical expertise within the province, discrepant stakeholder roles, the lack of digital systems exploitation, and short-term decision-making processes still destabilize the lifecycle based infrastructure management. Combining Stakeholder Theory, the Resource-Based View (RBV), and the Technology Acceptance Model (TAM), the research proves that the effectiveness of RAM is a multidimensional institutional problem rather than a technical one.

The lack of governance leads to undermined collective responsibility, non-strategic allocation of internal resources, and the unwillingness to go digital limits modernization. Gauteng performance of sustainable infrastructure is therefore determined by the co-ordinated institutional reform, better resource alignment and lifecycle planning that is digitally enabled.

Practical Implications

The results indicate a number of recommendations that could be considered by the policy makers and infrastructure managers:

To start with, formal adoption of a standardized province-wide Integrated Asset Management Framework (IAMF) must be made to harmonize the municipal and provincial asset management practices. This kind of framework must be characterized by the definition of roles, the commonality in performance measures and mechanisms of compliance monitoring to minimize duplication and improve accountability. Second, digital transformation should be institutionalized as opposed to being an optional upgrade. This involves the formulation of a provincial digital infrastructure plan that integrates centralized asset registers, GIS based monitoring, predictive maintenance equipment and interoperable databases. The users should also be trained and made digitally literate to achieve the adoption and minimize resistance. Third, the practice of RAM needs to be changed to be less reactive and more proactive and related to the lifecycle-based planning. That will necessitate incorporating the lifecycle costing, sustainability measures and climate-resilience standards in budgeting and procurement systems. The adoption of long-term maintenance funding models, which may involve a combination of the public and the private, should be considered in an effort to deal with the instability of the fiscal front. Lastly, greater intergovernmental coordination systems should be established in order to harmonize national programmes like RISFSA and NATMAP to the realities of implementation on the ground by the municipalities.

The collaboration and strategic continuity might be improved with regular cross-departmental forums and common reporting platforms.

Theoretical Implications and Further Research

This research paper adds to the body of knowledge by applying the Stakeholder Theory, RBV and TAM to the situation in the public infrastructure management of a developing provincial government. Compared to the technical optimization, which has been the focus of previous study on asset management, the current study brings out the institutional and behavioural dimension that influence strategic effectiveness. Applying the Stakeholder Theory, the results indicate that a disintegrated form of authority in multi-level governance systems undermines the ability to create collective values and the alignment of lifecycle. In the case of RBV, it has been demonstrated that technical expertise and institutional knowledge alone is inadequate unless there are complementary systems, leadership continuity and resource deployment systems. When applied to TAM, the study demonstrates that the perceived complexity, lack of digital preparedness, and organizational culture have a significant impact on the adoption of asset management technologies in the public sector. There are a number of limitations that need to be realized. The research was specifically on Gauteng and the sample size of professionals used was relatively small which can be a restriction to generalization. Future studies might involve comparative interprovincial analysis, quantifiability of the cost-efficiency in digital RAM adoption, or institutional long-term enablers of technological integration studies. More research on governance reform models to be applied in developing context would also enhance the knowledge on sustainable infrastructure transformation. Comprehensively, the paper highlights the fact that sustainable road infrastructure delivery in South Africa cannot be achieved by mere upgraded technicals, but must be through co-ordinated governance, resource management and digitally facilitated institutional alignment. Overall, the study underscores that sustainable road infrastructure performance in South Africa requires more than technical upgrades; it demands coordinated governance, strategic resource management, and digitally enabled institutional alignment.

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