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Operational Efficiencies on Roads Infrastructure Development within the City of Johannesburg

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2514742

A project report submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Business Administration

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TABLE OF CONTENTS

LIST OF TABLES v

LIST OF FIGURES v

LIST OF ABBREVIATION vi

DECLARATION vii

DEDICATION viii

ACKNOWLEDGEMENTS ix

SUPPLEMENTARY INFORMATION x

ABSTRACT 1

1 CHAPTER 1: INTRODUCTION 2

1.1 BACKGROUND 2
1.2 CONTEXT OF THE STUDY 3
1.2.1 DEFINE A NEED FOR THIS TOPIC (REASON FOR CHOOSING THIS TOPIC) 3
1.2.2 THE OBJECTIVE OF THE RESEARCH TOPIC 4
1.3 PROBLEM STATEMENT 5
1.3.1 MAIN PROBLEM 5
1.4.2. RESEARCH QUESTIONS 6
1.4 SIGNIFICANCE OF THE STUDY 7
1.5 DELIMITATIONS OF THE STUDY 7
1.6 DEFINITION OF TERMS 8
1.7 ASSUMPTIONS 8

2 CHAPTER 2: LITERATURE REVIEW 10

2.1 INTRODUCTION 10
2.2 DEFINITION OF TOPIC OR BACKGROUND DISCUSSION 11
2.3 OPERATION EFFICIENCY AND ROADS INFRASTRUCTURE DEVELOPMENT 12
2.4 MEASURE OF OPERATIONAL EFFICIENCIES 14
2.4.1 RESEARCH QUESTION 1: HOW DO YOU MEASURE OPERATIONAL EFFICIENCIES IN RELATION TO ROADS INFRASTRUCTURE? 16

2.5 THE IMPACT AND ADOPTION OF TECHNOLOGY IN ROADS INFRASTRUCTURE 18
2.5.1 RESEARCH QUESTION 2: HOW DOES THE APPLICATION AND THE TYPES OF TECHNOLOGY IMPROVE EFFICIENCY IN ROADS INFRASTRUCTURE LIFECYCLE MANAGEMENT? 22
2.6 SUSTAINABILITY OF ROADS INFRASTRUCTURE DEVELOPMENT 25
2.6.1 RESEARCH QUESTION 3: HOW WOULD STRATEGIC SOURCING HELP COJ TO IMPROVE EFFICIENCY AND SUSTAINABILITY? 26
2.7 CONCLUSION OF LITERATURE REVIEW 28

3 CHAPETER 3: DATA COLLECTION AND DATA ANLYSIS 29

3.1 RESEARCH METHODOLOGY / PARADIGM 29
3.2 RESEARCH DESIGN 30
3.3 THE RESEARCH ETHICS 30
3.4 POPULATION AND SAMPLE 31
3.4.1 POPULATION 31
3.4.2 SAMPLE AND SAMPLING METHOD 31
3.5 THE RESEARCH INSTRUMENT 33
3.6 PROCEDURE FOR DATA COLLECTION 34
3.7 DATA ANALYSIS AND INTERPRETATION 34
3.8 LIMITATIONS OF THE STUDY 35
3.9 VALIDITY AND RELIABILITY 36

4 CHAPTER 4: RESULTS PRESENTATION 37

4.1 INTRODUCTION 37
4.2 RESULTS IN RELATION TO RESEARCH QUESTION 1 38
4.2.1. RESEARCH QUESTION 1: HOW DO YOU MEASURE OPERATIONAL EFFICIENCIES IN RELATION TO ROADS INFRASTRUCTURE? 39
4.3 RESULTS IN RELATION TO RESEARCH QUESTION 2 45
4.3.1. RESEARCH QUESTION 2: HOW DOES THE APPLICATION AND THE TYPES OF TECHNOLOGY IMPROVE EFFICIENCY IN ROADS INFRASTRUCTURE LIFECYCLE MANAGEMENT? 47
4.4 RESULTS IN RELATION TO RESEARCH QUESTION 3 50
4.4.1. RESEARCH QUESTION 3: HOW WOULD STRATEGIC SOURCING HELP COJ TO IMPROVE EFFICIENCY AND SUSTAINABILITY? 52

5 CHAPTER 5: DISCUSSION OF THE RESULTS 56

5.1 INTRODUCTION 56
5.2 RESULTS DISCUSSION IN RELATION TO RESEARCH QUESTION 1 56
5.2.1. CONCERNED WITH THEIR OWN KPA/ WORKING IN SILOS 56
5.2.2. ALIGNMENT OF KPA WITH BUSINESS PERFORMANCE PLAN 59
5.2.3. RESOURCE CONSTRAINTS 60
5.2.4. INEFFICIENT SCM PROCESS 62
5.2.5. TURNAROUND TIMES TO ATTEND DEFECTS 64
5.2.6. PERCEIVED INADEQUATE TRAVEL TIMES 65
5.2.7. CONCLUSION IN RELATION TO RESEARCH QUESTION 1 66
5.3 RESULTS IN RELATION TO RESEARCH QUESTION 2 66

5.3.1. Better Asset Management 67
5.3.2. Efficient mobility: Better Traffic Management 68
5.3.3. Outdated Existing Technology 68
5.3.4. Limited application 70
5.3.5. Crime Prevention Infrastructure Protection (Curbs Theft) 71
5.3.6. Technology Improves Efficiency and Performance 72
5.3.7. Improves Quality and Saves Cost 74
5.3.8. Effective Project Management 74
5.3.9. Technology Reduces Employment Opportunities 75
5.3.10. Aware of 4IR 76
5.3.11. Critical Strategic will for Technology Adoption 77
5.3.12. Technology a major influence of the organization's core objective 78
5.3.13. Conclusion in Relation to Research Question 2 79
5.4 Results in relation to Research Question 3 80
5.4.1. Added Financial Resource or Muscle 80
5.4.2. Good for Particular Type of Operation 81
5.4.3. Improved Efficiency on Delivery on the Core Mandate 82
5.4.4. Strategic Asset would Work But Requires Proper Strategy 83
5.4.5. Public Private Partnership 84
5.4.6. JRA not Meant to Make Profits 86
5.4.7. Adding more Assets will not Improve Efficiency 87
5.4.8. Offering Services from Strategic Assets Augment Service Delivery 87
5.4.9. Conclusion in Relation to Research Question 2 89

6 CHAPTER 6: CONCLUSION AND RECOMMENDATIONS . 90

6.1 Introduction 90
6.1.1. Limitations of the Study 90
6.2 Conclusion 90
6.3 Recommendations 93
6.4 Suggestion for Further Research 96

7 REFERENCES 97

8 CONSISTENCY MATRIX 105

Research Questions 105

9 ANNEXURE 107

Annexure A: Research Instrument 107
Annexure B: Participant Information Sheets 107
Annexure C: Consent Form 107
Annexure D: Research Approval Letter 107

LIST OF TABLES

Table 1: Profile of Respondents **32**

Table 2: Emerged Themes in Relation to Research Question 1..... 38

Table 3: Emerged Themes in Relation to Research Question 2..... 46

Table 4: Emerged Themes in Relation to Research Question 3..... 51

Table 5: Consistency Matrix..... 105

LIST OF FIGURES

Figure 1: Six digital Transform and Six Analog Transform Technology Models (Source; Lee, et al., 2018)..... 22

Figure 2: Seven proposed Perspectives for benchmarking technology transfer (Source; Steward & Waroonkun, 2007) 22

Figure 3: Measure of Operational Efficiency 39

Figure 4: Impact of Technology on Roads Efficiency..... 47

Figure 5: Strategic Sourcing Improves Efficiency and Sustainability..... 51

LIST OF ABBREVIATION

4IR	Fourth Industrial Revolution
BSM	Bridge Management System
CAPEX	Capital Project
CCTV	Closed-Circuit Television
CIDB	Construction Industry Development Board
COJ	City of Johannesburg
GIS	Geographic Information System
HoD	Head of Department
IT	Information Technology
ITS	Information Traffic System
ITS	Information Traffic System
JDA	Johannesburg Development Agency
JRA	Johannesburg Roads Agency
MFMA	Municipal Finance Management Act
OPEX	Operational Project
OPs	Operations Manager
PSM	Pavement Management System
RSD	Road Surfacing Depot
SAP	System Analysis Program Development
SCM	Supply Chain Management
SDBIP	Service Delivery Budget Implementation Plan
SMME	Small Medium and Micro Enterprise
STS	Smart Traffic System
TMC	Traffic Management Centre

DECLARATION

I, Yonela Mdubeki, declare that this project report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the Graduate School of Business Administration, University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.



Yonela Mdubeki

Signed at ……Johannesburg……

On the ……30th…….. day of ……June…… 2023…..

DEDICATION

I dedicate my research project to my late grandmother Selina, whose steadfast love, support, and courage saw us through many difficulties and trials, as well as to my mother Nombeko, my brother Lihle, and myself. This adventure would not have been possible without your unceasing support and confidence in my talents. Your sacrifices and direction have been a guiding light for me, motivating me to seek out knowledge and pursue excellence.

Your support and presence have been a source of inspiration for me throughout my academic endeavours, to the rest of my family. The basis for my development and achievement has been your love and understanding.

To my late grandma, whose legacy of tenacity and perseverance will always live in our hearts. Your advice and guidance have had a lasting impact on my life, and I will always be appreciative of the priceless lessons you taught me.

This research project serves as a testament to the closeness of our family ties and the significant influence you have had on determining my goals and accomplishments. Your confidence in me has stoked my zeal for education and study.

May this effort, in some tiny way, make the world a better place while also paying tribute to the love and support of my family, both past and present.

With deepest gratitude and love,

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SUPPLEMENTARY INFORMATION

Supervisor: Dr Pius Oba

Word count †:

Supplementary files: e.g., Research instrument

Participant information sheet

Consent form

Research approval letter

Ethics Approval

† Including Executive Summary, References, etc.

ABSTRACT

South Africa faces economic uncertainty due to deteriorating infrastructure and a historical backlog in its management, especially in the City of Johannesburg (COJ), where there is immense pressure to provide and deliver sustainable roads that are safe and efficient. This study explores the operational efficiencies and inefficiencies within the infrastructure management sector, focusing on roads and related services. It aims to identify and address the challenges hindering COJ's ability to deliver efficient and safe road infrastructure. In the pursuit of addressing the primary research objective, which sought to gain insights into the attainable operational efficiencies in road infrastructure management, a qualitative research methodology was adopted, including a qualitative analysis where interviews were conducted with knowledgeable and experienced respondents. Three key research questions were posed: How do you measure operational efficiencies in relation to roads infrastructure? How does the application and the types of technology improve efficiency in roads infrastructure lifecycle management? How would strategic sourcing help COJ improve efficiency and sustainability? From the interview data, common patterns were identified and translated into themes to derive answers to the research questions. The study's findings revealed that various interconnected elements contribute to COJ's operational inefficiencies in road infrastructure development. Efficiency in road infrastructure is defined by its ability to transport goods and commuters safely and swiftly. Furthermore, technology adoption improves road infrastructure management, while strategic sourcing, utilising existing assets, can enhance efficiency and address maintenance challenges while alleviating budget constraints. To fully leverage technology and operational efficiencies, the study concludes with a recommendation for COJ to initiate a strategic review, aligning all resources, including supply chain management, strategic assets, and employee skills, with the organisation's goals of providing more efficient roads. Continuous improvement in personnel skillsets and strategic objectives will be crucial for achieving this transformation.

Keywords: Road infrastructure, Operational efficiency measure, Sustainability, Technology, Strategic Assets, City of Johannesburg

1 CHAPTER 1: INTRODUCTION

1.1 Background

The development of infrastructure such as roads, railway, bridges, water and sewerage reticulation systems, waste management, sanitation, etc. is an essential component of any country's economic growth (Snieška & Šimkūnaitė, 2009); as such, it is therefore crucial for developing countries to ensure that labour and capital are utilized efficiently in the development of these infrastructures. Scholars such as Sahoo, Dash & Nataraj (2010) in their paper suggest that a significant role has historically been played by engineering infrastructure development in the process of global economic transformation and poverty eradication, this idea is further supported by Anyanwu, et al. (2009) and many other scholars. There are various challenges facing both developing and developed nations when it comes to creating a sustainable construction industry (CIDB, 2022). It is therefore essential to understand the various aspects of construction that require strengthening and reforming through digitalization and innovative solutions (CIDB, 2022).

A vital component of meeting the millennium development goals (MIG) is the investment in infrastructure especially transportation infrastructure (Anyanwu & Erhijakpor, 2009; Plessis-Fraissard, 2007). While majority of literature has demonstrated that there are challenges in all infrastructure, but the focus of this study will be on roads infrastructure due to their significant role in investment, trade and poverty eradication in developing countries especially African continent (Anyanwu & Erhijakpor, 2009). Roads infrastructure development enables mobility for market trade purposes for people in rural areas to participate in the economic activities as well as international trades (Anyanwu & Erhijakpor, 2009).

According to Plessis-Fraissard (2007), a key element of the World Bank's transport or roads infrastructure development program has been and continues to be low-volume rural roads. The study Plessis-Fraissard (2007), further alludes that there is no doubt that transportation; mainly roads infrastructure is a large, diverse, and complex sector that serves numerous social and economic needs. When a road investment reduces transportation costs substantially, it will most likely stimulate

rural development (Plessis-Fraissard, 2007). Road infrastructure problems are repeatedly cited by various scholars as major impediments to growth. Experts suggest that the road sector needs more reform to generate the funds needed to fill those gaps. In order to bridge the gaps and to further expedite economic growth, efficient operations and / or operational approaches for roads infrastructure are to be speedily adopted (Plessis-Fraissard, 2007).

1.2 Context of the Study

1.2.1 Define a need for this Topic (Reason for choosing this topic)

South Africa's continuously degraded infrastructure and its history of backlogs when it comes to managing infrastructure is of great concern for the country's economic future. The challenge in infrastructure development at project level is that there is no short-term incentive due to oversupply of labour, which has hampered operational efficiency during construction and at operational level (maintenance) (Ofori, 2000). The lack of adoption of more efficient approaches in line with the recent technology trends has made it difficult to achieve operational efficiencies in roads infrastructure development and as such, the end users bear the cost of ineffective and inadequate infrastructure (Fan & Chan-Kang, 2005). This is mainly due to a crucial challenge facing the country; the high unemployment rate, which has left the population in poverty, with communities depending on construction projects aimed at developing infrastructure to survive (Fan & Chan-Kang, 2005; Oraboune, 2008; Anyanwu & Erhijakpor, 2009), and therefore, adopting technology mainly for construction and mining industry has been an issue (Oraboune, 2008; Anyanwu & Erhijakpor, 2009; CIDB, 2022; Osunsanmi et al., 2020).

A conference paper by presented on the 11th CIDB post graduate conference, as cited by Aigbavboa et al. (2020), highlighted that the issue facing South Africa is the adoption of automation and other technological approaches at project level due to the social dynamics emanating from high unemployment rate. This had led to many firms shutting down within the construction industry as contractors are not able to adopt or apply technology approach which are economically viable when

implementing infrastructure project. Contractors are expected to apportion a significant percentage of activities to be labor intensive thereby accommodating unskilled labor to carry out majority of activities (CIDB, 2022), although in most cases this approach is not always the cheapest. The world is in the fourth industrial revolution (4IR), therefore in order to provide efficient solutions in roads infrastructure development, government needs to develop and implement sustainable technology strategies and policies (Aigbavboa & Thwala, 2020).

According to CIDB (2022), the practise of delivering construction projects in an unsustainable manner has prompted the continual demand for a more sustainable construction industry—an industry that provides the means for judicious use of environmental resources, one that fosters a sense of community, and one that provides value for clients' investments. There are a number of ways in which the construction industry can meet the requirements for sustainability, thereby adopting available efficient approaches, as a result of the current wave of the industrial revolution driven by digital, physical, and biological technologies (CIDB, 2022). The 12th CIDB postgraduate conference held in 2022 suggested that technologies such as systems integration, the internet of things, artificial intelligence, augmented and virtual reality, building information modelling, cloud computing, cyber security, big data analytics, autonomous robots, simulations, etc. offer the construction industry the possibility of digital transformation. Integrated modular building, self-healing concrete, additive manufacturing (3D printing), smart construction, and diverse innovative building materials are all examples of innovative building solutions that can transform the building industry into a more sustainable one (CIDB, 2022).

1.2.2 The Objective of the Research Topic

The study aims at addressing operational efficiencies that exist and those that can be adopted by the City of Johannesburg (COJ) in road infrastructure development. The objective is to also understand the impact of technology on organisations within the construction industry and further understand the emerging technologies and transfer of technology in road infrastructure construction in order to improve efficiency. In order to address the main objective of this study, it is crucial to explore challenges facing the construction industry in infrastructure, particularly roads.

There is generally insufficient management, skills, and budget in many South African municipalities, and this negatively affects service delivery (Wall, 2021). Wall (2021) argues that this is largely due to a weak economic base, poor use of available funds, and difficulty attracting and retaining skilled personnel. Wall (20221) in this study further questions the relevance of the municipal model used in non-metropolitan areas in delivering services, considering the fact that the municipal systems in SA were developed for industrialising Britain in the 19th century before being transplanted to colonial nations without being tried and tested for. The existing systems within municipalities are failing to cope with rapid social and economic demands in order to create sustainability (Wall, 2021).

The use of one model of traditional contracting for the entire country is the reason why municipalities are failing to deliver services to communities; many of these problems have also been attributed to money wasted by various other means, including wasteful or corrupt spending (Wall, 2021). Available studies demonstrate that lack of adequate skills, financial constraints due to municipal overspend, inadequate leadership, and a dislocated and outdated municipal model are the major factors contributing to the failure of municipal entities to efficiently deliver services. COVID-19, coupled with the lockdowns and the weak economy in general, has undoubtedly hit municipal finances hard because businesses and households have found it increasingly difficult to pay their municipal debts (Wall, 2021).

1.3 Problem Statement

1.3.1 Main Problem

The COJ is currently under immense pressure to provide and deliver sustainable roads that are safe and efficient in providing mobility. COJ, being the hub of economic growth, still faces challenges in addressing social and economic inequalities (Rogerson & Rogerson, 2015). According to Rogerson et al. (2015), the lack of adoption of more efficient approaches, such as recent technology trends, has contributed to the city of Johannesburg's inability to provide safe roads due to ageing infrastructure, a backlog in implementing new and maintaining existing road

infrastructure, slow and inadequate procurement processes, and issues such as potholes, blocked drainage systems, insufficient skills and resources, budget constraints, a lack of historical data for existing services, budget overspends, and project stoppages.

The Johannesburg Roads Agency (JRA), an entity within the City of Johannesburg, is responsible for maintaining the road network of approximately 13 599 kilometres (12 431 kilometres of surfaced roads and 1168 kilometres of gravel roads). A total of 902 bridge structures have been inspected throughout the city, with 68 of them requiring urgent repair to ensure safety and structural integrity at an estimated cost of R1.28 billion. For the rehabilitation of all bridge structures, R16 billion is required; therefore, the annual budget of R110 million issued to the JRA is a drop in the ice bucket (JRA, 2023). The COJ is currently faced with challenges of inefficient infrastructure as a result of potholes, vandalism and theft of infrastructure, traffic lights that are not working, a lack of materials and equipment, etc. The COJ in general is faced with severe service delivery and customer satisfaction challenges in relation to road infrastructure development: a) labour instability; b) high maintenance costs for infrastructure; c) a lack of an automated fare collection system; d) an inadequate fleet; and e) inadequate procurement (JRA, 2023).

1.4.2. Research Questions

In order to identify and understand operational efficiencies that can be adopted by COJ in road infrastructure development, it is paramount to outline various concepts relative to the topic. Those are themes that are found throughout the literature review of several scholars, which will comprise the definitions of operational efficiencies, the relationship of operational efficiencies with road infrastructure, technology, and its impact on the development of new road infrastructure, construction, and maintenance thereof. The main research objective is to understand the impact of operational efficiencies that can be adopted in road infrastructure development within the COJ. Therefore, in order to address the above-mentioned objective or main question, the study will address the following questions:

- How do you measure operational efficiencies in relation to roads infrastructure?
- How does the application and the types of technology improve efficiency in roads infrastructure lifecycle management?
- How would strategic sourcing help COJ to improve efficiency and sustainability?

1.4 Significance of the study

The study determines the framework and approaches in line with global trends that can be applied in order to improve road infrastructure implementation in procurement, project implementation, and road infrastructure lifecycle management. The City of Johannesburg will gain some key insights on efficiency approaches that can be adopted for sustainable road infrastructure development. The findings of this study will further assist in formulating relevant policies and standards that are required within the road and construction sectors in order to achieve sustainability. Kuhn (1983), argues that It is essential that road and transport practitioners have access to a variety of information with respect to the provision and maintenance of infrastructure, operational and safety matters. It is important to note that one of the main deficiencies is the absence of an effective mechanism for feeding into research recurring practical problems or areas of innovation or improvement (Kuhn, 1983).

1.5 Delimitations of the study

The focus of the study was limited to COJ within the road infrastructure sector. An internal memo or letter seeking approval to conduct the study was issued to the company executive office (CEO), head of infrastructure department (HOD), and operations manager (Ops). Approval to obtain confidential and sensitive information to utilise for the study was obtained from the JRA, which is the implementing agency or municipal entity on behalf of COJ. The terms JRA and COJ will be used interchangeably in the context of this study since JRA is the implementing agency for road and stormwater infrastructure for the city of Johannesburg..

1.6 Definition of terms

- **Operational efficiency**: Ability of an organization to offer its products and services to its customers in a cost-effective manner while still ensuring high quality.
- **Roads Infrastructure:** A well-designed road infrastructure can be an effective way of improving road safety. This improves the quality of life for the people by increasing their access to jobs, schools, stores, and a variety of recreational activities. Poor quality, unsafe roads adversely affect people's daily lives.
- **Black Literature**: Literature that has been published, and/or that has undergone peer review.
- **Quantitative Studies**: Data produced by studies that can be converted to numbers.
- **Grey Literature**: literature which includes those works produced by a variety of sources including government, business, academia, and industry in both electronic and print formats but uncontrolled by commercial publications
- **Snowballing Technique**: It is a technique which primarily involves searching for and tracking references in journal articles, conference papers, bibliographies, footnotes, citations, company documents, and other search documents
- **OPEX:** refers to the ongoing operational expenses necessary for the day-to-day functioning of a business
- **CAPEX:** Investments in long-term assets that provide future benefits for an organization
- **Depot:** it is a unit responsible for operational and maintenance activities. A place where plant, materials , equipment, etc. are stored

1.7 Assumptions

- It is assumed that adequate representation from the participating population is representative.

- Before, during, and after the study's conclusion, the variables that determine the City of Johannesburg's operational effectiveness will be the same. Any difference will be insignificant.
- Improving operational efficiency, performance and service delivery of road infrastructure are the one key objectives of the COJ

2 CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The cost of constructing infrastructure that supports modern life can be very high. A paper by Kupec et al. (2018) highlights that operating and maintenance costs, if estimates are not done properly, can put a strain on an organizations owing these assets for its entire life cycle, often at the expense of other projects. This is also one of the challenges which leads to inadequacies on assets management as roads infrastructure life-time span decreases and operational and maintenance costs become too expensive (Kupec, Gibbons, Matchett, & Maher, 2018).

The COJ comprises of several municipal owned entities (MOEs) providing various activities like City Power that is tasked to provide electrical services, Joburg Water responsibility for water and sewer reticulation services, etc. The city of Johannesburg has also Johannesburg roads agency (JRA), Metrobus and Johannesburg development agency (JDA) who are tasked with the responsibility of managing and implementing roads infrastructure on behalf of the City (Overview: Joburg.org.za, 2022). While several scholars have demonstrated that not only roads infrastructure contributes to the economic growth of any country, the focus of this study will solely be on road infrastructure within the COJ, as the economic and public transportation infrastructure as a whole have been identified as key drivers of higher economic growth as well as improving mobility and reducing traffic congestion in the city (Company Documents Strategy & Stakeholders – The JRA, 2021) .

The financing mechanisms of transport in this instance roads, investment differ significantly, which, in turn, exacerbates the quality gap and the rate difference. In the case of high-level roads, especially highways, tolls and fees are the main revenue sources (Zou, Zhang, Zhuang, & Song, 2008). The study carried out in China by Zou et al. (2008), shows that in the eastern areas, where many vehicles are owned per capita and there is a high number of roads, it is easier to attract foreign and domestic investment to develop roads. While in poorer areas, especially those needing more roads, the local government is unable to finance road

construction because there are few vehicles and little road density, resulting in the vicious cycle of "income poverty and transport poverty", thus the rural area is even further behind when it comes to road construction (Zou, Zhang, Zhuang, & Song, 2008). The study further explains that, because of the complex geographical condition of the rural areas, the cost of construction is higher, but the payback period for roads is significantly longer and the return of investment is lower (Zou et al., 2008).

A study carried out by Seneviratne (2006), in China and India found that poor road infrastructure performance impacts on economic (trade) performance of the two countries, as a result improving efficiency in road transport and logistics, as well as asset performance, will increase the both countries GDP. The main characteristic of a transportation infrastructure from the viewpoint of economics is the fact that it provides public services; it facilitates movement of good and people which impacts on the economy and the society at large (Prus & Sikora, 2021). The development of a properly functioning road infrastructure can stimulate economic activity and facilitate competitiveness in terms of the environment within a given area (Prus et al., 2021).

2.2 Definition of topic or background discussion

The road infrastructure plays a critical role in a nation's development. For rural and urban transformation to be productive, safe, and secure, roads must be maintained (Benamghar & Iimi, 2011, as cited by Muzaale & Auriacombe, 2018). Managing road infrastructure projects involves a number of challenges, such as appointing and monitoring contractors. Due to the poor quality of constructed roads and delays in the construction process, production costs, employment creation, and market access remain a major concern (Wasike, 2011, as cited in Muzaale & Auriacombe, 2018). In this regard, Visse (2012) maintains that a nation's infrastructure is a key determinant of its ability to participate or not participate in the global economy (Arrows, 2010, as cited in Muzaale & Auriacombe, 2018). According to World bank (2010), some of the reason for issues found on roads infrastructure development

are due to supply chain process and monitoring of contractors at project level (Muzaale & Auriacombe, 2018).

2.3 Operation Efficiency and Roads Infrastructure Development

The literature by Slack at al. (2017), outlines that one of the critical components in driving efficiency is by having operations strategy, which will study the needs of the market in an aid to provide effective and efficient solutions which meets the expectations of stakeholders. According to the above scholars, operations strategy therefore assists in drawing up efficient systems and processes which organisations require to meet the market needs. The book by Slack, Brandon-Jones, Singh, Phihlela, & Johnston (2017), indicates that several scholars differ in perspective when it comes to operations strategy thereby defining operations strategy in four ways thereby; i) top-down map of what firms or groups intend to do, ii) bottom-up approach where operations innovations and improvement continuously build strategy, iii) market needs are continuously tracked and improved through operations decisions, and iv) distinctive capabilities and resources are fully exploited to fully achieve the value proposition of the chosen market.

According to Rogerson & Rogerson (2015), in order for Johannesburg to succeed in the future, it must be able to address the multiple challenges associated with urban growth, management, and absorption. The writers further indicate that the most challenging aspect of the city's future is to create new employment opportunities and livelihoods for its growing population. Gauteng is the hub of the country’s economic growth; therefore, Johannesburg's economic prospects are inseparable from those of the nation (Rogerson & Rogerson, 2015). For the future of South Africa's economy, the continuing decline of infrastructure and a history of backlogs of infrastructure management are of great concern (Rogerson & Rogerson, 2015).

A major problem facing the country is the high unemployment rate which has resulted in a continuous poverty rate, communities that depend on construction projects for a living which then leads to in ability of technology adoption on roads

infrastructure development and thus, operational efficiencies has proven to a challenge (Thwala, 2009). This has then led to uneconomical approaches adopted in roads infrastructure implementation and maintenance especially in developing countries due to labour intensive requirements and / or policies which are not effective for projects or organisations themselves (Ndevu & Muller, 2018). City of Johannesburg (COJ) as one of the largest municipalities in South Africa (SA) have been faced with inability to transform traditional roads infrastructure development into a more digitize space in order to ensure that projects are implemented successfully and effectively (Rogerson & Rogerson, 2015). What describes whether a project was a success? According to PMBOK which is applied universally, a successful project is the one which is completed within time, budget, approved designs, quality and customer satisfaction (Guide, 2001).

The paper by Wall (2021) states that every year, the Auditor General's reports identified many areas for municipalities in which the funds available could be spent more effectively. These reports outline the improvements that can be made by each municipality, sometimes saving tens of millions of rand. Amongst many this things, this can be achieved by appropriate hiring or purchasing decisions, as well as to improved supply chain management to increase value for money, and to taking into account the life-cycle cost of capital purchases. Throughout its history, SAICE has consistently identified that insufficient skills and systems; basically systems for collecting and analysing performance data, and systems for identifying the least costly alternatives for capital improvements, have adversely affected infrastructure operation and maintenance, causing its condition to deteriorate (Wall, 2021).

According to CIDB (2022), the practice of delivering construction projects in an unsustainable manner has prompted the continual demand for a more sustainable construction industry, an industry that provides the means for judicious use of environmental resources, one that fosters a sense of community, and one that provides value for clients' investments. There are a number of ways in which the construction industry can meet the requirements for sustainability as a result of the current wave of industrial revolution driven by digital, physical, and biological technologies. Systems integration, the internet of things, artificial intelligence,

augmented and virtual reality, building information modeling, cloud computing, cyber security, big data analytics, autonomous robots, simulations, etc., offer the construction industry the possibility of digital transformation. Integrated modular building, self-healing concrete, additive manufacturing (3D printing), smart construction, and diverse innovative building materials are all examples of innovative building solutions that can transform the building industry to a more sustainable one (CIDB, 2022).

Operating efficiently is the ability of an organization to offer its products and services to its customers in a cost-effective manner while still ensuring high quality. In order for entities to drive and improve operational efficiencies, they are to constantly focus on factors which constitute to efficient and effective performance of a products / asset / service, the focus should then be on controlling costs, flexibility, speed, ensuring best quality products / services and dependability (Slack, Brandon-Jones, Singh, Phihlela, & Johnston, 2017). The paper by Ismail et al. (2014) argues that as a result of the lack of adequate infrastructure, assets are being priced properly and as such these costs are then passed on to the consumers or end-users. Underinvestment in infrastructure is a common problem in developing economies such as South Africa's (Ismail, Pillay, Mabuza, & Xolo, 2014).

Literature by Kortmann et al. (2014), also supports the research by other scholars and argues that organizations should consider investing in a dedicated mass customization capability in order to increase product variety and operational efficiency. The scholars also further argue that flexible manufacturing technology is an important component of variety and efficiency, which also includes the ability to apply modular product architectures, in order to define modular processes and to navigate customer needs to the best set of product configurations (Kortmann, Gelhard, Zimmermann, & Piller, 2014).

2.4 Measure of Operational Efficiencies

A study by scholars Ismail, Pillay, Mabuza, & Xolo (2014), in measuring the efficiency in relation to infrastructure, highlights the issues which lead to

inadequacies in infrastructure development; one of which is poorly delivered infrastructure which leads to costs being transferred to consumers through asset pricing. The scholars further assert that poor selection of a financing and financing method, as well as project overruns are some of the factors which result in inadequate pricing. The authors found that users-pay mechanisms of funding are only effective if there is full transparency and communication between users and other stakeholders.

Diego, Valtueña-Ramos, & Frank (2021), in their study highlight that the concept of transforming the physical road infrastructure into a civil engineering structure with additional features beyond mere mobility has become increasingly relevant in recent decades. Some of the proposed concepts addressed on their study comprise of features such as intelligent communication (e.g. Car2Road communication), energy harvesting (e.g. to defrost or light roads), and improved vehicles positioning for autonomous driving. The problem with building and maintaining modern roads is that they are built and maintained based on the principles associated with 'ordinary' roads, so there is a likelihood of these roads becoming 'smart' posing challenges not included in its original planning stages. Although electric vehicles (EVs) can contribute to the sustainability of road transportation sector in the long run, use is currently restricted because of some technology constrained used in producing them (Diego et al., 2021). Application of automation and robotics technology in the building and management of roads enables affordable in construction projects with increased productivity and efficiency in various stages of the asset cycle life span. As a result of automation and robotic technology, operational efficiencies are realized through decreased production costs as well as increased user value proposition (Azhar, 2011).

A study by Kuhn (1983), suggest that each year, South Africa spends millions of rands on road accidents as a result of road hazards. The study further outlines that not only the vehicles that can be damaged in an accident, but also the victims themselves, who often suffer serious injuries and even death as the result of the accident. It is important to recognize that every accident is a result of multiple

variable, therefore, it is critical that factors resulting to accidents on the road be reduced and eliminated in order to improve efficiency (Kuhn, 1983).

2.4.1 Research Question 1: How do you measure operational efficiencies in relation to roads infrastructure?

One could argue that operational efficiency can be measured through performance and the life-cycle span of an asset, however Slack et al. (2017) suggest five performance measures to be considered different levels namely: a) broad strategic measure, b) functional strategic measure, c) composite performance measure, d) generic operation performance measure, and e) some detailed performance measure. In order to measure operational efficiencies in relation to roads, the operational performance measure technique to be applied should focus on *quality*, *dependability*, *speed*, *flexibility* and *cost* (Slack, Brandon-Jones, Singh, Phihlela, & Johnston, 2017). A paper by Pisu, Hoeller, & Joumard (2012) concurs with the above approach by Slack et al. (2017), the paper suggests that to measure infrastructure operation efficiency through performance, the infrastructure can be benchmarked against various approaches such as performance using cost benefits approach of new projects. The scholars discuss several cost benefits elements but the ones found relevant for roads were social benefits.

The study by Muzaale & Auriacombe (2018) suggest that operational efficiency on roads can be measured through cost, time, quality, stakeholder satisfaction (client and end user), and risk mitigation (health and safety). Delays in projects lead to additional time in a project which then leads to high operational expenses. One of the measure can be value derived from willingness-to-pay (WTP)by roads users for the use of public transport, deterioration in noise pollution, accidents, air pollution, travel time saving, reduced vehicle wear and tear, etc. (Eboli & Mazzulla, 2008).

A highly degraded infrastructure, significant budgetary constraints, and a rapidly growing traffic volume have created a tremendous interest in improving the efficiency and effectiveness of roads infrastructure maintenance practices that preserve the road infrastructure so as to better serve society (Fallah-Fini, Triantis, Jesus, & Seaver, 2012). This study suggests that some of the options adopted by

states departments of transport (DOTs) to measure operational efficiency in maintenance of roads infrastructure can be application of hybrid contracting methods: traditional and performance-based road maintenance contracting. The paper found that the traditional contracting (supply chain processes) method seems to be more efficient at improving the road conditions than performance-based contracting via Public Private Partnership (PPP) used by road authorities. Literature by Essuman et al. (2020), concurs with the above scholar, that a disruption to operations (including supply chain) directly and immediately impacts operational efficiency and effectiveness.

Scholars, Kaparias et al. (2011), argue that from the perspective of traffic efficiency, key performance indicators (KPIs) such as mobility, system condition and reliability are important in order to measure the performance and effectiveness of the infrastructure. They argue that in order to understand the efficiency, it is critical to understand the travel times and the ease of access in both in public roads and other transportation network in order ensure there is mobility. The scholars suggest that efficiency in roads infrastructure can also be measured through an introduction of another KPI for dealing with safety whereby road safety can be measures by the number of accidents occurred (Kaparias, Bell, & Tomassini, 2011).

The scholars, Eshtaiwi et al. (2018) also concurs with Kaparias et al. (2011), that evaluation of performance and effectiveness is necessary for organizations to determine whether or not they are achieving their objectives and comparing their performance with similar best practices. Eshtaiwi et al. (2018) further states that organizations have always faced a difficult task of developing key performance indicators, even though many organizations are using them today to measure their success. A lack of understanding of performance measures by business leaders is responsible for the fact that few organizations use the most appropriate KPIs to appraise their performances (Eshtaiwi, Badi, Abdulshahed, & Erkan, 2018).

2.5 The Impact and Adoption of Technology in Roads Infrastructure

The IMESA conference undertaken in 2018 in Port Elizabeth through the paper by Kupec et al. (2018), identifies that Aurecon with their teams and partners have been providing customers with more cost-effective, longer lasting, and more effective solutions for infrastructure needs for many years. In addition to offering improved operational performance Kupec et al. (2018) suggest that with higher resilience, the new approaches offer a greater degree of clarity for asset management over the long term. This paper examines interactions between engineers and other stakeholder groups, such as local governments, central governments, and the general public, and discuss the impact of new and innovative technologies. Automated airborne and terrestrial unmanned vehicles that generate point clouds and interactive 3D models are among these technologies (Kupec, Gibbons, Matchett, & Maher, 2018). The authors further point out that the use of virtual and mixed reality environments for data review, analysis, stakeholder interaction, and public communication is one of the new technologies. Artificial intelligence (AI) engines are outlined as one of the improved technologies adopted to analyse big data very accurately and compared to more traditional methods (Kupec at al., 2018). These scholars further conclude that technology is proving to be highly beneficial for designing, building, operating, and maintaining modern infrastructure.

Supporting the notion of investing in technology, Kortmann et al. (2014), states that a sustainable competitive advantage can be achieved by striking a balance between strategic flexibility and operational efficiency. In order to remain strategic, firms need to be able to invest in a variety of innovative projects with varying risks, planning horizons and strategic priorities (Kortmann, Gelhard, Zimmermann, & Piller, 2014).

Unexpected impacts from natural disasters can reduce the lifetime and increase operational and maintenance costs. This poses significant challenges for those who are charged with looking after those assets (Chen, et al., 2013). The government gazette (2018), suggest that the Fourth Industrial Revolution (4IR) has necessitated

that countries design new policies, strategies, and innovation plans to enable a comprehensive approach to the digital age that involves the whole society, with the government serving as a key facilitator. The government, private sector, and civil society all contribute to the 4IR in South Africa, but there is no plan or blueprint which brings everybody together under a single framework (Presidential Commission on the Fourth Industrial Revolution: Nominations invited, 2018). While automation technology has progressed in aerospace, ship building, and other industries, construction automation technology has grown slowly because the existing automation technology and engineering technology may not be appropriate for large scale construction products economically and efficiently (Ding, Wei, & Che, 2014).

a) Data Capturing and Information Management

The problem facing developing countries including South Africa is the lack of available data and information management tools as well as the adoption of the latest technologies in infrastructure development. Geographic Information System (GIS) is one of the important tools critical for any municipality or organisation for storing, retrieving, managing, and analysing spatial data (Kupec, Gibbons, Matchett, & Maher, 2018), this tool is critical for roads infrastructure development. GIS assist in capturing data about the existing services or assets; As-built information, availability of the correct information creates efficiency when designing and implementing infrastructure projects. The ability to receive and share information streams is at the heart of any GIS platform. The need to assess damage to infrastructure following the 2010 Christchurch earthquakes as outlined in Kupec et al. (2018), increased significantly after the initial earthquake and even further as the scope of damage became clearer. Facilities that were damaged and lack or inadequate accommodation, coupled with recurrent aftershocks, was a factor that discouraged out-of-town staff from relocating to Christchurch. The work involved field work, inspections, meeting with colleagues and government officials, as well as dealing with clients. In the professional services industry, this situation made offshoring and work sharing difficult, and this added an enormous amount of resource pressure that couldn't be addressed in the traditional manner. It was

urgently necessary to streamline, improve and innovate the way work was completed.

Early on in the history of mobile devices and tablets, it was recognized that it was possible to collect data digitally in the field. The need for integrating, comparing, and verifying field data became critical as more information was captured. The field teams had the ability to see where other teams were working and where data gaps were present on a map since mobile devices updated and synchronized with the centralised data in real-time (Kupec, Gibbons, Matchett, & Maher, 2018). The paper further states that a virtual geofence enabled field teams to avoid high-hazard areas not readily detectable on the ground. Field teams were able to capture data much more quickly than usual thanks to digital information, such as property boundaries, geohazards, and infrastructure assets. According to Kupec et al. (2018), after recognizing that obtaining detailed information about municipal infrastructure was critical for forming sound decisions, the City of Tshwane launched a fully paperless data collection system to address the need and complexity of the task.

b) Visualisation and Physical Environment

It is estimated that 30-50% of the human brain is exclusively utilized for visual processing (Thompson, 2018 as cited by Kupec, Gibbons, Matchett & Maher, 2018). Infrastructure planning, design, and management rarely utilize this ability in Civil Engineering. The 3D information for complex 3D problems, such as pipe routing and pipe conflict management, is often only shown on 2D drawings, despite its availability. The temporal dimension is rarely considered in infrastructure planning and management, i.e., when and not just where service provision takes place and how it interacts or conflicts over time. 3D models assist in understanding complicated terrains and geometry (Kupec, Gibbons, Matchett, & Maher, 2018). The technologies used are virtual reality (VR), Augmented reality (AR) which can be used to determine improvements to tunnels, Mixed reality (MR). The use of robotic inspection vehicle on assessing damages on roads, tunnels, rail and culvert structures is one of the technology application which enables efficiency. This technology can be used for collecting date which is necessary for designing and creating relevant maintenance plan, this technology makes it efficient to carry out

work in shorter durations. Virtual environments are already being utilized in New Zealand for testing, comparing, and prototyping complex infrastructure projects before implementation in the real world Kupec et al. (2018).

The scholars, Ding et al. (2014), in their paper display automation technology which has been adopted by Japan and United States in the construction industry in order to solve issues such as, a) safety during construction, quality, high costs, productivity, lack of skilled personnel. The paper further outlines that these countries invested huge some of funds in construction techniques and robotic systems. Literature by Ding et al. (2014), also reflects that the current available automation technology being utilized in construction especially engineering technologies are falling short in addressing operational efficiency gaps. Ding, Wei and Chei (2014) further outline the reasons for the slow adoption of technology in construction particularly engineering sector, and those are: a) automation technology not adequate for large scales of construction products, b) automation technology inadequate for conventional design approaches, c) amount of final output is perceived as less and types are fewer, d) material selection is limited, e) automation equipment makes this approach unattractive, and f) this type of technology has impact on traditional project management.

Understanding how technologies function together is more important than understanding them individually, so understanding the concept of self-organization is important. It is recommended that a new model be developed that consists of six digital transform technologies and six analog transform technologies together with AI as shown in *Figure 1*, namely the “AI + 12tech” model (Lee, et al., 2018).

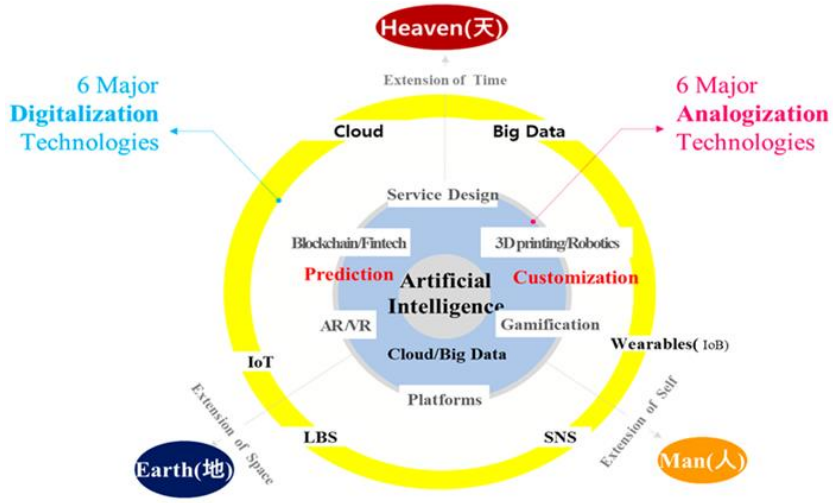


Figure 1: Six digital Transform and Six Analog Transform Technology Models (Source; Lee, et al., 2018)

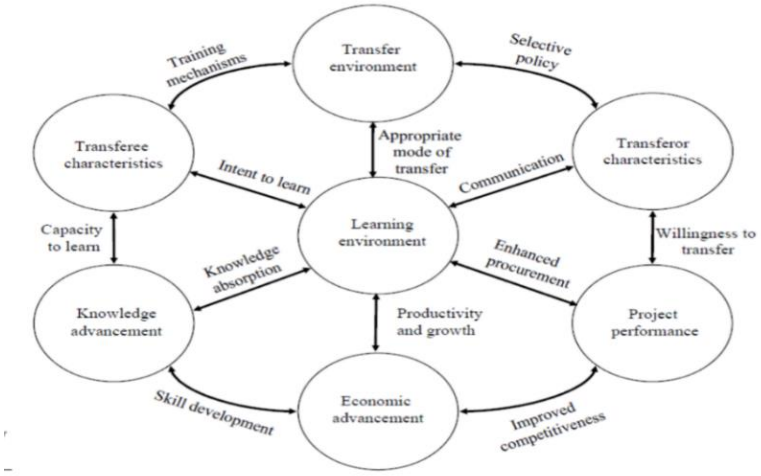


Figure 2: Seven proposed Perspectives for benchmarking technology transfer (Source; Steward & Waroonkun, 2007)

2.5.1 Research Question 2: How does the application and the types of technology improve efficiency in roads infrastructure lifecycle management?

The research conducted by Heinzel, Azhar & Nadeem (2017), they provide the benefits of technology transfer within engineering activities in the construction and engineering industry as; quality control, safety, efficiency in time spent at design and construction levels, effective daily output / production, eliminating errors earlier

in the process so inconsistencies can be detected. Innovations in technology can help field quality and trade managers identify and resolve quality issues, helping them save time and money by reducing the need to redo incorrect work (Heinzel, Azhar, & Nadeem, 2017). The authors also claim that in construction and infrastructure projects such as roads, augmented reality (AI) has a number of benefits, including: a) Real-time visualization of project activities, b) Better collaboration and communication among team members, c) Enhanced safety, d) Better scheduling, More efficient budget management, and e) great advancement in the use of building information modeling.

Scholars Heinzel et al. (2017), further highlight that Architecture, Engineering, and Construction (AEC) professionals have been transforming the way they design and visualize their projects with the adoption of Building Information Modeling (BIM). In line with the literature conducted by scholars, Kupec et al. (2018), Heinzel, Azhar & Nadeem (2017), in their study outlines the benefit of BIM process as that which can provide design professionals with a 3D model of a structure such as a road with accurate details about that structure. Literature review by Yılmaz & Bakış (2015) provides the efficient and sustainable vision that comes with industry 4.0 in the construction industry, primarily roads and bridges, and the social expectations as follows:

a) A reliable infrastructure that is durable with a long lifespan, easy to maintain, and can handle current as well as future demand
b) Eco-friendly infrastructure that conserves natural resources and controls pollution
c) The provision of safe, smart infrastructure that enhances all road user movement and accommodates all traffic types during construction, permanent and visible road signage, and traffic signals to ensure safe, efficient, and reliable traffic flow. Safety solutions for infrastructure are being developed based on the principles of safe design, smart design, smart communication, and smart monitoring.
d) Human Infrastructure, which is concerned with incorporating infrastructure with human dimensions.

Literature by these scholars such as Ding, Wei, & Che (2014), Ding et al (2014) and others, show that in order to improve operational efficiencies, new modelling systems such as, additive manufacturing (AM) for architecture printing, contours and concrete printing, building information modelling automated construction (BIM), 3D printing and advanced computer aided design (CAD) (Ding, Wei, & Che, 2014). In application of operations techniques, it is expected to benchmark construction operations based on the local and international standards and trends. Since the latest construction equipment trends result in greater efficiency, contractors must keep up with these trends. When considering the optimal use of recycled materials, such as road aggregate, resource efficiency is also on the agenda (Kganyago, 2019). One of the approaches used by Bakwena in ensuring efficiency and effectiveness of roads infrastructure is the tolling systems whereby tariffs are charged from the motorist in order to continuously maintain, rehabilitation of roads as well as provide alternative routes (Kganyago, 2019).

An article by Kannemeyer et al. (2012), suggest Asphalt Mix Performance Tester (AMPT) which was developed in Dick Kings as an effective performance test method that is quick with cost benefit savings on surfaced roads. In addition to evaluating resistance to permanent deformation, AMPT responses also contribute to quality control and acceptance of HMA mixtures on the job (Kannemeyer, et al., 2012). Furthermore, the study suggests that, AMPT has been implemented on a worldwide basis for the determination of dynamic modulus (Kannemeyer, et al., 2012).

According to Balado et al. (2020), Intelligent Transport Systems (ITS) and digital infrastructure are being developed simultaneously with new concepts in mobility, including autonomous vehicles, connected infrastructure, and electric vehicles. ITS and digital infrastructure are closely related concepts. To ensure safe mobility and good service conditions on highways and roads, any ITS must be based on digital roads and continuous monitoring (Balado, González, Arias, & Castro, 2020). The literature further suggests that in in improving road safety and efficiency, satellite images, aerial images, and Mobile Mapping System (MMS) solutions are among

the most widely used techniques and technologies to achieve digital road monitoring (Balado et al., 2020).

A study by Berglund, et al. (2020), states that using smart city technologies, infrastructure problems related to aging infrastructure and increasing demand can be solved. The scholars however point out that while smart cities concepts have the potential for improving infrastructure and urban life, they are still unable to be implemented due to technical, financial, and social limitations and criticisms (Berglund, et al., 2020). The literature on smart technologies which can be used for infrastructure management comprise of sensors, crowdsourcing and citizen science, actuators, data transmission, Internet of Things, big data analytics, data visualization, and blockchain (Berglund, et al., 2020).

2.6 Sustainability of Roads Infrastructure Development

According to Kannemeyer, et al. (2012), there has been a substantial deterioration in South Africa's Road infrastructure over the past decade; in 2008, the number of surface roads in poor to very poor condition increased from 8% (1998) to 22% (2008), and for gravel roads it increased from 35% to 63% (2008). The scholars identified several issues within roads authorities; insufficient asset management practices, and a significant number of potholes are developing because most authorities do not perform preventative maintenance (cleaning stormwater drainage structures, crack sealing, resealing, etc.).

The JRA currently owns an asphalt plant which is utilized for maintenance (operations) purposes to fix issues like potholes, cracks, corrugation, and other defects on surfaced roads. The maintenance activities are carried out under operations (Opex) programme while capital project (Capex) which are aimed at upgrading of gravel roads to surfaced standards which includes stormwater, traffic signals, etc. do not make use of the existing JRA asset (asphalt plant) and the road surfacing (RDS). The book by Slack et al. (2017), identifies five operational performance objectives which also found to be relevant to roads infrastructure development as they are as follows:

a) **Doing things right**: which talks to quality in line with the specification and designs and ensuring that the basic needs are met
b) **Doing things fast**: this relates to speed; delivering roads project within approved timeframes
c) **Doing things on time**: this then talks to dependability which forces firms to deliver on their promises service delivery and effective products satisfies the customer's (user) needs and eliminating backlog
d) **Ability to change what you do**: flexibility; depending on unexpected circumstances or customer needs, managers or engineers might consider modifying or adapting the operation's activities. The ability to correct design based on the unforeseen circumstance in order to provide sustainable roads, flexibility to achieve the most efficient approach as well as automation and technology adoption
e) **Doing things efficiently (cheap)**: cost is the factor here; ensure the taxpayers or any other party funding the operation receive good value for the asset. By doing this, the organization gains a cost advantage and transfer of cost to end users it eliminated as well as employing cost effective technology to manage roads infrastructure.

2.6.1 Research Question 3: How would Strategic Sourcing Help COJ to Improve Efficiency and Sustainability?

In order to remain competitive forward thinking companies are becoming more innovative and flexible in their value chains and organizational structures (Gottfredson, Puryear, & Phillips, 2005). The literature by Gottfredson et al. (2005), suggest that the vertically integrated business model has been declining for some time, and sourcing has become a strategic process for organizing and fine-tuning the value chain. The study these scholars ascertains that the most important factor for a company is not whether it owns capabilities but how it uses them, regardless of whether they are on its balance sheet (Gottfredson et al., 2005). The scholars, Gottfredson et al. (2005), recommend that an effective sourcing strategy can dramatically improve a company's competitiveness by revaluating their strategy and capabilities rather than focusing on incremental cost reduction targets. It is therefore

important to identify the core functions of the organization. By reducing costs, streamlining the organization, and improving quality, companies can improve their strategic position by relying more heavily on capability sourcing (Gottfredson, Puryear, & Phillips, 2005).

A case study by Ismail et al. (2014), concurs with other scholars that in addition to contributing to economic growth, infrastructure investments also improve quality of life. Investment in strategic assets by the government can take many forms; such as a public-private partnership which is created when the public and private sectors join forces to procure a facility (Ismail, Pillay, Mabuza, & Xolo, 2014). The literature suggest that as a result of this type of financing, many countries both in the developing world and in the developed world are now utilizing it. Governments and the private sector share the risks in this method of financing, making it a superior alternative to other financing methods (Ismail et al., 2014). According to these scholars, Ismail et al. (2014), this type of financing provides better outlook on government's balance sheet, enables a competitive bidding for infrastructure projects, enables efficient methods in infrastructure development and enabling government to adapt private sector practices.

Uzarowski & Bashir (2007) conference paper suggest that pavement preservation treatments and pavement rehabilitation come in a variety of forms. The authors further states that keeping up with all these developments can be challenging for pavement engineers, but for municipalities it is a total mystery. In order to keep the rapidly deteriorating road network maintained, they have to make rational decisions to maximize the use of scarce financial resources (Uzarowski & Bashir, 2007).

Literature by IIbeigi et al. (2017), found that transportation departments have found it difficult to budget for transportation projects with price variations in asphalt cement. The authors further found that as a result, contractors have also had difficulty developing appropriate estimates of transportation costs. While asphalt cement prices tend to rise over the long term, they fluctuate drastically over short periods of time (Ilbeigi, Ashuri, & Joukar, 2017). According to Lenferink et al., (2013), integrating stages of design, construction, and maintenance in a contract can result in more sustainable infrastructure development as a result of lifecycle

optimization incentives. Taking into account the findings of the study, the scholars recommend that sustainable infrastructure development be pursued in three avenues: green procurement, strategic asset management, and relationship contracting (Lenferink, Tillema, & Arts, 2013).

2.7 Conclusion of Literature Review

A company's operational efficiency is its ability to provide the best service and products at the lowest cost to its customers while maintaining the highest standards of quality (Slack, Brandon-Jones, Singh, Phihlela, & Johnston, 2017). From the literature conducted, it is evident that improving operational efficiency and reducing operating costs are important paths for the sustainable development of roads infrastructure. In order to achieve operational efficiencies in roads infrastructure thereby developing new sustainable materials and solutions which are more efficient, faster, and less expensive, it is crucial to continuously research and adopt latest trends, best practices, benchmarking etc. Research results should be used to inform policies (or amend policies) and standards regularly. The concept of operational excellence by Slack et al. (2017) assist in better understanding innovative practices which COJ particularly JRA and transport department as major entity for road infrastructure development, that help to achieve operational effectiveness, such as reducing defects in products / services (maintenance of roads) or faster development (supply chain & project duration) of better products. The literature further suggests for operation to be measures at tree levels; supply chain, operation and process.

3 CHAPETER 3: DATA COLLECTION AND DATA ANLYSIS

3.1 Research Methodology / Paradigm

The chosen research design for this study was the qualitative approach, as it provides a contextualised and in-depth understanding of how participants perceive operational efficiency in relation to road infrastructure development. This method assisted the researcher in understanding the organisation's standard operating procedures in comparison to those applied globally, as well as the key aspects that helped answer the research questions. An important part of the review method is identifying and defining the problem and conducting research into similar topics and/or situations that have already been experienced. In conducting a comprehensive and detailed search of studies, relevant information was obtained. A broad and inclusive search strategy was employed; this included both grey (unpublished) and black (published) literature..

The strategy adopted an electronic and manual search process in order to find relevant studies and offer a wider range of resources. During the data extraction process, all studies within the inclusion criteria were screened for quality, as well as ensuring that the literature was substantiated and free from bias. In addition, data will be examined to determine study limitations, biased publications, inaccurate or unclear information, and allusiveness. The study focused on research articles that are not older than 20 years to avoid using outdated information. However, where there was literature of relevance and significant value that was beyond the 20-year period, it was still considered.

This being a COJ-focused study, the study or prioritised group focused on both internal and external stakeholders using the qualitative research method. Interviews via face-to-face or online platforms were conducted for external stakeholders, and interviews were conducted for internal and professional stakeholders. As part of the analysis, the main concepts that address the research questions were discussed. The research questions were interpreted qualitatively by analysing stakeholder perceptions.

3.2 Research Design

The research methodology used in this study consisted of a descriptive cross-sectional design examining perceptions, strategies, and the impact of operating efficiency on road infrastructure development. One of the most common and convenient types of research design is cross-sectional research, also known as social survey research. As a result, the researcher adopted this research design since it is neither costly nor time-consuming; it allows the gathering of data at one point in time..

According to Lambert et al. (2012), a qualitative descriptive studies tend to conform to the naturalistic approach, which asserts that the purpose of research is to study something in its natural state. This approach eliminates preselection, manipulation, or prior commitment to any particular theory about a target phenomenon. They further ascertain that in qualitative descriptive studies, data is constantly compared when analysing the data, presenting grounded theory overtones. In contrast, a qualitative descriptive study is not grounded theory, since it does not develop a theory based on the data collected (Lambert & Lambert, 2012). An important part of descriptive studies is the observation of human behaviour in its natural environment and the provision of a comprehensive description and understanding of a particular event in the appropriate environment. This study used descriptive methodology to accumulate data that was related to its stated objectives.

3.3 The Research Ethics

According to Orb et al. (2001) and Arifin (2018), in any research study, it is crucial to protect human subjects by using the right ethical standards. Due to the extensive length of the research process, ethical questions have a special resonance in qualitative studies (Soltis, 1989). The scholars further state that, when conducting face-to-face interviews with a vulnerable group of participants, ethical concerns become more prominent (Arifin, 2018). The study by these researchers states that during the data collection, analysis, and reporting of the study results, withholding the names and identities of the respondents for their privacy and protection is of

paramount importance, and therefore anonymity and confidentiality should be maintained at all times.

A brief explanation of the study's goals and the data collection process was given to the organization's executive and to each possible volunteer personally. Permission was obtained from the JRA (COJ agency) to conduct the study and a signed approval included in ***annexure D***. There was no costs involved for respondents to participate in this study, Participant signed consent forms and their participation was voluntary. Only after a detailed description of the research process was given to participants did they agree to take part in the study. During interview sessions, data processing, and the dissemination of the results, the interview environment's privacy and confidentiality were carefully protected. In order to protect the participants identities, codes were created for each respondent.

3.4 Population and sample

3.4.1 Population

This study was conducted within the City of Johannesburg among professionals, managers, heads of departments, contractors within the construction and engineering sectors, and other relevant stakeholders who utilise road infrastructure. This approach enabled the researcher to take an inclusive, tangible, and holistic view of the operational efficiencies that were either lacking or to be adopted in order to improve sustainable road infrastructure for the COJ..

3.4.2 Sample and sampling method

As a general rule, a very large sample does not allow for the deep, case-oriented analysis that is essential to quantitative research, at least in constructivist or in-depth approaches (Boddy, 2016, as cited in Sandelowski, 1995). In terms of choosing the appropriate sample size, many scholars have raised several views, with Sandelowski pointing out that 50 interviews is a large sample for a qualitative study and others suggesting 30 sample size. Consequently, any qualitative sample size greater than 12 focus groups or 30 in-depth interviews in a single market or

country or population would have to be justified in a homogeneous market (Boddy, 2016).

On the sample, there are people that include HOD's, OPs, and engineering professionals. All the respondents are equally qualified, knowledgeable and experienced. They all had an understanding of the study from different angles. For the sake of anonymity, in line with research ethics in Section 3.3, ethical consideration requires that the respondent remain anonymous. In this study, the respondents (participants) are coded from 1 to 10, represented as Respondent 1, Respondent 2, and so on.

The initial targeted research sample was approximately 20 participants; however, this could not be achieved. Therefore, the achieved research sample is 10 participants; this sample size is deemed sufficient and is in line with the literature by Boddy (2016). The participants consist of higher and middle management, industry experts, consulting engineers, and other road users. Data collection was limited to Gauteng province, mostly within COJ; however, the case studies and literature used as support for the study followed concepts done in other countries.

Table 1: Profile of Respondents

	Description of Respondent Type		
Role of the Respondent	**Organization**	**Industry**	**Data Collection Method**
HOD	JRA	Construction	Interviews
HOD	JRA	Construction	Interviews
HOD	JDA	Construction	Interviews
OPs	JRA	Construction	Interviews
Ops	JRA	Construction	Interviews
OPS	JRA	Construction	Interviews
Consulting Engineer	Service Provider	Construction	Interviews
Consulting Engineer	Service Provider	Construction	Interviews
Engineer	JRA	Construction	Interviews
Manager	JRA	Information Technology	Interviews

3.5 The Research Instrument

The research instruments adopted were structured and semi-structured interviews, which were conducted via online platforms (Microsoft Teams) and face-to-face. Data was also collected via desktop (secondary data) using company documents and other available systems. According to Alshenqeeti (2014), Interviews and questionnaires are the most commonly used methods for collecting qualitative data (Alshenqeeti, 2014, as cited in Dörnyei, 2007).

The use of qualitative research approaches adopts the interview structure for data collection; this is a common approach for qualitative studies as recommended by Alshenqeeti (2014). The purpose of qualitative research is to gather detailed accounts of human attitudes and beliefs in the contexts in which they arise. This is an approach that social scientists often use, as they are interested in gaining a thorough understanding of human behaviour. Researchers have found that interviews elicit more narrative data than questionnaires, allowing them to analyse people's views in greater depth (Alshenqeeti H. , 2014). A similar view is also expressed by Cohen et al. (2007), who argue that interviews are a good way to explore meaning construction in a natural environment (Alshenqeeti, 2014, as cited in Cohen et al., 2007).

The research instrument entailed the three main research questions, and sub-questions were developed. In order to effectively address the above research question, to understand the similarities, and to engage an extensive understanding of the participant’s line of thinking, sub-questions were created, some of which comprised the following questions: Are there sufficient resources required to achieve the set KPIs? How does the availability or lack of resources affect the productivity or efficient delivery of road infrastructure services? What resources could those be? All sub-questions created can be found under **annexure *A*** of the research instruments. The sub-questions were developed to break down the discussion further and guide the participants so that they could go more into detail. This was done in order not to limit the respondents but to guide the discussion in order to get an in-depth understanding of their views, which is aligned with the research questions that stem from the objective.

3.6 Procedure for Data Collection

The research analysis method is simply a means by which data is collected. It can be done using a specific instrument that may be used, such as a questionnaire or structured interview schedule, or a participant observation process where the researcher listens and watches others (Bryman, 2012). The approach of the study was a qualitative study comprising of both primary and secondary data, this method enabled the analysis of the perceived approaches about the operational efficiencies which can be adopted in solving issues related to operational efficiencies in the COJ. Primary data was interviews whereby top and middle management, professionals, services providers and road users were interviewed. Based on the nature of the study and the industry, secondary data in a form of desktop analysis and company documents including archived company documents. The study followed a structured and semi-structured interviews approach which was conducted via online platforms and face to face. Data was also collected via desktop (secondary data) using company documents and available systems. Flexibility was adopted during the interviews to enable concepts that are not yet known.

3.7 Data Analysis and Interpretation

According to Bryman (2012), the reliability of a study refers to the repeated nature of its results. Coding of the participant's responses through thematic analysis approach was adopted in order to draw conclusion in answering the main research objective (Castleberry & Nolen, 2018). A thematic analysis was employed for this study, conclusion were drawn by organizing data according to themes. The answers from the respondents were then coded, themes developed and grouped in such a way that they answer the main research questions. All 10 participants answered the questions on approximately an hour long interview, as suggested by Castleberry et al. (2018), having to transcribe that much data will take long hours and therefore having to code data and develop themes in analysis the data through the thematic analysis is one of the reliable strategy for qualitative studies. In contrast to questionnaires, interviews are more effective at drawing narrative data that allows deeper investigations of people's perspectives (Alshenqeeti H. , 2014).

3.8 Limitations of the Study

The initial targeted research sample was approximately 20 participants; however, this could not be achieved; only 10 participants could participate. Although a poor response was anticipated as one of the limitations of the study, the number of respondents is deemed sufficient for a qualitative study..

The study was confined to the COJ, focusing mainly on municipal entities that are mandated to manage road infrastructure on behalf of the city. There was a limitation in accessing information about the organisation due to a lack of historical data and the preservation of the company's reputation. Some of the targeted groups, such as SMME's and ordinary road users, could not be interviewed due to language barriers for non-technical participants, which posed a limitation on the outcome of the study response. People in general do not really show interest in research interview participation, especially if they do not personally know the researcher and if there is no reward.The outcome of the interviews followed people's perceptions and experiences, which might not necessarily reflect the same sentiments across the city. There was a fear of bias, which could also lead to unrealistic results; participants may not answer questions accurately due to fear of stating certain factors or expressing how they feel. In this instance, some conversations were not recorded, and some of the participants opted not to participate..

Although some participants had initially shown interest, some could no longer participate due to various reasons, including work commitments, family responsibilities, etc. All of these contributed to the interviewer facing time constraints as some participants could not be available for scheduled interviews. As a result, some interviews had to be rescheduled several times. However, as discussions were held and issues were unpacked, the scheduled interviews exceeded their time limits..

The study was dependent on the availability of participants, which was a challenge as most people had work commitments, and as such, the proposed timelines could not be achieved. For the participants that opted for the virtual interview options, load-shedding posed a serious challenge for online interviews..

3.9 Validity and reliability

Any scientific research is greatly affected by issues of validity and reliability of its research instruments. According to Bryman (2012), the reliability of a study refers to the repeated nature of its results. The authors further explain that social scientists commonly use the term to enquire whether the measures used to comprehend concepts are consistent. Validity and reliability are two factors that guarantee the performance results of participants (Alshenqeeti, 2014, as cited in Dörnyei 2007). Alshenqeeti (2014), further extends the notion and states that, validity is related to the extent to which a study is able to capture the specific concepts it is attempting to describe in its broader context.

In order for the results of the research to be valid and appropriate, it was conducted with the assistance of credible sources. Since interviews provide people's perceptions, which might not always reflect the truth of the problem statement, the use of case studies done before and other scholars' research was adopted in order to draw common outcomes, which may then be adopted as a true and adequate reflection of the intended outcome. The chapter gives a practical demonstration of how analyses of similar studies and literature are conducted. A rigorous analysis and scrutiny of the material was conducted in such a way as to validate the credibility and impartiality of the authors and the literature studied..

4 CHAPTER 4: RESULTS PRESENTATION

4.1 Introduction

The interviews followed a structured to semi-structured process whereby transcripts were developed, data analysis was done using the thematic analysis approach, whereby coding of the results was conducted, and themes emerged in order to get a common understanding. The qualitative study has been used in various fields, including education, medicine, etc. It seeks to gain a deeper understanding of phenomena by studying those who have personally experienced them, acknowledging the value of participants' unique perspectives, which can only be fully understood in the context of their own experience (Castleberry & Nolen, 2018).

This section will deal with the presentation of the finding, whereby the sub-questions posed to the interviewers were derived from the three research questions outlined in Section 1.4 in order to gain an overall understanding of the main research objective, which will be dealt with in Chapter 6. The sub-questions were developed in order to observe similarities among the participants and gain an in-depth understanding of the respondent’s line of thinking. This section will deal with discussions from the sub-questions, but it will not deal with each and every sub-questions, as some answers cut across several themes. Refer to Annexure A of the research instrument for all sub-questions. The discussion in Chapter 4 will deal with a deep interpretation of the discussions with respondents. The researcher is aware that the information that is gathered is qualitative, but in order to obtain the coding and themes, Excel was used just to visually represent the outcome. This is not a statistical study; however, for the presentation, tables and graphs were created, indicating themes that emerged. Constructs with the same meaning or themes were then grouped together and presented by means of tables and charts (tables 2–5 and figures 3–5), whereby the frequency of appearance of each construct was also counted, documented, and presented..

The results coming from the findings of the study as shared by the respondents were coded as Respondents 1 to 10.

4.2 Results in relation to Research Question 1

This section will deal with data presentation of results which emanated from sub questions that sought to answer **Research Question 1**: How do you measure operational efficiencies in relation to roads infrastructure? The common constructs (themes) which emerged from the interviews with the respondents are presented in table 2 and figure 3 below where there were similarities among the themes, sub-themes were then formulated, chapter 5 will deal with main themes only.

Table 2: Emerged Themes in Relation to Research Question 1

Overview of Common Themes	**Frequency**	**Based on the sample size, %**
Concerned with their own KPA / Working in Silos	8	80%
Alignment of KPA with business performance plan	10	100%
Resource Constraints	10	100%
Inefficient SCM process	10	100%
Turnaround times to attend defects	10	100%
Perceived inadequate travel times	10	100%

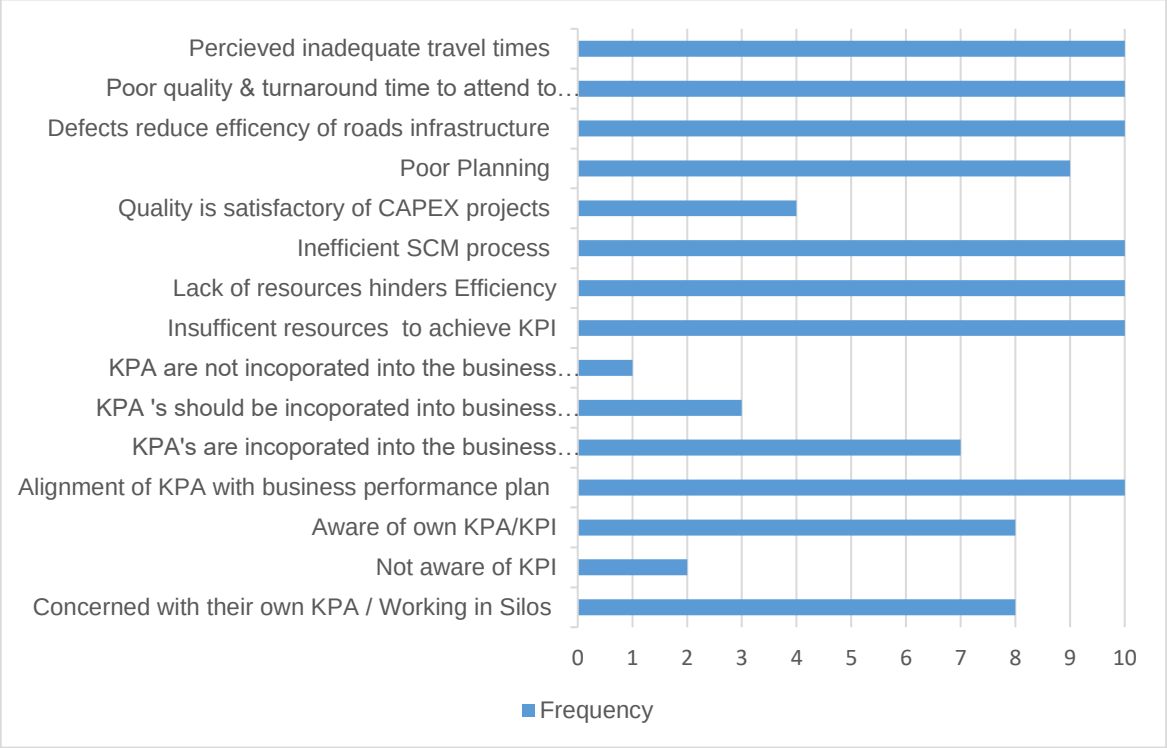


Figure 3: Measure of Operational Efficiency

4.2.1. Research Question 1: How do you measure operational efficiencies in relation to roads infrastructure?

Responses to sub-question 1a) and b): What are the key performance areas and Indicators (KPA / KPI) for roads operation efficiency in the JRA / COJ?

The respondents outlined several KPA's and KPIs for the organization which comprised of the maintenance of faulty traffic signals and roads signs within 24hrs, Spend 95% of the allocated budget (Respondent 2, 2023:Interview), road visual condition index (VCI) to maintain the roads in a serviceable state for mobility, road markings and to ensure that the greater proportion of the COJ is in a serviceable state (Respondent 4, 2023:Interview). The company chatter measures the number of days it takes to fix pothole on maintenance side, percentage (%) of expenditure of allocated budget on various programmes, a requirement that 90% of traffic signals to be functioning for mobility (Respondent 9, 2023:Interview). There is also kilometres of roads upgraded to surfacing for new projects, service delivery level (turnaround time) for repairing traffic signals, Upgrading of traffic signal cables,

rehabilitation and resurfacing of existing, number of bridges refurbished (Respondent 3, 2023:Interview), conversion of existing stormwater open drains to underground (Respondent 10, 2023:Interview) and SMME development and employment opportunities through EPWP (Respondent 5, 2023:Interview). One of the Respondents had the following to say:

"*So the key indicators (KPIs) associated with the organization in line with the roads operational efficiencies have various programs that we measure ourselves based on, ranging from upgrading or refurbishment of bridges, the road resurfacing, upgrading of gravel roads from unsurfaced to surfaced standard and various forms of stormwater. We are also as responsible for social indicators, such as the SMME development including creation of work opportunities through our EPWP program*"

(Respondent 5, 2023:Interview)

Responses to sub-question 1d): How does the availability or lack of resources affect the productivity / efficient delivery of roads infrastructure services? What resources could those be?

The respondents highlighted several constraints in relation to resources which results in lack of service delivery and the overall business performance. There is generally insufficient budget and as such the KPI does not align to the available budget (Respondent 3, 2023:Interview; Respondent 6, 2023:Interview), huge shortfall of resources for planning, regional operations (Depots) are affected by the lack of trained personnel and service providers lack capacity to effectively perform to the required satisfactory levels (Respondent 9, 2023:Interview). Targets are not met due to limited resources; technology or tools of trade are insufficient and existing machinery in not in good condition which impedes infrastructure management at operational level (Respondent 8, 2023: Interview). Respondent 7 and Respondent 2, (2023:Interview), if there was proper planning to effectively utilise the available resources, KPI's could be achieved and efficiency can be improved. Some of the respondents had the following to say:

"*Everything regarding infrastructure development and management resolve around resources; the JRA relies of budget allocation from COJ. It also revolves around*

availability of materials. For capital projects, the JRA is way behind on implementation of gravel roads upgrades to surfaced standards due to budget constraints."

(Respondent 7, 2023: Interview)

"*There is lack of resources which affect the successful delivery of roads, and those resources comprise of human capital, external contractors, budget, technology or tools of trade and inadequate machinery*"

(Respondent 8, 2023: Interview)

Response to sub-question 1e): what is the effect of supply chain processes in roads infrastructure implementation, where there are no available internal resources? (Have you identified supply chain a bottle neck? If so, explain how)

All respondents were of a view that supply chain is one of the key components in effective delivery of services within the organisation. The supply chain processes in the organization are inadequate and very long (not quick enough), this compromises the organization's credibility (Respondent 10, 2023:Interview). Respondent 10 (2023:Interview) also indicated that failures of supply chain to ensure that resources are deployed on time to quickly fix defects compromises the safety of road users. Respondent 7 (2023:Interview), stated that SCM impacts on how quick the JRA responds to issues on the ground and further indicated that the organization needs to improve on their current processes of vetting service providers. According to Respondent 9 (2023:Interview), currently the processes at SCM are not spread adequately; there are delays in tender processes (inadequate timeframes), ineffective timelines in procuring service providers and they also affect budget expenditure. There is often delays in approving Bid specifications and often at times, the bid specification is incorrect leading to the process being cancelled at tender stage.

Respondent 1 (2023:Interview) stated that one of the reasons of bottlenecks and poor performance is that SCM is not on the company's KPI from a business point of view. The personnel lack necessary training, there is also lack of collaboration

between SCM and Implementing departments (Respondent 5, 2023:Interview), SCM processes are slow due to stringent procurement policy and MFMA at times not favourable to Tender processes in respect to timeframes (Respondent 4, 2023:Interview). Respondent 5 (2023:Interview), stated that the JRA faces insufficient human resources capital which hugely affect the appointment of contractors and consulting engineers who are meant to carry out service delivery of infrastructure such as roads, stormwater, bridges, traffic signals, etc. Some of the respondents had the following comments:

"*In everything we do as the entire organization being a state-owned company or a public owned company it therefore means that we are highly regulated. Everything that we do has to go through the supply chain procurement process which is governed by the various prescripts that are available nationally.* "

(Respondent 1, 2023:Interview)

"*Some of the bottlenecks at SCM are the lack of ensuring that tenders are in line with industry new requirements. The tender process has been halted by delays in policy implementation due to constant changes in the composition of board members. The internal capacity / resources are unable to ensure that tender evaluations are concluded in time, this process often requires extension thus leading to under expenditure of the available budget by the organisation*"

(Respondent 2, 2023:Interview)

'Supply chain supply chain is a key department / unit in the organization but faces serious challenges in the form of the resources with; they are not adequately staffed, as a result they find themselves very much overstretched in terms of providing support to end user departments. This leads to abnormal extended procurement processes which often affect the actual delivery of services on ground"

(Respondent 5, 2023:Interview)

Responses to sub-question 1f): How does the existence of defects such as potholes, inadequate drainage system, etc., affect you as the end user of the road in terms of how you perceive performance of the road?

The respondents indicated that their perceived efficiency of the roads is based on when they can move from destination A to be quicker, safely and without any hinderances. Defects hinder reduce mobility, increase travel times (Respondent 4, 2023: Interview), compromise safety of road suers (Respondent 1, 2023: Interview), affect quality of life as they demoralise citizens (Respondent 2, 2023: Interview) and leads to rapid vehicle wear and tear and increase pollution from the carbon (CO_2) emissions (Respondent 3, 2023 Interview; Respondent 2, 2023:Interview). The structural defects impact functionality of the roads, leading to inefficiency and compromises safety of the road (Respondent 5, 2023:Interview), and this is mainly due to lack of maintenance of infrastructure (Respondent 5, 2023: Interview). These inadequacies create negative perception about the organization, when the road infrastructure is not providing satisfactory performance to road users, it create serious damage about the entity's reputation and clearly shows that something is amiss (Respondent 5, 2023:Interview; Respondent 7, 2023:Interview), Respondent 10 (2023:Interview), outlined the impact of defects on the roads as follows:

"As the end user of road infrastructure, the effect of defects is that they take away the customer utility due to longer travel times. I perceive these as inefficiencies which lead to bad / poor user experience and expectations. It is tiring to have to find alternative routes due to drainage systems that are not functional as a result of blockage or lack of having proper infrastructure".

(Respondent 10, 2023:Interview)

Responses to sub-question 1 g): Currently within the City of Joburg, would you say the turnaround time for attending to defects is effective? (Yes / No) Please explain. Is the quality of work done either to fix or construct a new road is adequate? (Yes / No), Please explain.

All the respondents cited the response time and quality being ineffective and very poor and as such COJ does not meet their set objectives for provide efficient road

infrastructure. Respondent 1 (2023:Interview), outlined the poor systems and inefficient quality on operational activities carried at maintenance by the depots. The organization has efficient mechanism to enforce adequate quality for new projects (Planning & implementation). The quality is found to be poor due to inexperienced contractors, there is lack of coordination among entities within the COJ which then leads to poor wayleave management resulting to delays and poor infrastructure reinstatement Respondent 4 (2023:Interview). The limited resources such as technology and skilled personnel contribute to the poor response time (Respondent 6, 2023:Interview). Respondent 5 (2023:Interview) added that the reactive maintenance approach results to negative feedback from the customers due to water ingress on newly constructed roads. The In summarising the challenges in relation to turnaround time and quality on road infrastructure development, the respondents said:

"*No, the customer chatter has 14 days to attend to defects which is adequate, however the JRA is unable to adhere to these timeframes . Yes, the quality is relatively adequate*".

(Respondent 10, 2023:Interview)

"*No, the turnaround time is effective; potholes / defects take longer to be attended to. The JRA has a reactive approach for maintenance, this affects the response time. The quality of work done is generally an issue due to inadequate skills, culture of the maintenance depots, lack of commitment, etc*".

(Respondent 3, 2023:Interview)

Response to sub-question 1h): What would you say are the critical issues facing the COJ in ensuring that roads are effectively serving its purpose to the stakeholders?

According to the responds, the critical issues facing the COJ are lack of sufficient and adequate resources, inability to meet demand in relation to fixing defects and providing new road infrastructure. Funding is the main critical issue; deficiency of funding causes infrastructure maintenance to be neglected (Respondent 3,

2023:Interview). The lack of dedication, the low staff morale, a lack of passion, the inability to retain experience and the lack of training for employees remains a huge constraint (Respondent 2, 2023:Interview). There is no robust proactive and preventative maintenance plan, the lack of adequate master plans affect forward planning (Respondent 4, 2023:Interview), the decline in revenue collection impacts road infrastructure management and increasing decline on the quality of infrastructure management (Respondent 5, 2023:Interview). The is no adequate town planning, lack of data on existing infrastructure, lack of PPE, machinery and materials (Respondent 9, 2023:Interview). Emphasising of the challenges facing the COJ, respondents had the following to say:

" *The lack of investment and maintenance / rejuvenation has led to road closures of major roads (M1 & M2)"*

(Respondent 9, 2023:Interview)

"*There is huge frustration by the road users that the COJ has no alternative technological interventions to deal with traffic lights that are not working resulting from loadshedding which affect traffic flows*".

(Respondent 7, 2023:Interview)

4.3 Results in relation to Research Question 2

This section will deal with data presentation of results which emanated from sub-questions that sought to answer **Research Question 2**: How does the application and the types of technology improve efficiency in roads infrastructure lifecycle management? There were 5 sub-question created in order to have an in depth understanding of the respondents views. In order to draw similarities from the respondent's answers in answering the research question, themes were created. Table 3 and figure 4 below entails the common constructs that emerged from the interviews with the respondents.

Table 3: Emerged Themes in Relation to Research Question 2

Overview of Common Themes	**Frequency**	**Based on the sample size, %**
Better asset management	10	100%
Efficient mobility: Better Traffic Management	6	60%
Outdated Existing Technology	10	100%
Limited application	8	80%
Crime Prevention Infrastructure protection (Cubs theft)	3	30%
Technology Improves Efficiency and performance	10	100%
Improves Quality and Saves cost	7	70%
Effective Project Management	10	100%
Technology Reduces employment opportunities	7	70%
Aware of 4IR	10	100%
Critical strategic will for technology adoption	5	50%
Adoption of new innovations is critical for infrastructure implementation and maintenance	10	100%
Technology a major influence of the organization's core objective	10	100%

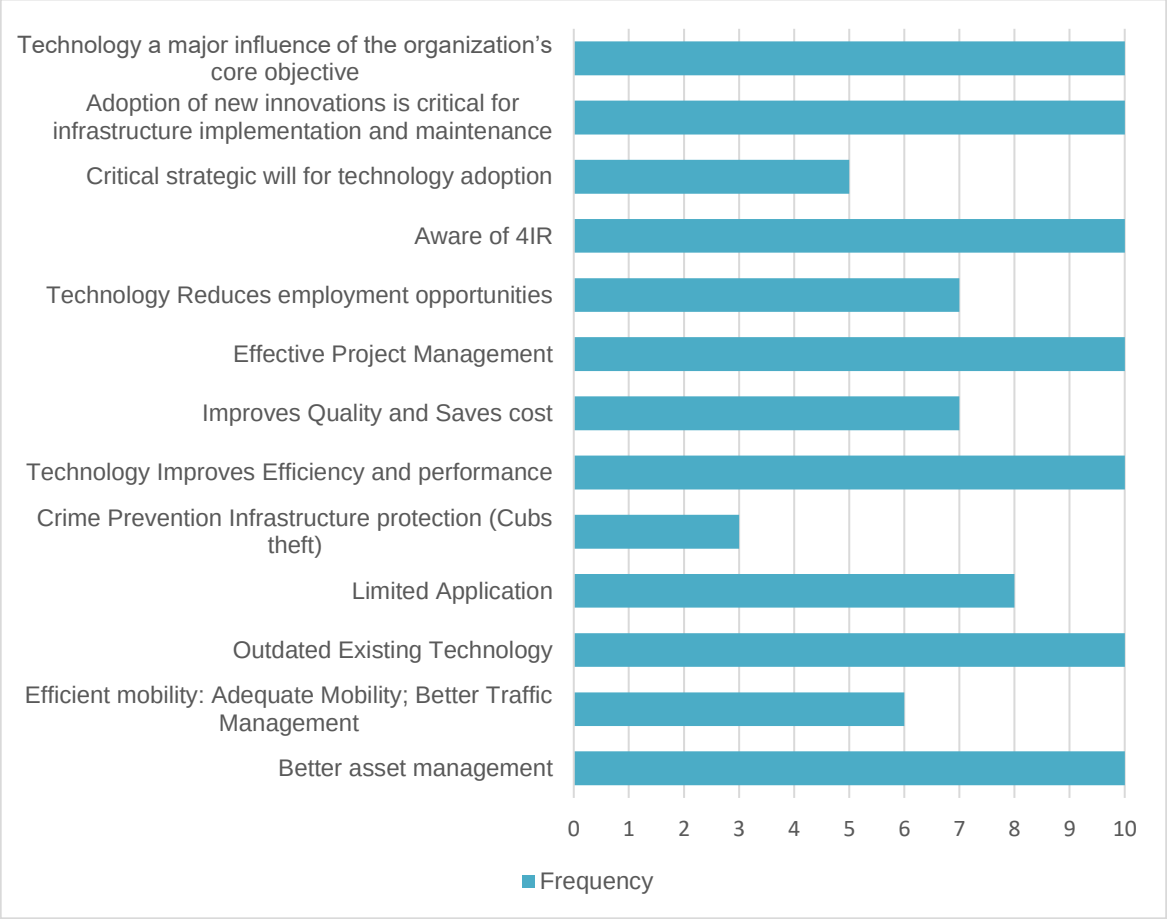


Figure 4: Impact of Technology on Roads Efficiency

4.3.1. Research Question 2: How does the application and the types of technology improve efficiency in roads infrastructure lifecycle management?

Responses to sub-question 2a): What is your understanding of the 4IR and how does it affect the business of the JRA or road infrastructure implementation?

The respondents referred to the fourth industrial revolution as the technological era of digitization of management of things and use of Algorithm and as one of the tool to be at the forefront of addressing social issues. Technology changes all the time (Respondent 2, 2023:Interview), technology enables efficient decision making in infrastructure prioritization for new and maintenance projects (Respondent 1, 2023:Interview), its impact within the JRA and the City of Johannesburg at large is that it can assist in managing traffic virtually considering that the organization is

failing at this (Respondent 3, 2023:Interview). 4IR is the cocktail of different technologies in order to improve efficiency through use of artificial intelligence (Respondent 5, 2023:Interview; Respondent 9, 2023:Interview), however COJ is way behind in terms of technology adoption (Respondent 3, 2023:Interview).

4IR further entails physical, biological and digital systems (Respondent 10, 2023:Interview), new innovation approaches of construction plant and various types of materials to be used in roads infrastructure development (Respondent 4, 2023:Interview), use of drones (Respondent 6, 2023:Interview). It provides improved efficiency, cost effective, automation and robotics (Respondent 8, 2023:Interview). Technology is critical in order to keep up with the environmental changes (Respondent 10, 2023:Interview). The effects of 4IR in the organization were summarized by Respondent 9 (2023:Interview) and Respondent 10 (2023:Interview) as follows:

"*The JRA or COJ has massive opportunity for infrastructure and project assessments through adoption of drones and other technologies*"

(Respondent 9, 2023:Interview)

"*Technology can assist the organization through use of robotics, this will enable efficiency. The amount of resources required for activities is reduced, it changes the nature of resources which are available and it enables quick response to infrastructure development*"

(Respondent 10, 2023:Interview)

Responses to sub-question 2b): What are the existing technologies does the JRA / COJ have in place in ensuring efficiency of the life span of a road?

Respondents cited that most of the existing technology in place is outdated, it no longer provides the level of output desired. The City utilizes old an outdated approaches for asset management, e.g. GIS but does not have all required information such as As-Built (Respondent 1, 2023:Interview; Respondent 3, 2023:Interview). There is Adoptive Control, Dynamic Signalling, Advanced

communication (5G) and Synchronization control (Respondent 2, 2023:Interview). According to Respondent 4 (2023:Interview), the organization previously had Find & Fix mobile Application, but it is not operational due to contractual issues with software developer. The organization also has ITS, CCTV systems at various intersections (Respondent 6, 2023:Interview), STS for remotely managing traffic (Respondent 8, 2023:Interview) and BMS for managing bridges (Respondent 9, 2023:Interview). Respondent 10 (2023:Interview) further stated that the organization has PMS which is used to record defects, Hansen, WhatsApp and Social media for capturing complaints (Respondent 10, 2023:Interview) While commenting on existing technologies, Respondent 5 (2023:Interview) and Respondent 2 (2023:Interview) stated that:

"*Mobility and Freight units use manual systems whereby traffic management the timing for traffic signal is done physically. There is no technology remotely manage traffic at peak and off peak hours*"

(Respondent 5, 2023:Interview)

"*As much as some of these technologies are existing, they are however not be implemented correctly*"

(Respondent 2, 2023:Interview)

Responses to sub-question 2c): Do you think the JRA would provide reliable roads infrastructure if it also adopt new innovative approaches to implement new and maintain roads infrastructure?

The respondents indicated that there is a huge opportunity for technology adoption in order to provide reliable roads infrastructure . According to Respondent 5 (2023:Interview), adoption of artificial intelligence can lead to fundamental improvements in the organization. Respondent 4 (2023:Interview), added that technology will increase available resources, assist in managing infrastructure vandalism and theft. Technology will provide efficient approaches for maintenance e.g. cutting of potholes & new materials (Respondent 7, 2023:Interview), enable efficient data management (Respondent 8, 2023:Interview) and it will assist to

adequately do things in line with the required standards (Respondent 10, 2023:Interview). New technology will enable continuous infrastructure improvement and reliable roads for the City of Johannesburg (Respondent 10, 2023:Interview).

Responses to sub-question 2d): How has the lack of adopting technology at project level affect completion, Cost, time and quality?

Respondents cited that lack of technology adoption has impacted the performance of the organization in meeting their core mandate with existing infrastructure deteriorating. Impact of technology adoption is late project completion (Respondent 1, 2023:Interview; Respondent 4, 2023:Interview), high cost resulting to budget overrun (Respondent 7, 2023:Interview), poor response time to issues (Respondent 2, 2023:Interview) and poor quality of work (Respondent 3, 2023:Interview). It creates inefficiencies with adverse consequences (Respondent 5, 2023:Interview), in emphasising the impact of the lack thereof, Respondent 7 (2023:Interview) said:

"*As a result of lack of technology the traditional approaches are no longer optimal in terms of time, quality and cost*".

(Respondent 7, 2023:Interview)

4.4 Results in relation to Research Question 3

This section will deal with data presentation of results which emanated from sub-questions that sought to answer **Research Question 3**: How would strategic sourcing help COJ to improve efficiency and sustainability?

There were 4 sub-question created in order to have an in depth understanding of the respondents views. In order to draw similarities from the respondent's answers in answering the research question, themes were created. Table 4 and figure 5 below entails the common constructs that emerged from the interviews with the respondents.

Table 4: Emerged Themes in Relation to Research Question 3

Overview of Common Themes	Frequency	Based on the sample size, %
Added financial resource / muscle	3	30%
Good for particular type of operation	5	50%
Improved efficiency on delivery on the core mandate	8	80%
Strategic Assets would work but requires proper strategy	5	50%
Public Private Partnership	3	30%
JRA not meant to make profits	3	30%
Adding more assets will not improve efficiency	4	40%
Offering services from strategic assets augment service delivery	7	70%

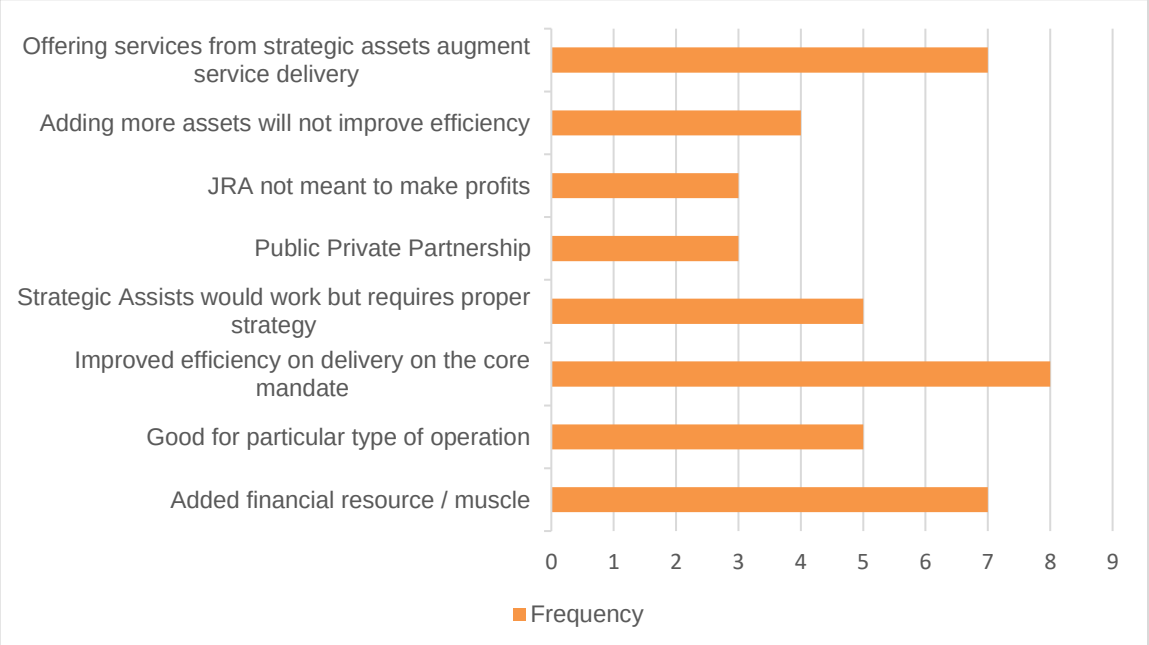


Figure 5: Strategic Sourcing Improves Efficiency and Sustainability

4.4.1. Research Question 3: How would strategic sourcing help COJ to improve efficiency and sustainability?

Responses to sub-question 2a): How does the existence of the asphalt plant and RSD contribute to the delivery of the JRA's core business objectives?

The asphalt plant and RSD are critical strategic assets for the realization of the organization's core objective. According to respondent 1 (2023:Interview), strategic sourcing will contribute positively on operational and maintenance of road infrastructure development. The asphalt plant enables production of asphalt cheaper than from outside, there is a cost saving for the organization having this asset, providing asphalt to the internal teams as well as the road surfacing depot (Respondent 2, 2023:Interview).. They provide an opportunity for the organization to be in control its own quality & quantity (Respondent 4, 2023:Interview), assist in attending to asphalt defects promptly and provide cost benefits (Respondent, 6, 2023:Interview). As such, they assist in alleviating service delivery pressures (Respondent 7, 2023:Interview), avoiding long procurement processes and further provide ability to manage the core functions (Respondent 10, 2023:Interview). Respondent summarized the importance of strategic assets by stating the following:

"*They add positively by shortening the value chain, SCM requirement, improves delivery timelines. They improve efficiency and makes the processes leaner by cutting out outside production role players*"

(Respondent 10, 2023:Interview)

Responses to sub-question 2b):Do you think a strategic asset has a potential of improving efficiency for the organization; for example if the JRA were to render services to the market or its appointed service providers?

Some respondents outlined that strategic assets provide the flexibility of doing things right, generation revenue from strategic assets adds value thereby improving efficiency. JRA is not realising the value of these assets due to underutilization, therefore having the asphalt plant fully operational will increase efficiency (Respondent 5, 2023:Interview). There is a potential of additional revenue stream

(Respondent 4, 2023:Interview; Respondent 6, 2023:Interview). With adequate capacity, the strategic sourcing can assist where there is lack of funding (Respondent 7, 2023:Interview). Asphalt it is a good asset to have but it must be cost effective (Respondent 9, 2023:Interview). In addition to that, producing asphalt and selling it reduces dependency from the allocated budget (Respondent 10, 2023:Interview). Contrary to this, at the moment the JRA is not registered as an income generating company, selling asphalt is not JRA's primary mandate therefore strategic assets can only provide efficiency as opposed to having income (Respondent 2, 2023:Interview; Respondent 8, 2023:Interview). One of the strategic asset to be considered is a traffic management centre (TMC) which will improve efficiency for turnaround times to fix defects. Respondent 3 (2023:Interview). The efficiency of the approach was summarised by Respondent 9 (2023:Interview) as follows:

"*Yes, there is a potential to realise efficiency and income but the JRA will have to be more efficient than private suppliers. It is a good asset to have but maybe this approach can work for maintenance depots*"

(Respondent 9, 2023:Interview)

In contrast to the above view, the following respondent said:

"*JRA or COJ is not with business of producing and selling asphalt to the market so it doesn't really have that core competency to manufacture asphalts*"

(Respondent 3, 2023:Interview)

" At the moment, there is Much Asphalt who holds the biggest chunk of the market, so am not sure whether there is a market gap for asphalt plant. So this means if the JRA were to compete on the market, they will have to compete on price, implying that they must produce at a price lower than Much Asphalt which is highly impossible".

(Respondent 3, 2023:Interview)

Responses to sub-question 2c): Do you think adding more strategic assets would improve efficiency and sustainability in the COJ?

The respondents indicated that strategic assets should be limited to maintenance through the depots of road infrastructure and management of traffic. Additional strategic assets for traffic signals will improve traffic mobility and records of incidents (Respondent 2, 2023:Interview; Respondent 6, 2023:Interview), this approach can only improve efficiency if the COJ is deliberate on the type of assets owned, some resources are more efficient when outsourced (Respondent 4, 2023:Interview; Respondent 10, 2023:Interview). More assets will definitely improve efficiency (Respondent 5, 2023:Interview), especially with the trust and relationship the organization has with the market (Respondent 7, 2023:Interview). Adding more strategic assets will not improve efficiency (Respondent 1, 2023:Interview), every strategic asset requires a proper business model (Respondent 8, 2023:Interview) and there is no culture in the organization which supports this approach (Respondent 3, 2023:Interview). Respondent 10 (2023:Interview) indicated that sustainability and efficiency cannot be improved by adding more assets. The views on additional assets were summarized by respondents as follow:

"*I believe so, the question though is whether to outsource or insource; the dilemma is whether the COJ would rather outsource all its operations and rely on the market or they would want to own some of the plants and operate them internally? It's not a cut and dry but there is a specific process that will be required to determine which direction to take. But on the surface of it the in-sourcing or a level of ownership in the form of strategic assets can certainly make a huge difference in terms of operational levels*"

(Respondent 5, 2023:Interview)

"*No, it is not the COJ's core business to add more assets, it does not align with our SMME development plan, it is better if someone else. Strategic assets should be limited to maintenance*".

(Respondent 10,2023:Interview)

Responses to sub-question 2d): Would you consider JRA sourcing key components of the project such as asphalt for contractors an efficient or sustainable approach for the organization's service delivery?

Respondents highlighted that service delivery on time is a critical objective for the organization, therefore ensuring that services providers are capacitated is of paramount importance. The use of sustainable methods for sourcing key components such as asphalt is an efficient and cost effective method (Respondent 1, 2023:Interview), it should however be done within legal framework (Respondent 6, 2023:Interview). This approach will require appetite from both the institution and Contractors (Respondent 2, 2023:Interview; Respondent 5). The plant will need to be fully operational (Respondent 8, 2023:Interview), production quality to be met (Respondent 7, 2023:Interview). This approach has previously worked, however logistics related to supply chain were an issues, therefore the JRA can supply internal RSD with asphalt from the internal asphalt plants (Respondent 9, 2023:Interview). It should be however be noted that private will always have a better price, the opportunity can only be realised in the production of asphalt (Respondent, 2023:Interview). Respondent 7 (2023:Interview) had the following to say:

"*The organization can permit contractor to source asphalt with no pre-payment and offset the cost from the payment certificates*"

(Respondent 7, 2023:Interview)

5 CHAPTER 5: DISCUSSION OF THE RESULTS

5.1 Introduction

In order to gain a deeper understanding of the research topic and research questions, 10 participants who have sufficient understanding of the COJ, some of whom are currently or have worked in the organisation, were engaged through interview sessions. The sample comprised engineering experts whose roles were executives, higher and middle management, and engineering consultants. While the literature assisted in drawing similarities and differences, the outcome of the research questions was purely based on the answers provided by the respondents during the interviews. In order to answer the main research questions, sub-questions were developed in order to have a more detailed understanding of the outcomes.

The findings of the data collected were converted into themes which were presented in a tabular and graphical format in chapter 4, so as to gain an understanding of the dominant themes that emerged from the interviews. The themes are ranked based on the frequency with which they appear in interviews; however, the highest ranked themes may not necessarily contribute independently to the research challenges. This section will therefore deal with the main themes (tables 3-5),sub-themes will not be discussed independently as they would have been already covered on the main themes.

5.2 Results Discussion in relation to Research Question 1

The themes discussed below emerged from **research questions 1**: *How do you measure operational efficiencies in relation to roads infrastructure*?

5.2.1. Concerned with their own KPA/ Working in Silos

8 out of the 10 respondents demonstrated awareness of the key performance areas and key performance indicators, which translates to 80% of the sample. The respondents that were not aware of the KPAs / KPIs are those participants that

were not working for the organization. It also emerged that although the majority of the respondents were aware of organization's KPAs and KPIs, they were particularly concerned about the KPI's within their respective sections, demonstrating that departments were working in Silos. The biggest challenge is the lack of synergy, more often departments are working in silos, this approach has a significant impact in terms of delivering any other objective when there is no synergy.

One of the respondents who confirmed the silo approach responded as follows when asked about the inclusion of their KPA on the scorecard:

"*Not all KPAs / KPIs are included on the company scorecard."*

(Respondent 2, 2023: Interview)

Echoing the sentiments of Respondent 8, (2023: Interview) who said "*My KPA do not contribute to the overall company performance, for instance, IT as a supporting unit are ensuring that there is a dashboard for managing projects. However, there is no coordination with the core departments in order to achieve this*"

(Respondent 8, 2023: Interview)

This is one of the theme which emerged from the 80% of the participant, demonstrating the silo approach in various departments within the organisation as one of the key constraint on the efficiency of the organization. Now you ask you ask a question as to what goal are these people working on if everyone is just concerned with the section which only affect them without understanding how their respective KPI's impact the overall organisation's performance. Although 20% of the respondents were not aware of the KPI/KPA for the organization, they still highlighted them as critical tool for the organization, Respondent 7 (2023:Interview) said:

"*I would agree most definitely that organizations like JRA and COJ should have to have KPI's and KPA's which start from the top and obviously filter down into whatever departments that are there. KPI is obviously a very important factor so*

that you are able to measure what you need to achieve and also measure what you've achieved and identify the gaps in running an efficient business in the entity".

(Respondent 7, 2023:Interview)

While also Respondent 1 also stated that:

"Although *you might not be aware of the exact KPA and KPI's, I should highlight that*, *KPA / KPI's are very important for any roads authority; they assist in reducing risks of fatalities by ensuring that infrastructure is safe and available through maintenance. They critical because you need to have a benchmark where you can be able to assess your performance*."

(Respondent 1, 2023: Interview)

According to scholar Albrecht (2002), whenever the "big idea" lands in various organizational silos, it instantly gets localized and become fragmented into various parts that don't fit together anymore. The literature suggest that this leads to a lack of cohesion in the organization, resulting in a breakdown of communication and collaboration between teams (Albrecht, 2002). They further state that majority of corporations, government agencies, universities, non-profits, etc. have fallen to a trap of being victims of being in constant conflict with themselves. Some organizations have even become legendary for their self-inflicted incompetence, otherwise known as ballistic podiatry.

The responses from the respondents concurs with the above literature. All the respondents echoed the sentiment that working in silos results to many failures of businesses. Therefore, in order for one to measure efficiency, organizations need to have interdepartmental performance measures that are aligned with the business plan. Integrated departmental strategies are essential; there has to be constant engagement with core departments in order to constantly monitor whether the set KPIs of the supporting departments are enabling the set objectives for the entire organisation.

It is paramount that each department is aware of their contribution to the bigger picture to enable efficient operations within the organisation. In the absence of an integrated performance management, each department is likely to be pulling in different directions which is evident from the current inefficiencies.

5.2.2. Alignment of KPA with business Performance Plan

This is another important theme that emerged strongly, 100% of the respondents (participants) were adamant that there should be synergy between the business plan of the company and the KPA of the department. The idea that KPIs should all be included in the company plan was firmly agreed upon by every respondent. The participants further agree that there should be an alignment among respective departments. They also agree that there should be an alignment of key performance areas and indicators among respective departments.

When KPAs are not part of the business plan, the implication could be one of two possibilities; Its either that the employees are doing something wrong or the business plan is insufficiently devised. Both are not good scenarios of a highly functional organisation. The misalignment of the key performance areas has a negative impact on the functionality of the overall infrastructure within the COJ, respondent 8 (2023:Interview) had the following to say:

"*My perception is that we are not coordinated with other core departments; there is a disconnect among the departments, we work in silos, we do not have a strategic forecast as a supporting documents which supports the business units in order to link our KPAs with the overall organization's core mandate. For example, if you go to HR, IT and finance, you will find out that people struggle to relate what they are doing with the fundamentals of what the entire business does. There is no link or communication to educate people about what JRA is trying to achieve. For instance there is a performance unit in the organization which measures the overall performance of the JRA for the City, however this is not communicated to other departments".*

(Respondent 8, 2023: Interview)

Contrary to the literature by Eshtaiwi et al. (2018) and Kaparias et al. (2011), who emphasise that having performance measure is critical in order for organizations to adequately to assess their performance and effectiveness in line with the approved industry standards, this theme suggests that the organisation is not operating according to best principles at the moment. Furthermore, other scholars such as Slack et al. (2017), suggest several strategies of performance measures for organizations to be efficient in their operations. This requires leadership in the organization to come up with applicable linkages of various operations strategies, develop processes for planning and control and to further ensure that they continuously build capabilities and processes which seek to improve the overall organization's objectives and performance.

The literature by some academics is centred on the premise that all organisations operate in essentially the same way for creating and delivering services and products, thus having performance measures in line with industry norms including international standards (Slack, Brandon-Jones, Singh, Phihlela, & Johnston, 2017). Based on the high level of uncertainty demonstrated by the participants, it can be deduced that the organisation lacks the stability and strong leadership which has a negative effect on both the performance and efficiency of the organisation.

5.2.3. Resource Constraints

All the respondents felt that the major issues are insufficient / unavailability of funds to implement new project and maintain the existing infrastructure, insufficient human capital for Opex projects, at planning and supply chain departments. Lack of resources is one of the critical themes that 100% of the respondents were adamant that is a major challenge and further affects the organization on being efficient in their core mandate. Respondents were of a view that the organization does not have adequate budget, human capital, materials, machinery, technology and systems to achieve the overall set key performance Indicators in various key performance areas as indicated in the business plan, this affect the overall performance of the organization. According to Respondent 6 (2023:Interview), the

city faces quality issues on the operational side and maintenance projects due to the lack of technology adoption:

"*Quality is not satisfactory on maintenance side; asphalt temperature during potholes patching and resurfacing is affected due to lack of technology to manage handling of asphalt*".

(Respondent 6, 2023:Interview)

In emphasising the lack of adequate resources, some of the respondents had the following to say:

"*In some cases, it may not necessarily be about the number of available resources, but the capability of those resources. For example, I do not recall the JRA conducting an exercise in which we attempted to determine whether or not individual project managers possess the appropriate experience. One might find out that the number of resources in other units are fine but the issue is more about synergy between the different departments and then the capability experience of the different people involved in the managing of projects, planning and approval of designs, quality compliance for maintenance and so forth*"

(Respondent 3, 2023:Interview)

"*Lack of adequate and registered (ECSA) expertise (Engineers and contractors)".*

(Respondent 10, 2023:Interview)

"*JRA needs to have a traffic management centre (TMC) for management of faults; currently the COJ relies on customers to report issues. it is critical to have necessary TMC with equipment to attend to defects*"

(Respondent 2, 2023:Interview)

Structurally as much as it can be argued that resources are limited, but the question is whether the available resources are being utilised effectively? What was observed is that, some of the skills are underutilized, there is lack of synergy amongst department, the type of machinery being utilised for maintenance works is

old and outdated. Alluding to the above statement, Respondent 3 (2023:Interview) had the following to say:

“The biggest challenge is maintenance; there is some form of technologies that exist, but the challenge is maintaining that technology. It does not matter how advanced the technology is, if it's not maintained it's not going to give performance require. The COJ can buy whatever technology they want but if it’s not serviced in line with the specification, it will not provide the required performance. However I still think there's a lot of opportunities for the city to adopt technology to improve efficiency”

(Respondent 3, 2023:Interview)

In line with the concerns raised by the respondents, Wall (2021) and CIDB (2022), outlines that adequate skills and systems have a positive impact on infrastructure operation and maintenance. This theme is interrelated to the above themes where it emerged that departments are working in silos and some of the participants are only concerned with the KPA/KPI that affect them directly. Moreover, it also appears as if the existing available resources and skillset are not being utilised, there is a high likelihood that the organisation might be utilising valuable resources, including funds (budget) on things that do not add much value to the operational efficiencies.

5.2.4. Inefficient SCM Process

With the scarcity of resources being cited by all of the respondents as one of the major obstacles for efficient roads and related infrastructure, the long and tedious supply chain process emerged as a common frustration amongst all the respondents. It is evident that there is no supply chain-related KPIs included on the company scoreboard; there is no real motivation for supply chain to try and improve the procurement processes in an efficient and effective manner. There is a lack of effectiveness in the supply chain as a result of delays in the procurement process, as well as sourcing service providers who lack capacity and capabilities to handle the project. Expressing their frustration with the inefficient supply chain processes, the Respondents had the following to say:

"Supply chain should have people with technical expertise who understand the specifications. The lack of technical capacity causes bottlenecks at SCM department"

(Respondent 1, 2023:Interview)

"*Procurement systems are very slow and include very lengthy processes; there is limitation on the use of section 32. The SCM processes are very frustrating and currently is a bottleneck on the organization*."

(Respondent 8, 2023: Interview)

"*A KPI that refers to supply chain turnaround timelines, quality of procurement processes is lacking in SCM from the point of view of business performance, similar to the city's overall scorecard. Additionally, there is a concern regarding the quality of service providers that are procured by supply chain; they may procure on time, but ultimately they end up procuring incorrect service providers*"

(Respondent 3, 2023:Interview)

"*We need to have the procurement strategy so that we reduce the number of procurement events so that we procure for things that actually need to undergo procurement. For argument sake, if what we are doing currently leads to 10 procurement events, our strategies would be that we limit those project events to six. Because by doing that we are reducing the pressure from the supply chain space understanding the limitations in the resources and at the same time it is preventing the delays and the impact of service delivery from the perspective of user departments*".

(Respondent 5, 2023:Interview)

Considering that Capex projects are deemed by the majority of the respondents to be of better quality than operational , and that all Capex projects are outsourced, it can be concluded that there is a lack of resources capabilities internally to undertaking core business function. The organisation is heavily dependent on external resources for sufficiency on road infrastructure development, but this

requires that the supply chain to play their role effectively. A study by Slack et al. (2017) suggest lean synchronization approach which is aimed at improving planning processes, meeting demand , achieving the required quality of products and eliminating waste. This notion concurs with the respondent's views that SCM processes should be streamlining. Scholars, Essuman et al. (2020), further alludes that in order to achieve satisfactory results on performance, supply chain management is one of the critical tool especially for public entities.

5.2.5. Turnaround Times to Attend Defects

This theme emerged from a variety of sub-themes which included poor planning, insufficient response to defects. All respondents agreed that the time taken to respond to defects is currently insufficient. They further cited that the majority personnel assigned for maintenance are not adequately trained and there is lack proper supervision of the works which in turns affects the overall quality of the work done. What also emerged was that the type of tools or machinery deployed are either no longer in a good state or they are insufficient. One of the respondent when asked about efficiencies in responding to issues on time, stated the following:

"The is poor response time to infrastructure defects; maintenance is mostly reactive resulting from shortage of resources and misuse of infrastructure"

(Respondent 4, 2023:Interview)

All the respondents indicated that there is no proactive planning in the organisation; there is no maintenance plan at all, and the organisation has reactive maintenance planning. Machinery is no longer in a good state due to the fact that the municipality is not using technology. Internal processes are mainly ineffective, slow, and poor due to a lack of streamlined processes. In terms of skills, what emerged was that people are not well equipped with new information or trends in doing things. There is also misalignment of skills; this could be that a new set of skills is required due to the fact that some people might have been with the municipality prior to the technical requirement and they never received the required technical expertise. And with the changes in the environment, the skills that are required in industry for

sufficiency might not be aligned with the skills that exist within the COJ, which is a contributing factor to the lack of efficiency in infrastructure delivery.

Literature by several scholars such as Muzaale et al. (2018) and Eboli et al. (2008) asset that the measure of operational efficiency on roads is through cost, time, quality, stakeholder satisfaction, this in line with the respondent's views. Slack et al. (2017) recommend several strategies at different levels and several operational measures which can be employed by the COJ in order to that the infrastructure is dependable, fast and safe.

5.2.6. Perceived Inadequate Travel Times

All respondents agreed that having defects on the roads such as potholes, inadequate traffic signal, lack of road signage, etc., leads to long travel hours and accidents, which according to their views, the road is no longer efficient in that state. This theme emerged as one of the frustrations and inconveniences that roads users face on daily bases. All the participants agree that measure of efficiency is how quick one can travel and how safely one can feel on the road. They all agree that the perceived efficiency is when they can travel on a road without delays nor defects. According to respondent 1 (2023:Interview), defects impact on the safety of the road users and further lead to delays on the traveling time, thus interventions are required urgently. Respondent 2 (2023:Interview) added by saying that:

"*Road efficiency is affected by traffic signals that are not working and road closures*"

(Respondent 2, 2023:Inteview)

With 13,599km of road network and significant no of potholes, the amount of time spend of travelling on COJ roads due to defective road network, characterised by inadequate road marking, dysfunctional traffic signals, traffic congestions, blocked stormwater infrastructure and potholes, one can argue that the road network is inefficient. It is clear that people measure road efficiency based on how safe it is, reaching their destination as quick as possible, proper road marking. Unlawfulness; as much as some of the issues are technical issues which can be addressed by the

JRA, some of the issues extend beyond the capacity of the agency that is responsible for the road network, whereby drivers are not adhering to road safety requirements which requires other law enforcement agencies to have an oversight on and ensure compliance with the City's bylaws.

The findings from the respondent are in line with the literature. The work done by Prus & Sikora (2021), suggest that efficiency in relation to road infrastructure should be measured by facilitating the movement of people and goods (mobility) without delays. They further state that effective mobility transportation infrastructure that providing mobility has impact on the economy and society at large. It is also worth noting that driver behaviour also affects efficiency of the road.

5.2.7. Conclusion in Relation to Research Question 1

The findings of the study confirm what has been suggested by the literature, which clearly shows that operational efficiencies in road infrastructure can be measured using a variety of metrics, encompassing perplexing aspects such as traffic flow optimisation, intelligent transportation systems, data-driven decision-making, performance metrics, road maintenance costs, safety, convenience, and environmental impact. By meticulously analysing these factors, stakeholders can meticulously evaluate the effectiveness and efficiency of managing road infrastructure. It can be deduced from the results above that resource availability plays a huge role in proving efficiency in road infrastructure development. The ability of the COJ to respond to issues on time and provide safe roads is a measure of operational efficiency. Well-maintained roads provide efficiency by eliminating safety risks, high wear and tear costs, traffic congestion, and infrastructure deterioration.

5.3 Results in relation to Research Question 2

This section addresses the themes which emerged from the discussion with the participants (respondents) under **research question** 2: How does the application and the types of technology improve efficiency in roads infrastructure lifecycle

management? It elaborates on the impact of technology in roads infrastructure development in COJ.

5.3.1. Better Asset Management

100% of the respondents acknowledge the organization lacks adequate technology to manage road infrastructure. Although 80% of the respondents were of the view that the systems in place for managing assets are inadequate; the organization lacks historical data. 20% of the respondents indicated that there are no systems or technology in place for data capturing and management of existing assets. The theme which then emerged from the discussions was that technology is required for better asset management which entails assessments, data capturing and road infrastructure lifecycle managing. Some Respondents had the following to add on the challenges of assets management:

“The JRA no longer have machinery or plant to assess the existing roads and fill in potholes. COJ has GIS for all infrastructure, however, the challenge is that the data is not 100% accurate”

(Respondent 6, 2023:Interview)

“*The existing GIS system is outdated while pavement management systems (PMS) and bridge management systems are in adequate*”

(Respondent 9, 2023:Interview)

With the world moving toward the use of Big Data and 4IR, what is being emphasised by the respondents suggest that the use of technology by the organization is not in par with the current era of industrialisation. According to Respondent 1 (2023:Interveiw), digitization is required for data capturing and management of existing infrastructure because availability of data will enables efficient decision making for infrastructure rehabilitation and maintenance. The reliance of the organization on manual data handling makes it difficult for the COJ to keep up with the demand / adequate level of service required. Literature by Kupec et al. (2018) acknowledges the GIS an effective of asset management including

data of existing infrastructure, interdepartmental information sharing. Data capturing is important in order to inform any maintenance or proactive planning. Integrating, contrasting, and confirming field data depend on technologies such as GIS. Furthermore, Yılmaz & Bakış (2015) also the fourth industrial revolution particularly for roads and bridges, is to build dependable infrastructure that is long-lasting, simple to maintain, and capable of meeting both present and future.

5.3.2. Efficient mobility: Better Traffic Management

The majority of the respondents were of a view that the use of technology can improve performance of all infrastructure assets, especially the digital and electronic assets such as traffic signals. When commenting on the impact of technology on their daily operations, one of the respondents in dealing with traffic signals had the following to say:

"*The use of technology can facilitate remote control of traffic signal thereby improving traffic flow*."

(Respondent 2, 2023:Interview)

The theme, efficient mobility, emerged based on the challenges demonstrated by the respondents who are concerned by the inadequate level of service (mobility) provided by the existing infrastructure with the COJ. One of the main objectives of the city is to ensure safe mobility, provide efficient access to road users while promoting economic investment and adequate business operations. A key objective of the city is to ensure safe mobility, easy access to road users, as well as encouraging business investment. Kupec et al. (2018) in reference to sustainable roads suggest that use of technology on the provide flexibility for traffic management

5.3.3. Outdated Existing Technology

Despite acknowledging the existence of existing technologies in the organization, all respondents felt that they were outdated. The organization relies heavily on

human resources capital, manual tools and outdate standards in relation to technical specifications. With so much road network needed to be maintained, it is clear that the current technology (machinery and construction plant) is unable to provide road infrastructure to the required level of service. Echoing the impact of technology in road infrastructure development and the poor level of service by COJ, Respondents stated the following:

“There is generally a poor maintenance approach which is not adequately aligned with the maintenance philosophy e.g. Conduct reseals every 7 years.”

(Respondent 5, 2023:Interview)

The industry has shifted in terms of technology use, the literature already have the technologies such as 3D printing, smart construction, etc are being applied in roads infrastructure development (CIDB, 2022). The industry is already looking at technology for the future which is more safer and effective such as Google car; an integrated system that enables the driverless operation of a car, (Poczter & Jankovic, 2014). The literature by these scholars demonstrate that the COJ is already behind with the current technology and it is not ready for the future. According to Mao et al. (2021), by implementing smart roads, present transportation systems can be made safer, more efficient, and enable mass deployment of connected and autonomous vehicles (CAVs).

There is a view by some the respondents that technology will take away jobs. According to the study by various scholars such as Manyika (2017) and Frey (2017), it has been reported that some of the jobs will be absolute in the future. The literature further states that there is an emerging need for new job skills and an aging workforce and as such the majority of activities workers perform today could be automated in the future (Manyika, 2017). Therefore some of the jobs being redundant is inevitable, unfortunately if the organization does not upskill people and adopt new technology by maintaining the status quo, then the COJ will not improve efficiency thereby not meeting their overall performance objective. Looking at the list of the jobs that will be redundant in the future, it can be seen that most of the current functions / jobs within the COJ will be redundant in the future, therefore, it

is important to prioritise upskilling the current work-force. This can assist the COJ to easily transition to technology with adequately skilled personnel while improving efficiency and ensuring sustainability

5.3.4. Limited application

Majority of the respondents indicated that technology is used partially, which implies that there is room for improvement. Some of the respondents stated that the current use of technology in the organization is mostly prioritized for traffic signals. The existing GIS systems does not capture data on all existing infrastructure and as such there is limited information on existing infrastructure. One of the aspect cited by the Respondent 1 (2023:Interview) , was the insufficient adoption of technology for Capex Project which leads to cost overruns, late project completion and quality control issues, concurring with this, supporting this statement some of the respondents said:

"*The organization is not aware that the industry has shifted thus falling behind with technology, latest technology is not adopted by the organization. Current Technologies in the organization have limitations and relies on conventional processes for managing infrastructure*"

(Respondent 5, 2023:Interview)

“JRA should start at looking at using technologies such as SAP to automate SCM processes, electronic approval of drawings for planning department”

(Respondent 6, 2023:Interview)

A study by Yılmaz et al. (2015) demonstrates that the 4IR enables efficiency by providing sufficient, durable, easy-to-maintain infrastructure that will be able to cope with current and future demands. Therefore the view by the respondents that application of technology will improve efficiency of road infrastructure is supported by these scholars.

This theme confirms what was observed before the study commenced. The organisation is lagging behind in the application of technology. Even the available systems are underutilised, this has a knock on effect of the public sector where stakeholders are forced to use outdated technology if they want to collaborate with the organisation. The overall effect of not applying technology effects the entire industry because public institutions are major role players in the performance of infrastructure.

5.3.5. Crime Prevention Infrastructure Protection (Curbs Theft)

30% of the respondents highlighted the challenge of infrastructure vandalism which emanate as a result of the lack of innovative approaches for infrastructure protection. In line with the views of the participants, crime-related issues could have potentially been prevented if the organization made use of technology to monitor the infrastructure from both an operational and safety perspective. Moreover, the organization could avoid theft and vandalism with the adoption of relevant technological infrastructure. For example, the technology that is used at currently for traffic management makes infrastructure such as Traffic signals, CCTV vulnerable to criminal activities such as theft. Furthermore, this has created enormous inefficiencies on the on the road and exposed the public to frustrations, respondent 2 (2023:Interview) added by saying:

"*There is new technology that we need to look at, but because of the vandalism and theft we experience on our copper cables, we need to look at different methods of communicating from the controller to the poles. Currently we are using 27 call cable…..If we can decrease the 27 call usage, it will decrease the amount of copper available which will hopefully curb theft.*

(Respondent 2, 2023:Interview)

Apart from functionality, roads within the COJ are generally unsafe for many reasons, unfortunately, some of the reasons emanate from other elements which are not directly related to the design of the road itself. Those include load-shedding and criminal elements such as cable theft and robbery. Again, technology can help

alleviate these challenges. Some of the technology that the organisation can use to achieve this include solar powered traffic signals, cableless traffic system, remote monitoring of cameras in various sections of traffic circles, Wi-Fi.

One of the respondents mentioned that the city currently uses sim cards as part of traffic signal operations. However, these sim cards are also exposed to theft and often do not have the capacity to accommodate big data. This necessitates a change of approach from the COJ through taking advantage of the current available technologies to assist in preventing various crimes such as infrastructure vandalism. in addressing this issue is supported by various scholars such as Heinzel et al. (2017), will enable the COJ to efficiently manage and protect the road infrastructure and associated infrastructure.

5.3.6. Technology Improves Efficiency and Performance

All of the respondents were adamant that the adoption of technology can improve the overall performance of the organization. The participant shared the view that, the current skills and machinery are outdated, therefore the organization is ought to invest on capacitating personnel with new skills that are in line with the 4IR, adopt new technology approaches which will enable proper response approaches to issues. In demonstrating the appetite to adopt new technology, respondents had the following to say following:

"*Technology changes all the time, it might not necessarily increase the lifespan of certain infrastructure such as traffic signal, but it will definitely improve the efficiency. The mobility section has derived a new strategy for traffic signals which will be implemented soon*"

(Respondent 2, 2023:Interview)

"*At project implemented technology allows you to see a holistic picture of all your projects, but if you don't have technology, you end up looking at projects as individual. Then you unable them to see the collective value of projects*"

(Respondent 3, 2023:Interview)

All of the respondents agree that adoption of new technology approaches (systems, processes, machinery) is critical for the organization in order to effectively develop and manage roads infrastructure. Some argued that the focus should be on traffic signals and traffic controls in order to improve mobility, whilst some suggested SCM processes to be streamlined. Based on the state of the infrastructure; the backlog and failure to be proactive in attending to any defects within the city, it is clear that the organization's current systems and resources are inadequate to ensure efficiency throughout the lifecycle stages of infrastructure management.

For any organization to function optimally in this environment, one needs to be up to date with new technology, for example Microsoft Project for Gantt chart is one of existing technologies which is used has always been used for project management. However, there are already other software which the private sector is already using such as Civil Design, AutoCAD 3D, drones, etc. Literature by Rogerson et al. (2015), suggest that in order for organization to be efficient in implementing projects, they ought to be agile in the digitize space. The scholars, Mao et al. (2021) agree that the development of an Internet of Things (IoT)-based system for smart roads, as well as the evolution of the IoT system to support the eventual mass deployment of CAVs, are being given particular attention. They further ascertain that this will allow for the creation of a digital twin of the traffic and road systems and the development of various applications that can be built on that foundation to increase traffic safety and efficiency (Mao et al., 2021).

In order to integrate with recent technology, the organization needs to at least have some form of technology which can enable effective transition to the latest technologies. It is very imperative for the COJ to adapt to new innovations which will also assist to integrate with other entities in various government spheres and the private sector. For example, with technology one is able to detect incident before they occur, it appears that at the moment, the organization has no technological systems in place which can provide adequate solutions quicker. The prescribed standard details are not updated to align with current wave of the 4IR and as such the organization does not adopt new technologies such as new seals, use of drones.

5.3.7. Improves Quality and Saves Cost

According to PMBOK, Quality and cost are some of the critical areas of project management (Guide, 2001). Thus, a project-based organization ought to manage these adequately to ensure the efficient delivery of road infrastructure services. Accordingly, this theme emerged strongly with the participants concurring with the notion that technology saves help save costs while at the same time improving quality.

One of the benefits indicated by the majority of the respondents within the COJ was that technology helps the organisation deliver services in a cost-effective manner. As the respondents argued, technology offers capabilities that are lacking in the human resource component. It eliminates the possibility of human errors. Furthermore, the respondents were of the view that technology will enable efficiency by reducing the number of resources required for an activity, which saves costs. The cost that gets saved through the use of technology can be used by the organization to achieve objectives that are sometimes difficult to achieve with the high labor costs. In essence, the adoption of technology can help the organisation exceed its service delivery mandate, as the money saved can be used to attend to more Opex and Capex needs and responsibilities of the organisation, thereby facilitating more efficiencies in road infrastructure.

5.3.8. Effective Project Management

Based on the lack of technology adoption at project implementation being cited by 100% of the respondents, one of the themes that also emerged was the employment of technology for effective project management. According to the respondents, the COJ is facing several issues, such as project overruns, high project costs, and many other inefficiencies, as a result of not adopting the latest technologies in both Capex and Opex projects. The positive impact emanating from technology, according to Respondent 9 (2023:Interview):

"There is a massive opportunity for infrastructure and project assessment through the adoption of drones and other technologies. There is basically a lack of

technology adoption at the design level: no use of CCTV for the assessment of defects, and no livestream"

(Respondent 9, 2023:Interview)

Echoing the same sentiment, Respondent 5 (2023:Interview) said:

"*The organisation's depots have a poor maintenance approach that is not adequately aligned with the maintenance philosophy internationally, such as conducting repairs and reseals every 7 years, and this has led to infrastructure compromise*"

(Respondent 5, 2023:Interview)

Literature by scholars such as Rogerson et al. (2015), in line with the above view, suggests that technologies like drones, CCTV, service detection, etc. are some of the innovations that can bring efficiency to the development of infrastructure.

5.3.9. Technology Reduces Employment Opportunities

70% of the respondents cited that the challenge is that there is no political will for technology adoption; the government's objective is to reduce unemployment, and as such, the COJ has a responsibility to ensure high employment opportunities through infrastructure development by creating labour-intensive approaches even though there is technology to provide efficiency. The following respondents had the following to say:

"Politically, there is still a need for labour-intensive work at the project level; therefore, it is difficult to apply technology to such projects. Generally, in SA, the construction industry is very slow in adopting technology due to socio-economic issues"

(Respondent 9, 2023:Interview)

Alluding to the above, Respondent 3 said:

“Local government is heavily unionised; unlike developed countries, COJ is expected to create job opportunities through a labour-intensive approach for projects and operations, and this impacts technology adoption”

(Respondent 3, 2023:Interview)

“There are innovations that can be adopted, but they are not well received by the industry due to social and economic factors (job creation for labour-intensive jobs)”

(Respondent 7, 2023:Interview)

According to various scholars which includes Ding et al. (2014), there will be redundant jobs in the future; for example, the municipality will also have some of these jobs, which will be impacted by 4IR. However, it will be difficult for the municipality to let go of people, although this might not be favourable to the government. It is necessary, and it will only happen if nothing changes. People feel like technology will take away jobs; however, this might not be necessarily true. This can be a result of people not being upskilled to deal with technology. The reality is that if the organisation does not adopt new technology and upskill personnel, the COJ runs the risk of being left behind by the rest of the developed and developing world. According to Ding et al.'s (2014) literature, operational efficiency gaps are not being adequately addressed by the engineering and construction industries' use of the present automation technology accessible at this time.

5.3.10. Aware of 4IR

There was a fair and/or satisfactory understanding of what the fourth industrial revolution is among all respondents. On the contrary, all of them agree that the current use of technology within the organisation is outdated and that there is a need to employ technology in order for the organisation to meet its core mandate. The following respondents summarised the challenges as follows:

“*Technology is very critical, especially to what we do as an organisation; the existing one is already outdated. Road seals are not being applied, mobility is very poor due*

to no adoptive control, a lack of dynamic signalling, a lack and inability to adopt advanced communication (5G), and no synchronisation control"

(Respondent 2, 2023:Interview)

"*Currently, the JRA is not leveraging the 4IR; the industry already has automated pothole patching vehicles, which are faster and do not require people to manually conduct pothole repairs*"

(Respondent 5, 2023:Interview)

Observing the behaviour of the respondents in terms of how they conducted themselves during the interviews and their use of technology, especially at a personal level, one could notice that the respondents were not far behind in terms of technology usage. For example, some of them were able to comfortably conduct the interviews on the latest virtual platforms, such as Microsoft Teams. Moreover, some of them carried the latest gadgets; this is an indication that the participants do not have any issue with the use of technology in their personal space. Therefore, the lack of technology use is mainly due to the environment itself; it can be deduced that the organisation's outdated systems prevent people from being technologically inclined in the work environment. Accordingly, Kortmann et al. (2014) emphasise that achieving a balance between strategic flexibility and operational efficiency can help businesses gain a durable competitive edge.

5.3.11. Critical Strategic will for Technology Adoption

A relative number of the respondents cited frustration with project cost overruns, compromised quality of work done, lack of technology deployment, and high labour-intensive job creation expectations; therefore, strategic will for technology adoption emerged as a common theme. The common view of the respondents was that there has to be a political will to incorporate technology into the COJ; however, due to the high unemployment rate, the municipality is expected to ensure that less machinery is utilised on projects and more human resources are deployed so as to ensure job

creation. Respondent 9 (2023:Interview) indicated one of the frustrations as the lack of political will for technology adoption within the COJ.

In order for technology to be adopted by the organisation, it will need leadership to provide a culture change in the perception of technology within the entire COJ. There has to be a strategic will to encourage the use of technology, and with the nature of how municipalities are governed, there has to be a political buy-in to the approach. Scholars such as Muzaale et al. (2018) and Slack et al. (2017), agree with the assertion made by the respondent that an organization need to have strategies in various levels within that organization in order to ensure that they effectively deliver. Kupec at al. (2018), also argues that in order for organization to keep up with changes and be efficient, they need to adopt technology.

5.3.12. Technology a major influence of the organization's core objective

All of the respondents agree that the application of technology and the adoption of new innovative approaches can enable the organisation to meet its core objectives in road infrastructure development. Some participants argued that the organisation is not leveraging the available new technologies in the industry, and as such, the existing road infrastructure is not effectively serving its purpose. A respondent echoed the above sentiment by saying:

"*In relation to the lifespan of a road, the road does not like water, so you must get the water off the road as quickly as possible. Now that the technology has been around for years, you just need to seal the road. But this is not happening; the roads have cracks and potholes, etc., which decreases the lifespan of a road. The problem might not be existing technologies; perhaps JRA or the COJ is not implementing them".*

(Respondent 2, 2023:Interview)

"Technology has a huge influence on the organisation's core objectives"

(Respondent 9, 2023:Interview)

COJ is arguably one of the most developed cities in Africa, which implies that there is a greater need for infrastructure maintenance. The majority of the respondents agree that the quality produced under the new project is substantively within the required standards as compared to the existing infrastructure. The majority of participants agree that the current use of technology is adequate to produce satisfactory quality for Capex projects. However, on the maintenance end, all of the respondents feel the turnaround times for attending to defects and the quality of work done is very poor. They further argue that this is mainly due to a lack of technology application and a lack of training of personnel on the use of existing technology. This is in line with literature by several scholars, such as Ding et al. (2014), who encourage the use of technology in driving efficiency.

5.3.13. Conclusion in Relation to Research Question 2

The use of technology in road infrastructure management offers numerous benefits, including improved efficiency, safety, and sustainability. By adopting technologies such as real-time data analytics, automation, and smart infrastructure, organisations can enhance decision-making, streamline processes, and optimise resource allocation. However, successful implementation requires considerations such as cybersecurity, data privacy, scalability, partnerships, regulations, and continuous evaluation. Embracing technology and fostering a culture of innovation is crucial for realising the full potential of technology in road infrastructure management. CIDB (2022), while alluding to the fact that the present wave of industrial transformation, which is fuelled by digital, physical, and biological technology, has created a variety of opportunities for the building industry to meet sustainability standards.

5.4 Results in relation to Research Question 3

This section deals with common constructs (see Table 5), which emerged from research question 3: How would strategic sourcing help COJ improve efficiency and sustainability?

5.4.1. Added Financial Resource or Muscle

The majority of the respondents concurred with the notion that the existence of strategic assets, in the form of asphalt plant and RSD, has a significant contribution to the cost-effectiveness of the operations of the JRA and the city at large. In addition to saving costs, some of the participants went further to suggest that strategic assets present an opportunity for the organisation to generate revenue, which they said could go a long way in supplementing the budget that gets allocated to the organisation by the COJ. When asked for comments on the potential of improving efficiency for the organisation, Respondent 4 (2023:Interview) said:

“Providing asphalt to our contractor will improve budget constraints, especially for Opex. JRA can generate income from our service providers when they buy asphalt from us"

(Respondent 4, 2023:Interview)

Although profit generation is not the organisation’s core mandate, the organisation needs funds to operate in order to effectively deliver infrastructure. Without the funds, the service delivery objective would not be accomplished. Thus, it is important for the organisation to use the available financial resources in the most efficient way possible. The possibility to make money from the strategic assets can help the organisation do more for the residents of the City of Johannesburg. Supporting this statement, Respondent 8 (2023:Interview) had this to say:

“There is value in having a strategic asset; the RSD could source asphalt internally to reduce costs”

(Respondent 8, 2023:Interview)

5.4.2. Good for Particular Type of Operation

A significant number of respondents argue that the use of strategic assets should be separated from the Opex versus the Capex point of view. This view is further justified by a theme: satisfactory quality on Capex projects and turnaround times to attend to defects. Respondent 9 (2023:Interview) argued that the asphalt plant can also service the road surfacing depot (RSD). The majority of the respondents agree that if the COJ can realise an additional opportunity through selling asphalt to service providers, it will improve the liquidity of the organization. They further argue that most of the contractors within the COJ's database do not have adequate funds to run projects; therefore, assisting them to procure asphalt from the JRA will improve efficiency in project delivery.

"As I have indicated our SCM issues, now just imagine if we did not have the asphalt plant; then the backlog on the potholes and the resurfacing for RDS would even be greater because there will be periods when we will be sitting without a contract in place and we cannot obtain asphalt. As a critical service to the public, having potholes fixed is quite crucial, and we have an asphalt plant"

(Respondent 2, 2023:Interview)

" Strategic assets can assist greatly, but they should be limited to maintenance"

(Respondent 9, 2023:Interview)

While another participant said:

"RSD and asphalt plant are critical and value-adding assets. Ownership of these assets and selling asphalt to service providers will certainly improve efficiency, but success will depend on the market differentiation strategy"

(Respondent 5, 2023:Interview)

The existence of these strategic assets helps to eliminate the current long and tedious supply chain process. As mentioned by Respondent 5 (2023: Interview), who concurred with Respondent 9 (2023:Interview) on the notion that the strategic

assets are currently underutilised, it is evident that with adequate planning and proper strategy, these strategic assets have the potential to improve the efficiency and stability of the organisation.

As also mentioned in Section 5.2.4 (Question 1) under the theme of inefficient supply chain, one of the current impediments to efficient operations in the organisation is the lack of capacity in the supply chain to provide resources on time. For planned capex projects, the assets may not necessarily increase efficiency because there are minimal unforeseen issues in the execution of Capex projects in comparison to operational projects. As it can be argued, a huge part of the core responsibilities of the organisation is to maintain existing infrastructure assets, where there can be a lot of unforeseen requirements for services of the strategic assets, such as asphalt for road maintenance. The availability of the strategic assets helps the organisation respond quickly to such demands because the services are readily available, as opposed to outsourcing, where the organisation would be required to go through the supply chain processes.

5.4.3. Improved Efficiency on Delivery on the Core Mandate

The majority of respondents were of the view that ownership of strategic assets would improve efficiency for the organization. They further stated that having control of strategic assets enables a shorter value chain while also ensuring lean processes (eliminating some of the unnecessary role players). Respondent 2 (2023:Interview) stated that one of the strategic assets of value to be added would be the traffic management centre (TMC), which is aimed at dealing with traffic signals. In ensuring effective delivery of the project and achievement of the key performance indicators on time, Respondent 2 (2023:Interview) and Respondent 7 (2023:Interview) said:

“Traffic management facilities, for example, could lessen the need for defect reporting from consumers”

(Respondent 2, 2023:Interview)

"The service providers often struggle to procure specialised (asphalt) material in advance; private suppliers expect payment in advance before the asphalt can be delivered on site; this then leads to delays in projects. The organisation can permit contractors to source asphalt with no pre-payment and offset the cost from the payment certificates"

(Respondent 7, 2023:Interview)

Respondent 6 (2023:Interview) argued that by adding more strategic assets, the City of Johannesburg will be self-sustaining. Additional strategic assets could include the manufacturing of traffic lights, electric equipment, and supply cables. Supporting the above statement, Respondent 10 (2023:Interview) also argues that strategic sourcing will enable JRA to be in control of the core mandate. Adding to this, Respondent 2 (2023:Interview) said:

"Strategic assets such as traffic management centres (TMC) could reduce dependence on customers to report defects"

(Respondent 2, 2023:Interview)

Based on the overwhelming argument by the respondents regarding the existing strategic assets, the full benefit of having strategic assets such as the asphalt plant and RSD is not realised due to these assets being utilized. This is evident in the current performance of the plant, where current performance is characterised by inefficiencies, a longer value chain, and poor performance on service delivery. This is contrary to the argument by Slack et al. (2017), who said that for an operation to be efficient, an organisation needs to respond timeously, quicker, and be flexible.

5.4.4. Strategic Asset would Work But Requires Proper Strategy

Respondents were of the view that for strategic assets to realise value, they must be fully utilised and that there should be market research done and a proper strategy derived. Although strategic assets can assist in saving costs, improving performance, etc., the respondents emphasised the importance of having a proper

strategy in place, and this approach was further summarised by some of the respondents as follows:

“There is already a new strategy in place: the traffic management centre (TMC), which will be implemented soon. This is one of the strategic assets for traffic signals, which will enable the city to ensure efficient mobility. The Fix and Find App is no longer in place due to IT issues; therefore, having this new asset will enable the mobility unit to respond effectively to defects”

(Respondent 2, 2023:Interview)

Based on the historical evidence where it was reported that these assets were functioning better in the past than in the current state, it is clear that the performance has decreased over the years. This is what scholars Johnson, Whittington, Regnér, Angwin, & Scholes (2020) refer to as strategic drift, where the pursued strategy does not align with the dynamic environmental demand. The scholars emphasise that failure to bring about proper historical and cultural change has an impact on the adequate strategy being formulated. Meanwhile, the competitors who are providing the same service are agile enough to adjust to the demands of the industry or environment to the extent that for JRA, it is more convenient to consider using external service providers for some of the activities due to demand that cannot be met internally. As argued by 30% of participants, one of the strategies to be considered for strategic sourcing is a public-private partnership (PPP), whereby a firm with adequate expertise in the production and sale of the product In that way, the organisation can manage the risks of failure without having the right skills and resources..

5.4.5. Public Private Partnership

Respondents were of the view that strategic sourcing in the form of selling asphalt can be realized through public-private partnership (PPP) with a firm with expertise in the production and selling of the product. In that way, the organization can manage the risks of failures, not having the right skills and resources. The majority of the respondents were adamant that strategic sourcing should be limited to

maintenance and specific parts of Capex projects. They further stated that the depots are ineffective in responding to defects, regularly maintaining the roads in line with the required standards, and reducing delays and high costs for new projects.

Respondent 1 stated:

" I don't think the JRA can have enough capacity to supply the whole of Joburg"

(Respondent 1, 2023:Interview)

"We are very inefficient at the moment; one of the reasons is being highly regulated, but there's a way to deal with that: we can privatise that element or have a private partner for the operations"

(Respondent 5, 2023:Interview)

"Strategic sourcing has the potential to succeed; however, the JRA will have to be more efficient than private suppliers. There is a risk in manufacturing any product; big expertise will be required; therefore, it is very important to have a proper strategy in place, which can also look at having partnerships with people who have relevant expertise"

(Respondent 9, 2023:Interview)

A case study by Ismail et al. (2014) suggests that state-owned enterprises (SOEs) and municipalities should form a public-private partnership (PPP) to attain and manage strategic infrastructure assets. One of the suggested approaches by scholars in the case study is Build, Operate, and Transfer (BOT); this is when the private partner designs, builds, and operates the strategic asset and hands it over to the government entity at the end of the operating contract. This theme, in line with the literature, suggests that strategic sourcing has the potential to succeed in the COJ through the PPP strategy.

5.4.6. JRA not Meant to Make Profits

30% of the respondents were adamant that rendering services to the market or its appointed service providers will not work for the municipality or government entity. This theme emerged from the argument that there is a risk of something going wrong that the entity might not necessarily have the expertise to address and from the way municipal entities are structured. In alluding to this theme and arising concerns about expanding strategic sourcing to the market, Respondent 3 (2023:Interview) stated that COJ does not have a culture that supports this approach, and the organisation is not enabled to leverage their existing strategic assets. Respondents argued that generally when the government is going at producing anything, to think that the government can efficiently and competitively produce asphalt is a farfetched idea and only because of the culture of inefficiency. In emphasising the concerns, Respondent 3 (2023:Interview) added by saying:

"Culture will eat strategy for breakfast, so for any strategic intention to be successful, the organisation needs the right culture. The COJ and the government in general have no culture that will support deficiencies that might arise from this strategy. So all of these things might sound like good ideas or good strategic options, but culture is not there to support them. So I would say strategic sourcing is a good idea, but it's not going to improve efficiency because of the culture"

(Respondent 3, 2023:Interview)

The respondents further argued that private contractors have a deep-rooted relationship with Much Asphalt; if they were to choose between Much Asphalt and a government entity, they would choose the private supplier purely based on their perceptions of quality and cost. Literature is limited with regards to the utilisation of strategic assets for profit gains by the government. In contrast to the above view, one can argue that if the JRA can produce asphalt at a cheaper cost as compared to the private supplier, it then improves the liquidity of the organization. According to IIbeigi et al.'s (2017) research, the price changes in asphalt cement have made it challenging for road infrastructure departments to budget for transportation projects. Similarly to what was raised by the respondents, the scholars allude to the

fact that contractors have struggled to produce accurate estimates of project costs, particularly roads, due to the high cost of asphalt.

5.4.7. Adding more Assets will not Improve Efficiency

Contrary to the wide spread view among Respondents which says that strategic assets improve efficiency, 40% of the participants strongly felt that adding more strategic assets will not improve efficiency. Arguing that even the existing strategic assets are not serving a strategic purpose, Respondent 3 (2023:Interview) had the following to say in relation to the strategic asset that currently exist in the JRA:

"Asphalt plant and RSD are not strategic assets. JRA does not have the capacity or competency to manufacture asphalt. Output in tonnes of asphalt laid by RSD per day is insufficient, although there is an existing asphalt plant"

(Respondent 3, 2023:Interview)

The argument that this strategic asset is not adding value needs to be tested in the form of market analysis. Moreover, a proper assessment needs to be done because there are other competitors that are producing better output and quality than the JRA. This will then imply that the organisation's strategy is not adequately positioned, and there has to be proper market segmentation. Should it happen that the performance of the organisation falls short of that of other competitors or similar role players in the market, it may be necessary to consider limiting it to only maintenance projects (Opex).

In contrast to the respondent’s views, the literature by both Gottfredson et al. (2005) and Palmatier et al. (2020) demonstrates that for the COJ to be efficient, they need to diversify and make some trade-offs by having proper strategies. Market research to segment the targeted market will need an extensive strategy in place.

5.4.8. Offering Services from Strategic Assets Augment Service Delivery

Almost all the respondents suggested that sourcing of asphalt for surfacing for contractors at project value would improve effectiveness on ensuring key

performance indicators are achieved on time. Respondent 8 (2023:Interview) alluding by stating , It would be a perfect scenario if the asphalt plant is fully operational. Respondent 7 (2023:Interview) argued that this approach is good provided that the quality of asphalt produced by the COJ is good. In ensuring effective delivery of projects the organization can permit contractor to source asphalt with no pre-payment and offset the cost from the payment certificates (Respondent 7, 2023:Interview). Efficient delivery of projects and ensuring customer satisfaction can be realised, summarised this, the following respondents said:

“Surely there is a big potential for strategic sourcing but that would depend on the market differentiation and how we (JRA/COJ) set ourselves apart. For instance we can say to our contractors, if you have a project with us, we would provide them with asphalt at 75% price per ton compared to what they would get from an ordinary private company. By doing that this, the JRA would not forcing your customers to buy from them but they will be are then attracting them through what they offer to them. So those are the advantages that we possess through the plant because we can play around with the with the differentiation strategies”

(Respondent 5, 2023:Interview)

Alluding to the above statement, Respondent 8 said the following

"Sourcing asphalt for service providers can work but it requires appetite. COJ (JRA) already has an advantage of owning some of these assets"

(Respondent 8, 2023:Interview)

Some service providers do not have the financial muscle to provide services beforehand; therefore, when these services can be provided to them, it has an advantage as it takes away the financial constraints, challenges, and service delivery delays. Sourcing key components of the products for the market provides the organisation with the opportunity to test its performance in proving a particular service against other role players in the market. It will also require organisations to conduct research on the targeted or specific market in order to further understand

the market. Considering the information gathered from the respondents, it appears that for capital projects, particularly, the service providers might not necessarily be looking for benefit in the form of sourcing the product cheaper but rather the convenience that can be provided by the JRA as a result of delivering the services by service providers without having to pay for them upfront.

The literature by Slack et al. (2017) suggests alludes that strategic assets and strategic sourcing present an opportunity of flexibility, doing things right, fast, on time and effectively. Supporting the views of the respondents, scholars, Gottfredson et al. (2005), In order to organise and optimise the value chain, sourcing has evolved into a strategic process.

5.4.9. Conclusion in Relation to Research Question 2

Based on the construct above, in answering research question 3, it is evident that strategic sourcing does provide a certain level of sustainability and efficiency if a proper strategy is in place. It is evident that strategic assets provide efficiency more on the operational side in ensuring that there is proactive maintenance of infrastructure. Furthermore, it is argued by Gottfredson et al. (2005), concurring with the respondents, that value can be realised in strategic sourcing, but a proper strategy should be in place to alleviate budget constraints, thereby increasing efficiency in road infrastructure management within the COJ.

6 CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

As a result of the research exercise, this section presents a summary and provides recommendations to the City of Johannesburg on how to achieve operation efficiency and further provide approaches that can be adopted by the COJ in ensuring sustainability and efficiency in road infrastructure development. The study adopted a qualitative research methodology, as this technique offers a contextualised and in-depth understanding of how participants evaluate operational efficiency in connection to the development of road infrastructure.

6.1.1. Limitations of the Study

The study focused on local government organizations managing city road infrastructure in COJ. Access to historical data and company reputation protection was limited. Language issues for non-technical participants, including SMMEs and regular road users, hindered the study's outcome. People generally show less interest in research interviews, especially if they don't know the researcher or have no reward. The research sample was initially expected to have 20 participants, but only 10 were able to participate. Despite the low response rate, the sample was considered adequate for qualitative investigation. The study faced challenges due to participants' work and family obligations, which made it difficult for the interviewer to complete the interviews within the allotted time. The interviews ran over their time allotments, and the majority of respondents had work commitments, making the suggested timetables unmet. Load-shedding was a significant issue for online interviews, especially for those who chose virtual interview choices.

6.2 Conclusion

This research was undertaken in order to identify the factors that affect the impact of operational efficiencies and to further understand the operational efficiencies that can be adopted by COJ in road infrastructure development. In addition to presenting

the data, recommendations and suggestions were to be shared to improve the status quo.

The **Main Research Objective**: The main research objective was to understand the impact of operational efficiencies that can be adopted in road infrastructure development within the COJ.

The literature review described operational efficiencies as the ability to effectively provide products and services to customers. It recognised that roads are one of the critical infrastructures that drive the social and economic needs of any country. Road infrastructure issues were cited by many scholars as impediments to economic growth. It went on further to acknowledge that operational efficiency measures include quality, dependability, speed, flexibility, and cost. The scholars agreed that operational efficiency in relation to road infrastructure is one of the most important aspects, and its measure is the ability of roads to provide safety, effective mobility, reliability, and connection for people. The literature also showed that one of the huge constraints on technology adoption is high unemployment in South Africa, which forces communities to rely on construction projects, making it a challenge for construction projects to adopt more efficient and effective approaches to developing infrastructure.

The analysis of the study revealed that there are several interrelated and integrated factors that contribute to the operational inefficiencies in road infrastructure development within the COJ. The lifecycle management of road infrastructure was found to be inadequate; there is a lack of maintenance of infrastructure, which affects the performance of existing roads. It was observed that road users measure the efficiency of road infrastructure as a function of convenience, from the perspective of vehicle wear and tear, and by the ability of the infrastructure to safely transport goods and commuters between two points in the quickest possible duration..

The study also found weaknesses in performance management practices with reference to the management of KPAs and KPIs. Generally, a silo approach does not support the core mandate of the COJ. It was further found that there are

generally insufficient resources, and as such, the city is under immense pressure with a huge infrastructure backlog and is unable to effectively deliver services. These include insufficient budget, human resource skills, technology, systems, machinery, tools, etc. In the maintenance space, there is a serious shortage of manpower or labour that is responsible for daily routine road maintenance. The study further showed that the quality of work done in maintaining infrastructure is generally poor, the response time to attend to defects is inadequate, and there are no proper systems to manage existing infrastructure. Where resources are available, they are not being efficiently utilised, and they lack the necessary skills. Supply chain management was found to be inefficient; the procurement strategies are not aligned with the demands of the COJ. Bid specifications are often weak, the calibre of service providers procured is a huge issue, and they lack the capacity to effectively deliver projects..

There was a clear indication that the city is currently experiencing a major infrastructure collapse with no pro-active maintenance plan. The regional depots rely on defects being reported by customers; they do not conduct visual impact assessments, which will inform any maintenance plan or appropriate measures. It was found that on Capex projects, quality is relatively good, but the lack of delivering road infrastructure on time and within the appropriate budget remains a huge constraint. The study also showed that there is a need to adopt the latest technology; the most existing technology has limitations and is outdated.

Political aspects were also found to be the drivers of dictating measures to deal with socio-economic imbalances, which in turn impacts the appropriate strategies to be implemented for road operational efficiencies. The existing culture and lack of commitment to address the inefficiencies pose a threat to service delivery.

The study also indicated that the strategic assets that are of great value to the organisation are being underutilised, and there is a need to have proper strategies in place in order to effectively manage the assets. The asphalt plant and RDS were some of the recognised strategic assets that improve efficiency and the overall

performance of the organisation if they are operated effectively. It was also found that the RSD, which is meant to be serviced by the asphalt plant, is outsourcing services that can be obtained internally due to SCM issues.

6.3 Recommendations

Accordingly, the following section discusses recommendations that could be implemented by Johannesburg to improve operational efficiency in road infrastructure development:

a) Integrative approach Systems approach (internal and external): All units in the organisation's KPA should be aligned with the company's scorecard. The integrative approach also requires the involvement of other external agencies in the quest to achieve the main objective of COJ, which is to create a world-class African city. For example, for traffic signals to function well, they require electricity and power, and for vandalism of infrastructure, like cable theft, it requires that thieves be apprehended; this then requires other agencies to be involved. It is imperative that the city have a holistic structure that will ensure proper and constant engagement with all agencies and the role that each has in overall infrastructure management.
b) Restructuring: There is a need to align key performance indicators across all departments within the organization. The KPIs of supporting units should feed into the key performance areas of the core department. This will enable the company score card to effectively address KPAs, which influence the overall efficiency, performance, and core mandate of the organisation.
c) New strategy and streamlined SCM processes: SCM processes should be lean synchronised in order to improve the efficiency of supply chain division. There is a need for a procurement strategy that will address all the KPAs and KPIs that influence the overall COJ's service delivery budget implementation plan. A procurement strategy could also be used to reduce the need for procurement activities as much as possible, so at least this would limit the number of procurement activities that an organisation would have to deal with. Procurement Process Optimisation: Examining the existing

procurement processes within the COJ to identify bottlenecks and inefficiencies This could involve analysing the stages involved in procuring road construction and maintenance services, evaluating the timeframes and resource allocation, and suggesting improvements to streamline the process and ensure timely project execution.

d) A complete update of the current system: There should be an integrated system that is linked internally for departments within the organization. The JRA systems should also be linked with other systems within the COJ and, ultimately, other systems with provincial and national governments.

e) Application of various technologies, which is asset management, to prevent problems and risks before they occur. The industry has already moved to Industry 4.0, where there is available technology that can be used to manage projects and monitor existing infrastructure. Technology can assist the COJ in improving their response time to defects and ensuring that the quality of work done is in line with the required standards. Employing new technology can also alleviate pressure on human resource capital; it can assist in informing appropriate maintenance plans and specifications. The technologies that can be deployed for operational efficiencies include, but are not limited to, the following:

    - Productive maintenance that uses robotics and drones
    - Integrated modular building, self-healing concrete, additive manufacturing (3D printing), smart construction, and diverse innovative building materials
    - Road surface seals
    - Sensors for vehicles and pedestrians
    - New technology will also monitor green time for traffic signals.
    - Technology for traffic signal optimisation for improving queuing and detection of vehicles will be deployed within 5-8 years.

f) Continuous improvement, upskilling of people, and building of culture innovation will improve efficiency. If COJ is agile and intentional about continuous improvement of competencies and adoption of technology, performance and the outlook of the organisation will be improved. This will

drive flexibility, dependability, cost-effectiveness, and quality of roads with the COJ.

g) The COJ, through the JRA, currently owns an asphalt plant and an RSD which are mainly used for maintenance purposes. An opportunity can be achieved through selling the asphalt plant at a lower cost to all JRA contractors; this will generate revenue for the organisation, and the money can be used for maintenance purposes of road infrastructure and its facilities, like traffic signals. The organisation can further purchase new technology, which will enable the firm to achieve effective and efficient road infrastructure development. For strategic assets to realise value, they must be optimally utilised.

h) New skills and other resources to deal with the backlog of defects in all the regions of the city will lead to time and cost savings.

i) Assess the performance of the existing strategic assets in comparison to similar assets in the markets. Should the assessment come with a result that is not better than the market, improve or get rid of them and add assets where the organisation is guaranteed dominance (play where you know you can win).

j) Although the majority of the participants agree that strategic assets are more useful for operational projects, these assets can also be used to increase efficiency on Capex projects, especially in cases involving service providers with limited financial resources to procure material on their own. The recommendation here would be to also use the strategic assets to improve performance on Capex projects. For Opex projects, the strategic assets can be used to shorten the value chain, where both assets can be used to serve each other in order to realise the ultimate value, e.g., RSD can source asphalt from the asphalt plant instead of sourcing it from private suppliers. It is not good practice to buy asphalt from external service providers while there is an internal asphalt plant that is currently operating below capacity. The use of these strategic assets will be realised and evident in the balance sheet of the company.

k) Strategy review: The issues of inefficiencies call for the current strategy to be reviewed to ensure that it meets the demands that come with on-going

environmental changes. Review the entire organisational structure to assess the performance of the existing assets, compare it to competitors, and restructure where and how these strategic assets sit.

6.4 Suggestion for Further Research

This study was initially undertaken with a broad scope and the ambitious goal of resolving the issue of operational efficiencies within the COJ. Furthermore, it was imperative to outline the inefficiencies experienced by the COJ before identifying the measures the COJ could take in order to optimise its operations. After going through the research process, efficiency in regards to strategic sourcing for state-owned enterprises in any setting has come to light as a challenging and integrated issue. It is important to note that this is not an exhaustive analysis of the topic at hand. With the objective of filling in the gaps in the corpus of literature that will still exist once this study is finished. The following areas are suggested for additional study:

a) Strategic sourcing: A research that will investigate whether state-owned entities can extend their value proposition and compete with private supplier on the market to provide goods and services for income generation.
b) Impact of the private sector versus the public sector: research that will compare the role of the private sector and that of the public sector in facilitating operational efficiencies.
c) Organisational culture: a study that will investigate the transformation of culture within the public sector, where the research will seek to find the factors or measures that can be implemented to build a more technologically savvy workforce in the public sector.
d) Leadership: research on the role of leadership in driving dynamic and adaptive public institutions in the South African context given the political dynamics of the country.

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8 CONSISTENCY MATRIX

Table 5: Consistency Matrix

Operational Efficiencies on Roads Infrastructure Development within the City of Johannesburg					
Sub-problem	**Literature Review**	**Research Questions**	**Source of data**	**Type of data**	**Analysis**
Measure of Operational Efficiencies	(Slack, Brandon-Jones, Singh, Phihlela, & Johnston, 2017) (Rogerson & Rogerson, 2015) (Wall, 2021) (Ismail, Pillay, Mabuza, & Xolo, 2014) (Diego, Valtueña-Ramos, & Frank, 2021) (Azhar, 2011) (Pisu, Hoeller, & Joumard, 2012) (Muzaale & Auriacombe, 2018) (Fallah-Fini, Triantis, Jesus, & Seaver, 2012) (Essuman, Boso, & Annan, 2020) (Eshtaiwi, Badi, Abdulshahed, & Erkan, 2018) (Eboli & Mazzulla, 2008) (Kuhn, 1983) (Kortmann, Gelhard, Zimmermann, & Piller, 2014)	How do you measure operational efficiencies in relation to roads infrastructure?	Interviews, case study and desktop	Descriptive	Thematic analysis

Operational Efficiencies on Roads Infrastructure Development within the City of Johannesburg					
Sub-problem	**Literature Review**	**Research Questions**	**Source of data**	**Type of data**	**Analysis**
Impact and the Adoption of Technology in Roads Infrastructure	(Kupec, Gibbons, Matchett, & Maher, 2018) (Heinzel, Azhar, & Nadeem, 2017) (Chen, et al., 2013) (Ding, Wei, & Che, 2014) (Lee, et al., 2018) (Stewart & Waroonkun, 2007) (Kganyago, 2019) (Yılmaz & Bakış, 2015) (Kannemeyer, et al., 2012) (Kortmann, Gelhard, Zimmermann, & Piller, 2014)	How does the application and the types of technology improve efficiency in roads infrastructure lifecycle management?	Interviews, case study and desktop	Descriptive	Thematic analysis
Sustainability of Roads Infrastructure Development	(Slack, Brandon-Jones, Singh, Phihlela, & Johnston, 2017) (Uzarowski & Bashir, 2007) (Ilbeigi, Ashuri, & Joukar, 2017) (Ismail, Pillay, Mabuza, & Xolo, 2014) (Lenferink, Tillema, & Arts, 2013) (Gottfredson, Puryear, & Phillips, 2005) (Kannemeyer, et al., 2012)	How Would strategic sourcing help COJ to improve efficiency and sustainability?	Interviews, case study and desktop	Descriptive	Thematic analysis

9 ANNEXURE

Annexure A: Research Instrument

Annexure B: Participant Information Sheets

Annexure C: Consent Form

Annexure D: Research Approval Letter